Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Recommendations Regarding Silvopasture and Alley Cropping Agroforestry Practices

Prepared for the Chesapeake Bay Programs Agriculture and Forestry Workgroups by the Agroforestry Expert Panel Establishment Group, July 23, 2025.

Summary

Due to increasing levels of Silvopasture and Alley Cropping practice implementation across the Chesapeake Bay watershed and the potential for these practices to improve water quality, the Agriculture Workgroup (AgWG) and Forestry Workgroup (FWG) were asked to consider these practices for crediting in the Chesapeake Bay Watershed Model. To satisfy this request (see Appendix E ***Recommendations to Establish an Agroforestry BMP Expert Panel Establishment Group****)*, the AgWG and FWG approved the formation of the Agroforestry Expert Panel Establishment Group (EPEG).

The purpose of the Agroforestry EPEG was to:

- Determine if there is a need for an Alley Cropping and Silvopasture BMP Expert Panel (EP).
    - If an EP *is* recommended, the EPEG would be tasked with:
        - Identifying priority tasks for the Phase 7.0 Alley Cropping and Silvopasture EP
        - Recommending areas of expertise that should be included on the Alley Cropping and Silvopasture EP
        - Drafting the charge of the Alley Cropping and Silvopasture EP
    - If an EP is *not* recommended, the EPEG would be tasked with:
        - Providing justification for not convening an EP
        - Providing an alternative recommendation to address Alley Cropping and Silvopasture practices in lieu of an EP

The Agroforestry EPEG reviewed the available research and determined that there was sufficient evidence to merit crediting these practices for their water quality benefits if appropriately managed and key qualifying criteria are met. The EPEG is recommending the Chesapeake Bay Program (CBP) credit these practices as efficiency BMPs based on the credit that would be received from converting 25% of the agricultural lands where the practice is applied into forest. This approach follows precedents for using a similar method to calculate BMP efficiency reductions in Chesapeake Assessment and Scenario Tool (CAST), including the animal mortality management BMP, Phase 5 Nutrient Management BMP efficiencies and original loading rates for the Conservation Tillage BMP. The EPEG further recommends crediting these practices without convening an EP because the approach is based on partnership-approved forested land use loading rates. There exists a precedent for this approach with the crediting evaluation conducted by an EPEG for the Agricultural Stormwater Management BMP in Phase 6 resulting in a formal report and approval for crediting.

Background

The seven major Chesapeake Bay watershed jurisdictions implement best management practices (BMPs) to achieve the goals set forth in the *2010 Chesapeake Bay TMDL for Nitrogen, Phosphorus, and*

Sediment. Through the *Protocol for Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls* (BMP Protocol), newer practices and technologies are considered and evaluated for inclusion in the CBP partnership modeling tools.

The Agroforestry EPEG followed the process outlined in the CBP BMP Protocol, which allows for well-supported adaptive management strategies to BMP evaluation. The EPEG met for one year and completed the following steps to evaluate these practices and develop recommendations. The EPEG did not develop a general description of how an EP would be supported as the group did not recommend convening an EP.

a.) Developed a clear and concise definition of the agroforestry practices including common versions of the practices that are either explicitly included or excluded from the requested practices. Includes specific scientific information on how the practice reduces nitrogen (N), phosphorus (P), and/or sediment, and the sources/loads that will be treated.
b.) Compiled references to available science/data on the nutrient and sediment removal efficiencies, including the geographical location of where the data was collected.
c.) Identified the types of data the jurisdiction(s) currently track and report for a practice and how the request could impact these efforts.

Following approval by the relevant sector Workgroups, EPEG members were identified and recruited based on their knowledge and expertise of the practices, experience with relevant state and federal programs, and jurisdictional representation (Table 1). The EPEG coordinators provided experience with previous BMP expert panels or subcommittees and knowledge of the Chesapeake Bay Program model and data reporting, verification and quality assurance protocols within the Chesapeake Bay watershed.

Table 1. Agroforestry EPEG membership and affiliations.

Name	Affiliation
Approved Members	
John Fike	Virginia Tech
Brett Chedzoy	Cornell University Cooperative Extension
Elizabeth Hoffman	Maryland Dept. of Agriculture
Nick Miller	Maryland Dept. of Agriculture
Mark Batcheler	United States Forest Service - National Agroforestry Center
Robbie Coville	Pennsylvania Department of Conservation and Natural Resources - Bureau of Forestry
Joshua Greene	Trees For Graziers
Advisors and Regularly Consulted Parties	
Joe Alley	United States Department of Agriculture - Natural Resources Conservation Service, *National Agroforester*

Aaron Hird	United States Department of Agriculture - Natural Resources Conservation Service, *Pastureland Assessment Leader, CEAP for Grazing Land*
Support Staff	
Katie Brownson	United States Forest Service - CBPO
Ruth Cassilly	University of Maryland - CBPO
Mark Dubin	University of Maryland - CBPO
Eric Hughes	United States Environmental Protection Agency - CBPO
Olivia Devereux	Devereux Consulting - CBPO
Helen Golimowski Smith	Devereux Consulting - CBPO
Jessica Rigelman	J7 Consulting - CBPO

From August 5, 2024 through July 2, 2025, the EPEG met virtually eight (8) times and worked collaboratively to complete the group's charge. Communication among EPEG members was through virtual meetings (Microsoft Teams) and email. Final EPEG approval of these report recommendations was obtained by consensus at the July 2nd, 2025, meeting and follow-up email confirmation of all EPEG members.

Practice Definitions

The EPEG began the evaluation process by establishing clear definitions and criteria for alley cropping and silvopasture BMPs that would ensure confidence in resulting water quality benefits. The EPEG evaluated the current Natural Resources Conservation Service (NRCS) Conservation Practice Standard definitions using best professional judgement and determined that refinements were needed to justify crediting these practices for their water quality benefits. Modifications were made to the existing NRCS definitions to promote confidence in the modeled reductions and ensure consistency across the large variation in site selection, design and management inherent in these practices.

Alley cropping (AC) Best Management Practice: Trees or shrubs planted in sets of single or multiple rows *integrated* with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.

The EPEG modified the NRCS definition to clarify that trees should be integrated throughout the agricultural system.

Silvopasture (SP) Best Management Practice: Establishment *and management* of desired trees and forages *on pasture*.

The EPEG modified the NRCS definition to emphasize that trees should also be managed as part of the silvopasture system and to clarify that the trees should be added to pasture. Some silvopasture systems involve the removal and management of trees from forests; however, silvopasture implemented in this

way would not be eligible for CBP water quality credit. The EPEG added key additional criteria to clarify that trees should be integrated throughout the agricultural system (i.e., distributed across the entire pasture).

Basis for Determining Water Quality Benefits

The EPEG did a preliminary review of 40 studies to evaluate whether they could be used to determine the water quality improvement potential for both alley cropping and silvopasture compared to conventionally-managed crop and pasture systems. Of those studies, 27 were identified as core studies for more detailed review and evaluation (see Appendix C for a complete list of studies reviewed).

For silvopasture, studies cited enhanced uptake, retention and cycling of N and P, with reduced nitrate contributions and leaching to shallow groundwater than conventional pasture (Boyer and Neel, 2010). Silvopasture can also exhibit enhanced phosphorus storage capacity due to phosphorus removal and uptake by trees, reducing the potential for phosphorus to be lost to groundwater and surface water runoff (Michael et al. 2007, Nair et al. 2007). A meta-analysis found that trees capture excess nutrients that may be lost from the root zone of understory forages and can therefore help mitigate non-point source pollution from runoff and provide greater water quality protection than treeless pastures (Poudel et al. 2024). Integrating trees into pasture can provide a "safety net" for nutrient capture with the shallower grass roots and the deeper tree roots working together to reduce nutrient leaching (Walter & Kumar, 2019). Although there was limited quantification of silvopasture impacts on water quality relative to conventional agricultural systems, a meta-analysis (Zhu et al. 2020) reported average reductions of nutrient leaching losses (45%), sediment (42%) and surface runoff (47%), with an average nutrient removal efficacy in North America of 45%.

Similarly, studies that addressed the impacts of alley cropping on water quality reported reductions in groundwater nitrate leaching (Allen et al. 2004, Sauer et al. 2015, Zumpf et al. 2017), improved N cycling (Allen et al. 2004, Ryszkowski & Kedziora, 2007), and reductions in N and P losses from agricultural fields (Udawatta et al. 2002). By improving infiltration, alley cropping can also reduce sediment and nutrient transport (Anderson et al. 2008) while increased surface litter can reduce flow rates and reduce erosion and nonpoint source pollution (Udawatta et al. 2021). There was similarly limited quantification of the impacts of alley cropping on water quality relative to conventional systems. However, a meta-analysis found that agroforestry buffer strips showed total nitrogen (TN) reductions of 20-94%, total phosphorus (TP) reductions of 17-91% and sediment reductions 0-97%, with lower values coming from studies measuring reductions within the first 3-years post-planting (Tsonkova et al 2012).

Overall, many studies described how these practices can generate water quality improvements due to the integration of deep rooted and permanent vegetation in these systems. This type of vegetation improves soil structure, nutrient retention and cycling, reduces surface runoff, groundwater leaching and erosion, and increases infiltration. This supports the water quality improvements cited in NRCS Conservation Practice Standard (CPS) documentation (**Alley Cropping CPS and Supporting Document**, **Silvopasture CPS and Supporting Documents**).

Crediting

Methods of Reporting and Crediting (Model Simulation):

Based on the research reviewed, the EPEG confirmed that if properly managed, both alley cropping and silvopasture practices are expected to provide water quality benefits by reducing N, P and sediment loads and should receive credit in CBP modeling tools. The EPEG evaluated various potential crediting approaches, including crediting through existing agricultural BMPs and establishing a separate agroforestry land use and implementing a land use conversion BMP. However, the EPEG ultimately concluded that agroforestry practices do not align closely enough with any existing agricultural BMPs, and it would not be practical to establish a separate agroforestry land use at this time.

The EPEG consulted with the CAST team and identified a defensible approach to establish these practices as efficiency BMPs based on the nutrient and sediment load reductions that would be achieved by converting a certain amount of the total practice area into a forested land use. This approach has the advantage of utilizing existing partnership-approved loading rates for forest while allowing the practice area to remain under agricultural land uses to facilitate applying additional agricultural BMPs to those same acres.

To facilitate crediting using this method, the EPEG established a minimum mature canopy coverage of 25% based on NRCS guidance for maintaining optimal forage production. The reduction in land-use loads is therefore based on planting trees and shrubs at a density sufficient to achieve an established minimum of 25% mature tree and shrub canopy coverage per acre (see Appendix B for guidance on recommended planting rates). The 25% simulated land-use conversion from Crop/Hay land uses (Alley Cropping) or Pasture land uses (Silvopasture) to True Forest results in a reduction in the loading rate (lbs./acre), which is used to calculate the TN, TP and Total Suspended Sediment (TSS) efficiency reductions for silvopasture and alley cropping BMPs (Table 2).

Table 2: Calculated Efficiencies:

BMP	Nitrogen	Phosphorus	Sediment
Silvopasture	21.75%	23.36%	3.29%
Alley Cropping	23.73%	23.16%	24.26%

Efficiencies for each BMP were calculated using the entire Chesapeake Bay watershed-wide average loads in a scenario with no other management practices. Reductions were calculated prior to the land-to-water delivery factors since the BMPs are credited prior to those being applied. The efficiencies derived using this approach reflect a conservative estimate of the water quality benefits generated by these practices documented in the literature. The modeled implementation of these practices does not include any change to the number of animals or amount of manure generated in the pastured area.

When the alley cropping or silvopasture BMP is applied to land-uses in the model, it can be stacked with other BMPs such as nutrient management, conservation tillage, alternative pasture watering, etc. on the

same acreage. The EPEG decided that silvopasture must be stacked with Precision Intensive Rotational/Prescribed Grazing to reflect the additional forage management required to effectively implement this practice and could be stacked with additional complementary BMPs. BMP stacking would not be unique to silvopasture; this is done regularly for other practices, such as Nutrient Management BMPs.

The full description of how these practices will be credited in CAST is summarized in the Technical Appendix (Appendix A) and is summarized here:

- Report for the entire field area (acres)
- Verify additional BMP criteria are met, including 25% minimum mature canopy coverage (see Appendix B for guidance on recommended trees per acre)
- For reported acres, CAST will convert 25% of the area to the forested land use loading rate and keep the remaining 75% of the area at the existing land use loading rate. Reported acres remain as crop, hay, or pasture land-uses and are not shifted to a new land use category.
- Reductions from these BMPs cannot reduce the existing loading rates of the applicable land-uses (i.e., cropland, hay and pasture loads/acre) below zero.

Additional Criteria

All acres that comply with the silvopasture and alley cropping best management practices defined in the EPEG report, which modifies NRCS CPS definitions and criteria, will receive credit for reducing nutrients and sediment (see Appendix D for a non-exhaustive list of programs that provide technical and financial support for these Agroforestry practices). The EPEG identified the key qualifying conditions required for these practices to receive credit for their water quality benefits.

Project plans (site designs) for both alley cropping and silvopasture must achieve a minimum mature canopy coverage of 25%. Trees must be planted at a density sufficient to ensure the 25% mature canopy coverage, distributed throughout the practice area. For guidance on determining appropriate planting rates and density, refer to the calculation method, planting rates and species canopy information provided in Appendix B. The 25% canopy minimum is based on a conservative estimate of canopy cover that could also support the growth of warm season grasses in silvopasture systems. Note many silvopasture systems also support cool season grasses that will tolerate up to 60% canopy coverage and may therefore have significantly more than 25% canopy cover.

In addition, Silvopasture must be accompanied by the integration of the CBP Precision Intensive Rotational/Prescribed Grazing BMP or equivalent NRCS CPS. NRCS is currently in the process of adding grazing management as a required condition of the Silvopasture 381 practice. Once this change is finalized, grazing management will be an assumed component of this practice, however, for the purposes of CBP reporting, the Silvopasture and Precision Intensive Rotational/Prescribed Grazing BMPs will continue to be reported separately. This decision is based on the differences in how the efficiencies are calculated. For both BMPs, the entire acre is reported; however, the silvopasture efficiency was derived from the percentage of the acre in trees, not the entire acre (applied to entire acre), and the Precision Intensive Rotational/Prescribed Grazing calculation was derived using the entire area on which

animals are grazed (and applied to entire acre). In addition, the silvopasture efficiency is derived using the CAST estimates for the forested loading rate, the Precision Intensive Rotational/Prescribed Grazing efficiency is derived from the literature.

The EPEG determined that both BMPs should have a 10-year credit duration, unless crediting options are revisited and modified before the end of that time period. This recommendation was made to address concerns raised by jurisdictional partners and EPEG members regarding the potential for double counting these practices in the Land Use Land Cover data. The 10-year credit duration will allow sufficient time for practice establishment while providing the partnership flexibility in revisiting approaches for applying credits as new data becomes available. The 10-year credit duration period also coincides with the Precision Intensive Rotational/Prescribed Grazing BMP credit duration.

Table 3: Agroforestry BMP Crediting Details

	Alley Cropping	**Silvopasture**
Additional Criteria*	● 25% minimum canopy coverage	● 25% minimum canopy coverage ● "Stacked" with Precision Intensive Rotational/Prescribed Grazing BMP
Applicable Land Uses	May be applied on all cropland and hayland where trees, shrubs, crops, and forages can be grown in combination.**	May be applied on any pasture that is suitable for the desired forages, trees, and livestock.** Silvopasture applied to forest is not eligible for CBP credit.
Measurement Units	Acres	Acres
BMP Type	Cumulative; visual assessment	Cumulative; visual assessment
Credit Duration	10 years	10 years

* For guidance on site selection and design, species (selection, establishment, maintenance), and system management, refer to existing NRCS/state practice recommendations for Alley Cropping 311 and Silvopasture 381.

**Qualifying acres must adhere to the established CBP land use definitions for cropland, hay, or pasture. Land-use/Load Source Definitions

The EPEG also determined that a review of crediting options for alley cropping and silvopasture BMPs should be conducted within 10 years of the adoption of these recommendations to ensure the most current research and technology supports the proposed crediting method. This future assessment of crediting options should include:

- A review of alley cropping/silvopasture misidentification in land use imagery (classified as forest rather than agriculture land use).
- A review of datasets and land use identification capabilities for Phase 8 to determine if practices can be captured in a more efficient and accurate manner as a land use.
- A review of the latest literature to determine if more accurate efficiency reductions can be established for either practice.

Tracking, Reporting and Verification

States may use relevant regulatory agencies to determine appropriate reporting, tracking, and verification procedures.

Tracking and Reporting

Given the association between the silvopasture and alley cropping BMPs and their respective existing NRCS practices, the responsible state or county entity can potentially use relevant NRCS data tracking forms and provide guidance to verifiers on added tracking requirements for CBP crediting. For silvopasture, in addition to verification of existing standards for management actions (for trees, shrubs, crops and forages) and site design, verifiers must ensure implementation occurs on pasture and ensure the use of Precision Intensive Rotational/Prescribed Grazing at the time of implementation. Both alley cropping and silvopasture require the determination of a minimum 25% mature tree canopy coverage.

For CBP reporting, states would report BMP name, # of acres, and date of implementation, the other requirements would be in place as "qualifying conditions" to report those acres for credit. This approach follows the "Specifications or Key Qualifying Conditions" provided in the BMP Quick Reference Guide. The jurisdiction would report 1 acre of verified silvopasture to the CBP as 1 acre of silvopasture BMP and 1 acre of Precision Intensive Rotational/Prescribed Grazing BMP.

Care must be taken to ensure that the same project is not reported from multiple sources, causing a risk that the BMP will be double counted towards annual progress in CAST.

Verification

Both alley cropping and silvopasture BMPs should be verified using a multi-year visual assessment, per approved AgWG BMP Verification Guidance. Each state determines the most appropriate methods for verifying BMP implementation given their specific priorities, programs, needs, and capacity. Ideally, states will leverage multiple existing and perhaps new avenues to verify that practices are sufficient to meet applicable BMP site design and performance criteria.

It is expected that all reported practices are initially certified or inspected on-site by someone with appropriate credentials or training based on the practice, and associated with the federal, state or local program through which the practice is funded, enrolled, tracked and/or reported. A credit duration of ten years for both silvopasture and alley cropping is recommended by this EPEG. Field inspections should be conducted at the time of implementation, with acknowledgement of individual state discretion regarding how inspections are implemented. These practices will not be eligible for re-verification beyond the initial 10-year credit duration to minimize the potential for double-counting when the trees have grown large enough to be picked up as forest in the aerial imagery that feeds the land use data.

Quality Assurance and Control

As with all BMPs reported to CBP in the future, the jurisdictions will document their verification protocols and procedures in their Quality Assurance Project Plan (QAPP) for practices that are reported in their annual progress runs. The jurisdictions' existing BMP verification plans that were approved by the EPA in 2024 describe their BMP priorities and procedures to verify practices using the CBP partnership's BMP Verification Framework, which includes the Agriculture Workgroup's BMP Verification guidance. For additional guidance on required elements of quality assurance and control documentation reference the CBPO Quality Assurance Webpage.

References:

Allen, S. C., Jose, S., Nair, P. K. R., Brecke, B. J., & Ramsey, C. L. (2004). Competition for 15N-labeled fertilizer in a pecan (Carya illinoensis K. Koch)-cotton (Gossypium hirsutum L.) alley cropping system in the southern United States. *Plant and Soil*, *263*(1), 151-164.

Allen, S. C., Jose, S., Nair, P. K. R., Brecke, B. J., Nkedi-Kizza, P., & Ramsey, C. L. (2004). Safety-net role of tree roots: evidence from a pecan (Carya illinoensis K. Koch)–cotton (Gossypium hirsutum L.) alley cropping system in the southern United States. *Forest ecology and management*, *192*(2-3), 395-407.

Amorim, H. C., Ashworth, A. J., O'Brien, P. L., Thomas, A. L., Runkle, B. R., & Philipp, D. (2023). Temperate silvopastures provide greater ecosystem services than conventional pasture systems. *Scientific Reports*, *13*(1), 18658.

Anderson, S. H., Udawatta, R. P., Seobi, T., & Garrett, H. E. (2009). Soil water content and infiltration in agroforestry buffer strips. *Agroforestry systems*, *75*(1), 5-16.

Boyer, D. G., & Neel, J. P. (2009). Nitrate and fecal coliform concentrations in silvopasture and pasture Leachates. Available online at: https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/84691/NAAC2009-Boyer.pdf?sequence=1&isAllowed=y

Chakraborty, D., Nair, V. D., Harris, W. G., & Rhue, R. D. (2011). The Potential for Plants to Remove Phosphorus from the Spodic Horizon. *University of Florida IFAS, SL*, *359*.

Chesapeake Bay Program Agriculture Workgroup's Agricultural BMP Verification Guidance. Available online at: https://d38c6ppuviqmfp.cloudfront.net/documents/Appendix+B+-Ag+BMP+Verification+Guidance+Final.pdf.

Chesapeake Bay Program. Chesapeake Assessment and Scenario Tool (CAST) Phase 6 Source Data. Available online at: https://cast.chesapeakebay.net/Home/SourceData.

Chesapeake Bay Program. Quality Assurance. Available online at: https://www.chesapeakebay.net/what/programs/quality-assurance.

Chesapeake Bay Program (2022). Protocols for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model. Available online at: https://www.chesapeakebay.net/files/documents/CBP-BMP-Expert-Panel-Protocol_clean_v11.7.2022-002.pdf.

Chesapeake Bay Program. (2022). Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters. CBP/TRS-323-18. Second edition. Available online at: https://www.chesapeakebay.net/files/documents/BMP-Guide_Full.pdf.

DeBruyne, S. A., Feldhake, C. M., Burger, J. A., & Fike, J. H. (2011). Tree effects on forage growth and soil water in an Appalachian silvopasture. *Agroforestry systems*, *83*(2), 189-200.

Derametz, V. (2017). Effects of Agroforestry on the agro-ecosystem: a study of the crops-soil-climate-biodiversity system in Short Rotation Coppice temperate agro-silvopastoral system. Available online at: https://orgprints.dk/id/eprint/32527/1/Study%20of%20the%20crops%20soil%20climate%20biodiversity%20system%20in%20Short%20Rotation%20Coppice%20temperate%20agro-silvopastoral%20system.pdf.

Fike, J., Beagle, D.K., Munsell, J.F. (2024). Tree selection guide for Mid-Atlantic silvopastures. Available online at: https://www.pubs.ext.vt.edu/content/pubs_ext_vt_edu/en/SPES/spes-476/spes-476.html.

Gaston, L., Blazier, M., Beasley, J., Dodla, S., Felicien, W., & Clason, T. (2019). Silvopasture switchgrass fertilized with poultry litter: nutrient removal, soil fertility, and runoff water quality. *Communications in Soil Science and Plant Analysis*, *50*(8), 948-958.

Hoosbeek, M. R., Remme, R. P., & Rusch, G. M. (2018). Trees enhance soil carbon sequestration and nutrient cycling in a silvopastoral system in south-western Nicaragua. *Agroforestry Systems*, *92*(2), 263-273.

Jose, S., Walter, D., & Mohan Kumar, B. (2019). Ecological considerations in sustainable silvopasture design and management. *Agroforestry Systems*, *93*(1), 317-331.

Kallenbach, R. (2009). Integrating silvopastures into current forage-livestock systems. Available online at: https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/84706/NAAC2009-Kallenbach.pdf?sequence=1.

Kaviyazhagan, S., Santhosh, R., Manibharathi, S., & Thirumarudhan, T. (2024). Agroforestry systems and their agronomic benefits. In: *Agronomy Compendium: Diverse Perspectives on Crop Science* (pp. 88-109). Stella International Publications. Available online at: https://www.researchgate.net/profile/Manibharathi-Sekar/publication/380394468_Agroforestry_Systems_and_their_Agronomic_Benefits/links/663a526206ea3d0b742f2b26/Agroforestry-Systems-and-their-Agronomic-Benefits.pdf.

MacFarland, K. (2017). Alley Cropping: An Agroforestry Practice. Available online at: https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an12ac01.pdf.

McGraw, R.L. (2021). Alley Cropping. In: *Training manual for applied agroforestry practices* (pp. 31-49). University of Missouri Center for Agroforestry.

McRae, S. M. (2024). Agroforestry in temperate-climate commercial agriculture: Feedback from agroforestry practitioners in the Mid-Atlantic United States. *Elementa: Science of the Anthropocene*, *12*(1).

Michel, G. A., Nair, V. D., & Nair, P. K. R. (2007). Silvopasture for reducing phosphorus loss from subtropical sandy soils. *Plant and soil*, *297*(1), 267-276.

Nair, V. D., & Graetz, D. A. (2004). Agroforestry as an approach to minimizing nutrient loss from heavily fertilized soils: The Florida experience. *Agroforestry systems*, *61*(1), 269-279.

Nair, V. D., Nair, P. K. R., Kalmbacher, R. S., & Ezenwa, I. V. (2007). Reducing nutrient loss from farms through silvopastoral practices in coarse-textured soils of Florida, USA. *Ecological engineering*, *29*(2), 192-199.

Natural Resources Conservation Service (2016). Silvopasture (Ac.) (381) Conservation Practice Standard and supporting documents. Available online at: https://www.nrcs.usda.gov/resources/guides-and-instructions/silvopasture-ac-381-conservation-practice-standard.

Natural Resources Conservation Service (2017). Alley Cropping (Ac.) (311) Conservation Practice Standard and supporting documents. Available online at: https://www.nrcs.usda.gov/resources/guides-and-instructions/alley-cropping-ac-311-conservation-practice-standard.

Nungula, E. Z., Chappa, L. R., Ranjan, S., Sow, S., Alnemari, A. M., Seleiman, M. F., Mwadalu, R., Maitra, S., & Gitari, H. I. (2024). Ecosystem services through agroforestry systems and its sustainability. *Agroforestry*, 223-254.

Nyakatawa, E. Z., Mays, D. A., Naka, K., & Bukenya, J. O. (2012). Carbon, nitrogen, and phosphorus dynamics in a loblolly pine-goat silvopasture system in the Southeast USA. *Agroforestry systems*, *86*(2), 129-140.

Orefice, J., Smith, R. G., Carroll, J., Asbjornsen, H., & Kelting, D. (2017). Soil and understory plant dynamics during conversion of forest to silvopasture, open pasture, and woodlot. *Agroforestry Systems*, *91*(4), 729-739.

Poudel, S., Bansal, S., Podder, S., Paneru, B., Karki, S., Fike, J., & Kumar, S. (2022). Conversion of open pasture to hardwood silvopasture enhanced soil health of an ultisol. *Agroforestry Systems*, *96*(8), 1237-1247.

Poudel, S., Pent, G., & Fike, J. (2024). Silvopastures: Benefits, past efforts, challenges, and future prospects in the United States. *Agronomy*, *14*(7), 1369.

Quinkenstein, A., Wöllecke, J., Böhm, C., Grünewald, H., Freese, D., Schneider, B. U., & Hüttl, R. F. (2009). Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. *Environmental science & policy*, *12*(8), 1112-1121.

Ryszkowski, L., & Kędziora, A. (2007). Modification of water flows and nitrogen fluxes by shelterbelts. *Ecological engineering*, *29*(4), 388-400.

Sauer, T. J., Coblentz, W. K., Thomas, A. L., Brye, K. R., Brauer, D. K., Skinner, J. V.,Van Brahana, J., DeFauw, S.L., Hays, P.D., Moffitt, D.C., Robinson, J.L., James, T.A., & Hickie, K. A. (2015). Nutrient cycling in an agroforestry alley cropping system receiving poultry litter or nitrogen fertilizer. *Nutrient cycling in agroecosystems*, *101*(2), 167-179.

Sauer, T. J., Dold, C., Ashworth, A. J., Nieman, C. C., Hernandez-Ramirez, G., Philipp, D., Gennadiev, A.N., & Chendev, Y. G. (2021). Agroforestry practices for soil conservation and resilient agriculture. In *Agroforestry and ecosystem services* (pp. 19-48). Cham: Springer International Publishing.

Sharrow, S. H., Brauer, D., & Clason, T. R. (2009). Silvopastoral practices. *North American agroforestry: an integrated science and practice*, 105-131.

Shults, P. (2017). Exploring the benefits of cover crops to agroforestry tree plantations: an analysis of direct and indirect nitrogen transfer in alley cropping systems. Michigan State University. Available online at: https://www.proquest.com/openview/0e82abc9356cc9e411d60eb2d7416b77/1?pq-origsite=gscholar&cbl=18750.

Smith, M. M., Bentrup, G., Kellerman, T., MacFarland, K., Straight, R., Ameyaw, L., & Stein, S. (2022). Silvopasture in the USA: A systematic review of natural resource professional and producer-reported benefits, challenges, and management activities. *Agriculture, Ecosystems & Environment*, *326*, 107818.

Staley, T. E., Gonzalez, J. M., & Neel, J. P. (2008). Conversion of deciduous forest to silvopasture produces soil properties indicative of rapid transition to improved pasture. *Agroforestry Systems*, *74*(3), 267-277.

Thomas, A. L., Kallenbach, R., Sauer, T. J., Brauer, D. K., Burner, D. M., Coggeshall, M. V., Dold, C., Rogers, W., Bardhan, S., & Jose, S. (2020). Carbon and nitrogen accumulation within four black walnut alley cropping sites across Missouri and Arkansas, USA. *Agroforestry Systems*, *94*(5), 1625-1638.

Tsonkova, P., Böhm, C., Quinkenstein, A., & Freese, D. (2012). Ecological benefits provided by alley cropping systems for production of woody biomass in the temperate region: a review. *Agroforestry systems*, *85*(1), 133-152.

Udawatta, R. P., Krstansky, J. J., Henderson, G. S., & Garrett, H. E. (2002). Agroforestry practices, runoff,
and nutrient loss: a paired watershed comparison. *Journal of Environmental Quality*, *31*(4), 1214-1225.

Udawatta, R. P., Kremer, R. J., Nelson, K. A., Jose, S., & Bardhan, S. (2014). Soil quality of a mature alley cropping agroforestry system in temperate North America. *Communications in Soil Science and Plant Analysis*, *45*(19), 2539-2551.

Udawatta, R. P., Gantzer, C. J., & Jose, S. (2017). Agroforestry practices and soil ecosystem services. In *Soil health and intensification of agroecosytems* (pp. 305-333). Academic press.

Udawatta, R. P., Garrett, H. E., Jose, S., & Lovell, S. T. (2021). Water quality and quantity benefits of agroforestry and processes: Long-term case studies from Missouri, USA. In *Agroforestry and ecosystem services* (pp. 113-139). Cham: Springer International Publishing.

Zhu, X., Liu, W., Chen, J., Bruijnzeel, L. A., Mao, Z., Yang, X., Cardinael, R., Meng, F., Sidle, R.C., Seitz, S., Nair, V.D., Nanko, K., Zou, X., Chen, C., & Jiang, X. J. (2020). Reductions in water, soil and nutrient losses and pesticide pollution in agroforestry practices: a review of evidence and processes. *Plant and Soil*, *453*(1), 45-86.

Zumpf, C., Ssegane, H., Negri, M. C., Campbell, P., & Cacho, J. (2017). Yield and water quality impacts of field-scale integration of willow into a continuous corn rotation system. *Journal of Environmental Quality*, *46*(4), 811-818.

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

List of Acronyms Used Throughout Text

AC: Alley Cropping BMP
AgWG: Agriculture Workgroup
BMP: Best Management Practice
CAST: Chesapeake Assessment Scenario Tool
CBP: Chesapeake Bay Program
CPS: Conservation Practice Standard
EP: Expert Panel
AF EPEG: Agroforestry Expert Panel Establishment Group
EPA: Environmental Protection Agency
FWG: Forestry Workgroup
GIT: Goal Implementation Team
NRCS: Natural Resources Conservation Service (USDA)
NRCS 381: Silvopasture Conservation Practice Standard
NRCS 311: Alley Cropping Conservation Practice Standard
QAPP: Quality Assurance Project Plan
SP: Silvopasture BMP
TN: Total Nitrogen
TP: Total Phosphorus
TSS: Total Suspended Solids
USDA: United States Department of Agriculture
WQGIT: Water Quality Goal Implementation Team
WTWG: Watershed Technical Workgroup

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Appendix A: Technical Appendix - Requirements for Entering the Agroforestry Practices Silvopasture and Alley Cropping into Annual Progress Reporting to CAST

Background: In June 2013 the Water Quality Goal Implementation Team (WQGIT) agreed that each BMP expert panel or expert panel establishment group (EPEG) would work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop and approve a technical appendix for each EPEG or expert panel report.

The purpose of this technical appendix is to describe the Agroforestry EPEG's recommendation to credit **silvopasture and alley cropping practices** as defined by the standards and criteria described in the Agroforestry EPEG Report. The information below explains how these agroforestry practices will be integrated into Annual Progress reporting to CAST.

Q1. What are the definitions of the alley cropping and silvopasture practices?

A1. Practice definitions are as follows:

Alley cropping (AC): Trees or shrubs planted in sets of single or multiple rows integrated with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.

Key Additional Criteria for BMP*:* Planting rates must result in a minimum of 25% canopy coverage per acre when mature. Applicable on all cropland and hayland where trees, shrubs, crops, and forages can be grown in combination.

Silvopasture (SP): Establishment and management of desired trees and forages on pasture.

Key Additional Criteria for BMP: Animals integrated into this system must be managed according to standards for the Precision Intensive Rotational/Prescribed Grazing BMP. Planting rates for trees/shrubs must result in a minimum of 25% canopy coverage per acre when mature. For guidance on planting rates and density, site selection, species selection, establishment, maintenance, and system management, refer to existing NRCS/state practice recommendations.

Q2. How much nitrogen, phosphorus and sediment reduction credit will be associated with the Silvopasture and Alley Cropping practices in the next CAST release?

A2. Efficiency Reductions for Alley Cropping and Silvopasture BMPs in the Chesapeake Assessment Scenario Tool (CAST- Phase 6.0 C-23):

BMP	Nitrogen	Phosphorus	Sediment
Silvopasture	21.749%	23.357%	3.287%
Alley Cropping	23.733%	23.163%	24.264%

These BMPs will be eligible to begin being reported with the 2025 Progress review and will be credited when a new version of CAST is released, expected with Phase 7. In the meantime, the practices will be available for planning purposes.

Q3. What types of projects are eligible to receive credit in the Chesapeake Assessment Scenario Tool?

A3. Alley cropping and silvopasture projects that are designed and managed according to the approved CBP BMP definitions (see above) for each and implemented on approved land-use load sources are eligible for credit.

Traditionally, these management practices have been designed and implemented according to existing state modified or federal NRCS CPS definitions, criteria and specifications. Crediting these existing practices for Chesapeake Bay Program purposes would not extend to projects/practices implemented according to these federal or state NRCS CPS that do not also meet the CBP BMP definitions and criteria approved by the Agroforestry EPEG for silvopasture and alley cropping BMPs.

Q4. What do jurisdictions need to submit for annual progress in order to qualify for reductions?

A4. Below is a complete list of the parameters that should be submitted to the Chesapeake Bay Program for annual progress for each silvopasture or alley cropping project.

- **BMP Name**: Silvopasture or Alley Cropping
- **Measurement Name/Unit**: acres
- **Original Land Use:**
  - Alley Cropping: Crop and Hay load sources
  - Silvopasture: Pasture load sources
- **Location**: Approved Chesapeake Bay Program reporting geographies: Latitude/Longitude (preferred); County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State (CBWS Only)
- **Date of Implementation**: date the project was completed
- **Type of BMP**: Visual, Cumulative practices (10-year credit duration)
- Practices can be combined with other BMPs

- **Acres of the Silvopasture BMP** must be reported in conjunction with equivalent number of acres of the Precision Intensive Rotational/Prescribed Grazing BMP to receive credit.

Synonymous BMP names for Watershed Model, NEIEN and other sources.	**NEIEN BMP name**	**Other common practice names**
Silvopasture BMP	Silvopasture	NA
Alley Cropping BMP	Alley Cropping	NA

Q5. Is this BMP an annual or cumulative practice?

A5. Both silvopasture and alley cropping BMPs are cumulative practices. Jurisdictions should report all measurement names only at the time of installation. Each practice will continue to receive credit in the model in future years, based on a 10-year credit duration.

Q6. Can the credit duration for silvopasture and alley cropping practices get further extended if practices are verified?

A6. No, the credit duration for these practices can't extend beyond the initial 10-year credit duration to avoid being double-counted when trees are large enough to be detected in the aerial imagery. The Precision Intensive Rotational/Prescribed Grazing BMP can still have the credit duration extended through verification.

Q7. How will the existing silvopasture and alley cropping practices be accommodated?

A7. To date, no jurisdiction has submitted silvopasture or alley cropping practices in a progress or planning scenario. It is up to each state to determine how to properly verify, track and report these BMPs.

Q8. Where do projects need to be located to receive credit for these BMPs?

A8. Jurisdictions can submit silvopasture projects on the pasture land use and alley cropping projects on the cropland/hay land uses.

Q9. Can jurisdictions submit historic silvopasture and alley cropping practices for credit?

A9. Yes. Jurisdictions may update their historical record of all approved BMPs in the current model at any time. For silvopasture, that means that the historical silvopasture practice must be verified to have been established through tree addition to pasture, have the minimum percent mature canopy coverage or density (number of trees/shrubs/acre) and to include the Precision Intensive Rotational/Prescribed Grazing BMP. For alley cropping, the minimum percent mature canopy coverage or density (number of trees/shrubs/acre) must be verified.

Appendix B: Planting Guidance to Ensure Minimum Mature Tree Canopy:

The EPEG devised an approach for achieving the mature tree canopy density when planning the site design of alley cropping and silvopasture practices. The method translates the required 25% minimum mature canopy density into guidance on a general number of trees per acre (TPA) weighted across a handful of unambiguous groups of woody plants. Spacing recommendations for achieving the minimum plant density were derived from Coder (2023).

Categories:

- **Small trees/shrubs**: multi-stemmed shrubs or small trees < 30' tall or 30' wide at maturity (based on a silvics guide). These are likely to be more commonly used.
- **Large trees**: large trees > 30' tall or 30' wide at maturity

The % mature canopy minimum translated to TPA (Trees per Acre):

Small trees/shrubs: 20 ft-wide canopies at 20 x 60 ft spacing equals **36 TPA**
Large trees: 30 ft-wide canopies at 30 x 60 ft spacing equals **16 TPA**

Method Used to Estimate a Minimum Planting Density for Trees/Shrubs to achieve Mature Tree Canopy Minimum:

- Number of square feet per acre= 43,560
  - 25% of one acre= 10,890 square feet
- Area of a circle: $A=\pi r^2$ (r=radius)
- **Small trees/shrubs:** For a 20 ft canopy, the canopy area is 314.16 square ft per tree ($A=\pi r^2$)
  - $A= 3.14159\ (10)^2$=314.16 sq ft.
  - 10,890/314.16= 34.6 trees
  - A **planting density of 36 trees/acre** could be achieved by planting trees 20 ft apart, with rows 60 ft apart (20ft x 60 ft spacing)
- **Large trees**: For a 30 ft canopy, the canopy area is 706.86 sq ft per tree (radius = 15 ft.)
  - $A= \pi\ (15)^2$ = 706.86 sq ft.
  - 10,890/706.86 sq ft.= 15.4 trees
  - A **planting density of 16 trees/acre** could be achieved by planting trees 30ft apart, with rows 90 ft apart (30ft x 90 ft spacing)

If alley cropping or silvopasture practices are designed to maintain trees at a less-than-mature state (for example, pollarded locust, coppiced hazels, chestnuts coppiced on long-rotation, fruit trees) the minimum planting density should be increased to achieve the 25% minimum mature canopy density.

Tree Species Planning Guidance:

VA Cooperative Extension Tree Selection Guide Mid-Atlantic Silvopastures
Summary of the Tree Selection Guide
Number of Trees per Acre by Spacing Distance (Coder 2023)

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Appendix C: References reviewed by the EPEG

Author(s), Year	Location	Study	Practice(s)	Pollutant(s)	Type of paper	Core paper?
Allen et al., 2004	Florida	Safety net role of tree roots: experimental evidence from an alley cropping system	Alley Cropping	N	Peer-reviewed publication	Yes
Allen et al., 2004	Southern US	Competition for 15N-labeled fertilizer in a pecan (Carya illinoensis K. Koch)-cotton (Gossypium hirsutum L.) alley cropping system in the southern United States	Alley Cropping	N	Peer-reviewed publication	Yes
Amorim et al., 2023	Arkansas	Temperate silvopastures provide greater ecosystem services than conventional pasture systems	Silvopasture	N,P	Peer-reviewed publication	Yes
Anderson et al., 2009	Missouri	Soil water content and infiltration in agroforestry buffer strips	Alley Cropping	Sed	Peer-reviewed publication	Yes
Boyer & Neel, 2010	WV	Nitrate and fecal coliform concentrations in silvopasture and pasture leachates	Silvopasture	N	Research study	Yes
Chakraborty et al., 2011	Florida	The Potential for Plants to Remove Phosphorus from the Spodic Horizon	Silvopasture	P	Research summary	Yes
DeBruyne et al., 2021	Virginia	Tree effects on forage growth and soil water in an Appalachian silvopasture	Silvopasture	N/A	Peer-reviewed publication	No
Deremetz, 2017	Florida	Effects of Agroforestry on the agro-ecosystem: a study of the crops-soil-climate-biodiversity system in Short Rotation Coppice temperate agro-silvopastoral system	Silvopasture	N, P, Sed	Student project report	No
Gaston et al., 2019	Louisiana	Silvopasture Switchgrass Fertilized with Poultry Litter: Nutrient Removal, Soil Fertility, and Runoff Water Quality	Silvopasture	N, P	Peer-reviewed publication	No
Hoosbeek et al., 2018	Nicaragua	Trees enhance soil carbon sequestration and nutrient cycling in a silvopastoral system in south-western Nicaragua.	Silvopasture	P	Peer-reviewed publication	Yes

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Author(s), Year	Location	Study	Practice(s)	Pollutant(s)	Type of paper	Core paper?
Jose et al., 2019	Multiple	Ecological considerations in sustainable silvopasture design and management	Silvopasture	P	Peer-reviewed publication	Yes
Kallenbach, 2009	Missouri	Integrating silvopastures into current forage-livestock systems	Silvopasture	None	Conference Proceeding	No
Kaviyazhagan et al., 2024	Multiple	Agroforestry Systems and their Agronomic Benefits	Silvopasture & Alley Cropping	N, P, Sed	Book chapter	Yes
MacFarland, 2017	Multiple	Alley Cropping: An Agroforestry Practice	Alley Cropping	N/A	Factsheet	No
MCGraw, R.L., 2021	Multiple	Training manual for applied agroforestry practices	Alley Cropping	N/A	Design Manual	No
McRae, 2024	Mid-Atlantic	Agroforestry in temperate-climate commercial agriculture: Feedback from agroforestry practitioners in the Mid-Atlantic United States	Silvopasture & Alley Cropping	N/A	Peer-reviewed publication	No
Michel et al., 2007	Florida	Silvopasture for reducing phosphorus loss from subtropical sandy soils	Silvopasture	P	Peer reviewed research	Yes
Nair & Graetz, 2004	Florida	Agroforestry as an approach to minimizing nutrient loss from heavily fertilized soils: The Florida experience	Silvopasture & Alley Cropping	N, P	Peer-reviewed publication	Yes
Nair et al., 2007	Florida	Reducing nutrient loss from farms through silvopastoral practices in coarse-textured soils of Florida, USA	Silvopasture	N,P	Peer-reviewed publication	Yes
Nungula et al., 2024	Multiple	Ecosystem Services through Agroforestry Systems and its Sustainability	Silvopasture	N, P, Sed	Book chapter	No
Nyakatawa et al., 2012	Alabama	Carbon, nitrogen, and phosphorus dynamics in a loblolly pine-goat silvopasture system in the Southeast USA	Silvopasture	N, P	Peer-reviewed publication	Yes
Orefice et al., 2017	NY	Soil and understory plant dynamics during conversion of forest to silvopasture, open pasture, and woodlot	Silvopasture	N, P	Peer-reviewed publication	Yes
Poudel et al., 2022.	VA	Conversion of Open Pasture to Hardwood Silvopasture	Silvopasture	N, P	Peer-reviewed	No

Author(s), Year	Location	Study	Practice(s)	Pollutant(s)	Type of paper	Core paper?
		Enhanced Soil Health of an Ultisol.			publication	
Poudel et al., 2024	Multiple	Silvopastures: Benefits, Past Efforts, Challenges, and Future Prospects in the United States	Silvopasture	N,P	Peer-reviewed publication	Yes
Quinkenstein et al., 2009	Temperate Europe	Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe	Alley Cropping	N, P, Sed	Peer-reviewed publication	Yes
Ryszkowski & Kedziora, 2007	Poland	Modification of water flows and nitrogen fluxes by shelterbelts	Shelterbelts (proxy for Alley Cropping)	N	Peer-reviewed publication	Yes
Sauer et al., 2021	Multiple	Agroforestry practices for soil conservation and resilient agriculture.	Silvopasture	N, P	Book chapter	Yes
Sauer et al., 2015	Arkansas	Nutrient cycling in an agroforestry alley cropping system receiving poultry litter on nitrogen fertilizer	Alley Cropping	N, P	Peer-reviewed publication	Yes
Sharrow et al., 2009	North America	Silvopastoral Practices	Silvopasture	General	Book chapter	No
Shults, 2017	Michigan	Exploring the benefits of cover crops to agroforestry tree plantations: An analysis of direct and indirect nitrogen transfer in alley cropping systems	Alley Cropping	N	Masters thesis	Yes
Smith et al., 2022	Multiple	Silvopasture in the USA: A systematic review of natural resource professional and producer-reported benefits, challenges, and management activities	Silvopasture	N/A	Peer-reviewed publication	No
Staley et al., 2008	West Virginia	Conversion of deciduous forest to silvopasture produces soil properties indicative of rapid transition to improved pasture	Silvopasture	N, P	Peer-reviewed publication	Yes
Thomas et al., 2020	Arkansas, Missouri	Carbon and nitrogen accumulation within four black walnut alley cropping sites across Missouri and Arkansas, USA	Alley Cropping	N	Peer-reviewed publication	No

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Author(s), Year	Location	Study	Practice(s)	Pollutant(s)	Type of paper	Core paper?
Tsonkova et al., 2012	Multiple, Temperate areas	Ecological benefits provided by alley cropping systems for production of woody biomass in the temperate region: a review	Alley Cropping	N, P, Sed	Peer-reviewed publication	Yes
Udawatta et al., 2002	Missouri	Agroforestry practices, runoff, and nutrient loss: a paired watershed comparison.	Alley Cropping	N, P, Sed	Peer-reviewed publication	Yes
Udawatta et al., 2014	Missouri	Soil quality of a mature alley-cropping agroforestry system in temperate North America	Alley Cropping	N	Research, peer reviewed	No
Udawatta et al., 2017	Multiple	Agroforestry practices and soil ecosystem services	Silvopasture & Alley Cropping	N, P, Sed	Book chapter	Yes
Udawatta et al., 2021	Missouri	Water Quality and Quantity Benefits of Agroforestry and Processes: Long-Term Case Studies from Missouri, USA.	Alley Cropping	N, P, Sed	Peer-reviewed publication	Yes
Zhu et al., 2020.	Multiple	Reductions in water, soil and nutrient losses and pesticide pollution in agroforestry practices: a review of evidence and processes.	Silvopasture & linear tree plantings	N,P, Sed	Peer-reviewed publication	Yes
Zumpf et al., 2017	Illinois	Yield and water quality impacts of field-scale integration of willow into a continuous corn rotation system	Alley Cropping	N	Technical Report	Yes

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Appendix D: Financial and Technical Assistance for Agroforestry in the Chesapeake Bay Watershed

NRCS provides financial support for Alley Cropping and Silvopasture in some, but not all states in the watershed through the Environmental Quality Incentives Program, Conservation Stewardship Program, Regional Conservation Partnership Program. However, there are multiple other sources of financial and technical assistance for agroforestry in the watershed (note this is a non-exhaustive list).

States That Currently Recognize NRCS Alley Cropping 311 and Silvopasture 381 Practices (May 2023)

State:	*NY	PA	DE	MD	VA	WV
Alley Cropping 311	no	yes	no	yes	yes	yes
Silvopasture 381	no	*no	no	yes	yes	yes

*PA is currently in the process of considering recognizing this practice for state support

General

Appalachian Sustainable Development: Ask an Agroforester Sessions
Appalachian Forest Coalition Catalyzing Agroforestry Grant Program
National Agroforestry Center

Maryland

MD Department of Agriculture MACS Program: Agroforestry Practices
MD Healthy Soils Competitive Fund
MD Department of Natural Resources agroforestry page

New York

New York Agricultural Environmental Management (AEM) framework
New York Agricultural Best Management Practices System Catalogue
New York Climate Resilient Farming Program
Cornell Small Farms Program
Cornell Cooperative Extension Agroforestry Resource Center

Pennsylvania

Pennsylvania Agroforestry Funding Opportunities
PA Resilient Food Systems Infrastructure Program
PA DCNR Riparian Buffers grants and technical assistance
Trees for Graziers
Rodale Institute & Propagate Partner to Grow Adoption of Agroforestry

Virginia

VA Cooperative Extension Silvopasture
Virginia Tech, Sustainable Agriculture Research and Education (SARE), ASD, VABF: Expanding the Agroforestry Regional Knowledge (ARK) Exchange Network in Virginia

Add Approved: AgWG date; FWG date; WTWG date; WQGIT date

Appendix E: Recommendations to Establish an Agroforestry BMP Expert Panel Establishment Group (EPEG)

Prepared for the Chesapeake Bay Program Partnership's Water Quality Goal Implementation Team's Agriculture and Forestry Workgroups.

Background:

Agroforestry is defined as the intentional integration of trees and shrubs into agricultural crop and animal production systems. Agroforestry practices are receiving increased attention and funding for research and implementation by USDA, conservation districts, academic institutions, and nonprofits due to the multiple conservation and agronomic benefits they provide. Agroforestry practices can also help improve the diversity and resiliency of agricultural production systems to climate change while providing additional carbon sequestration and storage benefits.

There are multiple established Agroforestry practices defined by NRCS:

- Riparian Forest Buffers (391): An area predominantly covered by trees and/or shrubs located adjacent to and up-gradient from a watercourse or water body.
- Windbreaks (380): Establishing, enhancing, or renovating windbreaks, also known as shelterbelts, which are single or multiple rows of trees and/or shrubs in linear or curvilinear configurations.
- Forest Farming (379): Managing or establishing stands of trees or shrubs in coordination with the management and/or cultivation of understory plants or non-timber forest products.
- Alley Cropping (311): Trees or shrubs are planted in sets of single or multiple rows with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.
- Silvopasture (381): Establishment and/or management of desired trees and forages on the same land unit).

Currently, only two of these Agroforestry practices, Riparian Forest Buffers and Windbreaks, crosswalk to Bay Program BMPs for nutrient and sediment reduction credits. Riparian Forest Buffers are credited under Forest Buffer BMPs, and Windbreaks are credited as Agricultural Tree Planting. The remaining Agroforestry practices do not currently crosswalk to a corresponding Bay Program BMP and so cannot be reported for annual progress nutrient and sediment reduction credits. Of the remaining three Agroforestry practices, there is particular interest in evaluating the potential to credit Alley Cropping and Silvopasture practices. Forest Farming is less likely to have significant effects on water quality that would merit practice tracking, verification, and crediting by the Bay Program partnership.

For Alley Cropping, the NRCS Conservation Practice documentation indicates that implementation can reduce surface water runoff and erosion and decrease offsite movement of nutrients or chemicals. For Silvopasture, according to NRCS's Conservation Practice documentation, implementation can improve water quality and reduce erosion, while providing multiple other on and off-farm benefits. More specifically, the permanent enhanced vegetation resulting from silvopasture implementation is estimated to result in substantial improvements in the uptake of excess nutrients from surface water, and moderate reductions in both sediment runoff and groundwater nutrient excess (Silvopasture 381 CCPE).

Given the potential for Alley Cropping and Silvopasture conservation practices to improve water quality, and the substantial investments being made in Agroforestry practices, the time is ripe to consider pathways for crediting these practices. Crediting these practices could help incentivize additional implementation, which would benefit the Chesapeake Bay restoration effort while generating multiple other on- and off-farm benefits, including improving climate adaptation and mitigation.

This proposal for establishing an Agroforestry Expert Panel Establishment Group (EPEG) is being put forward jointly to obtain support from the members of the Agriculture and Forestry Workgroups. The Chesapeake Bay Agroforestry Network, which was formed to help implement some of the priority actions for Agroforestry identified in the 2020 Chesapeake Forest Restoration Strategy, is also supporting this proposal. Establishing an Agroforestry EPEG would enable an initial evaluation of the scale of practice implementation in the watershed, and the availability of scientific research data as evidence for the water quality benefits of Alley Cropping and Silvopasture practices. Based on this evidence, the EPEG would evaluate whether Alley Cropping and/or Silvopasture are functionally similar enough to any existing Bay Program BMPs to merit crediting under an existing BMP.

Ultimately, the Agroforestry Expert Panel Establishment Group (EPEG) is proposed to:

- Determine if there is a need for a BMP Expert Panel (EP) for Alley Cropping and/or Silvopasture.
    - If an EP is recommended, then:
        - Identify priority tasks for the EP(s),
        - Recommend areas of expertise that should be included on the EP(s), and recommend members for consideration,
        - Draft the EP(s)'scope of work and charge for the review process.
    - If an EP is not recommended, then:
        - Provide justification for not convening an EP,
        - Provide an alternative recommendation to address the crediting of Alley Cropping and/or Silvopasture practices in lieu of an EP (i.e. crediting these practices under an existing established Bay Program BMP).