NRCS CONSERVATION INNOVATION GRANT

FINAL REPORT

Grantee Entity Name: Virginia Polytechnic Institute and State University	
Project Title: C-CAP (Conservation Credit for Agroforestry Production) Merging Water Quality Credit Markets	
Agreement Number: 69-3A75-16-045	
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Project End Date: September 30, 2019	

A. Project Status

The **Agroforestry Systems Topic Team** reviewed technical agroforestry extension and agency articles, explored agroforestry design options, strategies, and guidelines, and studied scientific literature. The team included the principal investigator, a project associate, and external collaborators, such as agroforestry producers and nutrient trading consultants, as well as agency and extension staff. Information from publications and input from technical service providers, consultants, academic faculty, and producers were used to finalize a descriptive list of design options representing regionally relevant agroforestry practices. A literature review examined the ecological, economic, and social benefits of tree planting on marginal and riparian lands using agroforestry practices, and focused on the effectiveness of low-density tree planting of native tree species, especially in terms of soil conservation and water quality. Other benefits that were examined included carbon sequestration, wildlife and biological diversity, and socioeconomic and on-farm benefits. Project findings were used to draft C-CAP (Conservation Credit for Agroforestry Production) recommendations for potential review and consideration by a Virginia Department of Environmental Quality (VDEQ) certification advisory committee that may form under the proposed regulation on the Certification of Non-Point Source Nutrient Credits (9VAC25-900).

The **Planting Locations Topic Team** guided use of grant funding from the National Fish and Wildlife Foundation (NFWF) to complement CIG-sponsored initiatives. NFWF supported the installation of C-CAP agroforestry demonstrations that protect water quality and maintain agricultural operations. Installations were established at Virginia Tech's Catawba Sustainability Center (CSC) in Catawba, Virginia and a private farm in Appomattox County, Virginia (Oak Grove). CIG-sponsored initiatives focused largely on the CSC installation, which converted riparian and upslope sub-prime land into a two-tiered agroforestry farm. The CSC facility was used to evaluate the compatibility of agroforestry with Virginia's Nutrient Credit Trading Program (NCTP) and shape model simulations of non-point nutrient offsets on a sample of properties in two Virginia watersheds.

CSC and Oak Grove facilities were used to evaluate whether agroforestry installations are cost-competitive in VDEQ's NCTP. The CSC facility was 9.5 acres and Oak Grove was 6.75. Both are located in the western part of the state and within the James River watershed and represent separate physiographic provinces. The CSC lies in the ridge and valley physiography of Western Virginia. Oak Grove is located in the Piedmont region of Virginia's Southside. Site variability was useful because it provides separate habitat types that support different tree, shrub and herbaceous species, as well as different service areas for credit generation and sale, though some overlap exists. A key finding was that existing NCTP trees per acre (TPA) requirements are prohibitive (400 TPA). Agroforestry practices rarely exceed 400 TPA across a management unit, but this threshold is regularly achieved in the rows and clusters of agroforestry trees established in strategic locations within the management unit. The implication is that creditable acreage is confined only to tree planting rows and clusters, which significantly reduces the area that can be enrolled in the NCTP. A group facility standard, referred to as AG-FAST (Agroforestry Group Facility Standard), was proposed as a solution. Acreage from multiple agroforestry nutrient trading facilities are aggregated in a single AG-FAST portfolio. AG-FAST farmers and brokers share costs, responsibilities, and revenue, but agricultural operations can continue where trees are not planted.

The CSC installation was established in March 2017 and November 2017. Preparation, protection, and maintenance activities included tree tube installation and replacement, mowing, herbicide spot application, mulching, and monitoring for tree disease, pest and animal damage, and mortality. The team worked with a group of public and private planting and design experts, to include EQIP-eligible landowners, which formed a taskforce liaison group. The group provided input and exchanged information with other topic teams to provide a descriptive list of agroforestry practices. The liaison group met face-to-face in January 2017. The group provided information, and synthesized data during the project, to include post-planting assessments, as well as analytical assistance. Team members provided advice and oversight throughout the project. Additionally, an EQIP-eligible landowner panel was scheduled to occur in Barhamsville, VA on January 17, 2018 but was cancelled due to inclement weather. A follow-on meeting occurred in Bealton, VA on April 4, 2018, and a final panel in Richmond, VA on January 12, 2019.

The **Nutrient Reductions Topic Team** used the Environmental Protection Agency's Bay Facility Assessment Scenario Tool (BayFAST) to model nutrient offsets from agroforestry practices. BayFAST simulations were constructed using corresponding percentages of best management practices (BMPs) as a proxy for agroforestry practices based on CSC demonstrations. In particular, the team modeled different levels of tradable nutrient credits on a 35% sub-sample of 306 randomly sampled properties in the Rappahannock basin (Carter Run and Lower North sub-basins). Properties contained stream frontage on at least one first, second, or third order stream and were owned by individuals that replied to a mail survey regarding interests in agroforestry and potential adoption. Scenarios applied five agroforestry conversions to four assumed pre-existing land uses. Conversions ranged from no action (status quo) to complete forest conversion (agricultural retirement), with different scales of agroforestry simulated in riparian and upslope areas.

Data were analyzed to determine if there is a linear relationship between tree planting density and nutrient offsets. In addition to BayFAST, the team used the Nutrient Tracking Tool (NTT) to model nutrient reductions at the CSC. The team compared N, P, tile flow, and sediment losses. NTT model findings were compared to measures of above- and below-ground nutrient flow using samples from monitoring wells installed at the CSC. Well data were compared more broadly to BayFAST simulations. Lastly, the team evaluated farming returns relative to nutrient offsets using bio-economic modeling of agroforestry tradeoffs between status quo farming and full forest conversion.

The **Site Preparations and Maintenance Topic Team** reviewed extension documents, forestry and agricultural BMPs, applied economic and operational literature, and baseline requirements in VA 62.1-44:15.35 and VADEQ landowner guidance. Findings were used to identify and list best practices for selecting, planning, and managing an NCTP agroforestry project. Detailed steps include how to develop an agroforestry management plan, assess conservation and nutrient offset values based on site conditions and system objectives, manage initial and long-term inputs to reduce costs and environmental impact, and apply operational practices that help maintain conservation and production values.

Site design and preparation techniques were developed and implemented through a partnership with Virginia's Department of Forestry (VDOF). Methods ranged from a control with no preparation, to scalping and spot- and band-spray. The US Department of Agriculture (USDA) National Agroforestry Center's (NAC) AgBufferBuilder application was used to design and establish a variable-width agroforestry buffer next to a fixed-width buffer. A tree tube study, initiated in 2017, examined the differences in tree growth and development between two types of tree tubes (ventilated and non-ventilated). Data were collected to determine growth and performance differences, including mortality, pest damage, height, and root collar diameter.

B. Project Results

Agroforestry practices intentionally combine annual and perennial crops on the same piece of land. They include multifunctional riparian buffers (planting food, floral, and timber trees and shrubs in streamside zones), upland practices like alley cropping (annual farming in alleyways between broadly spaced rows of trees), windbreaks (tree rows planted to prevent wind damage and improve microclimate), and multi-story cropping (crops, shrubs, and trees stacked together to enhance growth and food production). Agroforestry practices provide ecosystem services without retiring agricultural operations because trees and shrubs are planted and managed alongside annual crops. The dominant form of land use conversion in VDEQ's NCTP is open land to forest, which maximizes credit potential but prohibits agricultural production. C-CAP formed to develop recommendations and practical tools for using agroforestry practices to generate nutrient credits and continue agricultural activities in Virginia (Appendix 1).

Goal 1 Develop and submit project findings and recommendations to VDEQ regarding agroforestry systems in Virginia's NCTP.

The project team developed a site-structure-function matrix quantifying nutrient offsets for various agroforestry projects across a series of land use conversions. The matrix represents the magnitude of change in the average load reduction derived from modeled offsets across a large set of simulated facilities and the CSC demonstration. BayFAST data were created by modeling conversions of a set of existing land uses to agroforestry practices using trees at various densities and sizes. Practices were simulated on riparian buffer and upslope contours. The site-structure-function matrix cross-tabulates the average simulated reduction in nutrient and sediment loads (percent magnitude in offsets).

BayFAST simulations were conducted on 306 randomly sampled properties in two hydrologic unit code (HUC)-15 sub-basins in Virginia's Chesapeake Bay Watershed. Included were the Lower North and Carter Run – Rappahannock watersheds in the counties of Augusta, Culpeper, Fauquier, Madison, and Rockingham. Sampled properties contained frontage on first to third order streams and marginal land, and were owned by individuals who responded to a survey about their interest in and potential adoption of agroforestry practices. Simulations involved three land use conversions: 1) 0% conversion (status quo); 36% in riparian buffer zones and 37.5% alley cropping on upslope contours, and 2) 100% coverage as conversion to forest (agricultural retirement). Conversions were applied to four assumed existing land uses: 1) "hay without nutrients", 2) "hay and alfalfa all", 3) "pasture all", and 4) "row crops all". Each matrix simulation in BayFAST generated data on sediment, P, and N delivery outputs to tributaries (edge-of-stream) and the Chesapeake Bay (delivered).

The range of simulated agroforestry scenarios replicated riparian buffer and upslope contour alley cropping demonstrations at the CSC. The Catawba Creek transects much of the property and is in the headwaters of the Chesapeake Bay. Matrix configurations resulted in a set of 12 (3 conversions x 4 land uses) scenarios. After evaluating the results and considering the functionality of BayFAST relative to NCTP TPA requirements, it was determined additional scenarios were needed to improve the analysis. The purpose was to provide additional data, as well as more accurately reflect areas including acceptable TPA.

To generate additional BayFAST scenario data, a random subsample of 126 properties was taken from the original set of 306. Eight new conversion scenarios were conducted using two additional agroforestry densities

(18% buffer coverage and 18.75% upslope contour coverage; 5.5% buffer coverage and 12% upslope contour coverage). Subsequent densities more accurately reflect site occupancy where stem densities across an agroforestry farm do not achieve full coverage of 400 TPA, but rows or clusters of trees generally do. In other words, a threshold of 400 TPA is not achieved across the entire agroforestry farm unit but is within the rows or clusters of trees. A ten-foot row width, which corresponds to standardized tree spacing at 400 TPA, was used to calculate percent conversions in BayFAST. Reductions in the percent coverage of agroforestry tree planting that meets NCTP requirements were necessary to model realistic nutrient offsets.

Additional agroforestry scenarios were applied to the 4 baseline land uses (2 new agroforestry intensities x 4 land uses), and the 8 new scenarios were added to the existing 12 for a total of 20 scenarios for 126 subsampled properties (Appendix 2). Scenario results represent load reductions determined by cross-tabulating the effectiveness of agroforestry with respect to changes in modeled sediment, N, and P loads delivered to the Chesapeake Bay and its tributaries. BayFAST and GIS (ArcMap) were used to model output for each subsampled property. The scenario with 5.5% buffer and 12% upslope most closely represents agroforestry demonstrations at the CSC. Two-thousand five-hundred and twenty scenarios were completed, generating averages, standard errors, and ranges for each of the 20 matrix configurations.

NTT was used to further evaluate nutrient reductions at the CSC and Oak Grove. The NTT was designed and developed by the Texas Institute for Applied Environmental Research and Tarleton State University. Output estimated and compared N, P, tile flow, and sediment losses across agroforestry practices and a control at the CSC. The simulation used actual spatial parameters associated with site occupancy of trees at the CSC, where tree densities surpass the 400 TPA threshold within VDEQ's NCTP (i.e., tree rows with a 10-foot spacing width). Unlike BayFAST, the NTT only allows a single BMP to be evaluated at a time. Forest buffers and upslope alley cropping contour plantings were modeled separately and summed to create a single output.

NTT was used at the CSC to estimate total tree planting (buffer and upslope tree planting coverage) at 75 and 95 feet, respectively, in widths calculated as the actual riparian buffer and associated upslope tree planting. This took into account the estimated percentages of 5.5% forest buffer and 12% tree planting per actual planting densities. Parameters included no grass buffers and agroforestry installations planted on seeded pasture planted in year one. The control had the same parameters, but with 0% forest buffer and tree planting. Results indicate agroforestry treatments noticeably reduce loads of organic N and P, as well as less surface and subsurface flow, and surface erosion when compared to the control.

The project team also used baseline agroforestry installations at the CSC to simulate establishment of an approved facility under VDEQ's NCTP and to develop best practices for generate tradable credits using agroforestry systems. The process involved preparatory steps to generate appropriate plans (e.g., Nutrient Management Plan), before drafting a Nutrient Reduction Implementation Plan (NRIP) which is the basis for VDEQ approval of an NCTP facility. The process focused on existing stipulations (e.g., 400 TPA for conversion to forest) and compatibility with agroforestry systems, leading to recommended NCTP strategies.

Bio-economic modeling was conducted using a production possibility frontier that compared financial tradeoffs between annual farming (status quo) and full forest conversion (agricultural retirement). Agroforestry was tested as a pathway for optimizing returns and maximizing farm financial competitiveness between the status quo and agricultural retirement scenarios. Environmental and economic outcomes were evaluated across a spectrum of land use configurations, ranging from corn and bean farming with no riparian buffer or upslope plantings to pine reforestation. Varying planting densities also were evaluated, including hardwood riparian buffers, multifunctional agroforestry buffers, and multispecies alley cropping on contour.

Site Review and Selection

Site review and selection includes undertaking a market evaluation prior to parcel selection and facility installation. Project managers should look closely at the location of a potential facility, including watershed and service area (i.e., the area where nutrient credits can be sold). This involves assessing existing competition and credit availability. At the time of this project, VDEQ used land use classifications from 2005 as the baseline for credit generation. Focusing on the total number of credits is necessary for full cost accounting.

Long-term monitoring and maintenance, including invasive species tracking and treatment, is required to ensure the facility remains in NCTP compliance. This includes follow-up plantings and other maintenance activities to address mortality and threats to long-term performance. Additional considerations include financial assurances related to market performance and competitiveness, credit pricing and trading strategies based on market trends, and estimates of total potential revenue and net profit.

The CSC demonstration included 9.5 acres of multifunctional agroforestry systems established across a gradient of land classes, from hillside alley cropping contour plantings on marginal land to bottomland farming sites and creek side riparian zones. Multifunctional riparian zones included both fixed- and variable-width agroforestry plantings. The variable-width riparian buffer design was generated utilizing the AgBufferBuilder ArcGIS program, which was created by the USDA National Agroforestry Center. The application identifies varying widths of riparian buffer plantings to achieve targeted conservation and coverage efficiencies.

Due to slope, soil type, and land use, some conservation buffers require more vegetation whereas others require less to achieve targeted conservation efficiencies. In other words, streamside zones with a steep slope, large runoff area, highly erodible soils, and drainage from active cropland will require more vegetation to achieve the same load reduction compared to streamside zones with gentle slopes, smaller runoff areas, less erodible soil, and drainage from fallow lands require less buffer vegetation to mitigate non-point source pollutants. The AgBufferBuilder application delineates design parameters using multivariate modeling that accounts for land use/condition and different levels of cost and conservation.

Upland contour plantings were designed and implemented at the CSC in tandem with streamside buffer plantings. Objective were to extend the agroforestry system beyond buffer zones into upslope regions and to minimize sheet flow of water across the property. The goal is to minimize the volume and intensity of surface water flow to prevent rill erosion and transport of agricultural pollutants. Upland hillside slopes were planted slightly off contour with broadly spaced rows of trees. The goal is to capture surface water in swales, or furrows, parallel and slightly offset upslope from tree rows. This reticulation system distributes rather than channelizes surface water to promote tree growth on drier, rockier hillsides.

Nutrient Reduction Implementation Plan (NRIP) Development and Components

Once a project location has been identified and the nutrient credit project is found to be financially feasible, the next step is to set up a pre-application site visit with VDEQ. The intent is for VDEQ to verify land-use conditions prior to planting. The project coordinator assists VDEQ with the site visit by providing a property location, project limits within the property, and proposed land conversion types and activities. This enables VDEQ to conduct a preliminary evaluation of the project prior to submission of an NRIP proposal.

A NRIP generally contains five governing components. The first is a “project description”, which includes an overview of project priorities and goals. Next “operational practices” are outlined, such as baseline practices, the representative service area, credit broker identification, restrictive covenants preparation, credit derivation method, and a land conversion areas management plan. A schedule of "monitoring, maintenance, and reporting" follows, which outlines monitoring requirements, planned property maintenance and project limits, and regulatory agency reporting requirements. "Accounting/financial" notes identify financial assurance mechanisms and agency requirements regarding the tracking of credit transfers via a credit ledger. Lastly, "other information" outlines access and inspection terms, terms for alteration of land conversion areas, and documentation to verify credit transfers.

<u>Project Description</u>

- Purpose – The first component of an NRIP defines the reason and intent. This outlines the aims of the applicant (or "sponsor") and is the basis for prescribing the development, use, maintenance, and monitoring of a nutrient credit bank as outlined by the Virginia legislative code. It also provides a preliminary view of proposed land use changes for the nutrient bank. For example, the CSC installation proposed converting hay lands to an agroforestry farm. Goals included nutrient and sediment reduction, leaving the subject property and entering tributaries of the Chesapeake Bay, as well as generating associated nutrient credits resulting from said reductions.

- Property Location – This section provides an approximate physical address and an overview of the landscape position of the proposed facility. This description is accompanied by project location and project vicinity maps that graphically depict gross parcel limits, project limits, and if available major landscape features as outlined in the narrative.

- Property Description – This section presents a broad overview of the physical characteristics of the property, including historical and existing land use conditions of the property. A baseline date of July 1, 2005 was used. This is typically done using Farm Service Agency (FSA) crop records in conjunction with active remote sensing of aerial imagery for further confirmation of land use as of the baseline date. The property description also contains the gross parcel limits, specific tax map parcels (if applicable), graphic depiction of the property, project limits, and tax map parcels that constitute gross parcel limits.

- Project Location – The project location section is used to further refine credit activities to specific fields as identified by the USDA FSA tract and FSA field numbers. In most situations, a nutrient bank sponsor will not enroll the entirety of the farm's agricultural zones. This section also is used to identify specific fields or portions of fields where credit-generating activity conversions occur. It also is accompanied with a graphic depiction of an overall aerial image outlining gross parcel limits, FSA tracts, and FSA fields.

- Project Description – This section provides a detailed explanation of the land use conversion, and activities and associated acreages within proposed land conversion areas. A graphical depiction of the areas accompanied by historical aerial imagery is used as evidence and verification of the active land management of the land use throughout the years. This section also outlines the nutrient bank's "service area", which identifies the project location within a specific 8-digit HUC, as well as the adjacent 8-digit HUC's within the same river basin. The service area is used to identify where credits can be transferred from the facility to offset N, P, and sediment on an 8-digit HUC and watershed basis.

<u>Operational Practices</u>

Baseline Practices

- Soil Conservation Plan – A soil conservation plan is required for all fields within an FSA tract wherein nutrient credit-generating activities occur. This minimizes the amount of rill erosion within agricultural fields that can lead to sediment deposition in local waterways and eventually the Chesapeake Bay.

- Nutrient Management Plan – A nutrient management plan is required for all fields within an FSA tract wherein nutrient credit-generating activities occur. The nutrient management plan accounts for crop rotation cycle, soil type, soil saturation of nutrients, soil pH, and soil productivity based upon crop rotation cycles. A nutrient management plan is prepared by a Virginia certified nutrient management planner to account for these conditions and specify an agronomic rate and timing for nutrient applications that maximize nutrient uptake and minimize nutrient runoff during precipitation.

- Cover Cropping – Cover cropping is required on fields used for row crop production. Examples may include but are not limited to soybeans, corn, tobacco and cotton. After a crop is harvested, the soil is left exposed to the elements unless a cover crop is implemented. If left exposed over the course of late fall and winter, there is no root system established to retain soil structure and integrity. This leads to soil loss and sedimentation of local waterways and downstream resources.

- Livestock Exclusion – Livestock exclusion is the exclusionary fencing or removal of livestock from fields wherein nutrient credit-generating activities occur. Livestock exclusion is important to limit the destruction of riparian buffer vegetation that acts as a streamside BMP, as well as holds streamside bank sediment in place. The lack of vegetation leads to increased sedimentation from surrounding land uses, as well as loss of stream bank stability and increased stream bank erosion (vertically and horizontally).

- Riparian Buffer – A 35-foot wide vegetative riparian buffer is required on perennial streams adjoining areas in which nutrient credit-generating activities occur. Vegetative buffers are important because they filter runoff from upland uses, as well as help retain soil integrity and stream bank stability. Riparian buffers are the baseline practice most relevant to a credit-generating facility.

Service Area

The service area map graphically depicts discernible boundaries identifying facility location within the state, the river basin, 8-Digit HUC boundaries, and 8-Digit HUCs where the project is approved to transfer credits.

Identification of Offset/Credit Broker

Nutrient credit brokers transfer credits from the nutrient credit banks. The broker can also be the nutrient bank sponsor. The broker must possess a valid Virginia business license and federal EIN tax ID number, have a federal tax ID number, demonstrate the ability to provide adequate financial assurances, and prove intent and ability to deliver credits for permitted activities.

Restrictive Covenant

A legal mechanism in the form of a restrictive covenant (deed restriction) or easement is required for credit release from VDEQ. The restrictive covenant is required to address the level of allowable development, timber management, access roads, trails, commercial uses, and other information to secure the viability and availability of nutrient reductions and associated credits.

Credit Derivation Methodology

Credit derivation methodology uses current land use, land use conversion type, and acreage converted to determine the total number of N and P credits generated by the project.

Land Conversion Areas Management Plan

The land conversion areas management plan outlines project goals, land use conversion activities, planting schedule, and other implementation details. Based upon project goals, it also prescribes how to manage invasive species, as well as the type of herbicides allowed within land conversion areas. In the event a plan revision is required, it will specify the timing and duration in which an update to the land conversion areas management plan is required. The plan also discusses the regulations and details regarding how timber and other forest products may be harvested.

Monitoring, Maintenance, Reporting

- Monitoring Criteria – The bank sponsor is required to provide annual monitoring of land conversion areas. Monitoring criteria include but is not limited to maps depicting the project limits, woody stem survey survival success table, transect or vegetation plot monitoring station locations, location of invasive species, as well as photo documentation to depict project progress and success.

- Maintenance Criteria – Per the terms of credit release by VDEQ, the sponsor is required to maintain the land conversion to ensure nutrient reductions as outlined in the NRIP. If a planting survival problem is identified during monitoring, the sponsor is required to remedy the situation by installing additional stems or seedlings. In the event that invasive species occupy greater than 5% of the project limits, the sponsor is required to address the species of concern to bring the project back into compliance.

- Reporting Criteria – Once annual monitoring has been completed, and field data and photo documentation are tabulated, the bank sponsor provides a report to VDEQ documenting success or failure of site conditions. If a failure of planting survival is identified or if invasive species exceed 5%, then the report will note proposed remedies for particular issues. The sponsor/broker is required to report nutrient credit transference in the form of a nutrient credit ledger. The nutrient credit ledger identifies the Virginia Stormwater Management Program (VSMP) authority, the permittee or purchaser, the activity name or project name of the permittee, locality of the project, 8-Digit HUC, credit transfer date, total P transferred, total P balance, corresponding retired N, and total N balance.

Accounting and Financial

- Financial Assurances – Prior to nutrient credit release from VDEQ, either the sponsor or the broker is required to provide and maintain financial assurances in the form of a letter of credit, bond, or a CD assignment. The sponsor will need to maintain financial assurances to: 1) replant the entire installation in the event of failure; 2) conduct annual monitoring and reporting for the 10-year monitoring period; and 3) purchase compliance credits for one year to offset a failure at a price set by NCTP.

- Credit Ledger – The broker or sponsor is required to provide a copy of the bank ledger quarterly at a minimum to track transference of nutrient credits.

Other Information

- Access/Inspection Terms – The access and inspection terms are identified within the NRIP, but are also outlined in more detail within the restrictive covenants. This section acknowledges that VDEQ, as well as the sponsor, broker, or VSMP authority may request access to verify nutrient reductions. VDEQ usually performs annual inspections of nutrient credit-generating projects following monitoring report submission to verify report accuracy and to document on the ground nutrient reductions.

- Alteration Terms - Under some circumstances, the NRIP or a component therein requires adjustment or slight modification. Some situations in which a modification is required include a landowner request to adjust project boundaries, add agricultural lands to the project, or change from a lesser credit-generating activity to a higher credit-generating activity. If a change or alteration to the NRIP is needed, VDEQ must be notified of such change and the change/alteration must be approved by the agency prior to implementation.

- Purchase Documentation - The acquisition of nutrient credits takes the form of a purchase and sale agreement with a corresponding affidavit of credit transfer and bill of sale. The purchase and sale agreement acknowledge both the purchaser's requirements to fulfill the final obligation and the sponsor/broker's requirements to provide and deliver nutrient credits at closing. Once the purchase and sale agreement have been executed and the financial obligation has been fulfilled, the sponsor/broker issues the affidavit of credit transfer to VDEQ via electronic notification, and then provides original copies of the affidavit and bill of sale to the purchaser for documentation within their personal records.

Agroforestry NCTP Demonstrations

CSC

The 9.5-acre agroforestry installation at the CSC demonstrates a number of different of agroforestry practices (Figure 1). These systems demonstrate multifunctional riparian buffer planting options, as well as tree planting on contour across upland sites. Design was driven first by water quality, and then demonstrating a diverse range of practices, acreage, planting configuration, and tree species and spacing.

Riparian areas are zones of biophysical transition where terrestrial habitat meets aquatic habitat. Trees and shrubs in riparian areas can filter chemicals and slow sediment draining from upland areas, conserve soil and limit flood damage, c) shade water and deposit detritus to improve aquatic wildlife habitat, and d) provide terrestrial habitat. In most cases, when woody riparian buffers are intentionally planted they are designed and managed explicitly for ecosystem services. However, multifunctional riparian buffers merge production and conservation objectives by planting species that provide marketable products. Multifunctional agroforestry buffers at the CSC demonstrate both conservation and production. Practices were established in rows to ease harvest and maintenance (A1, B1, B2), as well as follow drainage and erosion patterns (A2, A3, B3, B4).

Most riparian areas established through cost sharing and grant-based conservation programs follow a fixed-width (e.g., 35 feet) parallel to a streamside (fixed-width buffers). However, some areas require protection beyond 35 feet to achieve suitable levels of conservation efficiency. Computer-based tools and site observation were used to create a variable-width buffer, which alters planting stock coverage based upon need, thus saving planting costs and optimizing water quality objectives. The CSC installations demonstrate both fixed-width (A1, B1, B2) and variable-width (A2, A3, B3, B4) buffers. Variable-width buffers were designed using the AgBufferBuilder ArcGIS program in ArcMap 10.4. The term multifunctional is used to describe buffer systems designed specifically to provide salable products, whereas conservation buffers was used to describe buffers with primary design to protect water quality even if composition includes fruit and nut producing species.

Upland zones are located on higher ground above riparian and associated flooding zones. At CSC, upland zone plantings were confined primarily to hillsides. Upland agroforestry practices further increase the amount of non-point source sediment and pollution entering riparian buffer baseline BMP zones, thereby increasing overall conservation efficiency. Keyline upland agroforestry design plants rows of trees and shrubs on contour to intentionally slow, distribute, and store water in agroforestry practices. Keyline systems utilize swales (small berms) that direct and store water supporting trees and other vegetation while also filtering non-point source pollutants. Over one mile of swales were created at the CSC and cut in slightly off contour on installation hillsides to capture run-off and enhance moisture where trees were planted.

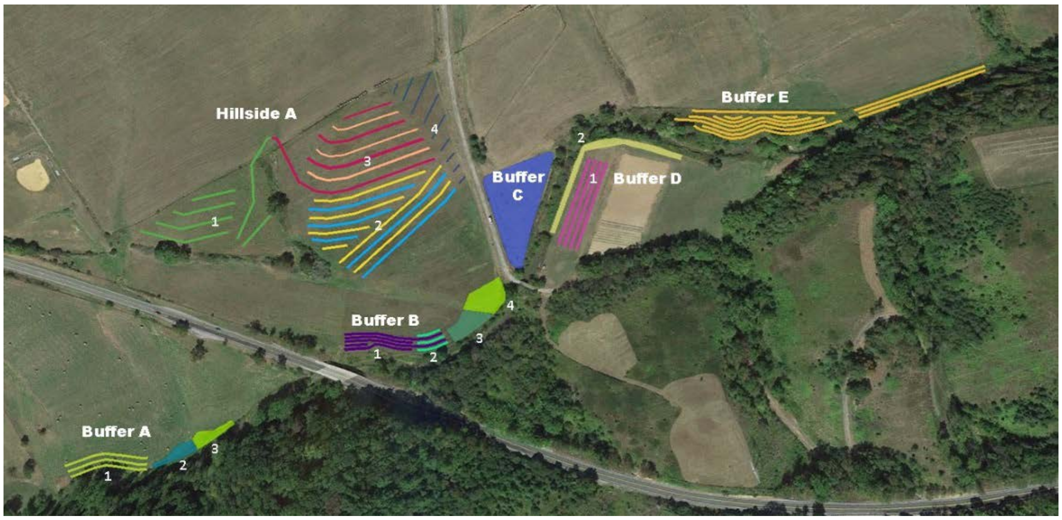

Figure 1. 9.5 acres of agroforestry practices installed at the CSC with support from NFWF and used to inform analysis and assessment for this project.

- Buffer A-1 – Fixed-width multifunctional riparian buffer planted in hybrid hazelnut (33) and American persimmon (18). Consists of three 250-foot rows for a total of 750 linear feet that cover 0.27 acres. Rows are 4-feet wide and spaced 16-feet apart. Inter-row planting was a repeating pattern with one persimmon followed by two hazelnuts at 10-foot spacing.

  The site was prepared two rows further from the creek using a scalper, which removed the top l-inch of soil to create a weed-free planting bed. The row closest to the creek was sprayed in the spring and summer of 2017 to prepare for a fall 2017 planting. The first row was planted with eight American persimmon and 17 hybrid hazelnuts (filbert variety).

- Buffer A-2 – Variable-width conservation riparian buffer encompassing 0.08 acres planted with bald cypress (7), sycamore (6), black walnut (7), and persimmon (9). Trees are spaced 10 to 15 feet apart. The site was spot sprayed (circles around each planting site) in spring 2017 and sprayed again in late summer/early fall to prepare for a late fall 2017 planting.

- Buffer A-3 – Variable-width conservation riparian buffer encompassing 0.09 acres planted in bald cypress (7), sycamore (6), black walnut (7), and persimmon (9). Trees are spaced 10- to 15-feet apart. The site was spot sprayed (circles around each tree) directly after planting in spring 2017.

- Buffer B-1 – Fixed-width 0.35-acre multifunctional riparian buffer with 1,087 linear feet of rows planted in American elderberry (278). Rows are 4-feet wide and spaced 6-feet apart. This system blends into Buffer B-2 and is considered an alley cropping system. Three varieties of native elderberry were planted, including 'Bob Gordon', 'Adams', and 'Ranch'. The site was prepared by rotary tilling and covering exposed soil with woven plastic ground cover.

- Buffer B-2 – Fixed-width multifunctional riparian buffer with three rows 90-feet long (A total of 282 linear feet) planted in red mulberry (12) and American persimmon (6). It is planted as an alley cropping system with elderberries on 0.11 acres. Rows are 4-feet wide and at 6-feet apart. Within rows, persimmons are planted following 2 mulberries. All trees are 10-feet apart.

  This system demonstrates three different site preparation methods. The row furthest from Catawba creek was scalped to remove the top layer of soil and vegetation. The second row from the creek was tilled using a rotary tiller. The row closest to the creek was sprayed in spring 2017, with a follow up in late summer/early fall to prepare the site for fall 2017 planting.

- Buffer B-3 – Variable-width conservation buffer encompassing 0.16 acres planted with bald cypress (7), sycamore (6), black walnut (7), and river birch (9). Trees are spaced 10- to 15-feet apart. The site was broadcast sprayed (the entire area) in spring 2017 and sprayed in late summer/early fall to prepare for a late fall 2017 planting.

- Buffer B-4 – Variable-width conservation buffer encompassing 0.21 acres planted in bald cypress (10), sycamore (10), black walnut (11), and river birch (10). Trees are spaced 10- to 15-feet apart. The site was spot sprayed (circles around each tree) directly after planting in spring 2017.

- Buffer C – Multifunctional riparian buffer designed as a food forest, for human consumption. This is 0.91 acres and planted loosely following the USDA's three-zone multi-functional riparian buffer structure with fast growing flood tolerant plants in the zone near the stream bank, and fruit and nut trees in the two upslope zones. This buffer includes the greatest diversity of tree species: sycamore (2), black walnut (3), black willow (1), buttonbush (9), witch hazel (5), American persimmon (13), elderberry (12), serviceberry (9), American hazelnut (3), Washington hawthorn (6), hydrangea (7), Virginia sweet spire (15), fothergilla (3), and slipper elm (2). Students in Virginia Tech's Engage program planted the remaining in spring in 2017.

- Buffer D-1 – Fixed-width multifunctional riparian buffer that includes a variety of woody floral shrubs. Most are coppiced every few years, and all are maintained as shrubs and spaced 4-feet apart. The woody floral riparian buffer consists of four rows that are 290-feet long, for a total linear footage of 1,140 feet. It encompasses 0.48 acres and is 65-feet wide. Rows are 4-feet wide with about 12-feet in between. This configuration has potential for converting to an alley cropping system that produces cut flowers and/or vegetables. Woody floral species include yellow twig dogwood (49), flame twig dogwood 'arctic sun or arctic fire' (15), pussy willow (30), winterberry 'winter red' (21), viburnum 'roseum' (28), sweet shrub 'hartledge wine' (15), and hydrangea 'limelight' (8). All species except yellow twig dogwood were planted in 2011. Some woody florals planted in 2011, which did not survive include aronia, black birch, and 'Incrediball' hydrangea.

- Buffer D-2 – Conservation riparian buffer of 0.26 acres, which adds to the conservation benefit of the woody floral riparian buffer using red twig dogwood (33), silky dogwood (18), and Washington hawthorn (12). These species were selected for aesthetic qualities and suitability for riparian areas. This planting extends and existing naturally vegetated riparian area, and spacing and configuration is varied.

- Buffer E – Multifunctional riparian buffer that intentionally does not follow a fixed- or variable-width configuration because it was designed around an existing livestock fence installed for the adjacent silvopasture. This buffer has a series of rows spaced 10-feet apart for 3,310 total linear feet and encompasses 1.31 acres. The rows follow the contour of the creek bank and include white oak (138), American persimmon (127), mockernut hickory (14), slippery elm (18), and black walnut (16). Trees within rows are also spaced 10-feet apart and configured to collect data and study the effects of vented tree tubes on tree growth and survival (complementary tree tube study sponsored by Tubex and Conservation Services).

- Hillside A-1 – Key line swale system planted in Chinese chestnut 'Gideon' (20), red mulberry (47), smooth alder (23), and false indigo (24). It encompasses 1.33 acres with 1,309 total linear feet of rows spaced 35-feet apart. Chestnuts are spaced 55-feet apart with a false indigo and smooth alder 5-feet to either side to utilize for soil amendments (coppice and N fixation).

- Hillside A-2 – Key line swale system encompassing 1.88 acres with two different rows interchanging. One including hybrid hazelnut (261) for 1,623 linear feet, the other including shagbark hickory (27), pawpaw (45), smooth alder (50), and false indigo (32) for 1,411 total linear feet. Rows are spaced 20-feet apart. The shagbark hickories are spaced 55-feet apart within rows with smooth alder and false indigo 5-feet to either side. Pawpaw were improved varieties include two of each of the following: 'Shenandoah', 'Susquehanna', 'NC-1', Pennsylvania Gold', and 'Mango.'

- Hillside A-3 – Key line swale system encompassing 1.68 acres and includes American plum (58), American persimmon (60), and smooth alder (57). The swales/rows are spaced 30-feet apart and alternate between a swale row (1,377 linear feet) and a row that is not planted on a swale (951 linear feet) in order to study the effects of swales on trees growth and soil water dynamics. All the rows have plum alternating with persimmon with 20-feet between each. Every other pair of persimmon and plum received two smooth alder N-fixing shrubs 5-feet away to study the effects of coppiced N fixing shrubs on tree growth.

- Hillside A-4 – Contoured rows of white oak (8), black oak (5), and mockernut hickory (4) that compromise 0.56 acres and 588 linear feet of rows. These rows and trees are space 35-feet apart. They are not planted in swales.

Additional details pertaining to the CSC project installation are in Appendix 3.

<u>Oak Grove</u>

- Riparian Buffers – The riparian buffer area, 35-feet from the stream, is the location of the tree tube study (in purple) and a basic buffer planting of bald cypress and black walnut (in yellow) (Figure 2). Tree-tube study calculations are based on 300 TPA. The basic buffer is based on 400 TPA.

Tree Tube Study (1.3 acres)	390 stems
White Oak	177 stems
Persimmon	177 stems
Black Walnut	36 stems
Bald Cypress and Walnut (3.27 acres)	1308 stems
Bald Cypress (70% of 1308)	916 stems
Black Walnut (30% of 1308)	392 stems

- Up-Slope Tree Planting Area – Black walnut and tulip poplar were planted in agroforestry zones beyond the 35-feet baseline buffer in Chewacla loam soils (next to the creek). The area upslope of the Chewacla loam soils on the southern side of the creek has Mecklenburg-Pointdexter complex and is 15-25% slope, which makes it suitable for tulip poplar. The species cannot tolerate the frequent flooding common of the lower-lying areas. All calculations are based on 400 TPA.

Tulip Poplar (South of Creek) (0.46 acres)	184 stems
Black Walnut (North of Creek) (1.21 acres)	484 stems
Black Walnut (South of Creek) (0.4 acres)	160 stems

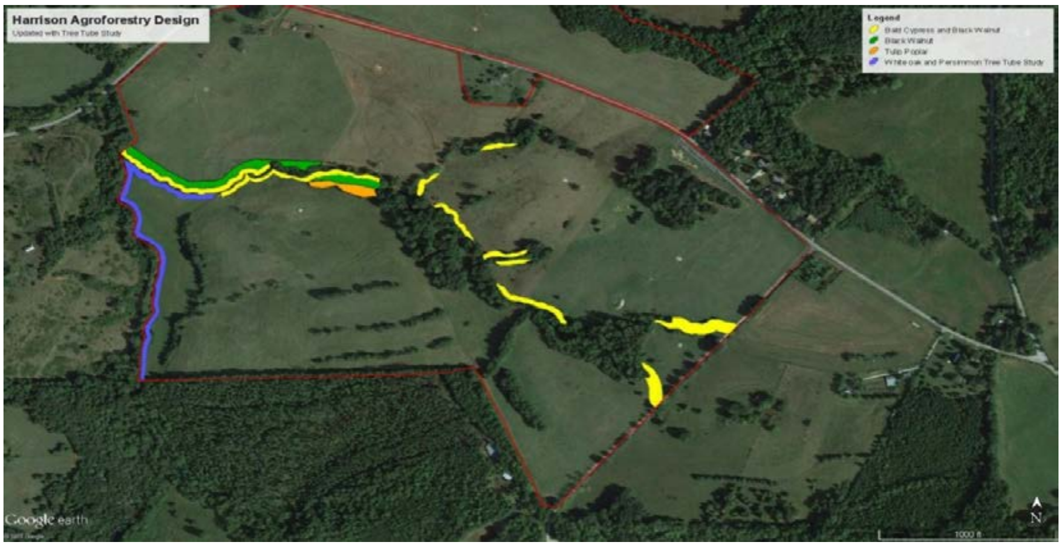

Figure 2. Oak Grove design with riparian buffers and associated up-slope tree plantings noted by color.

NRIP Potential and Insight

At the time of the C-CAP project, perpetual credits were not possible by installing a 35-foot agricultural riparian buffer BMP (known as the "baseline"). Perpetual nutrient credits for land conversion are only possible in addition to a riparian buffer BMP (known as "additionality"). Nearly 45% (4.23 acres) of the agroforestry practices installed at the CSC facility included riparian buffer plantings using multifunctional trees and shrubs. Agroforestry multifunctional buffers are established at widths that exceed the 35-foot agricultural baseline minimum, generally ~45-90 feet in width with three production zones (Figure 1).

In addition to wider multifunctional riparian buffers, widely spaced rows of trees were planted in alley cropping system on contour using key line plowing and a slope offset of 1°. Contour plantings were established on hills rising from bottomlands situated next to the multifunctional riparian buffers (Figure 3). Due to width and species selection, multifunctional agroforestry buffers extend into additionality zones and could generate perpetual credits beyond the 35-foot baseline, while also providing food, floral, and timber products. Upslope contour plantings increase acreage of forest conversion. Forest buffers also are often the highest and best use for vegetative water quality conservation, and upslope tree rows increase water control and filtration.

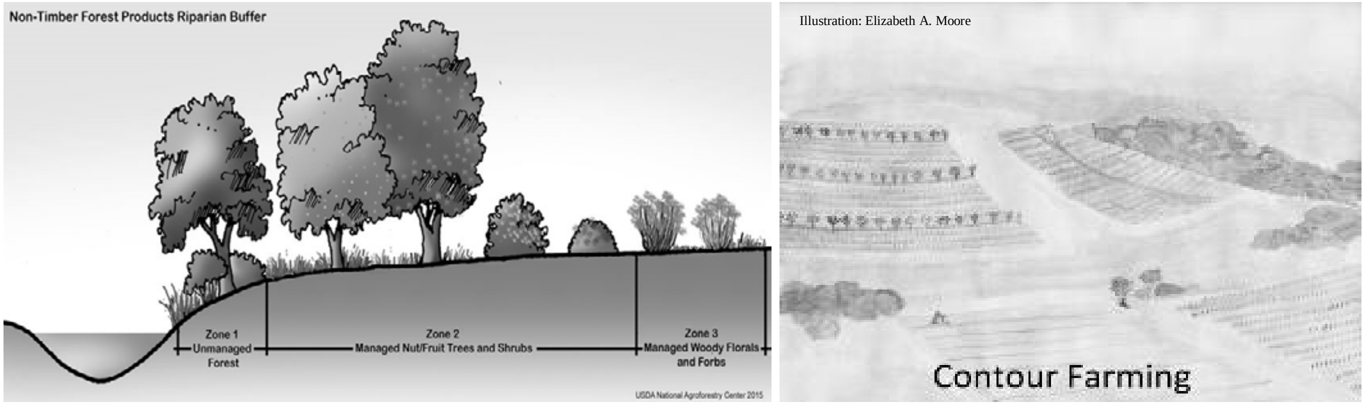

Figure 3. Multifunctional riparian buffer cross-section depicting three zones of management that balance water quality conservation and tree crop production (courtesy the USDA National Agroforestry Center). Contour farming depiction, representing alley cropping configurations used at the CSC upslope from multifunctional riparian buffers. The multifunctional agroforestry riparian buffer represents a last line of defense, with upslope water volume and direction managed using agroforestry plantings on contour.

Another factor is that NCTP stipulates a minimum 400 TPA in forest conversion. Agroforestry practices at the CSC did not meet this threshold on a land unit basis. Technically speaking, the installation would not meet the TPA requirement for a credit release unless a number of volunteer species were documented within those areas to assist in meeting required stem counts. The CSC planting also utilized various specialty species that make replanting more expensive. Upfront costs coupled with NRIP preparation and long-term monitoring and maintenance of specialty tree crops make agroforestry installations cost-prohibitive, assuming no returns from companion farming and tree crops. If a larger area is converted using a higher initial planting density and riparian buffers were not incorporated in the plan/costs, the CSC installation could potentially be a viable nutrient bank. Additional gains from annual and perennial farming would then be possible.

The Oak Grove installation reinforced lessons learned from the CSC project. A 35-foot multifunctional riparian buffer was installed using fruit bearing species such as downy serviceberry to establish a baseline conservation practice. The landowner can potentially earn revenue from the fruit bearing stems while simultaneously benefiting from grant funding and cost share to bear the financial burden of planting. In contrast to the CSC, pine species and yellow poplar were planted at 400 TPA in credit-generating areas. These species represent conventional NCTP mixes because they are less expensive, cost-effective alternative to specialty species. Passive management also helps minimize input costs. The Oak Grove project has one drawback in that credit generation only occurs on approximately four acres. When input costs are accounted for and coupled with monitoring activities relative to scale, the project cost is generally disadvantageous but considered as a sole revenue-source land use absent of additional production such as farming.

There are multiple and diverse benefits associated with agroforestry. Projects that rely solely on nutrient credit sales are likely to be financially unfeasible. It may be that at certain scales, likelihood declines, but findings suggest this will be rare. Location also is an important factor. Both the CSC and the Oak Grove installations are in the Middle and Upper James River basins. Land in these basins is available at a discount compared to other regions and basins. Conversely, the value of a nutrient credit in the Middle James is less than the value of credit in other regions of the James River basin, as well as other river basins.

The NCTP publishes standardized uniform credit allocations for basins even though water quality threats and thus potential impacts of conservation practices vary from site-to-site and even zone-to-zone on a single site. A production possibility frontier was used to evaluate water quality benefits and economic costs of land retirement, forestry, and a range of agroforestry practices (e.g., multifunctional riparian buffers, upslope contour alley cropping, species and planting density variations). A biophysical mass-balance model was coupled with an economic marginal costs model to evaluate financial-environmental tradeoffs between status quo monocrop annual agriculture, agricultural retirement through conversion to pine forests, and a range of blended agroforestry practices in riparian buffers and on adjacent hillsides.

Results indicated significant heterogeneity in water quality benefits across BMPs and demonstrate the need for differentiated water quality crediting, or ratio credits, based on variations in site characteristics of an NCTP installation. This would theoretically enhance the value of strategic agroforestry applications, which target areas that are of highest threat to water quality. Lower, strategic tree densities can reduce loads from problem areas without retiring all agricultural activities. A variable ratio credit regime reflecting differences in environmental threats to water quality would improve incentives for farmers to participate in the NCTP. Various bottomland and upland agroforestry practices and species configuration offer a spectrum of possible planting possibilities.

The bio-economic production possibility frontier offers a flexible, accessible, and modular approach to tradeoff analysis that policy makers, farmers, and researchers can use. Bioeconomic simulation could support NCTP policies by providing a tool that allows optimization of agroecological land management. Nutrient credits would be proportionally awarded in a working lands system that is more closely coupled to environmental outcomes, increasing the efficiency and effectiveness of market-based policy schemes. Given that nutrient credit value is the upfront revenue driver, it may be advantageous to use agroforestry within a specific river basin and/or more urbanized setting so that the value of the nutrient credit outweighs full-cost accounting of the nutrient bank.

Results of BayFAST modeling for sub-sampled properties were averaged and graphed across forest conversions applied to assumed pre-existing land uses. Simulated conversions ranged from no action (status quo) to complete forest conversion (agricultural retirement), with three simulated agroforestry densities in between. Findings supplement bio-economic modeling in that relationships between increases in tree planting density and nutrient loads were observed generally to be curvilinear. Increases in load reduction efficiency ranged from moderate to extreme as forest conversion increased from the status quo through lower densities of agroforestry application on assumed land uses. As the percentage of land converted to trees for agroforestry approached full agricultural retirement, nutrient load reductions increased but at a slowing rate.

Modeled output suggests substantive nutrient load reductions are possible without full forest conversion. Agroforestry plantings strategically placed in high-threat areas determined through biophysical modeling could additionally increase efficiencies at lower densities thereby furthering conservation gains. In addition to BayFAST, the NTT was used to model nutrient reductions related to agroforestry installations at the CSC, and deployed subsurface/surface nutrient flow wells (Ecotracker^{tm}) on transects through multifunctional riparian buffers perpendicular to the streamside. N, P, tile flow, and sediment losses were compared and results aligned with BayFAST output.

Limitations of scale could be addressed by aggregating agroforestry tree plantings across multiple farms within the same basin. This would pool acreages converted to trees for credit generation and potentially increase revenue to the point where the costs of plan preparation and establishment, as well as the cost curve of long-term monitoring flatten, particularly when shared among farms. Site aggregation coupled with a planting plan that incorporates passive management and a select list of species may allow sponsors to additionally reduce costs thereby making agroforestry a more attractive opportunity for farmers and brokers.

Project Data

See Appendix 4 for project data.

EQIP Requirements

An EQIP-eligible farmer meeting was scheduled to occur with eight farmers in Barhamsville, VA in January 17, 2018. Unfortunately, the meeting was cancelled due to a major snow event. The EQIP-eligible landowner meeting scheduled for April 4, 2018 at Bealton, VA occurred as planned and included three farmers. A final meeting occurred on January 12, 2019 in Richmond, Virginia with two farmers. Meetings proved useful in that participants received a project summary and overview of findings to date, and were asked to share reactions and consider the costs and benefits of using agroforestry practices generally and more specifically in terms of the NCTP. Open-ended discussions and questions pointed to the importance of full transparency regarding upfront costs, external investment, and risk related to future credit sales, all of which were hurdles to farmer adoption. Participants assessed possibilities for agroforestry and provided short presentations about the nature of their farm operations, which indicated silvopasture was the most likely agroforestry practice to be adopted. NCTP participation among conventional commodity farmers appears possible only insofar the benefits to farm operations are clear and predictable. Skepticism about the NCTP is perhaps a bigger sticking point than the notion of converting to agroforestry practices alone. Participants also questioned the real purpose of the NCTP, how the program is administered, the problematic nature of deed restrictions, impacts on specific farm operations due to forest-based retirement, and the economic effects on supporting businesses such as feed and seed stores and equipment sales, and the farm workforce more generally. Lastly, preferences for agroforestry conversion were largely focused on silvopasture, which involves co-managing livestock, forage, and trees. This practice is presumably not allowed as a BMP.

Project Pictures

See Appendix 5 for project pictures.

Goal 2 Identify and account for producer preferences for agroforestry products and associated market strategies.

Interviews were conducted with EQIP-eligible agroforestry stakeholders to identify limitations, potential, recommendations, and preferences for agroforestry practices, products, and marketing in the NCTP region.

- Limitations – Engagement efforts with key stakeholders and farmers indicated that the proposed agroforestry nutrient trading practices have limitations. Even if the program were modified to accommodate and enhance profitability of agroforestry installations, only some farmers are more likely to participate. Findings over the course of multiple meetings and multiday trainings suggest that participating farmers are likely to be smallholder, niche farmers who generally have off-farm income, tend to be more conscientious about interdependent biological processes, and are more interested in investing in and perpetuating regenerative agriculture that intentionally balances production and conservation goals. More generally, if broad-acreage forest conversion at 400 TPA remains the status quo, farmers of any philosophy, scale, or crop generally will continue to resist NCTP participation.

  Overall, stakeholders and farmers consider agroforestry as a potentially feasible model for farmers, but interest levels vary with biological farmers being most curious. Medium- and large-scale commercial producers, who depend on substantial capital investments and often farm full-time, are less likely to enroll in the NCTP, whether individually or as a group, because trees are seen as counterproductive to commodity cropping and as a problem for mechanized commodity agriculture. If equipment and technology can be used to effectively manage an agroforestry installation, some commodity producers may be interested. The overall number would likely be low because risk perceptions are salient and most farms operate on razorthin margins. Until risk is reduced and profitability is demonstrated, commodity farmers are not likely to adopt an agroforestry NCTP strategy.

Research indicates that large-scale farmers in Virginia are not completely opposed to agroforestry; rather they need it to pay. Agroforestry technologies are not commonly used in the United States. Thus, information about the profitability and operability of agroforestry practices in large-scale, commodity operations is not widely available. Interviewees commonly expressed the need for additional sustainability metrics in the NCTP, as well as strategic requirements and acceptable planting designs, but they also recognized that increasing complexity can drive up costs. Implementing changes would increase operational costs indefinitely and resources would be required at the outset to reform the NCTP.

- Potential – Stakeholders believed that greater emphasis on holistic land conversion that combines nutrient credit trading and existing forms of agricultural production has tremendous potential to benefit farmers, the environment, and the developers and municipalities who purchase credits. It also avoids the binary tradeoff paradox, where the choice is one land use (i.e., food production) versus another (i.e., water quality protection). The difficulty of small farm profitability is well known, and most depend on off-farm jobs. A substantial percentage of Virginia's food and fiber are sourced by farms under 50 acres, and they account for the overall largest percentage of farms classified by acreage.

  Trading revenue associated with water quality measures enacted by a group of ecologically minded, small-acreage farmers in an AG-FAST program could enhance overall profitability, resulting in a greater number of capitalized working farms that provide food, fiber, and ecosystem services. Benefits include increased food nutrition, biodiversity, wildlife and pollinator habitat, decreased water and air pollution, and small businesses supporting local agriculture.

An agroforestry workshop was held at the Catawba Sustainability Center in August 2019 for over 60 participants with varying experience and backgrounds, and many of whom are EQIP-eligible. Most were farmers/landowners drawn to the workshop to learn more about applicable agroforestry systems that enhance production and provide water quality and other ecosystem services. We evaluated behavior change using multiple surveys of program participants. Given the time constraints of stakeholders and voluntary completion, only 28 individuals completed a post-meeting survey. All pledged to implement lessons learned, demonstrating commitment to behavior change through self-reporting of likeliness to use information and techniques presented. Thirteen attendees were interviewed six months after the training to confirm and characterize behavior change. Change was inferred by comparing 2019 workshop evaluation results and a survey in 2020.

All of the 28 respondents stated that they were likely (71%) or highly likely (29%) to use information from the workshop, and 68% indicated information would significantly help them achieve their goals. Notable quotes from this workshop survey include:

- "lots of potential for both better functioning and profitable landscapes"
- "we have a lot of erosion issues that these Catawba planting methods can remedy!"
- "interested in riparian restoration"

To confirm behavior change, a 6-month follow-up interview was completed in early 2020 with 13 participants, a subset of 2019 workshop participants. All participants in the follow-up survey indicated that they had followed through with reported intentions and planted trees/shrubs on their farm or properties, with contour planting and riparian buffers being the most common agroforestry techniques. Just over half (54%) of respondents have, after 6 months, recognized a change in whole-farm land-management practices since the

2019 workshop. These include focusing on native species, eco-mimicry, contouring, and forest farming. Almost 7 in 10 (70%) of follow-up respondents indicated that their vision of farm/property management has changed since the workshop. Notable quotes.

- “taught me some great techniques…helped me to realize that it’s feasible for me to improve my property.”
- “I see different opportunities for food production, especially on steep slopes and poor land, allowing farmers more diversity in their products”
- “made us think about a lot of things we both have and have not been doing.”
- “it expanded our thinking about the forest area we want to protect.”
- “thinking more comprehensively and holistically about the overall management approach.”
- “We already had the ideas and vision. The workshop gave us ideas on how to implement and maintain...”

Comparing post-meeting survey results and follow-up interview content indicates that rates of pledged behavior change corresponded to actual behavioral change. Participants widely reported changes in behavior regarding tree planting in that all plan on or are using project BMP techniques in novel manners with ecosystem conservation in mind. Information from the workshop and project demonstrations set in motion a change in vision for land management and this change in behavior can be realized by use of agroforestry techniques that benefit the farm or property owner and the broader environment. Participants also learned about the NCTP and the role of CIG and NFWF in evaluating challenges and opportunities. Many participants were small-scale farmers and several expressed interest in pursuing a pilot AG-FAST project.

End-of-meeting survey results also provided tools and information, which could be used to diversify participant farming and land management portfolios. Input involved cost-share, technical consultation, guidelines for collaboration through programs such as AG-FAST, and other associations and networks. Participants with a firm grasp of agroforestry went from 7% pre-workshop to 38% post-workshop, while those with a limited understanding of agroforestry dropped from 43% to 3% after the workshop. Information from the workshop also provided insight and tools for changing visions regarding on-farm agroforestry and opportunities for using associated practices to enter into ecosystem services markets. Moreover, participants reported value in using agroforestry techniques that benefit their farm or property and the broader environment. Most participants were smallholder farmers, and perspectives differed large-scale commodity farmers, reinforcing earlier findings.

See Appendix 6 for additional detail.

Goal 3 Creation of an agroforestry nutrient trading toolkit.

See Appendix 7 for components of the toolkit compendium, to include the site-structure-function matrix. The toolkit will be published after VDEQ review and discussion. The agency may form a certification advisory committee under the proposed regulation on the Certification of Non-Point Source Nutrient Credits (9VAC25-900) to address findings and recommendations.

Goal 4 Apply for funding to support agroforestry NCTP pilot projects.

The C-CAP project received $250,896 from the National Fish and Wildlife Foundation in 2016 to establish, measure, value, and demonstrate agroforestry nutrient offset projects in Virginia’s region of the Chesapeake Bay Watershed. Demonstration projects were 9.5 acres at CSC and 6.64 at Oak Grove, as described above.

Several in-kind services not in the original proposal were provided during the project. Most notable was a protective tree-tube demonstration and efficacy project that will benefit future installation and other tree-based conservation projects. Over $10,000 in materials and time were donated by Conservation Services, a tree planting company, and Tubex, a tree tube manufacturer. Contributions benefited this project by supporting the planting, installation, and maintenance of tree tubes at both the CSC and Wildwood.

C. Conclusion

A report will be submitted to VDEQ pertaining to the incorporation of agroforestry practices into the agency's Trading Nutrient Reductions from Nonpoint Source BMPs in the Chesapeake Bay Watershed guidance document. The report includes a literature review of scientific publications and puts forth guidance regarding agroforestry nutrient trading as a BMP in the NCTP. The report also includes a site-structure-function matrix and specifications for establishing a pilot AG-FAST program.

Findings indicate that low-density agroforestry tree plantings in site-adapted arrangements can generate nutrients offsets. These credits, like those generated from broad-acreage forest conversion, can technically be traded in Virginia's nutrient trading market, but the NCTP TPA requirements are prohibitive. Agroforestry NCTP conversions supplementing agricultural operations can diversify and add-value to farms while providing ecosystem services. This strategy balances the economic realities of farming and water quality protection by providing additional financial opportunities in the form of non-timber and timber tree products, improved crop production by fixing N and conserving soil, decreased off-farm inputs, hunting and fishing revenue associated with biodiversity and healthy waterways, as well as tradable nutrient credits. Environmental benefits include reductions in non-point source pollutants in surface and ground water, enhanced soil fertility and physical characteristics, improved water quality, diversified habitat, and carbon sequestration.

Low-density, site-specific agroforestry conversions provide an alternative to conventional NCTP forest conversion, but farmers with small properties or those interested in converting only a small fraction of their land are generally unable to justify the upfront NRIP costs and risks. Yet they are most likely to adopt agroforestry practices. Potential profitability and farmer adoption are thought to be more competitive by aggregating agroforestry facilities across multiple farms in an AG-FAST (Agroforestry Group Facility Standard) project.

The AG-FAST model allows a farmer consortium within a watershed to pool agroforestry BMPs, thereby overcoming barriers of scale and opposition to agricultural retirement associated with 400 TPA. Farmers organized under an AG-FAST group certification would form a Limited Liability Corporation (LLC) and select a group manager who would be responsible for maintaining internal control and ensuring all criteria are met, as well as serving as a liaison with certifying and auditing entities. The group manager may be a group member or an outside entity, such as a trading broker.

Costs and risks associated with establishing an NRIP for a group and nutrient credit trading are theoretically reduced in AG-FAST because upfront outlays are distributed, auditing requirements are shared, monitoring needs are reduced, and economies of scale are improved. Remote sensing technologies can be used for auditing purposes. Devices and applications have become cost-efficient, and the availability, operability, and reliability of equipment have increased. This improves the group manager's ability to efficiently conduct necessary oversight at multiple AG-FAST facilities distributed throughout a watershed.

Results have shown that low-density agroforestry tree plantings in multifunctional riparian buffers and associated upslope alley cropping utilizing site-specific designs can generate tradable offsets in Virginia's nutrient market. Furthermore, this project demonstrated that land does not need to be retired to incentivize NCTP. Utilized land may be very productive and provide conservation services leading to a diverse economic portfolio for farmers while providing regional and global ecosystem services.

The strategies outlined in this project balance economic realities with environmental conservation by optimizing high-value timber, non-timber forest products (NTFPs), crop production, on- and off-farm inputs, hunting and fishing, as well as nutrient credits. Environmental benefits include non-point pollution mitigation, soil fertility, water quality, biological diversity, carbon sequestration, and healthy environments. It is recommend that multifunctional agroforestry buffers and associated upslope alley cropping on contour be integrated into VDEQ guidelines for BMPs. If the minimum requirement for 400 TPA is maintained, then group certification based on the AG-FAST standard would be appropriate.

Itemized project recommendations.

1. Enable farmers to pool properties/credits and become umbrella certified (i.e., AG-FAST).
2. Simplify NCTP and ensure information is readily available and easy to navigate.
3. Engage the professional forestry community in design and maintenance of agroforestry installations.
4. Encourage and/or incentivize intentional tree and shrub plantings as baseline riparian BMPs
5. Increase credit for upland plantings if woody perennials are planted along the streambank.
6. Identify ecologically critical sites and value credits generated there more highly
7. Tailor fluid agroforestry designs to maximize efficiencies in critical sites.
8. Require GeoDesign applications and high-resolution site assessment protocols (e.g., LiDAR).
9. Differentiate relative conservation efficiencies using existing models (e.g., AgBufferBuilder, MUSLE).
10. Create a ratio-based scoring structure that weights precision conservation plantings according to threat.
11. Allow properties to provide multiple services beyond nutrient capture in the following ways:
    a. Qualify and encourage agroforestry as a NCTP BMP.
    b. Assess the tree density, percent coverage, and design patterns necessary for desired reductions.
    c. Award credits according to variable site-specific tree densities, and coverage and design parameters.
    d. Use modeling tools such AgBufferBuilder and Modified USLE formula (MUSLE).
    e. Recognize that TPA in agroforestry systems resembles tree densities in natural stands.
    f. Encourage planting of diverse tree species to improve forest resistance to disease and insect
    g. Add tree crop opportunities using a combination of fruit, nut, sap, and timber species.
    h. To save time and money, avoid planting trees where threats to water quality are low.

i. Improve strategic tree planting and targeted facility design by rewarding higher credit ratios.

j. Plant strategically according to property modeling, farming goals, and socioeconomic, benefits.

Project results presentation and communication.

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Munsell, J.F. 2018. A Community on Ecosystem Services – Water Quality Trading Panel. A Community on Ecosystem Services (ACES) Conference. Washington D.C.

Munsell, J.F. and B.J. Addlestone. 2017. Incorporating Agroforestry into Virginia's Nutrient Credit Trading Program. Society of American Foresters National Convention. Albuquerque, New Mexico. November 2017.

Addlestone, B.J., and J.F. Munsell. 2017. Utilizing BayFast to Simulate Agroforestry Technologies in Virginia's Chesapeake Bay Region. 15th North American Agroforestry Conference, Blacksburg, Virginia. June 27-29, 2017.

Trozzo K.E., K. Commender, and J.F. Munsell. 2016. Multifuncational Riparian Buffers in Virginia. PA DCNR Riparian Forest Buffer Summit. State College, PA. August 11, 2016.

Trozzo, K.E., J.F. Munsell, and K.E. Commender*. 2016. Multifunctional riparian buffers in Virginia. Pennsylvania Department of Conservation and Natural Resources.

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Appendix 1 Project videos

Three videos highlight the C-CAP project. (total views = 4,021 views)

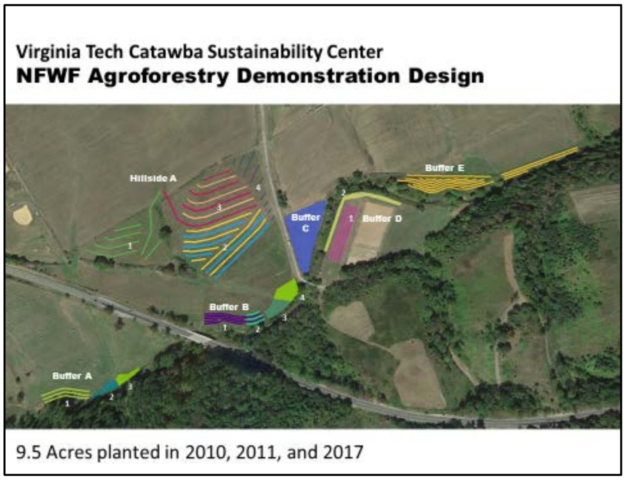
- Video 1: C-CAP – Conservation Credit for Agroforestry Production Overview (727 views)
- Video 2: C-CAP Advanced Technology, https://www.youtube.com/watch?v=DO35QIAPrtg (1,774 views)
- Video 3: Farms of the Future, https://www.youtube.com/watch?v=9TjYCHZFfio (1,520 views)

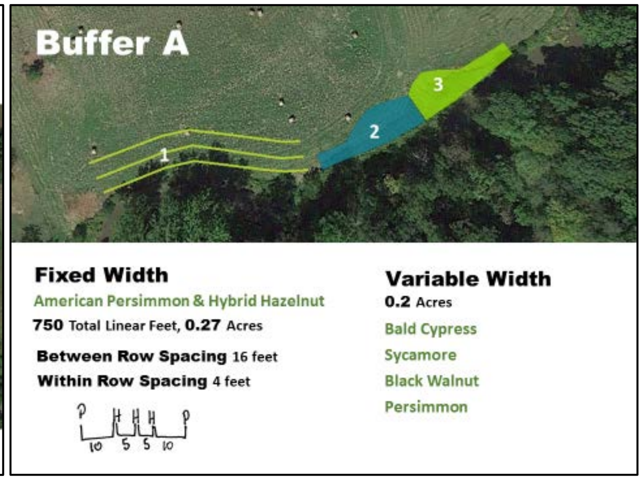
Appendix 2 BayFAST scenarios

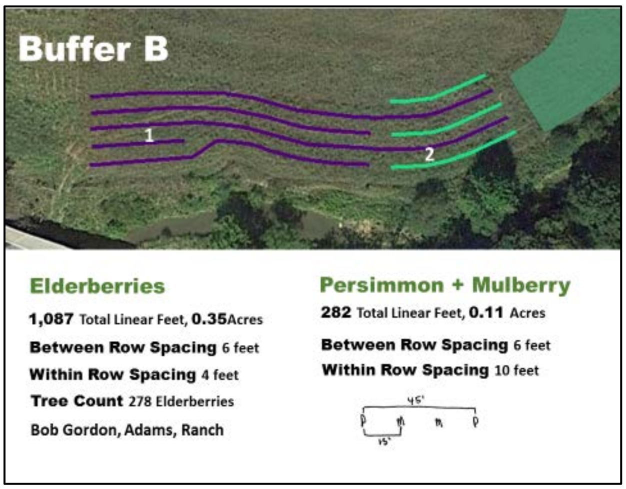
Twenty tree planting scenarios simulated consisting of 5 tree planting intensities across 4 land-use intensities. Tree planting intensity scenarios include 0% and 100%, with 3 percent coverage densities reflecting pilot agroforestry NCTP installations. 5.5% Forest Buffer and 12% Tree Planting represent CSC planting densities.

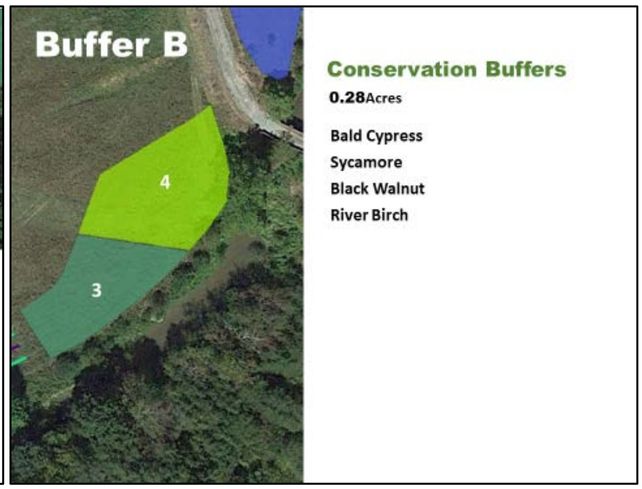
Scenario	Facility	Share With			
(11) Hay without Nutrients, 0% Forest Buffer and 0% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(12) Hay without Nutrients, Agroforestry (36% Forest Buffer and 37.5% Tree Planting)	CBAFP2352	No Users	View	Edit	Delete
(13) Hay without Nutrients, 100% Forest Buffer and 100% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(14) Hay without Nutrients, Agroforestry (18% Forest Buffer and 18.75% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(15) Hay without Nutrients, Agroforestry (5.5% Forest Buffer and 12% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(21) Hay and Alfalfa All, 0% Forest Buffer and 0% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(22) Hay and Alfalfa All, Agroforestry (36% Forest Buffer and 37.5% Tree Planting)	CBAFP2352	No Users	View	Edit	Delete
(23) Hay and Alfalfa All, 100% Forest Buffer and 100% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(24) Hay and Alfalfa All, Agroforestry (18% Forest Buffer and 18.75% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(25) Hay and Alfalfa All, Agroforestry (5.5% Forest Buffer and 12% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(31) Pasture All, 0% Forest Buffer and 0% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(32) Pasture All, Agroforestry (36% Forest Buffer and 37.5% Tree Planting)	CBAFP2352	No Users	View	Edit	Delete
(33) Pasture All, 100% Forest Buffer and 100% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(34) Pasture All, Agroforestry (18% Forest Buffer and 18.75% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(35) Pasture All, Agroforestry (5.5% Forest Buffer and 12% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(41) Row Crops All, 0% Forest Buffer and 0% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(42) Row Crops All, Agroforestry (36% Forest Buffer and 37.5% Tree Planting)	CBAFP2352	No Users	View	Edit	Delete
(43) Row Crops All, 100% Forest Buffer and 100% Tree Planting	CBAFP2352	No Users	View	Edit	Delete
(44) Row Crops All, Agroforestry (18% Forest Buffer and 18.75% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete
(45) Row Crops All, Agroforestry (5.5% Forest Buffer and 12% Tree Planting)	CBAFP2706	No Users	View	Edit	Delete

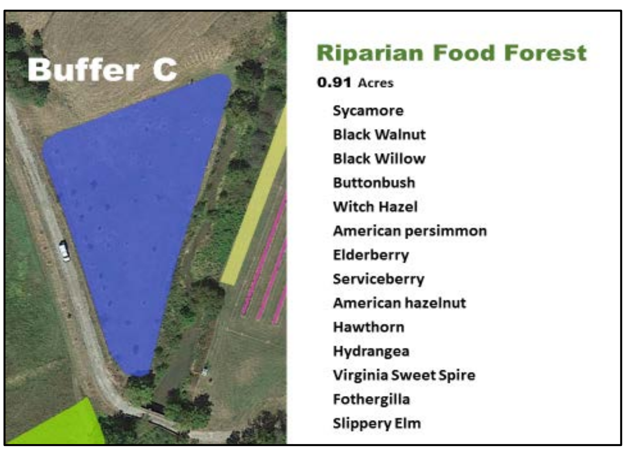
Appendix 3 Detailed planting designs at CSC.

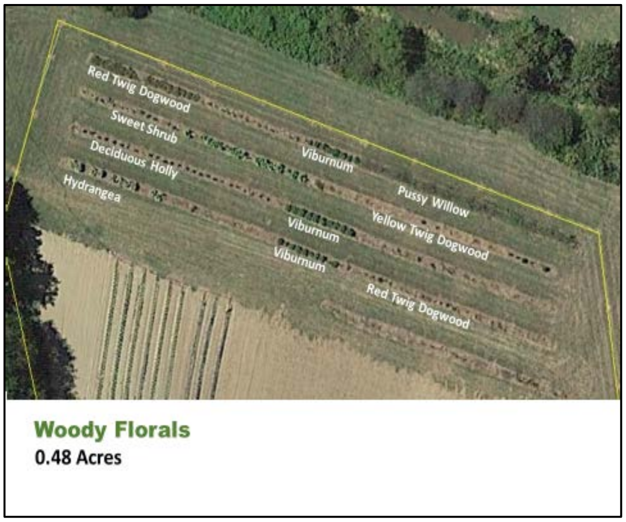


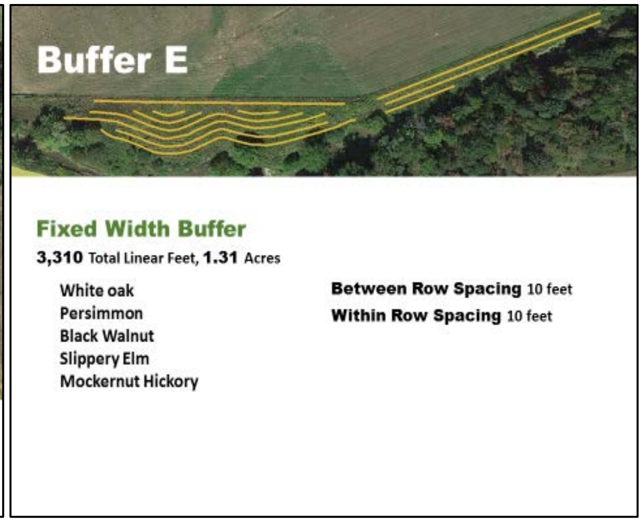


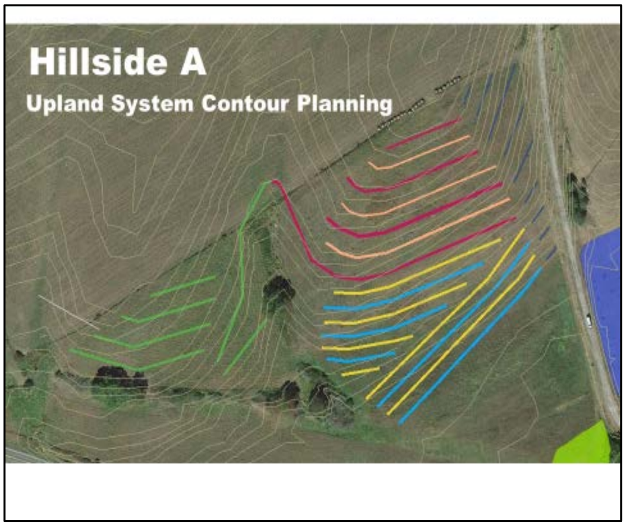






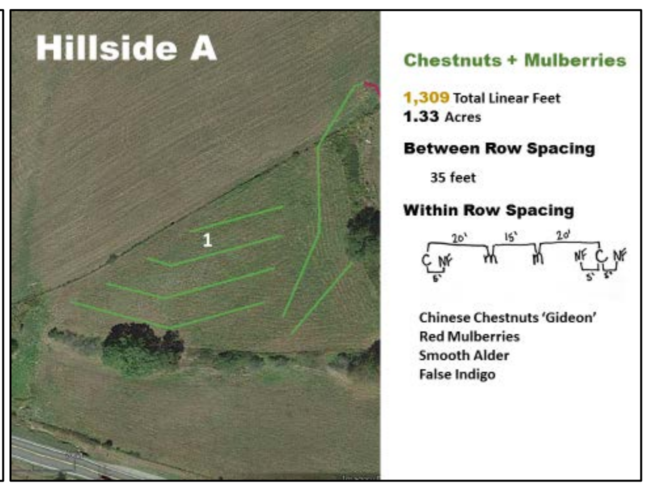

Red Twig Dogwood
Sweet Shrub
Deciduous Holly
Hydrangea
Viburnum
Pussy Willow
Yellow Twig Dogwood
Viburnum
Viburnum
Red Twig Dogwood
Woody Florals
0.48 Acres

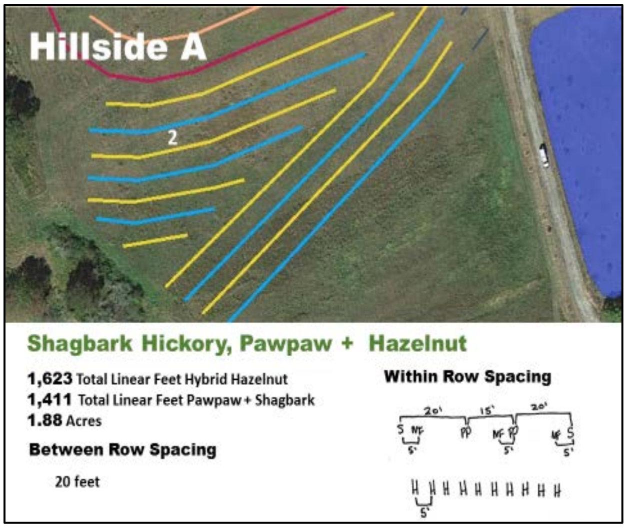

Buffer E
Fixed Width Buffer
3,310 Total Linear Feet, 1.31 Acres
White oak
Persimmon
Black Walnut
Slippery Elm
Mockernut Hickory
Between Row Spacing 10 feet
Within Row Spacing 10 feet

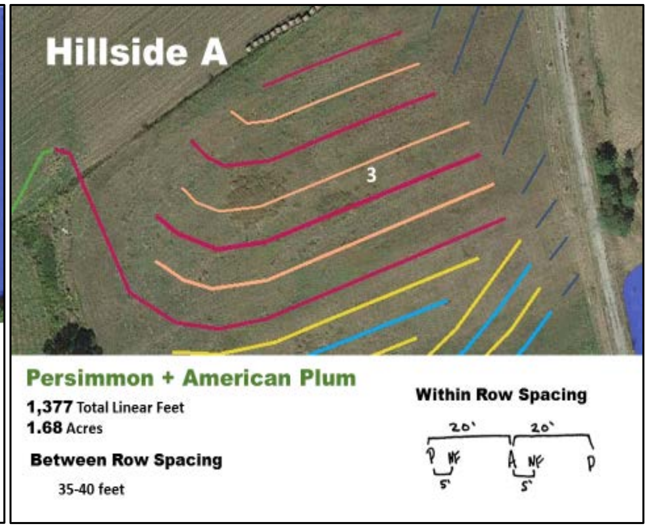

Hillside A
Upland System Contour Planning


Swales


Keyline Plowing


Hillside A
1
Chestnuts + Mulberries
1,309 Total Linear Feet
1.33 Acres
Between Row Spacing
35 feet
Within Row Spacing
Chinese Chestnuts 'Gideon'
Red Mulberries
Smooth Alder
False Indigo


Hillside A
2
Shagbark Hickory, Pawpaw + Hazelnut
1,623 Total Linear Feet Hybrid Hazelnut
1,411 Total Linear Feet Pawpaw + Shagbark
1.88 Acres
Between Row Spacing
20 feet
Within Row Spacing


Hillside A
3
Persimmon + American Plum
1,377 Total Linear Feet
1.68 Acres
Between Row Spacing
35-40 feet
Within Row Spacing

Appendix 4 Project data

Examples of BayFAST output in terms of N, P, and Sediment loads to the Chesapeake Bay (Delivered) and to tributaries (Edge-of-Stream).

Description: Pasture All, 0% Forest Buffer and 0% Tree Planting
Facility: CBAFP2695
Date Created: 3/2/2017 2:28:51 PM

Download Results | Compare Scenarios

Total Loads

Load Type	Lbs Nitrogen Edge of Stream	Lbs Nitrogen Delivered	Lbs Phosphorus Edge of Stream	Lbs Phosphorus Delivered	Lbs Sediment Edge of Stream	Lbs Sediment Delivered
Landuse	105.1	16.1	10.0	4.6	4,867.6	3,153.8
Septic	1.0	0.2	0.0	0.0	0.0	0.0
Total:	106.1	16.3	10.0	4.6	4,867.6	3,153.8

Description: Pasture All, Agroforestry (36% Forest Buffer and 37.5% Tree Planting)
Facility: CBAFP2695
Date Created: 3/2/2017 2:31:24 PM

Download Results | Compare Scenarios

Total Loads

Load Type	Lbs Nitrogen Edge of Stream	Lbs Nitrogen Delivered	Lbs Phosphorus Edge of Stream	Lbs Phosphorus Delivered	Lbs Sediment Edge of Stream	Lbs Sediment Delivered
Landuse	69.4	10.6	8.4	4.0	3,241.2	2,100.1
Septic	1.0	0.2	0.0	0.0	0.0	0.0
Total:	70.4	10.8	8.4	4.0	3,241.2	2,100.1

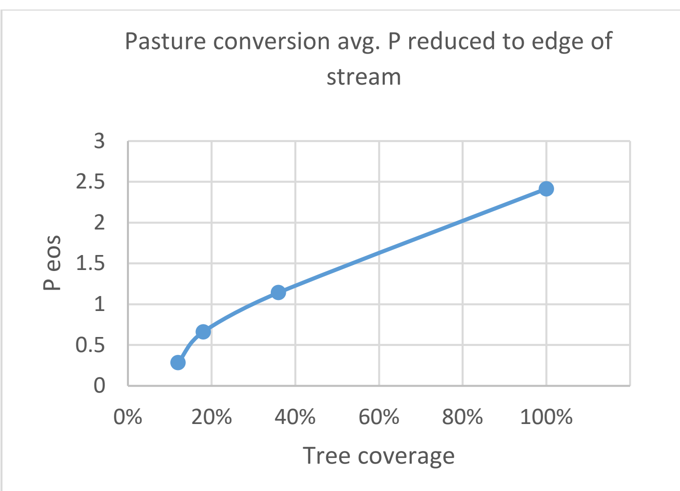
Description: Pasture All, 100% Forest Buffer and 100% Tree Planting
Facility: CBAFP2695
Date Created: 3/2/2017 2:33:34 PM

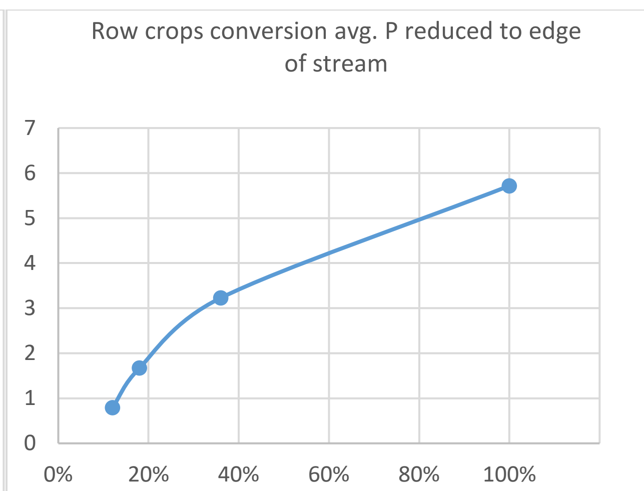
Download Results | Compare Scenarios

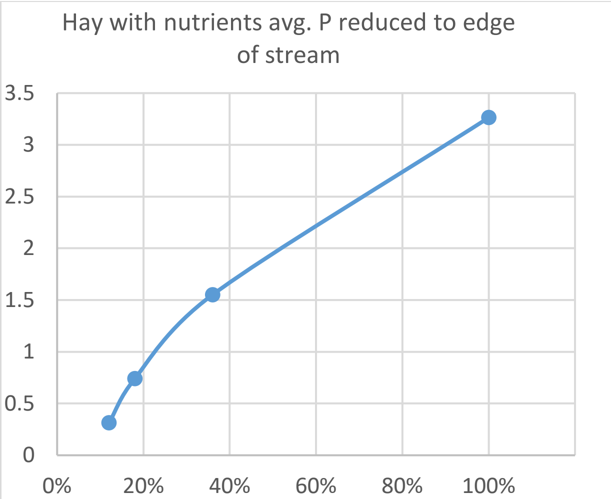
Total Loads

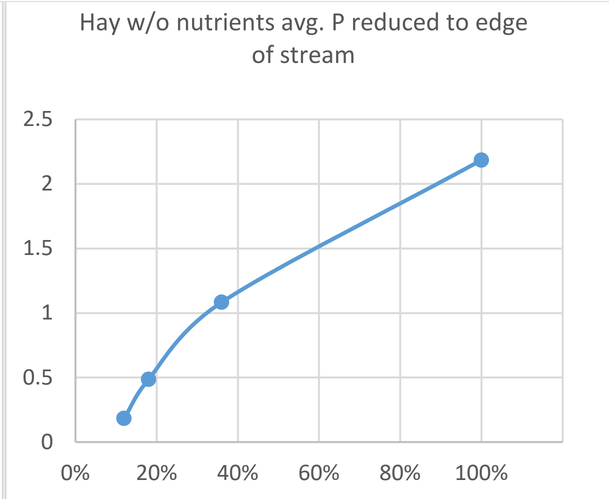
Load Type	Lbs Nitrogen Edge of Stream	Lbs Nitrogen Delivered	Lbs Phosphorus Edge of Stream	Lbs Phosphorus Delivered	Lbs Sediment Edge of Stream	Lbs Sediment Delivered
Landuse	66.0	10.1	7.6	3.5	2,436.3	1,578.6
Septic	1.0	0.2	0.0	0.0	0.0	0.0
Total:	67.0	10.3	7.6	3.5	2,436.3	1,578.6

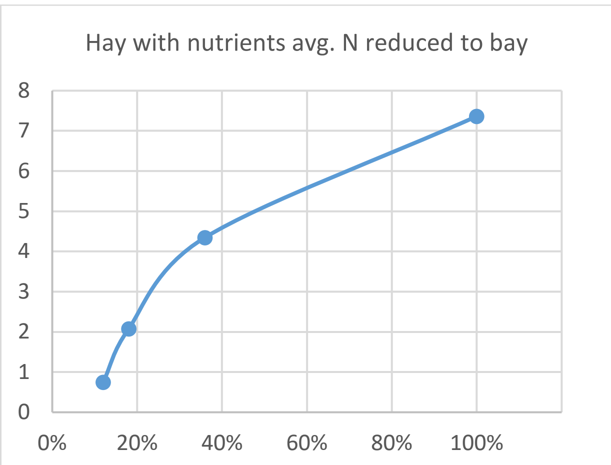
Average BayFAST efficiency rates across a sample of properties as demonstrated by percent tree cover (x-axis) and delivery in lbs/ac to edge of the stream or bay (y-axis) of N and P across the range of simulated tree-planting densities.

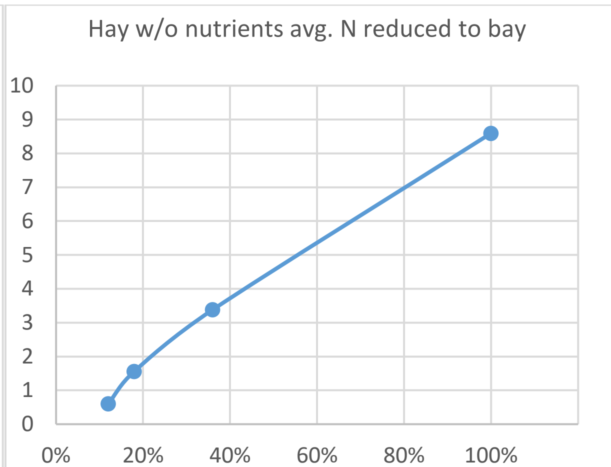


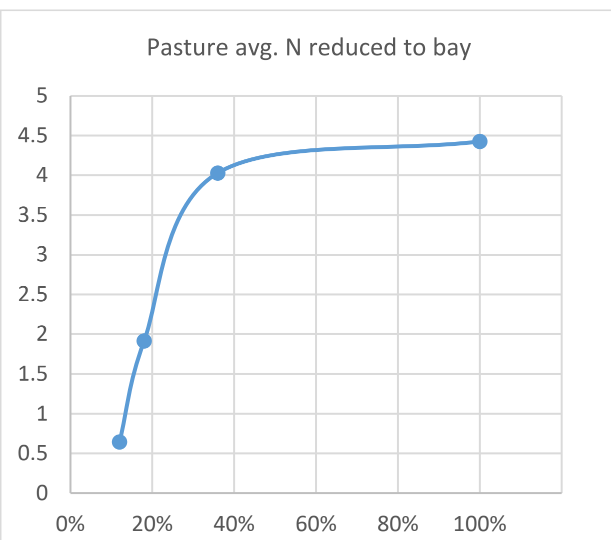


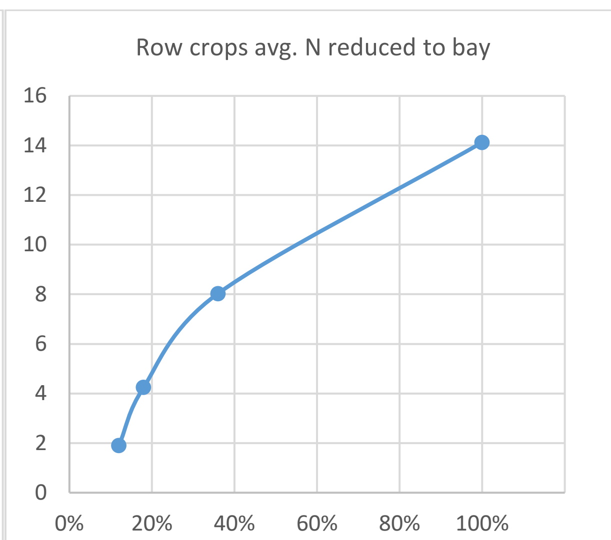

Hay with nutrients avg. P reduced to edge of stream
3.5
3
2.5
2
1.5
1
0.5
0
0%
20%
40%
60%
80%
100%

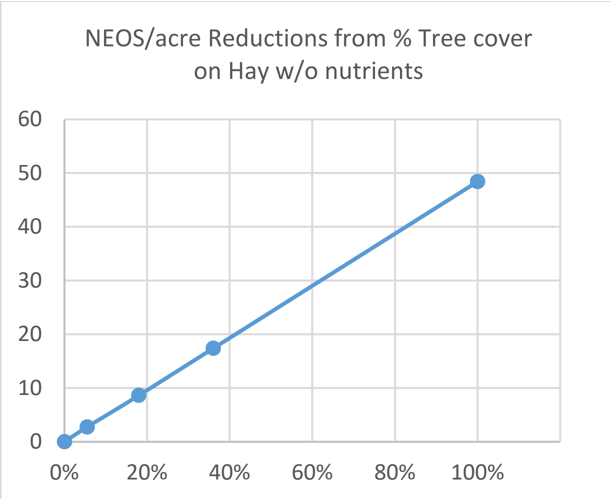

Hay w/o nutrients avg. P reduced to edge of stream
2.5
2
1.5
1
0.5
0
0%
20%
40%
60%
80%
100%

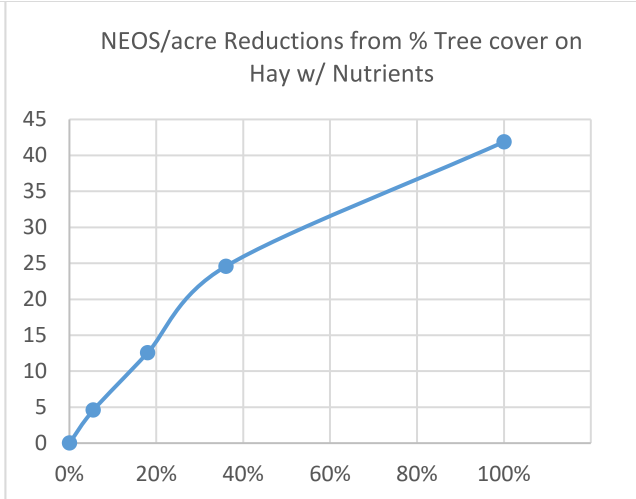

Hay with nutrients avg. N reduced to bay
8
7
6
5
4
3
2
1
0
0%
20%
40%
60%
80%
100%

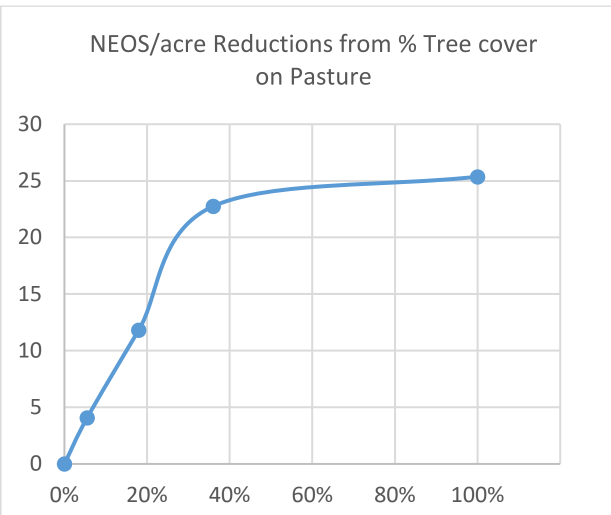

Hay w/o nutrients avg. N reduced to bay
10
9
8
7
6
5
4
3
2
1
0
0%
20%
40%
60%
80%
100%

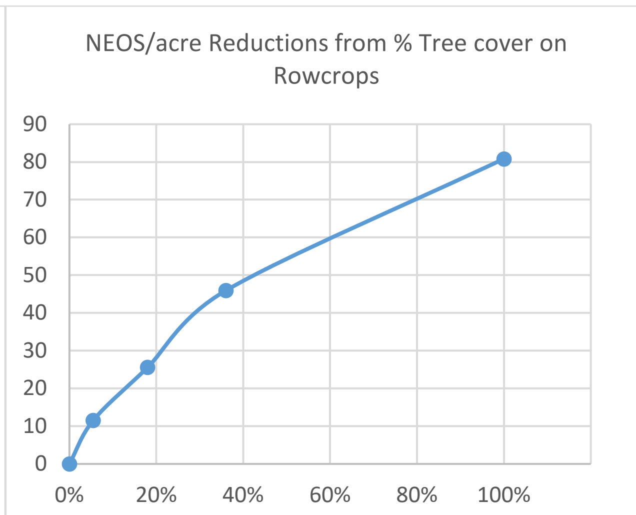

Pasture avg. N reduced to bay
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0%
20%
40%
60%
80%
100%

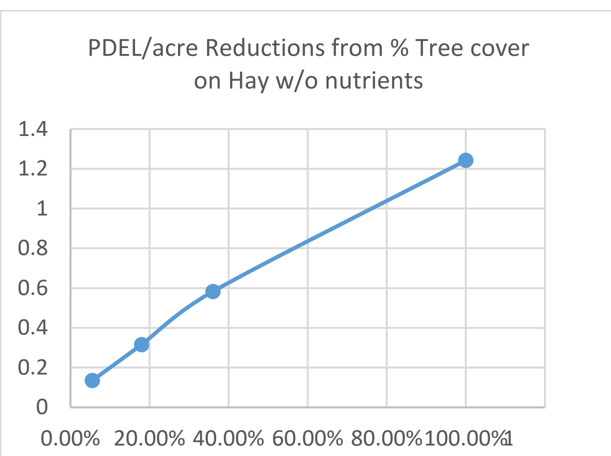

Row crops avg. N reduced to bay
16
14
12
10
8
6
4
2
0
0%
20%
40%
60%
80%
100%

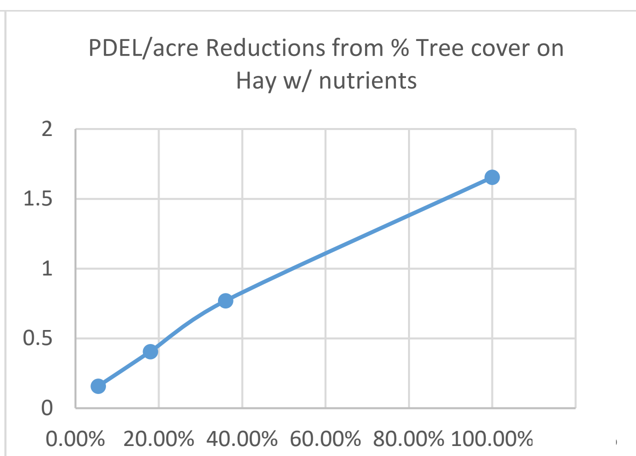

NEOS/acre Reductions from % Tree cover on Hay w/o nutrients
60
50
40
30
20
10
0
0%
20%
40%
60%
80%
100%

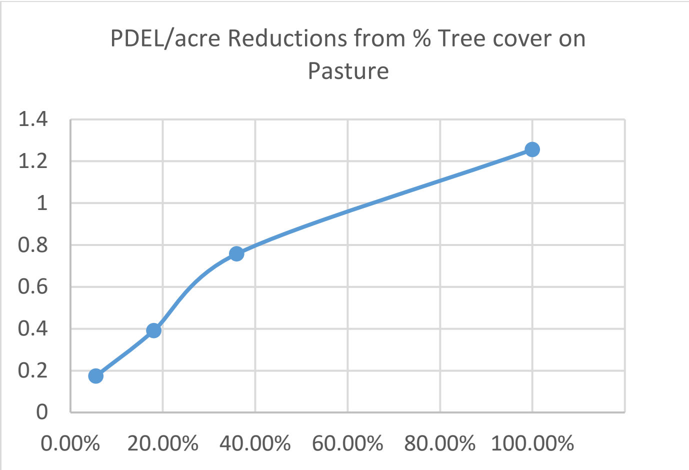

NEOS/acre Reductions from % Tree cover on Hay w/ Nutrients
45
40
35
30
25
20
15
10
5
0
0%
20%
40%
60%
80%
100%

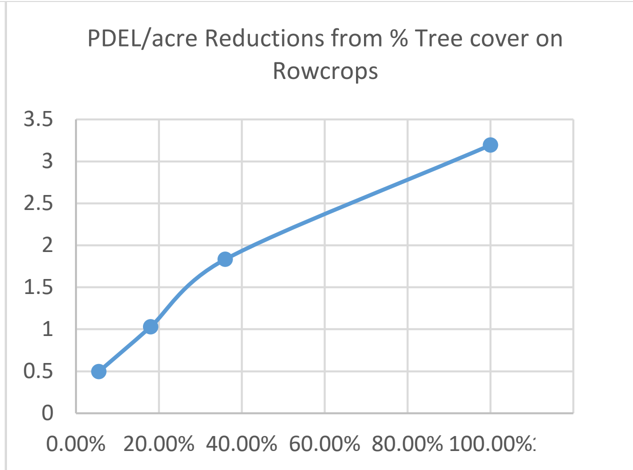

NEOS/acre Reductions from % Tree cover on Pasture
30
25
20
15
10
5
0
0%
20%
40%
60%
80%
100%

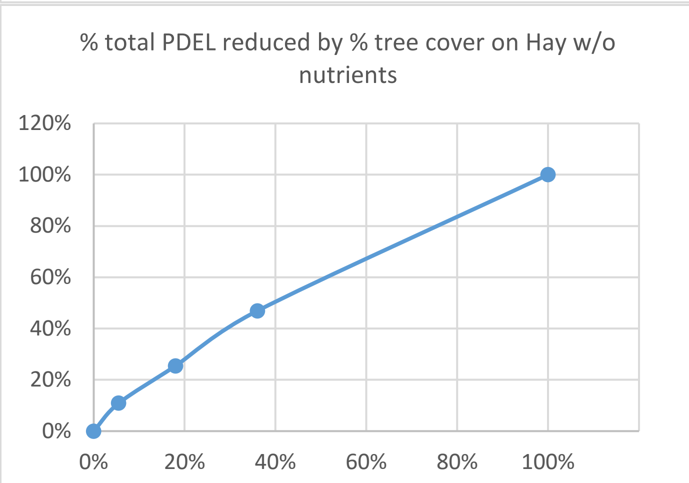

NEOS/acre Reductions from % Tree cover on Rowcrops
90
80
70
60
50
40
30
20
10
0
0%
20%
40%
60%
80%
100%

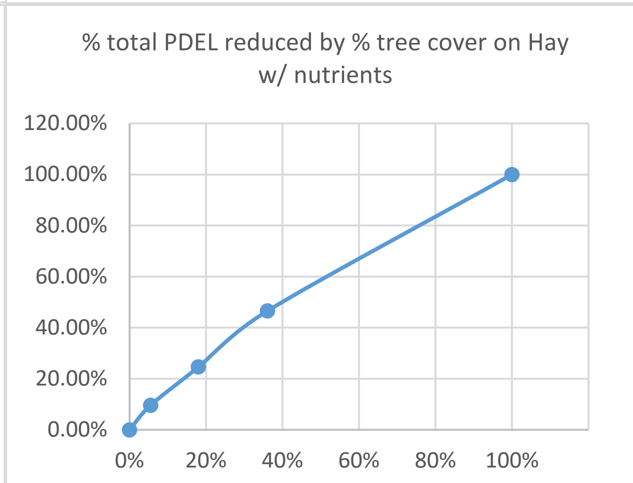

PDEL/acre Reductions from % Tree cover on Hay w/o nutrients
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
1

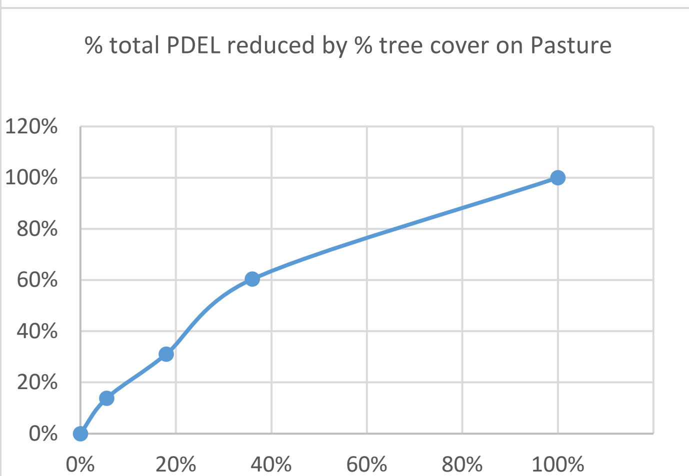

PDEL/acre Reductions from % Tree cover on Hay w/ nutrients
2
1.5
1
0.5
0
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%

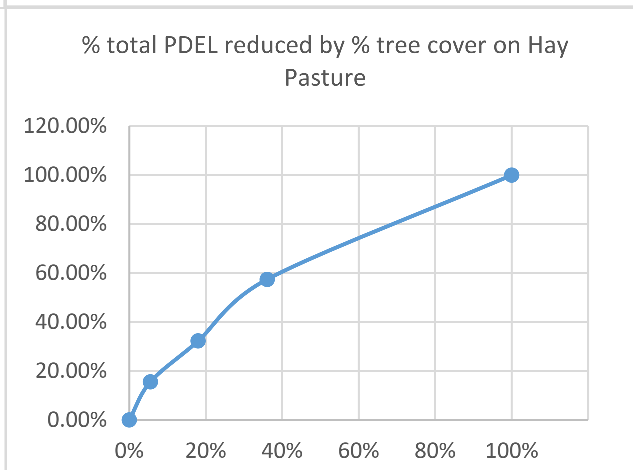

PDEL/acre Reductions from % Tree cover on Pasture
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%


PDEL/acre Reductions from % Tree cover on Rowcrops
3.5
3
2.5
2
1.5
1
0.5
0
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%


% total PDEL reduced by % tree cover on Hay w/o nutrients
120%
100%
80%
60%
40%
20%
0%
0%
20%
40%
60%
80%
100%


% total PDEL reduced by % tree cover on Hay w/ nutrients
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
0%
20%
40%
60%
80%
100%


% total PDEL reduced by % tree cover on Pasture
120%
100%
80%
60%
40%
20%
0%
0%
20%
40%
60%
80%
100%


% total PDEL reduced by % tree cover on Hay Pasture
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
0%
20%
40%
60%
80%
100%

BayFAST N and P efficiency rates by tree coverage and land use.

Pasture

% Tree cover	Edge of Stream P Reduction	Efficiency %
12	0.284	11.76
18	0.661	27.37
36	1.143	47.33
100	2.415	100

Row Crops

% Tree cover	Edge of Stream P Reduction	Efficiency %
12	0.79	13.82
18	1.671	29.23
36	3.228	56.46
100	5.717	100

Hay with Nutrients

% Tree cover	Edge of Stream P Reduction	Efficiency %
12	0.312	9.56
18	0.74	22.68
36	1.551	47.53
100	3.263	100

Hay Without Nutrients

% Tree cover	Edge of Stream P Reduction	Efficiency %
12	0.183	8.38
18	0.485	22.20
36	1.083	49.57
100	2.185	100

Hay Without Nutrients

% Tree cover	Bay N Reduction	Efficiency %
12	0.603	7.01
18	1.562	18.17
36	3.382	39.34
100	8.596	100

Hay with Nutrients

% Tree cover	Bay N Reduction	Efficiency %
12	0.747	10.15
18	2.075	28.19
36	4.349	59.07
100	7.362	100

Row Crops

% Tree cover	Bay N Reduction	Efficiency %
12	1.908	13.51
18	4.251	30.10
36	8.032	56.86
100	14.125	100

Pasture

% Tree cover	Bay N Reduction	Efficiency %
12	0.646	0.146
18	1.915	0.432
36	4.03	0.911
100	4.426	100

NTT results at CSC. Trends in the averages generally reflect BayFAST output.

Description	Forest Buffer Losses	(±)	Control Losses	(±)	Change	(%)
Total N (lbs/ac)	0.7	0.2	0.8	0.3	0.1	15.5
Org N (lbs/ac)	0.48	0.2	0.6	0.2	0.11	23.03
Runoff N (lbs/ac)	0.05	0	0.05	0	0	2.15
Subsurface N (lbs/ac)	0.16	0	0.16	0	0	-2.56
Tile Drain N (lbs/ac)	0	0	0	0	0	0
Total P (lbs/ac)	0.1	0	0.1	0	0	20.5
Org P (lbs/ac)	0.07	0	0.09	0	0.02	21.87
PO4 (lbs/ac)	0	0	0	0	0	-0.38
Tile Drain P (lbs/ac)	0	0	0	0	0	0
Surface/Subsurface/Tile Drain Flow (in)	4.6	0.8	4.7	0.8	0.2	3.4
Surface Flow (in)	0.83	0.3	0.86	0.3	0.03	3.19
Subsurface Flow (in)	3.72	0.6	3.85	0.6	0.13	3.46
Tile Drain Flow (in)	0	0	0	0	0	0
Total Other Water Info (in)	5.8	0.8	5.8	0.8	0	0.1
Irrigation Runoff (in)	0	0	0	0	0	0
Deep Percolation (in)	5.77	0.8	5.78	0.8	0.01	0.11
Total Sediment (t/ac)	0.1	0	0.1	0	0	55.6
Surface Erosion (t/ac)	0.0559	0	0.087	0	0.0311	55.57
Manure Erosion	0	0	0	0	0	0
Crop Yield						

Notes:

a) CSC-Combined Forest Buffer and upslope Tree Planting for 75' total planting.

b) Crop/rotation parameters standard (pasture, seeded year1).

c) Utilized estimated percentages of 5.5% Forest Buffer and12% Tree Planting.

d) No grass buffers were included.

e) Control has 0% Forest Buffer and Tree Planting with same conditions.

NTT results at Oak Grove.

Description	Forest Buffer Losses	(±)	Control Losses	(±)	Change	(%)
Total N (lbs/ac)	0.4	0.2	0.5	0.2	0.1	31.8
Org N (lbs/ac)	0.3	0.1	0.42	0.2	0.13	42.96
Runoff N (lbs/ac)	0.08	0	0.08	0	0	-3.1
Subsurface N (lbs/ac)	0.02	0	0.02	0	0	6.53
Tile Drain N (lbs/ac)	0	0	0	0	0	0
Total P (lbs/ac)	0.1	0	0.1	0	0	33.4
Org P (lbs/ac)	0.05	0	0.07	0	0.02	40.41
PO4 (lbs/ac)	0.01	0	0.01	0	0	-4.48
Tile Drain P (lbs/ac)	0	0	0	0	0	0
Surface/Subsurface/Tile Drain Flow (in)	5.1	1.2	5.2	1.2	0.2	3.3
Surface Flow (in)	1.26	0.5	1.26	0.5	0	0.01
Subsurface Flow (in)	3.82	0.7	3.99	0.7	0.17	4.37
Tile Drain Flow (in)	0	0	0	0	0	0
Total Other Water Info (in)	6.2	1.1	6.2	1.1	0	0.8
Irrigation Runoff (in)	0	0	0	0	0	0
Deep Percolation (in)	6.18	1.1	6.23	1.1	0.05	0.8
Total Sediment (t/ac)	0	0	0.1	0	0	59.9
Surface Erosion (t/ac)	0.0324	0	0.0518	0	0.0194	59.9
Manure Erosion	0	0	0	0	0	0
Crop Yield						

Notes:

a) Wildwood-Combined Forest Buffer and upslope Tree Planting for 95' total planting.

b) Crop/rotation parameters standard (pasture, seeded year 1).

c) Utilized estimated percentages of 5.5% Forest Buffer and 12% Tree Planting.

d) No grass buffers were included.

e) Control has 0% Forest Buffer and Tree Planting with same conditions.

Metrics presented below are calculated using the NTT, as well VDEQ's Nutrient Trading Manual lookup tool, which has localized N and P conservation data in tables based on land conversion BMPs. Ecotracker^{tm} data also are offered to add empirical findings to modeled results.

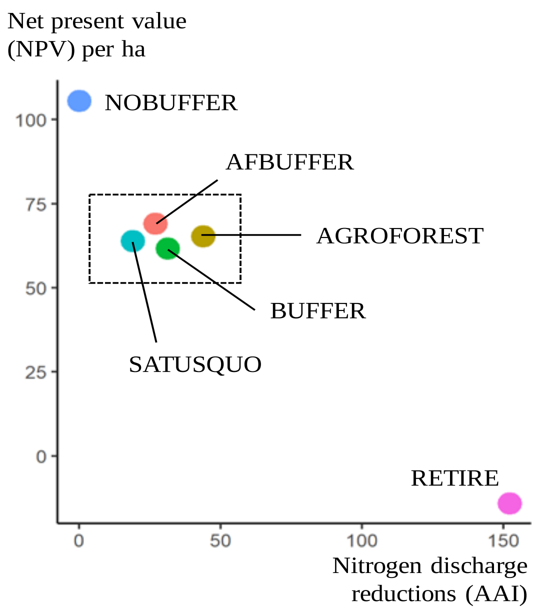
Utilizing the NTT sediment avoided was 848.6 lbs. At CSC, the agroforestry plantings were 62.2 t/ac more efficient than the control at sediment reduction, while at WW the agroforestry plantings were 38.8 t/ac more efficient. This represents a 55.6% and 59.9% change, respectively. This is more sediment avoided than 512 lbs predicted. VDEQ lookup tables do not calculate sediment and Ecotracker^{tm} does not measure avoidance of sediment loss.

Utilizing the NTT, initial P avoided was 1.33 lbs. At CSC, the agroforestry plantings were 0.19 lb/ac more efficient than the control (i.e., status quo) at P reduction, while at WW the agroforestry plantings were 1.133 lb/ac more efficient. This represents a 20.5% and 33.4% change, respectively, but is less P avoided than the 11.47 lbs annually predicted.

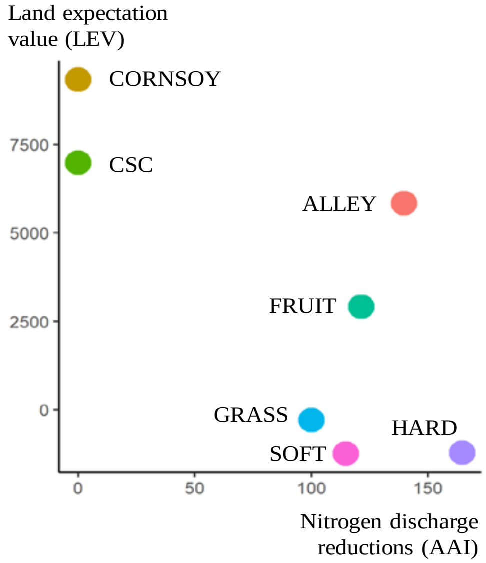
Utilizing the NTT, initial total N avoided was 1.91 lbs. At CSC, the agroforestry plantings were 1.05 lb/ac more efficient than the control at N reduction, while at WW the agroforestry plantings were 0.86 lb/ac more efficient. This represents a 15.5% and 31.8% change, respectively, but is less N avoided than the 12.7 lbs annually predicted.

It is important to note that the NTT does not allow the user to set pre-installation land use conditions, but alternatively lookup tables published by VDEQ do. When accounting for hay management prior to land use conversion at the CSC, the lookup tables project that the CSC agroforestry installation will reduce loss of P by 9.31 lbs. At the WW site, prior use was pasture with livestock and lookup tables project that the conversion there will reduce loss of P by 3.32 lbs. Reductions in total P lost using the lookup tables is 12.63 lbs. This is approximately 18 times more N and 9 times more P reduced than calculated utilizing NTT.

Calculations utilize the VDEQ Trading Manual's James River Basin Land Conversion Tables for West of 95 and the BMP hay to forest for CSC and pasture to forest for WW. Ecotracker^{tm} data at CSC support these findings and show that P decreased more dramatically, almost four-fold, throughout the buffer over time. Estimated nutrient reductions before project commencement were 11.47 and 12.7 lbs of P and N, respectively.



Environmental and economic outcomes of baseline model results, at the alternative level on a Production Possibility Frontier surface with intermediate alternatives in the dashed box. Dashed box represents a range of conversions that blend agricultural and conservation practices. AGROFOREST best optimizes the bio-economic frontier, exceeding all practices in reductions of N discharge and second only to AFBUFFER in terms of NPV.



Environmental and economic outcomes of baseline model results at the land-management practice level on a PPF surface. ALLEY extends the bio-economic production possibility frontier further compared to other evaluated practices.

Appendix 5 Project pictures

Fall 2017, NRCS JED Training at the CSC

Fall 2018, Collecting data from the on-site tree tube study

Fall 2018, Collecting data from the on-site tree tube study

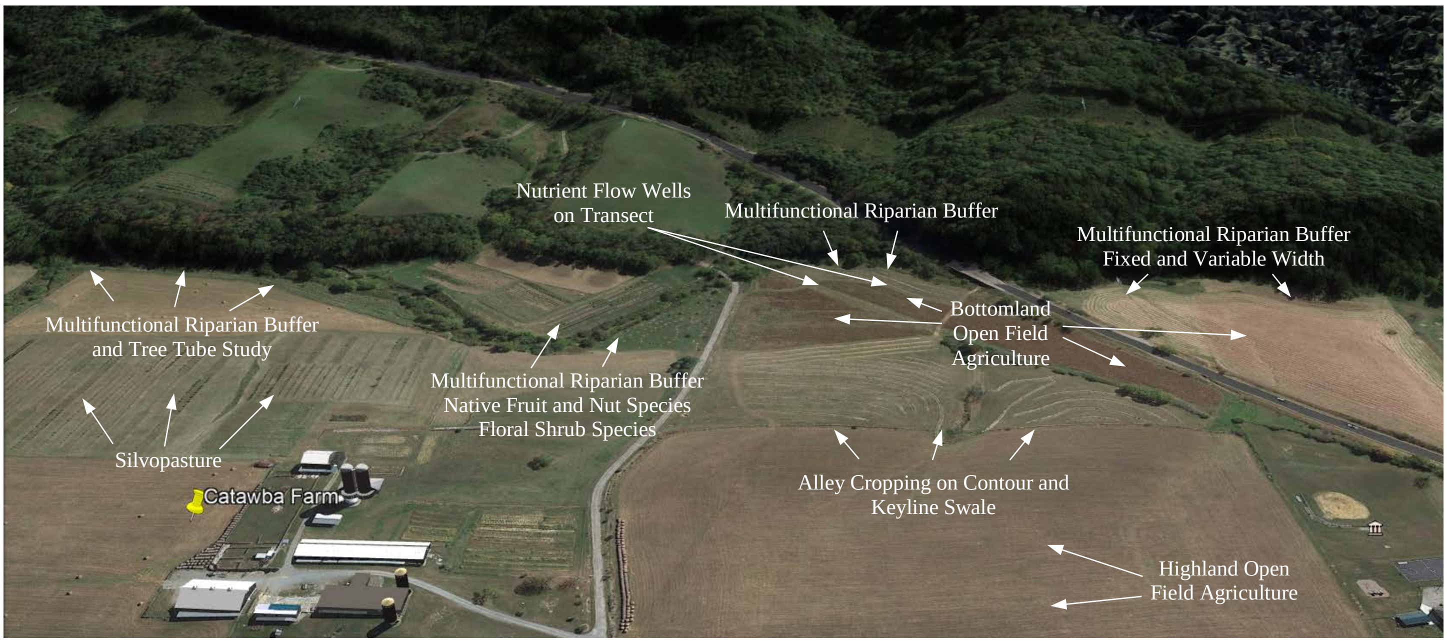
Spring 2018, VT engage Volunteer maintenance

Spring 2018, VDOF planting at CSC

Fall 2018, VDOF tree planting at CSC with tree tube installation

Fall 2019, Agroforestry Workshop with farmers at the CSC

Summer 2019, mulberry on contour with keyline swales, intercropped among Chinese chestnut (Gideon) and N fixing shrubs false indigo and smooth alder



Summer 2018, Google earth aerial of C-CAP agroforestry project zones

Appendix 6 Stakeholder Surveys

C-CAP Stakeholder Interview Summary
Assessing Virginia's Nutrient Credit Trading Program

Introduction

The Virginia Stormwater Management Program created a marketplace for P credits to manage compliance with regulations governing stormwater runoff. This program requires developers to implement runoff control practices and allows them to meet some of their requirements by purchasing credits from off-site by landowners related to long-term reductions in N and P runoff, usually by converting farmland to forest. The C-CAP project focused on nutrient offsets derived from agroforestry practices rather than forest conversion. Six C-CAP project team members were interviewed to record member opinions on the current state of the NCTP, and identify its limitations and estimate its potential.

Nutrient credit trading program assessments and suggestions

Virginia is one of the most active nutrient trading states in the country, but refinement of its program would render it more effective and could increase participation. Present day nutrient credit trading in Virginia generally involves absentee landowners who, with the assistance of a trader or broker, convert agricultural land to forest by planting 400 TPA to generate the maximum number of tradeable credits. Other conversions are possible, such as conversion of cropland to hay or fallow land, but conversion to forest is the most lucrative. Conversion takes place before payment for credits is received, so program participants must make upfront financial investments.

The forestry community is not meaningfully involved in design or maintenance. It is unclear if there are any maintenance requirements for additionality zones following certification of the credits, although some monitoring is performed using drone or satellite imagery to ensure installation stability. A healthy forest requires maintenance and engaging foresters would benefit the forest, landowners, and ultimately improve numerous measures of ecological health.

Streamlining the program might increase participation. The bureaucracy involved in certifying credits is challenging and information on how to generate nutrient credits was difficult to find. The certification process was perceived as complicated and clarification difficult to come by. Tree and shrub requirements in the baseline buffer zone would benefit overall conservation. Most facilities rely on grass buffers for baseline, which is least costly but inviting to invasive species. More trees and greater diversity along waterways would provide better water quality and erosion control. One way to encourage woody buffers is to increase credit for upland plantings if perennials are planted in the baseline.

Farmers are not likely to participate in the NCTP for two reasons. First, many farmers work relatively small acreages and are not generally capitalized enough to justify upfront investments. Second, status quo credit generation generally amounts to retirement of agriculturally productive land since conversion to forest (rather than to hay or fallow mixed open land) provides the greatest number of credits and therefore the greatest return on investment. Farmers are reticent to sacrifice a familiar and perpetual source of income in favor of a one-time payment contingent upon significant up-front investment and competitive trading over time.

Farmers also tend to weigh economic ripple effects in their decision-making, such as the effects on seed suppliers and other businesses ancillary to farming, which would be harmed by agricultural retirement. All C-CAP team members were adamant about the need for farmers to maintain rather than cease agricultural production while generating trading credits. This is possible because they expect research to demonstrate that plantings significantly less dense than 400 TPA can provide comparable nutrient capture while enabling farmers to continue farming using an agroforestry model interspersing trees with crops and/or pasture.

Pooling credits to create an aggregate facility can improve economies of scale. This would not only increase the potential number of credits available, but may significantly benefit small farm finance. Even so, small farmers will be reluctant to convert productive agricultural land to perpetual forest, which is common in the current program based on the investment required and the credit value of forest versus hay or mixed open land. Strategic plantings would enable participating properties to provide sufficient nutrient capture while providing additional services such as agricultural production. If the program were modified to allow farmers to maintain production in additionality zones through agroforestry, farmers may be more inclined to enroll.

The NCTP was judged too simple, focusing only on N and P capture without considering other ecosystem factors and limiting the land to providing only a narrow scope of benefits. This narrow focus renders the program easier to administer, but overlooks numerous other ecological and economic opportunities that would incentivize participation. All properties are currently treated identically regardless of sensitivity in terms of threats to water quality and potential protection. Land with minimal environmental threats to water quality is assigned the same credit value as land with the potential for greater impact, and 400 TPA typically are planted to maximize credit generation regardless of site suitability.

Because no species requirement exists, most landowners plant inexpensive softwoods, resulting in dense pine forests, which are cost effective but subject to the same increased vulnerabilities as any monoculture, such as pests and disease. White pine forests in the northeast are succumbing to various pathogenic fungi, insects, and a changing climate and thinning stands of white pine has been found to increase forest health. The American elm is another example of a monoculture resulting in large-scale die-off. In the early part of the 20^{th} century, American elms graced many streets in the United States, but Dutch elm disease, a wilt fungus, decimated them in part because they had been planted *en masse* which allowed the disease to easily spread.

Planting designs and requirements should be strategic and provide multifaceted benefits rather than simply capture N and P. Ecologically critical sites should be identified and valued more highly. They should be planted in a fashion that will not only retain N and P, but also provide additional services such as maintenance of biodiversity, agricultural production, recreation, and nutrient cycling. Properties could be graded on a map using an aggregate of environmental variables to delineate areas that are more valuable in terms of ecosystem damage/risk and enhanced credit value should be possible to incentivize facilities in these areas.

Trees should not be planted where they are not needed, and the program should establish standards for the trees that are planted or offer some incentive for planting a variety of tree species in the additionality zone. Some trees take up more nutrients than others do; data on this subject could provide impetus for creating tree species standards or incentives. Planting more diverse tree species would contribute significantly to healthier ecosystems more resistant to climate, pathogens, and insect pressure.

Farmer goals are important. If farms fulfill nutrient capture requirements while continuing to serve agricultural purposes, then agroforestry designs can be tailored to suit farmer needs. For example, an additionality zone on a hillside might be suitable for an agroforestry model where trees are less densely planted to allow livestock grazing in the same area, whereas a flat bottomland could feature row crops or productive perennials interspersed with trees, perhaps with management restrictions on fertilizer, pesticide, and herbicide application.

Site designs should allow farmers to diversify income and meet agricultural goals while providing ecological benefits. Agroforestry offers a design palate with sufficient flexibility and modifying the program to support implementation represents a step toward basing the NCTP on multiple sustainability pillars (human, social, economic, and environmental). Developing metrics for human, social, economic, and environmental benefits in addition to N and P capture and predicating the program upon them would demonstrate investment returns beyond its current environmental and economic scope.

Limitations

Even if the NCTP were modified to accommodate agroforestry and enable farmers to maintain agricultural production while providing ecosystem services, some farmers are more likely to participate. Medium and large commercial producers who depend heavily on equipment and are more likely to farm full time are less likely to participate compared to small-acreage farmers given that trees can limit their use of large-scale mechanized equipment. However, if equipment and technology can be used to manage and harvest an agroforestry installation in an additionality zone, fruit and nut trees may provide income opportunities and appeal to this class of farmer. Convincing farmers that such a model is profitable may still be challenging. Interviewees commonly expressed a wish for more sustainability metrics in the program and strategic requirements and planting designs, but recognize that increasing complexity increases cost. Implementing the changes described would increase operational costs indefinitely and resources would be required at the outset to reform the program.

Potential

The NCTP has tremendous potential to benefit farmers, the environment, and developers who purchase credits. The difficulty in making a living as a small-acreage farmer in the United States today is a nationally acknowledged truth and most small-acreage farmers depend on off-farm jobs to make ends meet. Nutraceuticals and tree syrup represent potentially lucrative enterprises, and ecological services may represent another. If farmers can be paid for services like improving or maintaining soil quality or carbon sequestration, small-acreage farming might become more widely profitable, resulting in a greater number of small working farms that provide farmer income and nutrient capture, as well as other ecological, social, and economic benefit. These benefits include increased food nutrient density, biodiversity, wildlife and pollinator habitat, decreased water and air pollution, and increased small businesses supporting local agriculture, among others.

Additional references

Virginia Department of Environmental Quality, *Trading Nutrient Reductions from Nonpoint Source Best Management Practices in the Chesapeake Bay Watershed: Guidance for Agricultural Landowners and Your Potential Trading Partners*, viewed 11/10/2019, <https://www.deq.virginia.gov/Portals/0/DEQ/Water/PollutionDischargeElimination/VANPSTradingManual_2-5-08.pdf>

Stephenson, K. et al., 2016, *Virginia Citizen's Guide to Environmental Credit Trading Programs: An Overview*, Virginia Tech Extension Publication ANR-173P, viewed 11/10/2019, <https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ANR/ANR-173/ANR-173-PDF.pdf>

Addlestone, B.J., J.F. Munsell, and D. Winn. 2019. Nutrient Trading in Virginia: Where Does the Forestry Community Fit In? Virginia Forests. Spring Edition. 12-15.

Appendix 7 Toolkit

Sections below constitute a toolkit compendium that can guide agroforestry NCTP installations. Project partners intend to publish the Toolkit as a Cooperative Extension document or a similar technical transfer document following review by a VDEQ certification advisory committee that may form under the proposed regulation on the Certification of Non-Point Source Nutrient Credits (9VAC25-900).

Design and Practices

Multifunctional Agroforestry Buffers

The University of Missouri Center for Agroforestry describe multifunctional riparian forest buffers as living filters comprised of diverse and productive trees, shrubs, forbs and grasses, including native plants, established in distinct zones. Riparian buffers filter nutrients from surface run-off and shallow ground water, where excess nutrients are utilized for plant growth. Riparian buffers protect the water quality and are a tool for controlling erosion, providing wildlife habitat, and sequestering carbon. Multifunctional riparian buffers are multispecies riparian buffers managed for diverse benefits (Trozzo et al. 2013). For example, decorative woody florals, such as red osier dogwood may be planted in the shrub zone while fruit and nut crop trees may be planted in tree zones, providing additional income.

Multifunctional riparian buffers reduce the impacts of nonpoint source pollution on stream quality by increasing soil quality in the riparian zone. Soil-water infiltration was compared under a multi-species riparian buffer, a cultivated field, and a grazed pasture in a study by Bharati et al. (2002). Cumulative infiltration was five times higher under the multi-species riparian buffer (silver maple, grass, switchgrass) than under the cultivated field and pasture. Soil bulk densities were significantly smaller than in the cultivated field and pastures. Results indicated that when using infiltration as an index, an established multi-species riparian buffer improves soil quality over time (six years). Water infiltration is important to crop production as it is linked to agricultural drainage and is affected by soil properties. Higher infiltration rates increase the amount of contact between nonpoint source pollutants and plant material, such as the roots of a riparian buffer. The more water infiltration, surface velocities will decrease, thus reducing soil erosion potential (Bharati et al (2002).

Multifunctional riparian buffers were shown by Simpkins et al. (2002) to decrease nutrient, pesticide, and sediment concentrations in runoff from adjacent fields in Iowa. They also hypothesize that multifunctional buffers have the capacity to remove nitrate from groundwater, which depends on residence time and usable carbon. Gikas et al. (2015) found in a study conducted under Mediterranean climatic conditions that planting trees in cultivated fields can contribute to the reduction of nitrate pollution to groundwater. Treatments that had a combined roots system of trees and crops appeared to uptake greater amounts of N and P as compared to fields comprised of solely annual shallow-rooted crops. N showed more mobility to the deeper soil layers than P, indicating higher N concentrations in the lower soil profile. N concentrations were lower in the soil zone near the trees than they were farther from trees. Shultz et al. (1995) found significantly more roots below a multifunctional riparian buffer than adjacent fields suggesting better soil stabilization, absorption of infiltrated water, interaction with non-point source pollutants than adjacent fields. Nitrate concentrations were lower under the buffer than the cropped fields. Water quality data indicate that multifunctional buffers are effective at reducing non-point source pollutants, such as Atrazine, below the rooting zones and keeping them from moving beyond the buffer strip.

Lee et al. (2000) evaluated the ability of a multifunctional riparian buffer to remove sediment, N, and P from cropland runoff. Simulated rainfall was applied to bare cropland, cropland with a grass buffer, and a grass-woody perennial buffer. The grass and grass/woody perennial buffer trapped 70% and 92% of the sediment, respectively. During a 2-hr simulated rainfall, the grass buffer removed 64, 61, 72, and 44% of the incoming total N, nitrate, total P, and phosphate, respectively. During the same simulation, the grass/woody perennial buffer removed 80, 92, 93, and 85% of the incoming total N, nitrate, total P, and phosphate, respectively. The grass buffer was effective in trapping coarse sediment and nutrient bound in sediment while the addition of the grass/woody perennial buffer showed effectiveness in additionally trapping clay and soluble nutrients due to the higher rates of infiltration provided by deep-rooted woody plants. Lee et al. (2003) examined the effectiveness of an established multifunctional riparian buffer in trapping sediment, N, and P in the runoff from cropped agricultural land after natural rain events. Cropland without a buffer was compared to a grass buffer and grass/woody perennial buffer. The grass-woody perennial buffer removed 97% of the sediment, 94% of the total N, 85% of the nitrate, 91% of the total P, and 80% of the phosphate. All measurements indicated higher sediment/nutrient retention under the grass-woody perennial buffer than the grass buffer alone. The grass buffer was effective at removing sediment and nutrients bound in sediment, the added width of the grass-woody perennial buffer increased the removal of soluble nutrients by 20%.

Additional literature are reviewed in the report prepared for a VDEQ certification advisory committee that may form under the proposed regulation on the Certification of Non-Point Source Nutrient Credits (9VAC25-900).

Bharati, L., et al. 2002. Soil-water infiltration under crops, pasture, and established riparian buffer in Midwestern USA. Agroforest Syst. 56:249-257.

Gikas, G.D., Tsihrintzis, V.A, and D. Sykas. 2015. Effect of trees on the reduction of nutrient concentrations in the soils of cultivated areas. Environ Monit Assess. 188(327):1-19.

Lee,K-H., et al. 2000. Multispecies Riparian Buffers Trap Sediment and Nutrients during Rainfall Simulations. J. Environ. Qual. 29:1200-1205.

Lee, K.T., Isenhart, T.M., and R.C. Shultz. 2003. Sediment and nutrient removal in an established multi-species riparian buffer. J. Soil Wat. Cons. 58(1):1-8.

Shultz, R.C., et al. 1995. Design and placement of a multi-species riparian buffer strip system. Agroforest Syst. 29:201-226.

Simpkins, W.W., et al. 2002. Hydrogeological constraints on riparian buffers for reduction of diffuse pollution: examples from the Bear Creek watershed in Iowa, USA. Wat. Sci. Tech. 45(9):61-68.

Trozzo, K.E., J.F. Munsell, and J.L. Chamberlain. 2013. How to Plan for and Plant Streamside Conservation Buffers with Native Fruit and Nut Trees and Woody Floral Shrubs. VCE Publication. ANR-69P. 20p. https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ANR/ANR-69/CNRE-27.pdf

Trozzo et al. (2013) is a feely available Cooperative Extension publication that provides a set of design and planting processes for establishing multifunctional riparian forest buffers composed of native fruit and nut trees and woody floral shrubs. The document includes a “tool box” that provides links to resources and presents a case example of a native fruit and nut tree and woody floral riparian buffer.

Alley Cropping on Contour

Alley cropping is the planting of two or more sets of single or multiple rows of trees or shrubs at wide spacings, creating alleys within which agricultural, horticultural, or forage crops are cultivated (University of Missouri, 2015).

It is possible to grow timber or other tree products in an alley cropping system while providing an annual income through the production of additional compatible crops. Farm portfolios are diversified by providing short-term cash flow from annual crops while also providing medium and long-term products from the tree and/or shrub components. Both timber and non-timber products may contribute to income generation. In addition to marketable materials, alley cropping can enhance ecosystem services provided by farms.

Soils with a high erodibility index are highly susceptible to damage and are difficult to protect when cropped. Alley cropping protects fragile soils through its root network produced by the trees and additional groundcover resulting from fallen leaves and companion crops. Rows of trees, shrubs, and/or grasses planted on the contour of a slope will also serve to reduce soil movement down the slope. Trees intercept rainfall and increase water infiltration, while herbaceous plants reduce soil erosion. Non-point source pollution leached beyond the root zone of agronomic crops may be absorbed by the deeper tree roots, minimizing pollutants from reaching ground water (University of Missouri, 2015).

Alley cropping with leguminous trees can be used as a source of mulch and fertilizer for organic farming. In Georgia, Jordan (2004) found that dry weight annual production of prunings of *Albiza julibrissin* was up to 18.4 Mg ha $^{-1,}$ which is enough to maintain sorghum crop production on the experiment site. Sorghum production was higher in the alley cropping system than in an annual legume-based agricultural system. Nutrient pools in the agroforestry system continued to increase after three years.

Additional literature are reviewed in the report prepared for a VDEQ certification advisory committee that may form under the proposed regulation on the Certification of Non-Point Source Nutrient Credits (9VAC25-900).

Jordan, C.F. 2004.Organic farming and agroforestry: Alley cropping for mulch production for organic farms of southeastern United States. Agroforest Syst. 61:79-90.

University of Missouri, Agroforestry Center. 2015. Training Manual for Applied Agroforestry Practices. Chapter 3: Alley cropping (p.31-49)

Keyline Swale

Farmers use Keyline design to conform agricultural operations to land contour and intentionally direct and store water for use in production zones. P.A. Yeoman developed the system, which includes small-scale ditches (aka swales) that direct and store water, and offer a place to plant trees and other vegetation. Swales can be installed using equipment available on most farms, such as a double bottom moldboard plow followed by passes with a rotary tiller.

The use of Keyline design is extremely beneficial for effective flood irrigation practices. The practice is inexpensive and allows flood irrigation of undulating land and flat cropland while reducing the likelihood of anaerobic conditions in flat lands, resulting in poor soil quality. Keyline design also incorporates the use of trees, generally planted in lines, and strategically positions dams, irrigation channels, fences, farm roads and buildings (University of Kentucky, 2020).

University of Kentucky. ACS Distance Education. https://www.acsedu.co.uk/Info/Alternative-Living/Alternative-Technology/Swales-and-Keylines.aspx. Website accessed 24 April 2020.

Technology and Tools

AgBufferBuilder

The AgBufferBuilder is a GIS-based computer program for precision design of vegetative filter strips around agricultural fields. The tool analyses the terrain for spatial patterns of overland runoff and designs a variable-width configuration that matches those patterns to provide a constant, user-selected, level of performance along the field margin. The tool also can assess the performance level of existing or hypothetical configurations. The AgBufferBuilder tool can be used to improve filter strip performance by identifying areas in need of enlarged vegetation where overland flow concentrates. It also can be used to reduce costs by downsizing filter strip where little runoff flow occurs, and assess and compare the efficacy of alternative buffer designs. On average, AgBufferBuilder configurations are, on average, twice as effective as fixed-width buffers covering the same number of acres (https://www.fs.usda.gov/nac/resources/tools/AgBufferBuilder.shtml).

NTFP Calculator

The NTFP calculator is a tool produced by the USDA National Agroforestry Center (https://www.fs.usda.gov/nac/resources/tools/ntfp.shtml). This Microsoft Excel-based tool provides general estimates of income potential from selling NTFPs harvested from multifunctional agroforestry systems. It was developed in cooperation with the Virginia Tech, College of Natural Resources and Environment with fuding from Virginia NRCS CIG. The NTFP calculator allows a user to select species and number of plants, as well as the area of land required and product price. Results include potential income in areas of conservation plantings if used instead of crop or forage alternatives. At a given interest rate, the calculator renders financial indicators at the 10- and 25-year period, and compare them to crop and forage alternative annual equivalents.

Steps and Organization

NCTP Procedures

The general steps needed to create a NCTP. Specific summaries for each step are presented earlier in this report.

1. Detailed Project Description
2. Operational Practices
3. Service Area Description
4. Identification of Offset/Credit Broker
5. Restrictive Covenant Creation
6. Credit Derivation Methodology
7. Land Conversion Areas Management Plan
8. Monitoring, Maintenance, Reporting Criteria
9. Accounting and Financial Information
10. Additional Information (access, inspection, alteration terms, purchase documentation)

AG-FAST

Group Facility Standard for Nutrient Trading (AG-FAST) DRAFT v2.0

Introduction

Landowners of all sizes and economies should be able to access to the NCTP market in Virginia. Smaller landowners often are not able to meet the financial obligations needed to develop a NRIP. To facilitate access and reduce costs, a draft group certification model was developed (AG-FAST). The certification allows multiple landowners within a similar watershed to combine agroforestry farm BMPs were tree densities exceed 400 TPA into a single facility. An organized group of landowners under group certification will form a LLC and select a group manager who is responsible for maintaining internal control and ensuring all criteria are met, as well as serving as the liaison with the certifying and auditing entities. The group manager may be an LLC member or an outside entity. Costs associated with the establishment of a nutrient trading management plan for an AG-FAST group and nutrient credit trade will be reduced due to shared auditing and monitoring needs. Remote sensed technology can be used to track and assess BMP performance across multiple properties, along with spot checks and well sampling on transect.

Scope of Standard

This standard is intended for landowners in the Commonwealth of Virginia's Chesapeake Bay Watershed. This standard specifies the requirements for a regional group of landowners within a common watershed involved in nutrient trading to be certified as an AG-FAST group formed into an LLC. This includes requirements for agroforestry as a BMP, auditing, a group manager, as well as economic considerations.

Associated Standards and Documentation

- Trading Nutrient Reductions from Nonpoint Source Best Management Practices in the Chesapeake Bay Watershed: Guidance for Agricultural Landowners and Potential Trading Partners, VDEQ.
- Memorandum of Understanding between group members and group manager.
- Memorandum of Understanding between group members, group manager, and certifying bodies.
- Examples of approved agroforestry BMPs.
- NRCS Standards 390 or 391: In USDA-NRCS Field Office Technical Guide.

Terms and Definitions

Additionality
Agroforestry
Alley Cropping
Baseline
BMP
Group
Group Manager
HUC
LLC
Multi-Functional Riparian Buffer
Nutrient Credits
Nutrient Reduction Plan
Offset Broker
Riparian Buffer
Windbreaks

Standard Criteria

1.0 Group Requirements

1.1 The Group shall consist of members who have formally joined the group.

1.2 The Group shall form an LLC, who will be the client selling nutrient offset credits.

1.3 The LLC shall consist of members whose properties considered for group certification are within the same HUC xxx watershed.

1.4 The LLC shall elect a Group Manager who is responsible for the LLC's compliance with the Standard, overall LLC documentation, LLC monitoring, and reporting.

1.5 The Group Manager may be a member of a particular LLC or may be an outside entity.

1.6 If the Group Manager is an outside entity, they may be responsible for auditing and additional compliance monitoring and reporting.

1.7 If the Group Manager is an LLC member, then they shall have the same obligations as other members of the LLC in respect to compliance with this Standard.

1.8 Group documentation shall include documenting and monitoring compliance with this Standard and associated guidance documents and monitoring individual LLC members for compliance and other relevant aspects that may affect compliance (e.g., membership status, production, problems, compliance).

1.9 The LLC number shall not exceed the maximum number of members that the Group Manager can technically support or that is supported by the LLC management system.

1.10 The LLC shall be the client and shall be formed and maintained according to all applicable laws and regulations of the state and county.

1.11 The LLC shall have officers who shall fulfill their respective duties according to the laws and regulations of the state and county.

2.0 Generating and Selling Group Offsets

2.1 The VDEQ "Trading Nutrient Reductions from Nonpoint Source Best Management Practices in the Chesapeake Bay Watershed: Guidance for Agricultural Landowners and You Potential Trading Partners" shall be the main guidance document.

2.2 The LLC, including the Group Manager if a member, shall meet all relevant seven-step NCTP requirements, as well as referenced documentation, in order to authenticate offsets and trade nutrients.

2.2.1 LLC individual members shall assess their progress toward achieving the minimal baseline (VDEQ p3-5).

2.2.2 LLC individual members shall calculate the offsets that can be generated on their land (VDEQ p 5-7) through agroforestry techniques (see 3.0 and annex xxx). Offsets calculated in 2.2.1 and 2.2.2 shall be on land converted from non-tree-based systems to agroforestry and other tree-based systems (see 3.0 and annex xx).

2.2.3 Group Manager shall identify one offset broker (VDEQ p 7-8) for the LLC.

2.2.4 The offset broker shall consider all LLC member portfolios as one transaction.

2.2.5 LLC individual members shall achieve and verify baseline requirements (VDEQ p 8).

2.2.6 Group Manger shall qualify LLC's offset generation project (VDEQ p 9-10).

2.2.7 LLC individual Members shall implement their portions of the group project (VDEQ p 10-11).

2.2.8 Group Manager shall authenticate the offsets generated and trade (VDEQ p 11)

2.3 A minimum of one Riparian Buffer shall be installed on each LLC member that meets specifications found in USDA-ARS Field Office Technical Guide.

2.4 Additional BMPs are encouraged to be implemented according to VDEQ guidance, however this standard only applies to tree-based agroforestry practices.

3.0 Agroforestry and Tree Planting

3.1 Agroforestry practices implemented that may be utilized include windbreaks at field edges, alley cropping on flat or sloping lands, and riparian buffers parallel to water bodies. Guidance regarding these practices can be found in *annex xxx.*

3.2 Minimum baseline for all linear agroforestry practices is a 35 feet Riparian Buffer, or the current baseline minimum guideline.

3.3 Tree planting beyond the baseline shall be considered additionality and the portion of the property where one can generate offsets.

3.4 Additionality is calculated on each LLC member property; however, the total combined additionality shall be what is traded for nutrient credits.

3.5 Management within the baseline zone may be diversified, while management in the zone of additionality shall be limited to the same three management techniques per LLC.

3.6 For non-contiguous linear agroforestry systems (e.g., multiple rows or clusters, or alley cropping on contour), tree density shall be calculated on a row-by-row basis at 10 feet wide.

3.7 Baseline requirements and additionality are measured on a property-to-property basis and shall not be grouped.

3.8 Land shall not be retired within agroforestry rows or clusters.

3.9 Non-woody perennials such as grasses and shrubs may be a component of an agroforestry system.

3.10 When economically and ecologically feasible, species in agroforestry systems shall be native species.

3.11 In addition to nutrient reduction, agroforestry plantings shall provide at least one additional environmental benefit (e.g., soil erosion, reduction of wind, biodiversity).

3.12 In addition to nutrient credits, agroforestry plantings shall provide at least one additional economic benefit (e.g., fruit for sale, timber, medicinal products).

3.13 Agroforestry plantings may be actively managed following approved management plan guidelines (e.g., for fruit, timber, nuts, berries).

3.14 Management may occur in between agroforestry plantings following approved management plan guidelines (e.g., corn, hay, beans).

4.0 Group Manager

4.1 The Group Manager shall demonstrate knowledge of the requirements and all seven steps necessary to authenticate offsets and trade nutrient credits.

4.2 The Group Manager shall demonstrate knowledge of relevant agroforestry techniques and their environmental and economic benefits.

4.3 The Group Manager shall demonstrate sufficient relevant resources to enable effective and impartial technical and administrative management of the Group certification.

4.4 The Group Manager shall have the capacity to monitor, evaluate, and assist Group members regarding their compliance to requirements of this Standard and relevant technical materials. The Group Manager may be responsible for compliance and monitoring.

4.5 The Group Manager shall regularly communicate and perform site visits and possible audits in determined and documented frequencies.

4.6 Policies regarding communication between Group Manager and Group members, as well as other certifying and accrediting agencies shall be documented.

4.7 Group operating structure defining management and documentation, as well as decision-making within the group shall be documented.

4.8 All Group records shall be kept for at least five years.

4.9 The Group manager shall maintain documented membership records including requirements for joining and leaving the group, requirements for participation, and remedial procedures for non-compliance.

4.10 Non-compliance will result in Corrective Action Requests (CAR), which shall specify timeframe for compliance, depending on the severity. Penalty for not meeting a CAR in a timely fashion shall be described.

4.11 Results of compliance and auditing shall be kept on file for at least five years, as well as resulting plans for implementing improvements and correction action requests.

4.12 A summary of all the land-use data shall be kept and updated regularly. This shall include total acres, types of agroforestry management, crops, additional BMPs, traded nutrient credits, environmental benefits, and additional products sold.

5.0 Economic Considerations

5.1 Group members receive profits from traded nutrient credits proportional to their eligible acres of land.

5.2 The Group Manager may receive additional percentages or other incentives to compensate him or her for their work. This shall be agreed upon by the group and documented.

5.3 Individual Group members may receive all non-nutrient trading profits (e.g., fruit and nut sales, milk and meat, hay and straw) from agroforestry operations on their eligible properties.

5.4 The Group Manager may work with outside investors (e.g., Propagate Ventures) which may invest in projects and provide funding opportunities, technical resources, and financial advice and planning.

5.5 Work with outside investors shall be agreed upon by the Group and documented.

6.0 Auditing Considerations

6.1 Group Manager is responsible for periodic monitoring of Group members to ensure compliance is proceeding according to management plans. Frequencies of site visits will be determined and documented.

6.2 Auditing will be performed according to determined and documented procedures.

6.3 If the Group Manager is an outside entity and not a member of the group, they may be responsible for auditing.

6.4 Group Managers will be audited annually.

6.5 25% of each Group members (Group Manger’s portfolio) will be randomly audited annually.

6.6 Auditing may be accomplished on the ground or by means such as drone surveillance and the use of satellite imagery (e.g., Sentinel).

7.0 LLC Member Compatibility

7.1 In order to facilitate auditing in an efficient manner, LLC members shall have similar characteristics.

7.1.1 LLC members shall have similar land use practices.

7.1.2 Management in the zones of additionality shall be limited to three management practices.

7.1.3 LLC members shall be contiguous and in the same HUC watershed.

7.1.4 LLC members shall have a similar price per nutrient credit.

7.1.5 LLC members shall have similar yields for nutrient credits.

7.1.6 LLC members shall have a similar scale of nutrient credit production.

8.0 Deed Restrictions

8.1 Portions of the land in the LLC portfolio that is part of the Group shall be legally established as a deed-restricted easement for the life of the NRIP.

8.2 If LLC properties change ownership, the proportion of the land in the NRIP shall remain in said plan.

8.3 Access to land occupied by the NRIP shall remain open to auditors and other personnel as described in the easement.

Site-Structure-Function Matrix

A proposed site-structure-function matrix will allow landowners and brokers to rapidly assess quantified nutrient reductions (*function*) associated with different agroforestry systems (*structure*) at different planting locations (*site*). The matrix uses conditional branching that directs users to central tendencies of nutrient credit offsets determined by BayFAST model scenarios. Application will result in distinct values for specific agroforestry projects and thus deliver an applied tool for comparison of credit offsets across a range of percent tree cover, those under 100% representing potential agroforestry designs.

Generalized average percent efficiencies in nutrient load reduction, percent margins of error of the average, and an efficiency factor. The efficiency factor is reported as the rate of load reduction relative to tree planting density assuming 400 TPA in the percent area converted to trees. An efficiency factor of 1 means that for each percentage of land converted to agroforestry trees, a one percent increase in nutrient load reduction efficiency is achieved. An efficiency factor greater than 1 means that for each percentage of land converted to agroforestry trees, there is more than one percent increase in the load reduction efficiency. An efficiency factor less than 1 means that for each percentage of land converted to agroforestry trees, there is less than one percent increase in the load reduction efficiency.

P Efficiency to Edge of Stream (function)

% Tree Cover (structure)	**Pasture Conversion (site)**	**% ME**	**Efficiency Factor**	**Row Crops Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay with Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay without Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**
12%	12%	3.2%	1.00	19%	2.6%	1.58	10%	4.7%	0.83	8%	3.6%	0.67
18%	23%	4.3%	1.28	29%	2.0%	1.61	23%	4.1%	1.28	22%	3.2%	1.22
36%	47%	4.2%	1.31	56%	2.5%	1.56	48%	4.1%	1.33	50%	2.4%	1.38
100%	100%	5.0%	1.00	100%	3.0%	1.00	100%	5.0%	1.00	100%	3.1%	1.00

P Efficiency to Chesapeake Bay (function)

% Tree Cover (structure)	**Pasture Conversion (site)**	**% ME**	**Efficiency Factor**	**Row Crops Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay with Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay without Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**
12%	14%	2.4%	1.17	16%	2.3%	1.33	10%	3.5%	0.83	11%	2.1%	0.92
18%	31%	2.5%	1.72	32%	2.4%	1.78	25%	3.1%	1.39	26%	2.9%	1.44
36%	60%	2.7%	1.67	57%	2.7%	1.58	47%	3.5%	1.31	47%	3.1%	1.31
100%	100%	4.2%	1.00	100%	3.8%	1.00	100%	4.0%	1.00	100%	2.5%	1.00

N Efficiency to Edge of Stream (function)

% Tree Cover (structure)	**Pasture Conversion (site)**	**% ME**	**Efficiency Factor**	**Row Crops Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay with Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay without Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**
12%	16%	6.3%	1.33	14%	3.4%	1.17	11%	4.3%	0.92	6%	2.3%	0.50
18%	47%	6.1%	2.61	32%	4.3%	1.78	30%	4.5%	1.67	18%	2.4%	1.00
36%	90%	5.7%	2.50	57%	4.7%	1.58	59%	2.6%	1.64	36%	4.0%	1.00
100%	100%	5.9%	1.00	100%	4.3%	1.00	100%	4.6%	1.00	100%	3.7%	1.00

N Efficiency to Chesapeake Bay (function)

% Tree Cover (structure)	**Pasture Conversion (site)**	**% ME**	**Efficiency Factor**	**Row Crops Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay with Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**	**Hay without Nutrients Conversion (site)**	**% ME**	**Efficiency Factor**
12%	16%	3.0%	1.33	14%	2.9%	1.17	11%	2.7%	0.92	8%	2.8%	1.50
18%	48%	3.9%	2.67	32%	3.4%	1.78	30%	3.2%	1.67	19%	2.5%	1.06
36%	92%	3.6%	2.56	57%	4.2%	1.58	59%	2.7%	1.64	38%	2.5%	1.19
100%	100%	3.9%	1.00	100%	4.2%	1.00	100%	3.9%	1.00	100%	3.2%	1.00