Evaluating an Improved Systems Approach to Wetland Crediting: Consideration of Wetland Ecosystem Services

STAC Workshop Report
March 22-23, 2022
Chesapeake Bay Foundation, Annapolis

STAC Publication 24-004

About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program (CBP) on measures to restore and protect the Chesapeake Bay. Since its creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay Watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical workshops, and (5) interaction between STAC members and the CBP. Through professional and academic contacts and organizational networks of its members, STAC ensures close cooperation among and between the various research institutions and management agencies represented in the Watershed. For additional information about STAC, please visit the STAC website at http://www.chesapeake.org/stac.

Publication Date: April 29, 2024

Publication Number: 24-004

Suggested Citation:
Mason, P., G. Noe, Berlin, C., D. Clearwater, S. Claggett, D. Goerman, B. Landry, and A. Santoro. 2024. Evaluating an Improved Systems Approach to Crediting: Consideration of Wetland Ecosystem Services. STAC Publication Number 24-004, Edgewater, MD. 82 pp.

Cover graphic from: (Pamela Mason, VIMS)

The enclosed material represents the professional and expert findings of individuals undertaking a workshop, review, forum, conference, or other activity on a topic or theme that STAC considered an important issue to the goals of the CBP. The content therefore reflects the views of the experts convened through the STAC-sponsored or co-sponsored activity. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

STAC Administrative Support Provided by:

Chesapeake Research Consortium, Inc.
645 Contees Wharf Road
Edgewater, MD 21037
Telephone: 410-798-1283
Fax: 410-798-0816
http://www.chesapeake.org

Workshop Steering Committee:
Pamela Mason, VIMS, Wetland Workgroup Chair (Co-Chair)
Greg Noe, U.S. Geological Survey (Co-Chair) *
Brooke Landry, Maryland Department of the Environment, SAV Workgroup Chair
Denise Clearwater, Maryland Department of the Environment
Dave Goerman, Pennsylvania Department of Environmental Protection
Alison Santoro, Maryland Department of Natural Resources, Stream Health Workgroup Co-Chair
Alicia Berlin, U.S. Geological Survey, Black Duck Action Team Co-Chair
Sally Claggett, U.S. Forest Service

**STAC member*

STAC Staff:

Meg Cole, STAC Coordinator, Chesapeake Research Consortium
Tou Matthews, STAC Projects Manager, Chesapeake Research Consortium

Acknowledgements:
The steering committee would like to thank the speakers and both the in-person and virtual attendees of the workshop (Appendix B) for their constructive contributions.

Table of Contents

Executive Summary

The Chesapeake Bay Agreement (CBA) has numerous direct goals for improving habitat, living resources, and water quality, conserving lands, engaging communities and addressing a changing climate. To date, the progress toward the wetlands outcome (creation/ restoration of 85,000 acres and enhancement of 150,000 acres) has been very slow and the outcome is projected to be off course for 2025. Two specific confounding issues arise in efforts to achieve the Bay wetlands goal: 1) the idea that restoration is driven, and incentivized and accounted for, in order to meet the TMDL's water quality (WQ) benefits, leaving habitat benefits undervalued; and 2) there is often tension between competing restoration priorities and financial resources among different Best Management Practice (BMP) types that include wetlands, such as wetland restoration/creation/rehabilitation, stream restoration, and the creation or restoration of forest buffers.

The collaborative workshop "Evaluating an Improved Systems Approach to Wetland Crediting: Consideration of Wetland Ecosystem Services" was held March 22-23, 2022 to explore the wetland accounting system and provide insight on improved approaches to promote wetland projects toward the wetlands outcome. Four sessions were organized around topics of 1) Accounting, 2) Landscape Systems Approach, 3) Wetlands Projects and Co-Benefits, and 4) Management Implications and Recommendation Development with 21 presentations, Q and A and facilitated discussions.

Acknowledgement of the limitations of the current management framework to achieve significant gains in wetland area supports the conclusion that absent significant adaptive management of wetlands efforts, any outcome for net wetlands gains beyond 2025 will be similarly confounded. Workshop findings included suggestions for how to approach restoration projects at a systems level (e.g., creek, shoreline reach, watershed) in order to maximize synergies for multiple ecological outcomes and ecosystem services. Recommendations for improvement on existing efforts, as well as new processes, tools and partnerships are suggested from the workshop's analysis of the state of the science as considerations to increase implementation of wetlands projects.

Major Recommendations

1. **Key Finding:**
   Wetland projects are not accurately accounted for toward the wetlands goal or as BMPs. Efforts have focused only on wetlands for pollution load reduction. Wetlands in urban landscapes are not counted via this process.

Immediate Needs:

- Create, initiate, and maintain a standing process to account for all wetlands restoration, creation, and enhancement projects.
- Provide training on data entry.
- Review and ensure BMPs reporting includes the area of wetlands restored or created.

Recommendations:

Proposed CBP Partner(s): Wetland habitat accounting database developers, data reporters, project proponents, funders.

1. Ensure all wetland projects are being counted regardless of whether they are a BMP or habitat or other service.
2. Examine the existing accounting processes and identify approaches to account for awarding credit or incentive for ecosystem benefits that arise from all management actions; suggest providing data to support CBP Wetlands and Black Duck data efforts.

2. **Key Finding:**

The benefits of Wetland Projects are dependent on landscape position and location, and the planning and implementation of wetland management actions can be integrated into larger scale systems thinking. Wetland projects could benefit from moving beyond opportunity driven restoration at a specific location that may be less suitable for holistic benefits to targeted restoration at suitable locations.

Immediate Needs:

- Investigate the synergistic value-added benefits of wetlands projects that are part of a larger scale multi-habitat or goal effort.
- Investigate the unintended consequence of habitat trade-offs between wetlands and other habitats.
- Create a multi-benefit geospatial decision support tool for wetland restoration and creation.

Recommendations:

Proposed CBP Partner(s): Water Quality Goal Implementation Team, Maintain Healthy Watersheds Goal Implementation Team, Fish Habitat Action Team, Forestry Workgroup, USGS, GIS Team

3. Seek systems level wetland restoration projects (as part of a larger wetland complex, or part of a multiple practice effort to include synergistic restoration such as stream, riparian buffers and fish passage) which avoid habitat tradeoffs by incorporating landscape level thinking into such projects and maximize multiple benefits.

4. Promote and incentivize restoration projects designed and constructed so that biological function is not negatively impacted while managing for water quality improvements.
5. Develop a process for project funders to include negative and positive indicator responses for habitat co-benefit and ecosystem services criteria when evaluating proposals (see Appendix D).

3. **Key Finding:**

Wetland Projects provide multiple benefits (i.e., ecosystem services) that are linked to multiple differing local, state, federal, and regional outcomes and goals. As such, assessing the net benefits for wetlands projects, especially in comparison to other habitat/water quality restoration efforts, is difficult.

Immediate Needs:

- Directed CBP effort to explore avenues for increasing the "credit" for wetland projects based on provision of co-benefits and linkages to other CBP outcomes (i.e., fish habitat, water quality, etc.)
- Develop a framework, such as multiple ecosystem services, to attribute multiple benefits credit for wetlands projects.

Recommendations:

Proposed CBP Partner(s): Water Quality Goal Implementation Team, Maintain Healthy Watersheds Goal Implementation Team, Fish Habitat Action Team, Forestry Workgroup

6. Investigate the possibility of adding or subtracting load reduction credit for wetland projects relative to habitat services provisioning, and expand to other types of habitat restoration BMPs (such as stream restoration and riparian forest buffers).
7. Support development of advances in understanding and predicting outcomes of multiple ecosystem services of wetland projects in addition to nitrogen (N), phosphorus (P), and sediment load reduction, such as habitat provisioning and flood reduction.
8. Support and encourage partners to consider multiple ecosystem services when evaluating wetland projects, such as rating proposals for funded efforts.

4. **Key Finding:**

Wetland project implementation could increase to better meet CBP goals by providing additional incentives and tools that properly capture and credit wetland co-benefits beyond water quality improvement.

Immediate Need:

- Develop tools for use by project proponents to attribute multiple benefits from wetlands projects.

Recommendations:

Proposed CBP Partners: Water Quality Goal Implementation Team, Maintain Healthy Watersheds Goal Implementation Team, Fish Habitat Action Team, Forestry Workgroup

9. Investigate the development of an accounting system to track co-benefits and cross-outcome ecosystem services.
10. Develop a process for decision makers to plan and prioritize actions to address negative and positive indicator response for habitat co-benefit and ecosystem services criteria to include in decision making.
11. Investigate crediting for other ecosystem benefits which advance other Chesapeake Bay habitat and living resources outcomes.

Introduction

The Chesapeake Bay Agreement (CBA) has numerous direct goals for improving habitat, living resources, and water quality, conserving lands, engaging communities, and addressing a changing climate. These goals are in addition to Total Maximum Daily Load (TMDL) requirements, which are intended to improve water quality and support aquatic habitat through sediment and nutrient reduction. Best Management Practices (BMPs) implemented to meet the Chesapeake Bay TMDL (hereafter, "TMDL"), if not appropriately designed for specific site and landscape conditions and consideration of other CBA goals, may result in unnecessary resource tradeoffs and unintended consequences, and unintentionally slow progress toward meeting other goals. Wetland ecosystems are an illustrative and useful example for considering a more holistic perspective on BMP placement in the landscape and impacts on habitat.

Two specific confounding issues arise in efforts to achieve the Bay wetlands goal: 1) the idea that restoration is driven, and incentivized and accounted for, in order to meet the TMDL's water quality (WQ) benefits, leaving habitat benefits undervalued; and 2) there is often tension between competing restoration priorities and financial resources among different BMP types that include wetlands, such as wetland restoration/creation/rehabilitation, stream restoration, and the creation or restoration of forest buffers. The ecosystem services of wetlands should not be defined or described by any single specific function, such as nitrogen (N), phosphorus (P), and sediment load reduction, or a specific species habitat. The complement of various elements in an ecological landscape provides "value-added" habitat services at a systems scale. In other words, wetlands within floodplains, and channelward of forested buffers, potentially provide additional water quality, habitat, and resilience benefits greater than any of those individual settings or as a sum of those settings. The reason is that habitat quality and spatial targeting of high pollutant loading areas both benefit from landscape clustering of restoration activities. For example, little green herons are a niche species reliant on tidal marsh and proximal riparian loblolly pines. A restoration project that combines these two habitats will provide suitable habitats that each alone would not.

Current accounting processes driven by the TMDL, resulting in implementation of water quality BMPs, do not adequately account for wetland restoration, creation, and rehabilitation efforts. In addition, with the TMDL as a programmatic and financial driver for implementing management and conservation practices such as wetland projects, as well as other possible projects such as riparian forest restoration, stream restoration, and floodplain reconnection, there is potential unintended "competition" between project types, Chesapeake Bay Agreement goals, and project proponents. BMPs that may include wetland restoration as part of the project, but not as the primary focus, include riparian buffers, stream restoration, and living shorelines. The TMDL nutrient and sediment reductions for these BMPs are typically reported to the Chesapeake Bay Program as pounds reduced without any habitat acreage information. **While the TMDL nutrient and sediment reductions are counted, the acres of wetlands created/restored in association**

with buffer, floodplains, and tidal wetlands projects are not; therefore, we have lost the data that is necessary for tracking progress towards the Wetlands Outcome. In addition, implementation of other water quality BMP practices may result in unintended wetlands loss or adverse impacts. This in turn reduces the perceived importance of work done to improve wetland habitat, or, when there are unintended consequences, reduces the ability to meet other living resource commitments.

To address these issues, a workshop was held in March 2022 to evaluate: 1) existing accounting of wetlands projects toward the restoration/creation and enhancement goals and consider improvements to ensure accuracy; 2) opportunities to incentivize habitat benefits in relation to TMDL and water quality outcomes, and that are part of Chesapeake Bay Agreement commitments; and 3) the efficacy of a more holistic "systems approach" to wetland crediting, specifically how wetlands are, or are not, considered as BMPs or toward the wetland outcomes by multiple workgroups and Chesapeake Bay Program Goal Implementation Teams (GITs), and how wetland BMP functions are influenced by other BMP types in the connected landscape.

Recommendations from this workshop included suggestions for how to approach restoration projects at a systems level (e.g., creek, shoreline reach, watershed) in order to maximize synergies for multiple ecological outcomes and ecosystem services and accurately calculate pollutant reductions along with habitat value to restoration projects that include multiple habitats, as well as options to consider if a goal were developed to incentivize habitat benefits and outcomes in addition to nitrogen, phosphorus, and sediment reduction goals.

Workshop Format

This hybrid workshop, "Evaluating an Improved Systems Approach to Crediting: Consideration of Wetland Ecosystem Services," convened on May 22nd and 23rd, 2022 at the Chesapeake Bay Foundation in Annapolis, Maryland. Due to COVID-19 concerns and traveling, a remote option for virtual participation was made available for workshop participants. More information on this STAC-funded effort, including workshop presentation slides and recordings, can be accessed on the workshop webpage.

Presenters were asked to speak on topics related to accounting, landscape and systems approaches, wetlands projects and co-benefits, and management implications and recommendation development. Throughout the workshop, participants met in small and large group discussions to focus on questions, gaps, and science needs. Breakout groups were split by in-person and virtual participants, with remote groups utilizing online tools such as interactive whiteboards to help bridge the communication gap. There was a pre-assigned notetaker and facilitating steering committee member in each breakout group.

Presentation Summaries

A series of presentations provided the scientific and management background for participants prior to the facilitated discussions. Workshop presentations were split into four sessions focused on accounting, landscape/systems approach, wetland projects and co-benefits, and management implications and recommendation development, respectively. Each session included a collection of talks from various invited speakers.

This information was the foundation for recommendations on existing data gaps and science needs. Links to all presentations can be found on the STAC workshop page and they are linked individually through the presentation titles in this document.

Session 1: Accounting

Evaluating an Improved Systems Approach to Crediting: Consideration of Wetland Ecosystem Services – *Jeff Sweeney (CBPO)*

Accounting for progress toward the Chesapeake Bay TMDL goals includes evaluations of 1) tidal water monitoring data, 2) nontidal water monitoring data, 3) EPA evaluations of jurisdictions' programs, and 4) reported BMP implementation and loads from annual model progress assessments using CAST (Chesapeake Assessment Scenario Tool). The Chesapeake Bay Program (CBP) tracks two general categories of wetlands, floodplain and headwater (or isolated) wetlands. Tidal wetlands are excluded from the watershed model but are being mapped for future input to the Water Quality and Sediment Transport Model of the tidal Bay. For wetland projects over the 1985-2020 period, Bay Program accounting considers annual reporting of BMP gains as well as BMP losses if wetlands are not inspected and reported as fully functional. For changes in total wetland acres through time, both natural and restored, Bay Program data and methods estimate a net loss of about 60,000 acres from 1985 to 2020.

The Chesapeake Bay Program is developing wetland restoration co-benefit scores where BMPs are ranked to indicate their impact on the co-benefits evaluated. A scoring matrix can be used in multiple ways: 1) to characterize additional benefits beyond nutrient and sediment reductions, 2) to select priority BMPs to adopt based on management priorities, and 3) to help "sell" a restoration plan to public and private groups. The BMPs selected should be efficient, maximize the return on investment, and improve quality of life. In addition to co-benefit tools, there is a CBP optimization project where wetland goals can be used as "constraints" (minimum acres) or part of the measure of the relative cost-effectiveness of BMPs if benefits can be monetized.

State plans call for protecting and maintaining what we have regarding forests, wetlands, and productive agricultural land. Economies that are natural resource-based contribute tens of billions of dollars to state economies annually but the ecosystem services provided by these resource lands are not typically valued through traditional markets. The resources provide important public services such as removing air pollution, carbon sequestration, recharging groundwater, stormwater mitigation/flood prevention, and providing habitat for wildlife. In addition to contributing to nutrient and sediment loading goals and reducing implementation costs through preservation, wetlands protection supports human health, economic development, and infrastructure.

Overview of Current BMP Crediting – *Olivia Devereux (Devereux Consulting, Inc.)*
Olivia Devereux of Devereux Consulting Inc. showed that a systems approach to measuring progress toward the wetlands outcome of the 2014 Chesapeake Bay Agreement was possible and demonstrated an improved method developed to account for all wetlands and not limited to the existing water quality team's counting of BMP acres of wetlands. This systems approach uses a landscape perspective for evaluating project impacts on species habitat, flood control, black ducks, and other ecosystem services. Specifically, projects that include wetlands can be evaluated for multiple ecosystem service goals. These projects can include multiple management practices that include public access to waterways as well as creating new wetlands and enhancing existing wetlands. By collecting project level data and the related project characteristics, functional gains can be evaluated. Using site-specific data, we can evaluate the adjacency to other natural lands or to developing urban lands, which will impact the likelihood of the project site supporting black ducks and other critical species.

Overview of Crediting from the Jurisdictional Perspective – *Greg Sandi (MDE)*
Greg Sandi (MDE) presented an overview of crediting from a jurisdictional perspective. Based on his personal and professional experience, Sandi does not feel the current Chesapeake Bay model data reporting process would be the most appropriate method for tracking ecosystem services. This data collection would be better served by an alternate reporting process that is developed from the ground up starting with a solid foundation which one can use to add on to as data needs change.

Additionally, new methods for collecting this information would need to be taken and passed through state agencies to the local level where most information originates. This would pose a challenge as often there is push back from local partners when more information is requested, especially as Sandi noted, if the estimation of the benefits is from historic practices. Moreover, Sandi highlighted that it would be more feasible to work in the existing framework as opposed to creating new data for the States to track. The simplest way would be to create "new" BMP names for CAST that would have different efficiencies rather than to follow the stream restoration protocol examples.

Accounting for ecosystem services in the current suite of data input tools for CAST would require a significant amount of effort to help define the acceptable currency and metrics that would be included. Ultimately it is up to the partnership to decide how to navigate the process, but Sandi suggests starting small and incorporating more detail over time.

Session 2: Landscape/Systems Approach

Synergistic Chesapeake Bay Goals and Outcomes – *Carin Bisland (EPA-CBPO)*

Carin Bisland (EPA CBPO) provided a presentation on Chesapeake Bay Agreement goals and outcomes, including a history of the CBP. Bisland provided definitions of synergistic benefits, co-benefits, ecosystem services, and functional uplift for workshop participants, as these terms are often used interchangeably when describing symbiotic Bay goals. Though the CBP is split by groups, it seeks to observe the Bay as a system with symbiotic interrelationships that can be leveraged in order to achieve management targets.

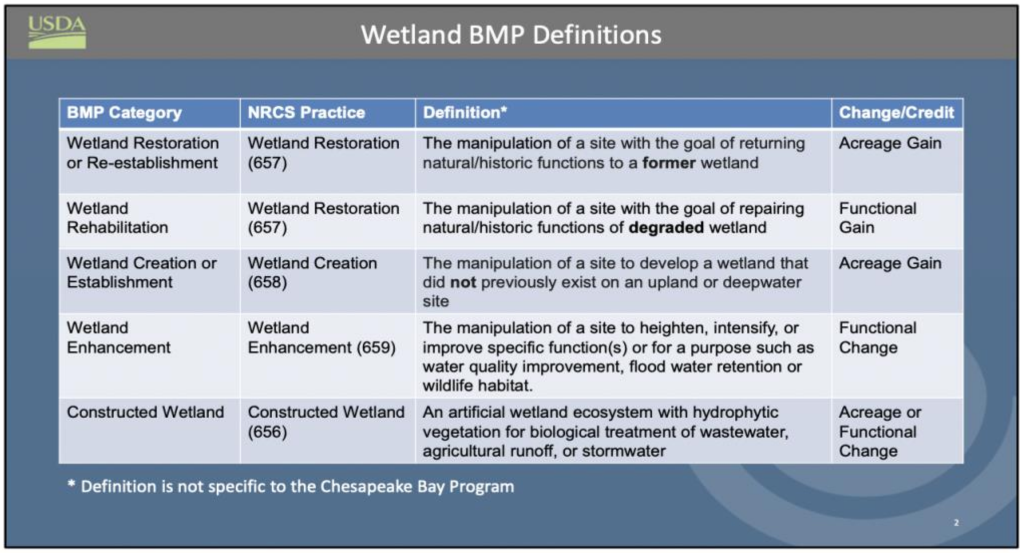
The Wetlands Outcome is an "uber-outcome" or Keystone outcome, Bisland noted, meaning that if the CBP were to focus and meet this outcome, other goals would be lifted and attained more easily. Interdependent outcomes include Water Quality, Habitat (Black Duck, Brook Trout, Stream Health, Fish Habitat, and Forage Fish), Climate Adaptation, and Healthy Watersheds.

Bisland described both tidal and nontidal synergies across CBP groups, highlighting outcomes with the potential to support the system as a whole as the combined effects of taking action on each improves the system overall. While evaluating the potential for tidal wetlands across the landscape, it is important to consider climate adaptation and resiliency for future wetland migration, as well as any overlap between protected lands, tidal wetlands, SAV, oyster restoration and Black Duck habitat. Similarly, vegetated wetlands response may be advanced by boosting the use of Living Shorelines as a BMP in the tidal region.

In the watershed nontidal areas, Bisland argues there may be an even greater opportunity to impact the system by promoting habitat and water quality, using practices such as stream restoration and floodplain reconnection.

Wetland Projects in Agricultural Landscapes in Maryland – *Steve Strano (NRCS)*

Steve Strano (USDA-NRCS) spoke on the opportunity for wetlands enhancement within agricultural regions in Maryland by evaluating opportunities for BMP expansion within current NRCS practices that provide either an acreage gain or functional gain/change. (Figure 1).



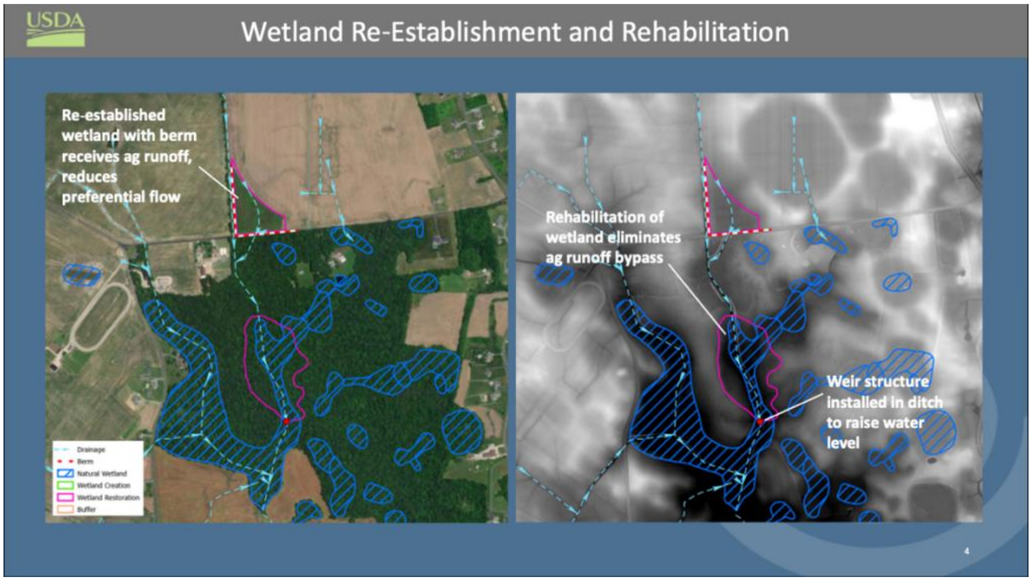
Wetland BMP Definitions

BMP Category	NRCS Practice	Definition*	Change/Credit
Wetland Restoration or Re-establishment	Wetland Restoration (657)	The manipulation of a site with the goal of returning natural/historic functions to a **former** wetland	Acreage Gain
Wetland Rehabilitation	Wetland Restoration (657)	The manipulation of a site with the goal of repairing natural/historic functions of **degraded** wetland	Functional Gain
Wetland Creation or Establishment	Wetland Creation (658)	The manipulation of a site to develop a wetland that did **not** previously exist on an upland or deepwater site	Acreage Gain
Wetland Enhancement	Wetland Enhancement (659)	The manipulation of a site to heighten, intensify, or improve specific function(s) or for a purpose such as water quality improvement, flood water retention or wildlife habitat.	Functional Change
Constructed Wetland	Constructed Wetland (656)	An artificial wetland ecosystem with hydrophytic vegetation for biological treatment of wastewater, agricultural runoff, or stormwater	Acreage or Functional Change

* Definition is not specific to the Chesapeake Bay Program

Figure 1. Wetland BMP Definitions as defined by the USDA.

The history of wetland drainage has reduced natural wetlands overall and disconnected others from the agricultural landscape. A common practice for the re-establishment of wetlands within agricultural fields provides an opportunity to trap agricultural runoff and mitigate preferential flow paths. Bypassed wetlands can be rehabilitated to reduce bypass by installing ditch plugs or weir structures. Figure 2 shows a number of wetlands that were established to combat agricultural runoff, provide wildlife habitat, and improve water quality benefits on the Eastern Shore. Due to the topography in this landscape, more wetlands were required to overcome the depressional features in order to capture agricultural runoff.



Wetland Re-Establishment and Rehabilitation

Figure 2. Re-established wetlands within agricultural fields can trap ag runoff and mitigate preferential flow paths.

When establishing wetlands, it is best to utilize the natural topography to restore natural drainage when possible and consider opportunities for water quality treatment if practical.

Coastal Wetlands Ranking for Co-Benefits – *Pamela Mason (VIMS)*

Increasing the preservation and creation of natural and nature-based features (NNBF), like wetlands, living shorelines, beaches, dunes and other natural features, to improve community resilience in the face of increasing coastal flooding may be achieved by highlighting the locally relevant benefits that these features can provide. We have developed a novel application of the least-cost geospatial modeling approach to generate inundation pathways (Ips) that highlight landscape connections between NNBF and vulnerable infrastructure. Inundation pathways are then used to inform a ranking framework that assesses existing NNBF based on their provision of multiple benefits and services to vulnerable infrastructure and for the broader community, including 1) the flooding mitigation potential of NNBF, 2) the relative impact of those NNBF on local infrastructure, and 3) co-benefits for the broader community linked to incentive programs like nutrient reduction crediting and the Federal Emergency Management Agency's Community Rating System.

Inundation pathways are also used to identify locations lacking in benefits from NNBF as target areas for NNBF restoration or creation. NNBF targets were aligned in the shoreline where project implementation would provide the greatest likelihood for benefit provision and programmatic credits. While we selected targets based on the IPs that lacked any NNBFs, all areas along an IP could be a NNBF creation or restoration project to provide the assessed services. We also applied the Virginia Institute of Marine Science Shoreline Management Model (SMM) (Nunez et al. 2022) to indicate where a living shoreline or other NNBF would be suitable. Consideration for other planning processes, including federal, state, local or regional agency outcomes or goals can be included in the identification of restoration efforts to enhance co-benefits. This can include habitat, flood storage, open space, recreational and cultural benefits in addition to those assessed in this analysis. This approach, applied here for coastal Virginia, can be customized for application in any community to identify high-priority NNBF that are particularly beneficial for preservation and to identify target areas for new or restored features (Hendricks et al. 2023).

Watershed-Scale Restoration – *Ben Hayes (Bucknell)*

The science of restoration is evolving in ways that emphasize the need to better understand hydrogeomorphic processes (e.g., channel-floodplain connectivity) and ecosystem function at the watershed-scale. For example, one could view the Chesapeake Bay watershed as a complex network of "hydrogeomorphic patches" (Ward et al. 2002) or "functional process zones" (Thorpe et al. 2006), each having different valley architecture/geologic settings, flow regimes, flow histories, flood pulses, and stream hydraulics that are alternatively constrained and unconstrained by dams or land-use.

By their nature, site-specific projects focus mitigation efforts to one small area and ignore the processes operating elsewhere in the watershed. This becomes problematic because the effects of human agency that obscure critical ecosystem process–response relationships tend to operate on the landscape scale. Thus, it's no surprise that many restoration projects often underperform and do not bring about broad ecological uplift.

Fluvial and wetlands systems in the Chesapeake Bay watershed are highly complex, dynamic, and interconnected. They exist across a hillslope-valley-floodplain-river-estuary continuum with fluxes of materials, energy, and biota through three spatial dimensions, plus time. Watershed-scale approaches to restoration require we address these connections: laterally between the channel and the riparian area and floodplain; longitudinally between channel segments upstream and downstream; vertically between the channel or floodplain and the aquifer; and temporally, from short term 'behavioral response' to long term 'evolutionary change'.

Watershed-scale restoration emphasizes three key concepts: (1) processes (geomorphic and ecologic), (2) thresholds (intrinsic and extrinsic), and (3) redundancy (urban and non-urban environments). Examples were shown of the geomorphic response of streams-wetland complexes in the north-central Susquehanna region to catastrophic flooding by tropical storms Irene and Lee in 2011. Previous stream restoration projects that employed hardened structures to "stabilize" the bed and banks to reduce erosion and meet TMDLs were completely eroded or buried as the fluvial system completely readjusted its width, energy gradient, and channel pattern. Legacy barriers, such as historic logging berms and splash dams, were breached and streams are seeking a new equilibrium condition by adopting a multi-threaded channel pattern that offers a greater diversity in ecological niches, increased redundancy in habitats and species, and improved resiliency to future flooding events (Kochel et al. 2016).

Adopting a watershed-scale approach enables practitioners, natural resource managers, and agencies to expand their monitoring practices to directly measure ecologic and hydrogeomorphic processes, such as (1) whole-stream or wetland metabolism, (2) groundwater-surface flow directions and rates, (2) sediment erosion, storage, and transport, (4) nitrogen (N) uptake, or (4) rates of decomposition. Measuring process rates and directions does indeed require more time and effort, but it provides a better assessment of watershed-scale system behavior and the factors that may be limiting long-term ecological response. Process data greatly improve numerical models used to evaluate future contingencies and they can help prioritize areas within the Chesapeake Bay watershed that require immediate attention and protection.

Large Scale Projects – *Rick Bennett (FWS)*

Rick Bennett (US FWS) is the Regional Scientist in the North Atlantic Appalachian region of the US Fish and Wildlife Service (USFWS) and provided an overview of challenges, considerations, and approaches to implementing wetland restoration. Currently, continental United States wetlands have significantly decreased over time with nearly half of the historical 3 million acres remaining. As of 2010, ~280,000 acres of tidal wetlands remain in the Chesapeake Bay, with 2025 restoration goals striving to create or reestablish an additional 85,000 acres of wetlands and enhance 150,000 of degraded wetlands. According to the USGS Coastal Vulnerability Index (CVI), most of the Chesapeake Bay is at high risk for Sea Level Rise (SLR) due to variables such as geomorphology, regional coastal slope, tide range and wave height, shoreline erosion, and accretion rates. Figure 3 shows the various processes that determine the success of wetland protection and restoration (Cahoon et al. 2009). Bennett highlighted subsidence as a significant factor impacting the system.

Marsh Restoration

Issues :

- Low elevation, Elevation deficit
- Historic accretion deficit
- Ponding of water,
- Vegetation death
- Peat collapse
- Conversion to open water
- Erosion
- Impacts to habitat, wildlife, and coastal communities

Approach:

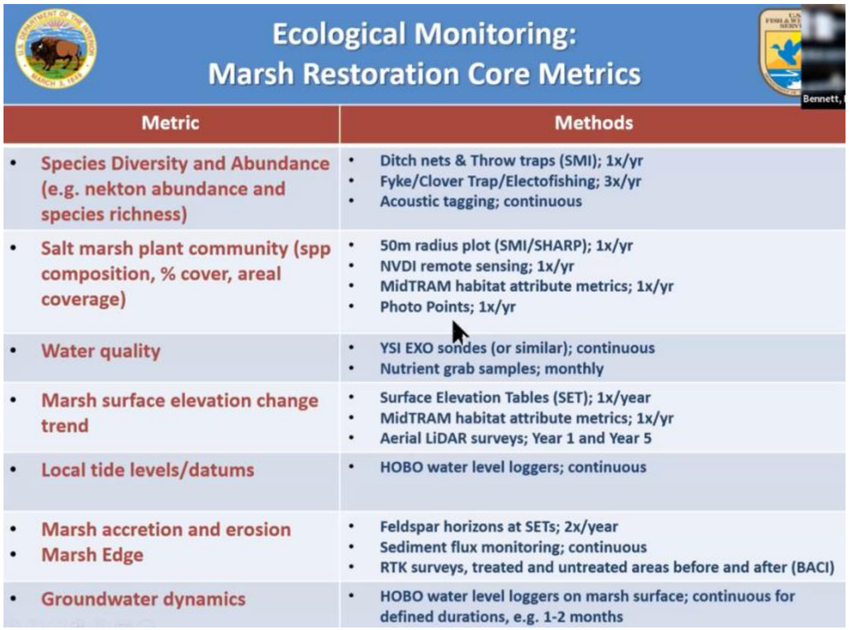
- Restore Hydrology
- TLD to increase elevation

Figure 3. Processes that determine the success of wetland protection and restoration (Cahoon et al. 2009).

To examine the vulnerability and resiliency of unvegetated-vegetated marshes, Bennett shared the UnVegetated-Vegetated marsh Ratio (UVVR) tool which can be used to determine marsh status. UVVR is defined as the ratio of unvegetated area to vegetated area across an entire marsh system, covering marsh plains, channels, ponds, and intertidal flats. Through various studies, Bennett highlighted that the crossing-over point from a positive to a negative sediment budget in a marsh is around 0.1 UVVR. Most marshes in the Chesapeake Bay region are at a UVVR of 0.1 or higher, signifying many of Bay marshes are at a deficit in terms of sediment accretion. Further, studies have shown the sediment capital within the marsh (or 'marsh equity') and lateral instability of a marsh (UVVR) can be combined to yield a lifespan estimate of a marsh (Ganju et al. 2017).

Overall, wetland ecosystems can have some of the highest ecosystem service values compared to other ecosystems, providing habitat, biodiversity, a buffer against erosion and flooding, regulation of water quality, and more. In the past, the USFWS has restored habitats tied to a particular species and Bennett voiced the desire to pivot to ecosystem restoration and focus on hydrology. Hydrodynamic modeling is imperative to implementing a functional system and can provide the best available science and data for decision making. Bennett discussed further considerations for ecosystem-based restoration, such as working with the natural processes and keeping sediment in the system, revisiting the federal standard as well as tidal restrictions, moving away from fixed structural protection, etc.

Looking ahead, Bennett provided a number of next steps for future projects based on past experience in resiliency projects following flooding events like Hurricane Sandy in 2012. First, it is important to determine if conservation actions are sustainable and then, design projects for future conditions while being informed by historic composition. To walk through this process, Bennett shared a recent marsh restoration project at the Prime Hook National Wildlife Refuge in Delaware Bay that had experienced low elevation, historic accretion deficit, ponding of water, vegetation death, peat collapse, erosion, conversion to open water, and other impacts. This site is the largest restoration on the East Coast at 4000 acres supported by Hurricane Sandy Disaster Relief Funds. Using a restoration hydrodynamic modeling approach and raising the marsh platform, USFWS restored a barrier beach and salt marsh complex using a network of tidal channels, removal of water control structures, and using dredge material to augment marsh. In addition to presenting project case studies, USFWS developed a standardized set of metrics and long-term monitoring program that will be completed by 2024. Using standard core metrics, project results can be coalesced to provide best practices that will help conserve resources and funding. A list of ecological monitoring marsh restoration core metrics can be seen in Figure 4. The metrics are species-specific.



Ecological Monitoring:
Marsh Restoration Core Metrics

Metric	Methods
Species Diversity and Abundance (e.g. nekton abundance and species richness)	Ditch nets & Throw traps (SMI); 1x/yr Fyke/Clover Trap/Electofishing; 3x/yr Acoustic tagging; continuous
Salt marsh plant community (spp composition, % cover, areal coverage)	50m radius plot (SMI/SHARP); 1x/yr NVDI remote sensing; 1x/yr MidTRAM habitat attribute metrics; 1x/yr Photo Points; 1x/yr
Water quality	YSI EXO sondes (or similar); continuous Nutrient grab samples; monthly
Marsh surface elevation change trend	Surface Elevation Tables (SET); 1x/year MidTRAM habitat attribute metrics; 1x/yr Aerial LiDAR surveys; Year 1 and Year 5
Local tide levels/datums	HOBO water level loggers; continuous
Marsh accretion and erosion Marsh Edge	Feldspar horizons at SETs; 2x/year Sediment flux monitoring; continuous RTK surveys, treated and untreated areas before and after (BACI)
Groundwater dynamics	HOBO water level loggers on marsh surface; continuous for defined durations, e.g. 1-2 months

Figure 4. List of species-specific ecological monitoring marsh restoration core metrics.

Watershed-level Effects of Nutrient Sinks: Lessons from analysis of riparian buffers

– Matt Baker (UMBC)

Matt Baker (UMBC) presented slides compiled in coordination with Donald Weller (SERC) on watershed level effects of nutrient sinks using lessons analyzed from riparian buffer projects. Riparian buffers have many ancillary benefits aside from retaining nutrients, though there is currently little evaluation of their effectiveness at the watershed scale. Baker and Weller examined simulation models (Weller et al. 1998) to better understand what characteristics of buffers are most relevant to nutrient discharges downstream, revealing transmissivity plays a huge role in watershed-scale nutrient concentrations. To realize this simulated study in a real landscape using geographic data, Baker found that simple geographic characterizations are highly effective at bringing key concepts into focus (Baker et al. 2006, Baker et al. 2007). Using new geographic methods, they were able to connect the nutrient sources to the streams and assess the import of buffers as nutrient sinks. Another implication is that near-stream forests or wetlands that are not between source and stream are largely unrelated to the retention of excess nutrients and may be ignored.

To link the geographic characterizations directly to water quality residency, long-term grab sample measurements were studied evaluating how patterns of landuse were related to nutrient concentrations and yields in streams (Weller et al. 2011, Weller and Baker 2014). Statistical models were then developed related to the patterns of buffers across watersheds to nutrient discharges, revealing that riparian characteristics of buffers were effective at capturing a key component of the way nutrients move from croplands to streams, and conventional models may overestimate actual yields. It is possible to guide restoration more effectively and to have a greater impact on nutrient discharges if targeting is considered. The expected impact of restoration depends upon the context and how well the restoration targets pollutant sources, and whether restoration retains or transmits pollutants. Another lesson found that comparing modeled results using different features along flow paths allows estimates of their relative impact. When looking at various measures of riparian wetness, statistical predictive capacity is improved (Baker et al. 2001, Van Appledorn 2018).

Continuing research is being done in the field of high-resolution terrain data: new hyper-resolution hydrology methods detect concentrated flow paths and can add them to hydrologic networks for blue line mapping or modeling. This can help determine where wetlands may be created in the future; high resolution mapping indicates where water is likely to flow as well as where it is not. Though there is significant value to utilizing high resolution data, it does not mean there are highly realistic estimates of overland hydrologic flow pathways, as often high-resolution data provides an overly deterministic perspective.

Finally, Baker ended by sharing that despite two decades of modeling lessons, the management-level continues to be unchanged; a statement from 2015-2025 CBP Riparian Forest Buffer

Outcome Management Strategy document assumes all land area equal and ignores stream map issue and source-sink connectivity. Riparian and wetland function are often spatially and temporally variable and there needs to be an explicit recognition between wetland function hydrogeomorphic context.

Session 3: Wetlands Projects and Co-Benefits

MS4/Urban Impacts – *Sujay Kaushal (UMD)*

Sujay Kaushal (UMD) provided an overview of the benefits of restoration, tree tradeoffs in water quality, salt tradeoffs in water quality, and management implications for restoration. Related to tree tradeoffs, specifically tree removal, trees are often removed from riparian zones during stream restoration despite their ability to provide key water quality functions (nutrient uptake, soil stabilization, etc.). Overall, there is a lack in the general understanding of this disruption during the construction process on water quality.

Kaushal shared graduate work completed by Kelsey Wood (UMD) examining the consequences of tree disturbance (removal) on nutrient and contaminants in groundwater. Collecting over 190 samples over a 2-year period, Wood used a multiple-element approach to examine the effects on water quality holistically (Wood et al. 2022). Out of the 20 elements studied, most showed significantly elevated concentrations following tree removal over a 5-yr period based on mean concentrations; there were similar pulses in extreme concentrations following tree removal. At one of the sites studied, Minebank Run in Montgomery County, MD, the long-term water quality improved over time after-restoration (Mayer et al. 2022). Loads of nitrogen over time and in response to precipitation events were monitored (Figure 5). As the restoration project ages, it will need to be maintained in order to continue to perform efficiently. Salt tradeoff in stormwater wetland BMPs is a major issue especially in urban streams. Salts are retained throughout the year in sediment from road deicing and are released along with other elements in exchange (Kaushal et al. 2022). Together, tree and salt tradeoffs affect evolving water quality over time. After restoration, there can be spikes in contaminants due to soil disturbance and then a reduction over time.

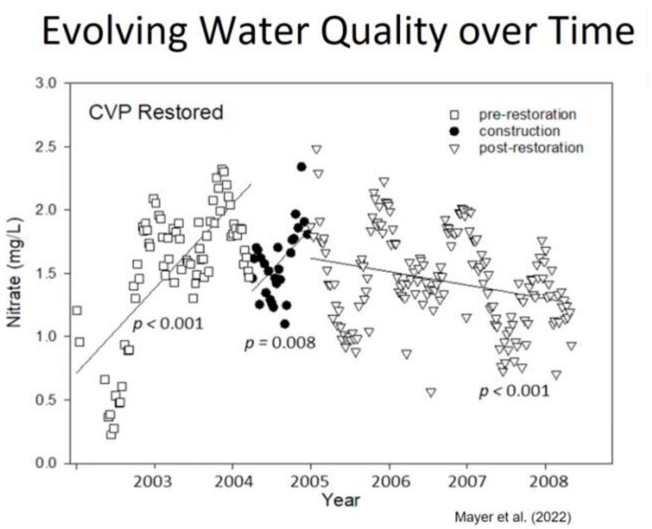


Figure 5. USGS bi-weekly Minebank Run surface water NO_3^- concentrations (mg/L) at restored CVP and control Intervale (IV). NO_3^- shows increasing trends prior to the restoration and during construction at the restored, downstream CVP reach. NO_3^- trends decline steadily after the restoration. Seasonal cycles are evident and NO_3^- was especially low during a severe drought in 2002 and then rose concurrently with a rapid shift to a wet season in 2003 (Mayer et al. 2022).

Systems Degradation – *Dave Goerman (PA DEP)*

The presentation recommended restoration project needs and design should use an evidence-based approach to identifying historic and modern alterations to the valley, not just the stream (channel) or wetland resources. Understanding the pre-alteration underlying valley conditions are critical to developing comprehensive restoration approaches that address the causes of degradation. Many pervasive legacy alterations result in boundary conditions that persist and continue to restrict resource recovery. Without addressing these underlying alterations, resource recovery is arrested and often results in short-lived benefits and long-term project failures.

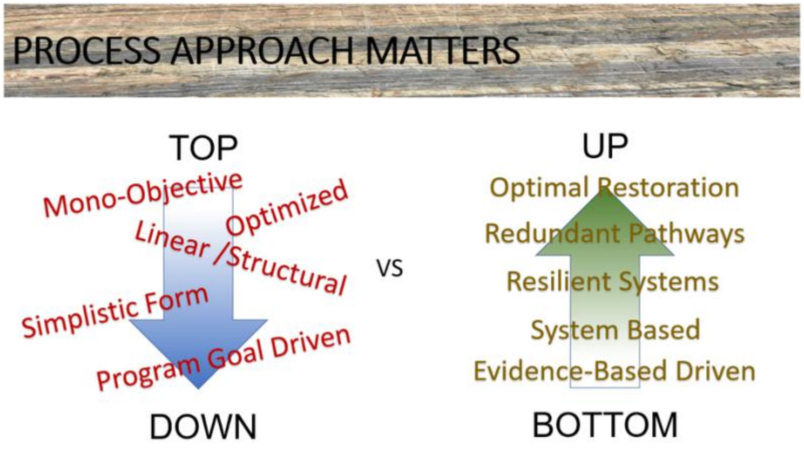


Figure 6. Top-down and bottom-up approaches to project design.

Broader water objectives tend to lead project developers to develop project approaches in a top-down manner that do not address underlying causes of degradation, while an evidence-based approach leads to a bottom-up design approach, better project goal development, and long-term success (Figure 6). A pivot needs to be made by programs to a bottom-up approach and an understanding that when addressing underlying causes of degradation with appropriate restoration practices numerous objectives can be achieved at one time. The resulting projects have robust conditions with redundant pathway features as compared to linear solutions that rely upon one pathway to ameliorate the targeted objective.

If one approaches project development using an evidence-based approach from the bottom, the project will trend towards the correct identification of the most appropriate resource type and condition and will provide optimal natural functions and processes that are inherent to the site, rather than trying to fit a one size fits all into an inappropriate site. Pennsylvania has seen tremendous results from this proven approach to restoration and rehabilitation of watershed resources and inherent processes.

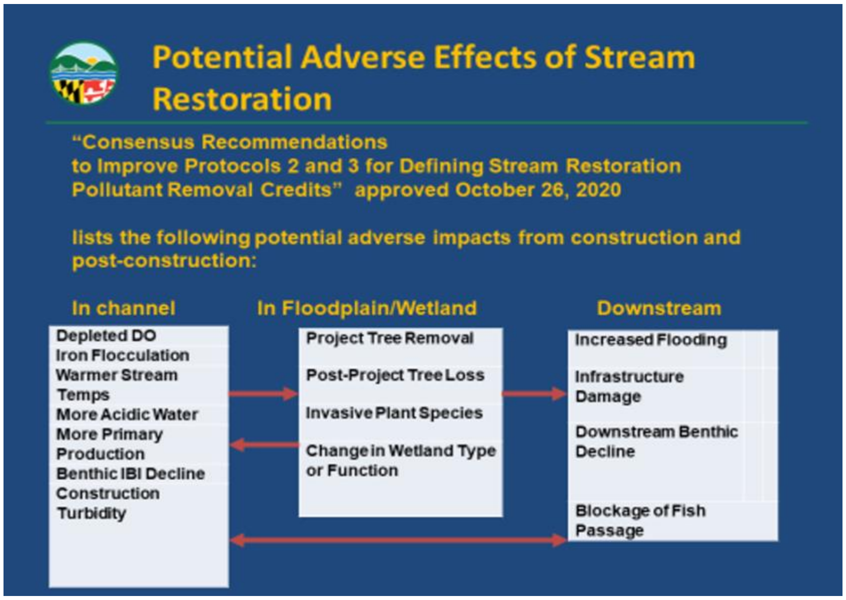
Much of the wetland restoration done in Pennsylvania is associated with stream/floodplain restoration projects where groundwater and surface water systems are reconnected resulting in both habitat and water quality improvements. Shifts in primary production, geo-chemistry, hydrodynamics, and seasonal patterns of water quality maintenance are re-established. These co-occurring benefits are not being recognized in wetland projects and often omitted if they are associated with regulatory activities.

Consequences of BMP Crediting, Resource Tradeoffs, and Need For an Ecosystem Approach – *Denise Clearwater (MDE)*

The presentation noted that crediting for TMDL is only given for nutrient and sediment load reductions, without consideration of the living resources which are to be the beneficiaries of the load reduction. The importance of living resources and maintaining and improving their habitat is mentioned in numerous other Chesapeake Bay Agreement commitments. These commitments include goals for improving Submerged Aquatic Vegetation (SAV); wetlands; riparian forest; healthy streams, fish passage; and anadromous fish, brook trout, and other fisheries.

Outcomes of restoration projects are known to vary. There may be overall improvement, while only some components may benefit. Other elements of the ecosystem may be lost or perform at a lower level of functioning in services and processes.

The presentation included the slide below, which shows a table from "Consensus Recommendations to Improve Protocols 2 and 3 for Defining Stream Restoration Pollutant Removal Credits," approved in October 2020 by the Chesapeake Bay Program Water Quality Goal Implementation Team (WQGIT) for use in assigning credits for floodplain reconnection projects. Arrows were added to the tables for the presentation showing the interconnected relationships between riparian resources. For example, construction and installation of structures in stream channels may result in additional turbidity and a decline in index of biotic integrity (IBI) scores. Water level increases from the channel may result in loss of shade due to tree loss from excessive inundation, as well as from clearing of vegetation during construction in the riparian area. This in turn again affects the water chemistry in the channel, with increases in primary productivity, warmer temperatures, and lower DO when there is less flow due to impounding of water. These conditions may affect downstream resources, resulting in worse conditions for aquatic habitat. Instream structures may also result in blockages to aquatic life passage, if aquatic life cannot move over, through, or around the structure, so that the restored stream segment may have limited usage as habitat.



Potential Adverse Effects of Stream Restoration

"Consensus Recommendations
to Improve Protocols 2 and 3 for Defining Stream Restoration
Pollutant Removal Credits" approved October 26, 2020

lists the following potential adverse impacts from construction and post-construction:

In channel

- Depleted DO
- Iron Flocculation
- Warmer Stream Temps
- More Acidic Water
- More Primary Production
- Benthic IBI Decline
- Construction Turbidity

In Floodplain/Wetland

- Project Tree Removal
- Post-Project Tree Loss
- Invasive Plant Species
- Change in Wetland Type or Function

Downstream

- Increased Flooding
- Infrastructure Damage
- Downstream Benthic Decline
- Blockage of Fish Passage

Figure 7. "Consensus Recommendations to Improve Protocols 2 and 3 for Defining Stream Restoration Pollutant Removal Credits" approved October 26, 2020 by the Chesapeake Bay Program Water Quality Goal Implementation Team (WQGIT) for use in assigning credits for floodplain reconnection projects.

Adjustments to a crediting approach for an ecosystem approach, rather than only nutrient and sediment reductions, can be accomplished through two different scenarios. For one, bonus credit for retention or restoration of desired components and processes can be made. This would be a positive incentive for greater contribution toward a jurisdiction's load reduction allocation by protecting valuable, functioning, existing resources. Another approach, credit reduction, would be a debit from the reductions assigned through relevant protocols when existing valuable function and ecological processes are degraded. This would result in a greater amount of additional load reduction needed than if the resource was managed to maintain a suite of existing functions and a resource which still had fair-good condition.

Unintended Consequences – *Michael Williams (UMD)*

As a similar practice to wetlands restoration and creation, analogies can be drawn from stream creation and restoration in the generation of a number of adverse and unintended consequences, particularly with regard to water quality. Observations and results from four study sites were used to elucidate a variety of unintended consequences from stream projects. The first study site is in the Cypress Creek tributary of the Magothy River sub-estuary of Chesapeake Bay on the western shore of Maryland. Results from this study clearly indicate that removing the overlying forest canopy from the original forested stream corridor increased light availability thereby increasing average water temperatures by about 3^{o} C; maximum temperatures increased by about 4^{o} C (~30 to 34^{o} C). In conjunction with relatively high nutrient levels in the created wetlands from urban runoff, increased water temperatures enhanced primary production and biological oxygen demand (i.e., metabolism) and decreased dissolved oxygen concentrations to levels well below the 5 mg/L criterion threshold for healthy freshwater systems, sometimes for extended periods. Detailed results of this study are available in Williams et al. (2017).

In studies that include other forms of stream restoration, such as regenerative streamwater conveyances (RSCs), changes in hydrology can have adverse effects. For example, in heavily incised stream corridors, restoration that reconnects the floodplain often increased the groundwater table (Figure 8). In such instances, the water table during high water periods can penetrate the upper soil horizons that are rich in organic matter (O horizon). These areas create seeps rich in labile organic matter and iron that flow into the adjacent waterway and can enhance the production of flocculate from iron oxidizing bacteria (Williams et al. 2016). In some instances, the production of iron flocculate is severe enough to restrict viable benthic habitat for freshwater macroinvertebrates. Other adverse and unintended consequences of wetland creation include the loss of riparian trees due to elevated water table levels and associated flooding during high water periods, as well as post-construction disturbances from extreme precipitation events that destroy the integrity and effectiveness of stream and wetland restoration/creation structures.

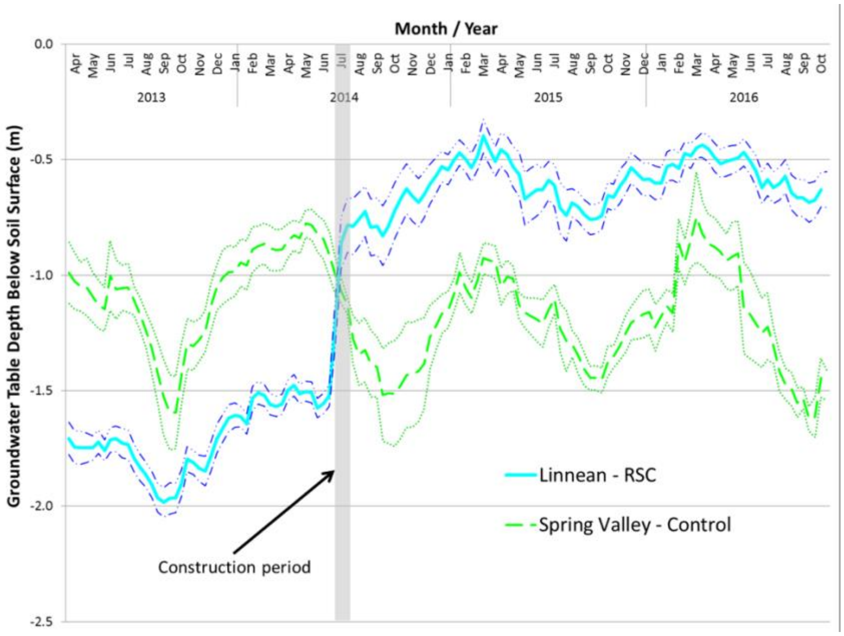


Figure 8. In heavily incised stream corridors, restoration that reconnects the floodplain often increased the groundwater table (Williams et al. 2017).

Some wetland restoration projects have more to do with habitat creation than an attempt to improve water quality. For example, Delmarva bays on the eastern shore of Maryland are sometimes restored by plugging drainage ditches to elevate water levels in depressional wetland areas. Clearly, there is the benefit of habitat creation with such restoration efforts. However, the question of the capacity of these wetlands to sequester carbon thereby mitigating climate change effects is unclear. One disadvantage of the conversion of farmland to wetlands is the increase in greenhouse gas emissions (i.e., methane - CH_4 and carbon dioxide - CO_2). Preliminary research of greenhouse gas emissions indicates that CH_4 fluxes increase substantially, and this is a powerful greenhouse gas. Methane persists in the atmosphere for about 40 years (slowly converted by OH to CO_2), whereas CO_2 persists for about 200 years.

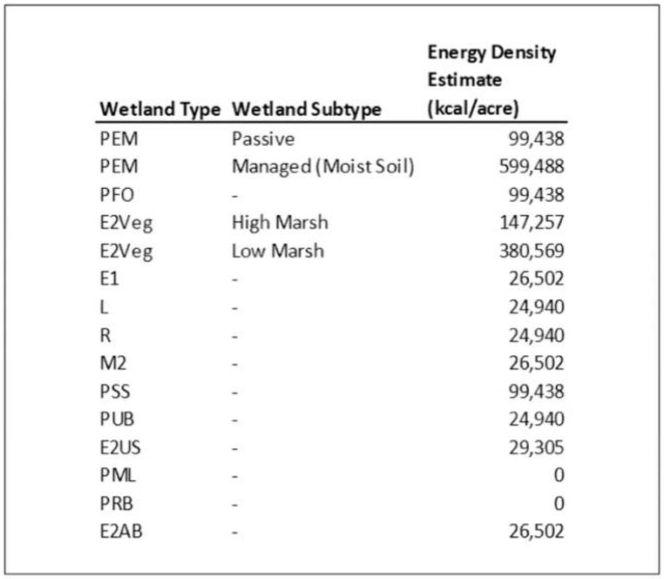
Wetlands and Waterfowl – *Jake McPherson (Ducks Unlimited)*

Jake McPherson, Manager of Conservation Programs with Ducks Unlimited, briefed attendees on wetlands and their relationship to waterfowl. Wetlands are important to waterfowl from a biodiversity standpoint, and waterfowl depend on wetlands to fulfill nearly all their basic needs. The Chesapeake Bay is largely a wintering landscape for most waterfowl species and hosts nearly one-third of the total Atlantic Flyway waterfowl population over the winter, which by 2022, was about half the population of historical estimates. This decrease is not due to population decline but a shift in geography resulting from habitat loss.

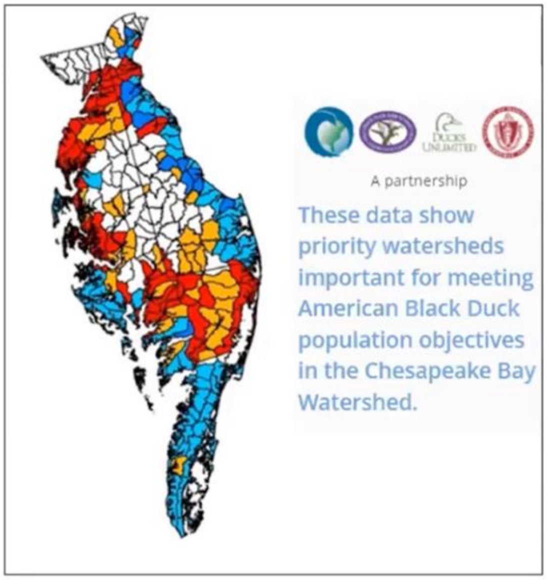
Waterfowl have a diversity of physiological and morphological adaptations that allow species to exploit a number of niches within a complex variety of habitats. Examples include the wide range of bills and preferred foraging depths among waterfowl. Similarly, species have preferred habitats but can utilize a diverse number of landscapes while migrating. Ducks Unlimited prioritizes broad-scale geographies to cover a full range of migratory birds and has aligned efforts with those outlined in the North American Waterfowl Management Plan. This is due to the varied needs within each geography depending on the ecological stressors. In addition, Ducks Unlimited focuses resources on wetland types that are observing declining trends and habitats associated with species of conservation concern such as the American black duck.

McPherson advocated for the accommodation of moist soil management when designing wetlands. This practice focuses on seasonal emergent freshwater vegetation and incorporates water control structures that allow habitat managers to intensively manage water levels. In this way, plant community productivity can be maximized to be most beneficial to waterfowl. Moist soil management tends to cross a broader segment of species types than comparable wetlands and often supports dozens of waterfowl. Restoring a wetland for waterfowl brings multiple co-benefits such as improved water quality and water storage, groundwater recharge, coastal resiliency, etc., but can create trade-offs as well. When implementing moist soil management, managers would drain a wetland in the spring for the promotion of fall vegetation for migratory birds. This is at the expense of resident populations such as the wood duck breeding in the spring. It is important to consider impacts on all species, especially local populations and those not of concern.

Quantifying outcomes for waterfowl is done through bioenergetics modeling. Wetland conservation efforts are estimated by evaluating the total metabolizable energy (TME) and daily energetic requirements (DRE), calculating Duck Use Days (DUD). One DUD is a measure of habitat that will provide adequate forage to meet the nutritional requirements of one duck for one day. Figure 9 shows the energy density estimate (kcal/acre) for varying habitats that were utilized to create the Black Duck Decision Support Tool. This information was applied to the wetlands occurring on the landscape across the Flyway and can be used to prioritize where restoration, enhancement, and protection can occur.



Wetland Type	Wetland Subtype	Energy Density Estimate (kcal/acre)
PEM	Passive	99,438
PEM	Managed (Moist Soil)	599,488
PFO	-	99,438
E2Veg	High Marsh	147,257
E2Veg	Low Marsh	380,569
E1	-	26,502
L	-	24,940
R	-	24,940
M2	-	26,502
PSS	-	99,438
PUB	-	24,940
E2US	-	29,305
PML	-	0
PRB	-	0
E2AB	-	26,502



These data show priority watersheds important for meeting American Black Duck population objectives in the Chesapeake Bay Watershed.

Figure 9. Map showing HUC 8 watersheds. Based on harvest data and population objective, blue denotes areas that have enough energy on the landscape now to support black duck objectives, while red denotes energy deficit areas.

Brook trout – *Steve Faulkner (USGS)*

Stephen Faulkner (USGS) presented on brook trout and their related co-benefits and ecosystem services. High quality brook trout habitat depends on cold water, clean water, and complex stream habitat, all conditions best supported by intact forested watersheds. This relationship is identified when plotting the number of occupied brook trout streams with the percentage of forest cover in the watershed (Figure 10). This graph is for the entire range of Eastern Brook trout but the pattern applies also to the Chesapeake Bay; there is a large drop in occupied streams when the forest percentage drops below 75%. Overall, forest practices are more advantageous for brook trout and large, shallow wetland complexes may increase downstream temperatures. However, comprehensive understanding is constrained by available BMP data.

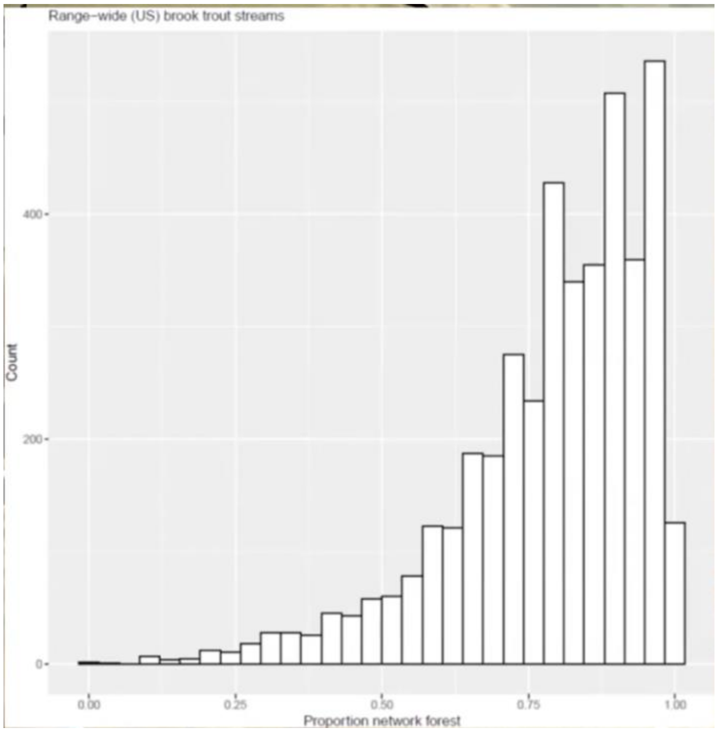


Figure 10. Number of occupied brook trout streams as a function of the percentage of forest cover in the watershed for the entire range of Eastern Brook trout.

Additional challenges related to quantifying BMP impacts on brook trout are listed below and further explained in Walker et al. (2021):

- Measuring and modeling ecological responses is more difficult than measuring and modeling water quality;
- Studies to date have been unable to document any significant BMP impact on stream habitat and biota related to variables other than water quality;
- There is not enough data on how BMP quality varies across the landscape;
- It is challenging to account for the lag between BMP implementation and biological response;
- Biotic condition is controlled by a complicated group of stressors and not a single stressor;
- Constraints on BMP data aggregation can produce data at too coarse of a scale. For example, watershed scale is not sensitive enough to detect changes in water temperature to BMPs.

Many challenges presented are equally relevant to ecosystem services. Ecosystem services (cultural - recreation and education; regulating - floodwater storage, nutrient retention; provisioning - biodiversity, habitat quality; and supporting - biomass production, nutrient cycling) are directly linked to ecosystem functions and processes, which are influenced by ecosystem structure and pattern. The quality and quantity of ecosystem services are further constrained by where the system is located among various conditions on temporal and spatial gradients.

Co-benefits of Submerged Aquatic Vegetation – *Brooke Landry (MD DNR)*
Submerged aquatic vegetation (SAV) refers to rooted, vascular, flowering plants that, except for some flowering structures, live and grow below the estuarine and marine water surface. SAV habitat includes SAV beds and standing populations of various species and densities, including bare areas of sediment within a bed. SAV *habitat* is characterized by the current or historical presence of rhizomes, roots, shoots, or reproductive structures associated with one or more SAV species.

The ultimate restoration goal established by the Chesapeake Bay Program is to "sustain and increase the habitat benefits of SAV in the Chesapeake Bay" in order to "achieve and sustain the ultimate outcome of 185,000 acres of SAV Bay-wide necessary for a restored Bay. Progress toward this ultimate outcome will be measured against a target of 90,000 acres by 2017 and 130,000 acres by 2025."

In 2020, 62,169 acres of SAV were mapped during the Bay-wide annual survey. This represents 48% of the 2025 target of 130,000 acres and 34% of the ultimate 185,000-acre goal. Because of the significant loss of SAV in 2019 and 2020, the SAV Outcome is considered "off course" to achieve the target of 130,000 acres by 2025. Although the 62,169 acres mapped in 2020 is a 60% increase from the 38,958 acres observed during the first survey in 1984, it is a 20% decrease from the current 10-year average of 78,168 acres and a 7% decrease from 2019 when 66,684 acres of underwater grasses were mapped.

Factors that influence SAV *management* success include habitat conditions and availability, protection of existing and recovering SAV, SAV restoration potential and activity, SAV research and monitoring, public perception, knowledge, and engagement. Consequently, the SAV workgroup management approaches are to 1) Support Efforts to Conserve and Restore Current and Future SAV Habitat and Habitat Conditions, 2) Protect Existing and Recovering SAV, 3) Restore SAV, 4) Enhance SAV Research and Monitoring, and 5) Enhance Community Involvement, Education and Outreach.

Regardless of our management approaches, SAV has habitat requirements that dictate its distribution and abundance throughout the Bay. First and foremost, SAV occupies fresh, brackish, and salt waters, but each species of SAV has a particular range of salinities that it can tolerate. Changes in salinity can lead to changes in species distribution. Water clarity is also vitally important to SAV. Sunlight is needed for photosynthesis. Most Chesapeake Bay species are generally limited to waters no deeper than 2 meters. Light availability is determined by total suspended solids (TSS), nitrogen and phosphorus concentrations and loading, chlorophyll *a*, macroalgae, and epiphytes.

Substrate and water movement are also important. Some species need sandy substrate, while others prefer muddy or silty areas. Most SAV do not tolerate peat-rich sediments associated with marsh substrates, nor do they tolerate strong waves or currents. Finally, water temperature requirements differ between SAV species. Changes in temperature impact the ability of SAV to survive and persist in areas where they have historically thrived.

The primary wetland ecosystem service that benefits SAV is that of filtration – wetlands help filter out TSS, N, and P before they enter the Bay and impact habitat conditions for SAV. Wetlands and SAV also share a number of co-benefits.

- SAV beds provide forage for black ducks and other waterfowl that use wetlands as habitat.
- SAV and wetlands provide co-mingled nursery and forage grounds for fish and invertebrates.
- In a landscape-level analysis documenting shoreline impacts to SAV, Patrick et al. (2014) found that *herbaceous* wetland in the local watershed was the strongest positive predictor of SAV abundance, explaining 16.3 % of the variation among subestuaries (Patrick et al. 2014).

Interestingly, however, the same study showed that marsh shoreline was negatively related to SAV in all three salinity zones, but the effect was strongest in the polyhaline zone. The amount of shoreline with marsh was the strongest single predictor (explaining 17.6 % of the variation among subestuaries), and it was negatively correlated with SAV abundance. The significant negative effect of shoreline marsh on SAV may seem counterintuitive, especially since herbaceous wetland in the local watershed was the strongest positive predictor of SAV abundance (explaining 16.3 % of the variation among subestuaries) but it is likely that the negative effect comes down to cDOM (colored organic matter) and sediment. The negative correlation between shoreline marsh and SAV abundance indicates that not all natural ecosystems necessarily foster SAV (Patrick et al. 2014).

SAV in Chesapeake Bay faces many barriers to recovery, including water clarity, climate change impacts, and shallow water use conflicts. Shallow water use impacts include such things as aquaculture, shellfish harvesting, SAV harvesting /removal for navigation, and shoreline armoring for erosion control, including living shoreline installation, although conflicts with living shorelines are not always present or straightforward.

A NOAA-funded study found that hardened shorelines negatively impact SAV at both the system and local scale (Patrick et al. 2014, Landry and Golden 2018), but a study by Palinkas et al. (2023) found that living shorelines do not appear to impact SAV at the system scale. What is less clear is whether living shoreline installation affects SAV at the local scale. Regulatory provisions aim to reduce potential local impacts to SAV by not permitting living shoreline construction at sites where SAV is present, but this may be counterproductive if shoreline riprap is used for erosion control instead. In some cases, living shoreline projects are permitted regardless of their impacts to SAV because the overall system benefits outweigh the local negative impacts. This is appropriate but it raises the question of TMDL crediting for wetland creation. If a living shoreline construction project destroys SAV habitat and in its place creates wetlands, is it appropriate to award TMDL credits for that wetland creation? At this time, there is no precedent to reject credits based on impacts to SAV, which could incentivize loss of SAV through wetland crediting of water quality benefits.

Mid-Atlantic Salt Marshes Co-Benefits to Fisheries – *David O'Brien (NOAA)*

David O'Brien (NOAA) presented on the importance of salt marsh habitat in supporting fisheries. Wetland restoration or living shoreline projects that incorporate existing salt marsh typically support fisheries to a greater extent than those that do not. Salt Marshes provide many societal benefits including shoreline and sediment stabilization, wave attenuation, storm surge attenuation, sediment accretion, biogeochemical processes, nutrient cycling, aesthetics, increase property values, and habitat.

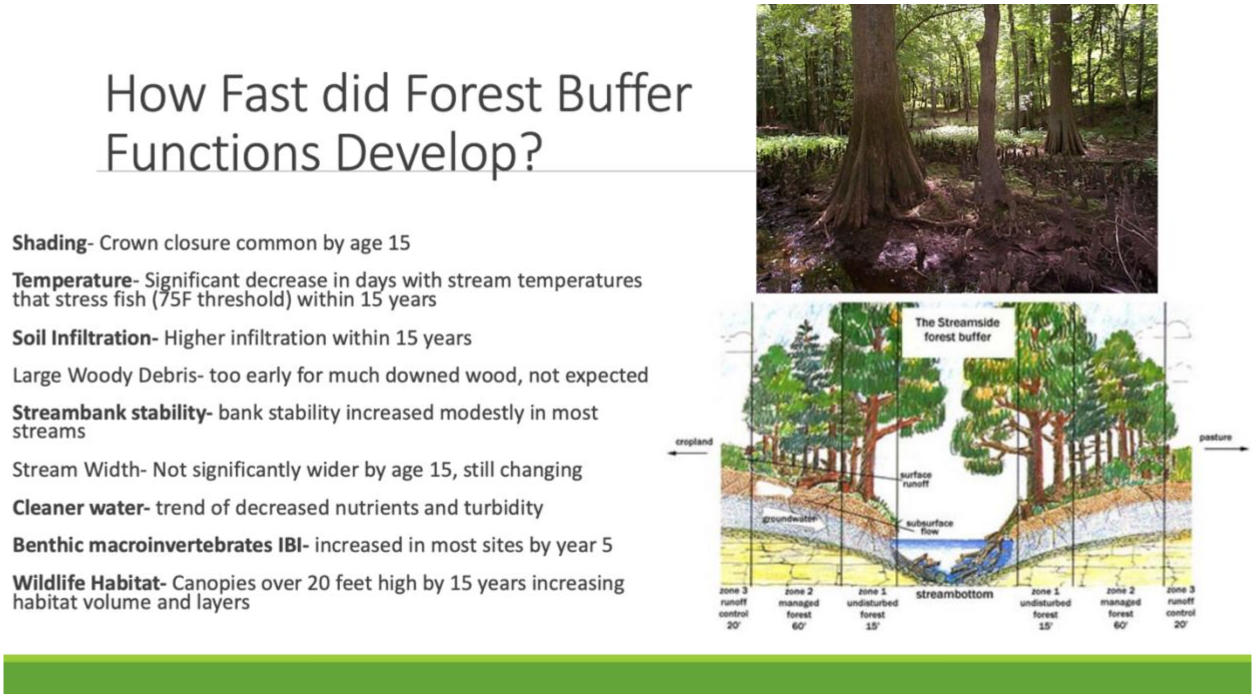
One of the best ways to maintain healthy fisheries habitat is to protect, restore or construct saltmarsh and other important aquatic habitats in close proximity to one another, effectively providing corridors for fish and other aquatic organisms to move between different habitat types to accommodate a range of activities or different life stages.

Salt marsh provides exceptional functions and services, such as forage, refuge, spawning, and nursery habitats for fish. When properly sited and designed, a living shoreline can not only reduce shoreline erosion, but provides valuable restored or created habitat, especially when the marsh is integrated with other unique habitats such as SAV or an oyster reef.

Marshes provide important habitat for a large variety of terrestrial and aquatic plants and animals. Marshes play a critical role throughout various life stages of commercially and recreationally important fish species. Speckled trout, gray trout, summer flounder and red drum all use the salt marsh at some point in their life history.

Forestry and Streams – *Anne Hairston-Strang (DNR)*

Wetlands and forests are frequently intermingled and overlapping, making them challenging to separate for BMP crediting. Forests add functionality for shade/temperature moderation, wildlife habitat niches, in-stream habitat, streambank stability, and water infiltration. Newly planted forest buffers show increased plant diversity, infiltration, and other elements within 15 years, and potential to improve buffer functions by better addressing concentrated flows (Figure 11). The Chesapeake Healthy Watershed Assessment could provide a useful framework for tracking functions in habitat mosaics.


How Fast did Forest Buffer Functions Develop?

Shading- Crown closure common by age 15

Temperature- Significant decrease in days with stream temperatures that stress fish (75F threshold) within 15 years

Soil Infiltration- Higher infiltration within 15 years

Large Woody Debris- too early for much downed wood, not expected

Streambank stability- bank stability increased modestly in most streams

Stream Width- Not significantly wider by age 15, still changing

Cleaner water- trend of decreased nutrients and turbidity

Benthic macroinvertebrates IBI- increased in most sites by year 5

Wildlife Habitat- Canopies over 20 feet high by 15 years increasing habitat volume and layers

Figure 11. Development of forest buffer functions over time.

Co-benefits: Amphibians and Wetlands – *Paula Henry (USGS)*

The health of an ecosystem, such as a wetland, is based in part on its biodiversity in terms of its genetics, species or communities, the physical geology/hydrology/topography, energy and nutrient flow, and interspecific interactions. Ecosystem services of wetlands as they relate to amphibians include improving water quality through processes such as sediment trapping, nutrient removal, and chemical detoxification.

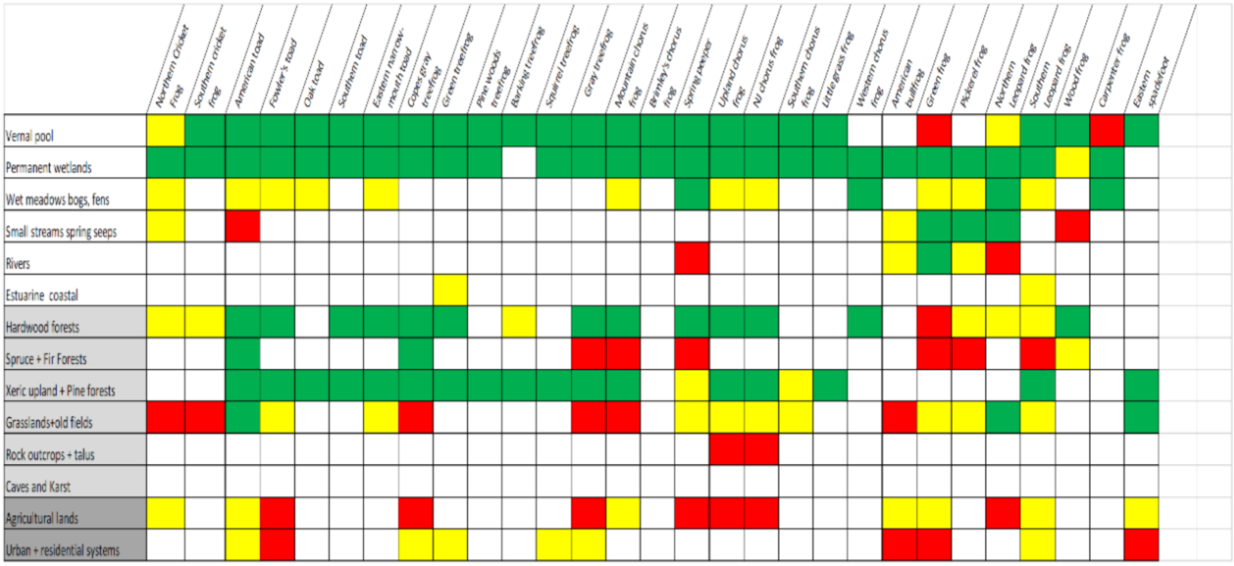
Amphibia exhibit a wide diversity of life and natural history strategies, in terms of their reproduction, embryonic development, partitioning of the post-hatch stages of growth and development, and resource needs. In addition to providing direct benefits to humans via medical applications (e.g., understanding of nerve-muscle connections, methods of limb regenerations), their contributions to ecosystem health are numerous. Specific factors for this include life cycle partitioning between aquatic and terrestrial environments, differences in resource needs across species and developmental stages, variable behaviors (e.g., caecilians burrowing, salamanders adapted to head streams vs cave dwellers and those breeding in vernal pools), and their transferring of energy and biomass between habitats. Amphibians hold prominent roles in the food chain as primary producers, biological control predators of algae and terrestrial and aquatic insects, and as prey to wildlife such as fishes, birds, mammals, reptiles, and other amphibians. As a result of these physical and biological linkages, significant deviations in distribution, presence, and behaviors of resident amphibians are often sensitive measures of changes in the health of an ecosystem.

The 29 species of anurans and 57 species of caudates found in the Chesapeake Bay watershed and their habitats are presented in figure 12. Species include the threatened Cheat Mountain (*Plethodon netting)* and the endangered Shenandoah salamanders *(Plethodon shenandoah).* Species such as the marbled salamander (*Ambystoma opacum*) depend on: dried substrates for nesting and overwintering; temporary water sources such as from snowmelts or other precipitation for reproduction and nursery; and forested habitats rich in mesic rich soils for terrestrial foraging, refugia, and nesting. Alternatively, the non-arboreal treefrog, Northern cricket frogs (*Acris crepitans),* prefer permanent wetlands, but can be found across all habitat types.

Amphibians do not migrate great distances. Given the diversity of the CB watershed amphibian resources, which include wetlands connected to some terrestrial habitat, the need is to effectively apply best management practices to highlight both benefits of wetlands to amphibians and benefits of amphibians and wetlands both to the CB's ecosystem health.

If one can manage the habitat effectively, a whole suite of species and their communities will benefit. One approach would be to define the goal - be it biodiversity, species richness, or a particular species, and apply a management or structured decision process to select the most relevant and effective monitoring tools and measures to apply prior to, during, and following restoration. To achieve this and minimize unintended consequences, such as introducing diseases into a clean site or establishing attractive nuisance situations, information on the resource needs and biology of the focal species or communities as well as on the hydrology and seasonal inputs of the habitats is necessary. Quantitative measures, such as water quality, occupancy, and biodiversity monitored over time may help establish account criteria other than restored acreage, to meet the goals for improving the Bay's resources.

Chesapeake Bay Frogs & Toads – all regions



	Northern Cricket frog	Southern cricket frog	American toad	Fowler's toad	Oak toad	Southern toad	Eastern narrow-mouth toad	Copes gray treefrog	Green treefrog	Pine woods treefrog	Barking treefrog	Squirrel treefrog	Gray treefrog	Mountain chorus frog	Brimley's chorus frog	Spring peeper	Upland chorus frog	NJ chorus frog	Southern chorus frog	Little grass frog	Western chorus frog	American bullfrog	Green frog	Pickerel frog	Northern Leopard frog	Southern Leopard frog	Wood frog	Carpenter frog	Eastern spadefoot
Vernal pool	🟨	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩			🟥		🟨	🟩	🟩	🟥	🟩
Permanent wetlands	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟩	
Wet meadows bogs, fens	🟨		🟨	🟨	🟨		🟨							🟨		🟩	🟨	🟨			🟩		🟨	🟨	🟩	🟨		🟩	
Small streams spring seeps	🟨		🟥																			🟨	🟩	🟩	🟩		🟥		
Rivers																🟥						🟨	🟩	🟨	🟥				
Estuarine coastal									🟨																	🟨			
Hardwood forests	🟨	🟨	🟩	🟩		🟩	🟩	🟩	🟩		🟨		🟩	🟩		🟩	🟩	🟩			🟩		🟥	🟨	🟨	🟨	🟩		
Spruce + Fir Forests			🟩					🟩					🟥	🟥		🟥							🟥	🟥		🟥	🟨		
Xeric upland + Pine forests			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟨	🟩	🟩	🟨	🟩						🟩			🟩
Grasslands+old fields	🟥	🟥	🟩	🟨			🟨	🟥					🟥	🟥		🟨	🟨	🟨	🟨			🟥	🟨	🟨	🟩	🟨			🟩
Rock outcrops + talus																	🟥	🟥											
Caves and Karst																													
Agricultural lands	🟨		🟨	🟥				🟥					🟥	🟨		🟥	🟥	🟥				🟨	🟨		🟥	🟨			🟨
Urban + residential systems			🟨	🟥				🟨	🟨			🟨	🟨									🟥	🟥			🟨			🟥

Chesapeake Bay Salamanders – all regions

	Streamside	Jefferson	Blue-spotted	Mabee's	Spotted	Marbled	Mole	Small-mouthed	Tiger	Two-toed	Green	Hellbender	Southern dusky	Northern dusky	Shovel-nosed	Seal	Allegheny mountain dusky	Blue ridge dusky	Black-bellied	Black mountain	Pygmy	Northern two-lined	Southern two-lined	Three-lined	Long-tailed	Cave	Blue-ridge two-lined	Spring
Vernal pool	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩												🟥	🟥					
Permanent wetlands		🟩	🟥		🟨		🟩		🟨	🟨				🟨								🟥	🟨	🟨	🟨			
Wet meadows bogs, fens					🟥									🟥								🟨	🟨					
Small streams spring seeps	🟩	🟥	🟥		🟥					🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟩	🟩
Rivers												🟩		🟥								🟨						
Estuarine coastal																												
Hardwood forests	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Spruce + Fir Forests			🟨		🟨	🟨								🟥		🟨	🟩	🟨	🟨	🟨	🟨	🟨					🟨	🟩
Xeric upland + Pine forests		🟩	🟩	🟩	🟨	🟥	🟩		🟩		🟩		🟥		🟩				🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟨	🟥
Grasslands+old fields	🟨	🟨	🟥		🟨			🟨																				
Rock outcrops + talus						🟥					🟩		🟩												🟥			
Caves and Karst						🟥																			🟩	🟩		🟩
Agricultural lands				🟥	🟥																	🟥						
Urban + residential systems																						🟥						

	West-VA spring	Four-toed	Mudpuppy	Dwarf waterdog	Red-spotted newt	Atlantic coast slimy	Eastern red-backed	White-spotted slimy	Northern Ravine	Northern slimy	Valley and Ridge	Peaks of Otter	Cumberland plateau	N Grey-cheeked	Cheat mountain	Cow knob	Southern ravine	Shenandoah	Big levels	Southern Zigzag	Shenandoah mountain	Wehrle's	Weller's	Yonahlossee	Mud	Red	Lesser siren	Greater siren
Vernal pool		🟩			🟩										🟦			🟧							🟨			🟩
Permanent wetlands		🟩	🟨		🟩										🟦			🟧							🟨	🟩	🟩	🟨
Wet meadows bogs, fens		🟩			🟥										🟦			🟧							🟩	🟩		
Small streams spring seeps	🟥	🟥	🟩	🟩	🟩										🟦			🟧							🟩	🟩	🟩	🟨
Rivers			🟩	🟩	🟩				🟩	🟩					🟦			🟧										🟥
Estuarine coastal															🟦			🟧										
Hardwood forests		🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		
Spruce + Fir Forests		🟨			🟩		🟨			🟥					🟩	🟨		🟧				🟩	🟨			🟥		
Xeric upland + Pine forests		🟥			🟩	🟩	🟨	🟥	🟥	🟨	🟨	🟩	🟥		🟦	🟨	🟥	🟩	🟨	🟩		🟩	🟩	🟩	🟩	🟥		
Grasslands+old fields					🟨										🟦			🟧										
Rock outcrops + talus					🟥		🟥								🟦			🟩				🟨						
Caves and Karst	🟩														🟦			🟧										
Agricultural lands					🟥										🟦			🟧										
Urban + residential systems					🟥		🟥	🟥							🟦			🟧										

Figure 12. Habitat usage by Chesapeake Bay watershed frogs & toads (top image) and salamander species (bottom image). Descriptors for colors used in both images are as the following: Habitat resource: green – required habitat; yellow – suitable; red – marginal; Habitat types: white– waterways; mid grey—forest, caves, dark grey: agriculture and urban.

Session 4: Management Implications and Recommendation Development

Ecosystem Services Quantification – *Ryann Rossi (EPA)*

Wetlands best management practices, such as wetland creation and restoration, have the potential to provide many ecosystem services such as habitat for important recreational and commercial species and flood control (Figure 13). Eight ecosystem services associated with wetland BMPs were quantified using the best available land cover land use data and models (Table 1, Figure 14). These estimates can be used to compare provision of ecosystem services between wetland and other conservation/restoration BMPs and provide a snapshot of potential ecosystem service supply due to BMPs (Rossi et al. 2022). This work could be improved with better land use land cover data, particularly with respect to wetland areas, and with data that tracks ecosystem service supply over time to provide more accurate estimates on the provision of ecosystem services throughout the life of a BMP (e.g., 1 year vs. 10 years post-implementation).

Ecosystem Service (ES)	**Metric used**	**Source**
Carbon sequestration	Soil C sequestration (lbs yr-1)	Literature search; COMET planner tool
Bird species	Bird species richness	USGS GAP data
Soil quality	Soil C stock (lbs)	Literature search; COMET planner tool
Open space	Open space per capita	Census data
Pollinator supply	Habitat suitability for pollinator species	inVEST (Pickard et al. 2015, Sharp et al. 2020, Warnell et al. 2020)
Flood control	Maximum water retention (yd3)	Curve Number Method
Pathogen reduction	% FIB reduction	Wainger et al, 2016; Richkus et al 2016
Water quantity	Surface water flow (in yr-1)	CAST model

Table 1. List of ecosystem services quantified, metrics used to quantify them, and source of data and/or

method used.

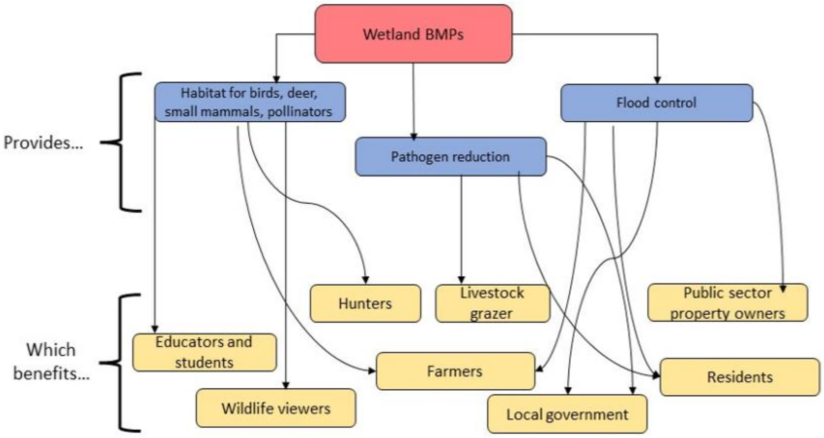


Figure 13. Examples of ecosystem services (blue boxes) and those who benefit (yellow boxes) due to wetland BMP implementation.

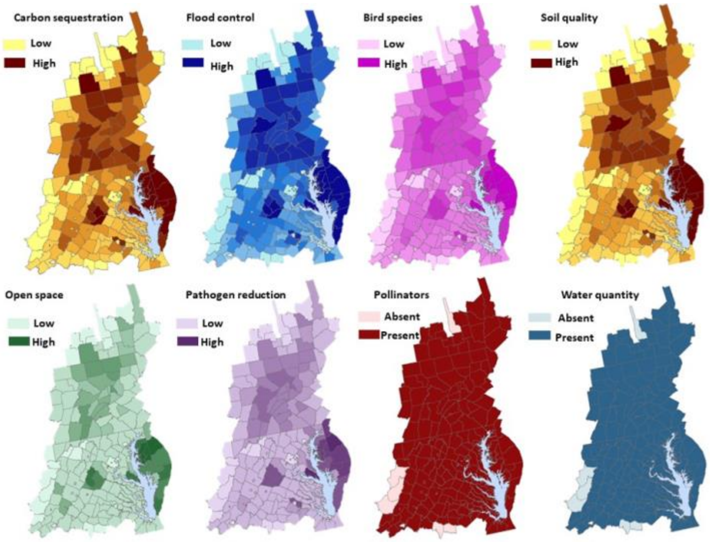


Figure 14. Estimated ecosystem service provisioning based on wetland BMP Targets for WIP3 plans for each county in the watershed. WIP3 target acres were obtained from CAST.

Fairfax Recovery Wheel – *Meghan Fellows (Fairfax County, Virginia)*

Ecosystem restoration goes beyond regulatory or function-based restoration. As a practice, targeting and meeting one or two function-based outcomes has become standard practice. As a science, we've generally come to the understanding of how function-based restoration does not meet the holistic benefits of ecosystem restoration. However, the pendulum is swinging back to the understanding of meeting both the project driver (a function-based restoration) and understanding the more complex effects on the ecosystem as a whole. But holistic restoration is complicated and needs a simple organizing and communication tool. Society for Ecological

Restoration has developed the Ecological Wheel approach, nimble enough to accommodate multiple metrics and multiple levels of restorative action in each metric; this tool was applied to Fairfax County Stream Restoration projects as a proof of concept (Figure 15).

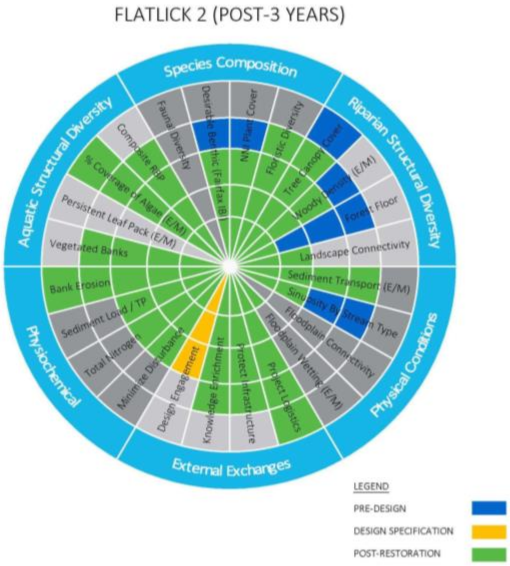


Figure 15. An example of holistic assessment of stream-riparian restoration outcomes.

First, the County identified and prioritized 24 ecological metrics inclusive of the function-based restoration metrics (sediment, nitrogen, and phosphorus). The additional metrics included biological, social, and logistical goals. More than half of the new metrics are biological, reflecting the more holistic understanding of the ecosystem effect of restorative action. The 24 metrics were estimated before and after implementation of a restoration practice (stream restoration), with the resulting graphic showing areas of both ecological uplift and lag post-construction. This tool can be used to compare multiple sites pre-restoration; sites before restoration to identify areas where ecological function is high and/or in need of improvement; and post-construction over multiple years to track restoration recovery.

Facilitated Discussion

With the CBP goals to minimize unintentional negative consequences to wetland ecosystems and incentivize behavior towards activities that would help meet the CBP goal for wetland restoration and creation, a transition in focus is warranted from the accounting of BMP implementation effort to the outcomes generated from increased wetland ecosystem services. An emphasis and focus on wetland outcomes, not the predominant focus on counting BMP implementation, could help attain the CBP goals for wetland habitats. These outcomes could include multiple ecosystem services and not focus solely on N, P, and sediment load reduction. However, the framework and tools and needed science to implement such an effort have not been clear.

The CBP approach for translating management efforts to expected changes in loads of N, P, and sediment offers a potential framework for the development of metrics of wetland ecosystem services provisioning as the result of management efforts (Figure 16). For a given type of BMP, expert panels have been convened to summarize the best available science and to generate a "transfer function" of expected results from the management effort. These transfer functions are a logical or mathematical description of the expected result of implementing the BMP on changing downstream loading of N, P, and sediment. These expert panel summaries and reports are collectively used by practitioners to choose their most appropriate and effective management action to meet their voluntary or mandated goals for achieving load reduction. These actions are then reported to the states who then provide to the CBP the amount of BMP implementation. The CBP then calculates and publishes the expected load reductions.

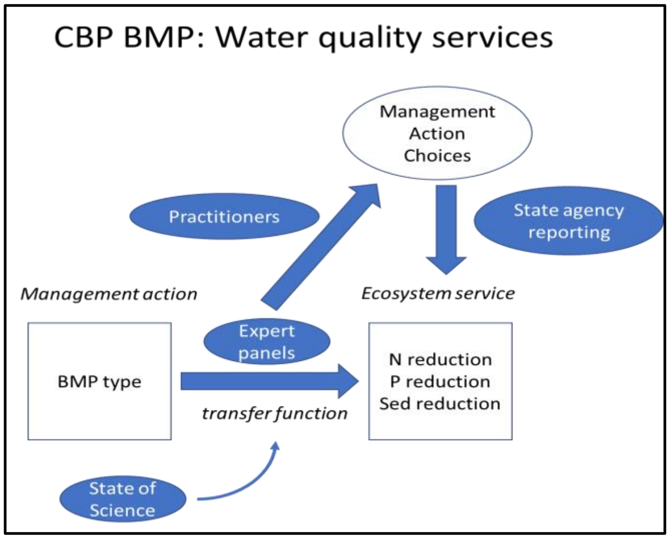


Figure 16. The current CBP framework for translating BMP implementation to an expected ecosystem service of N, P, and sediment load reduction.

Similarly, the CBP would need an approach for translating management effort into expected provisioning of ecosystem services. Like the N, P, and sediment load approach by the CBP, transfer functions are needed to estimate expected change in targeted ecosystem services from specific management actions (such as a BMP; Figure 17). First, the list of prioritized ecosystem services would need to be identified. Then transfer functions developed for expected outcomes from each management action considered. Like for N, P, and sediment, expert panels are one approach to the development of these transfer functions. However, if available, an existing tool could be used to provide transfer functions. Alternatively, the changed ecosystem services could be directly measured for the project. This approach for wetland ecosystem services could be replicated for other ecosystems as well. Yet fundamentally the current state of scientific knowledge is likely insufficient for existing tools, expert panels, or direct measurement to be readily implemented into a reliable and trustworthy transfer function. There is the need for additional science to measure and predict ecosystem services changes in response to management efforts to be able to generate increased precision and reduced uncertainty of ecosystem service transfer functions. The approach outlined is one way to structure ecosystem services as an outcome of CBP goals.

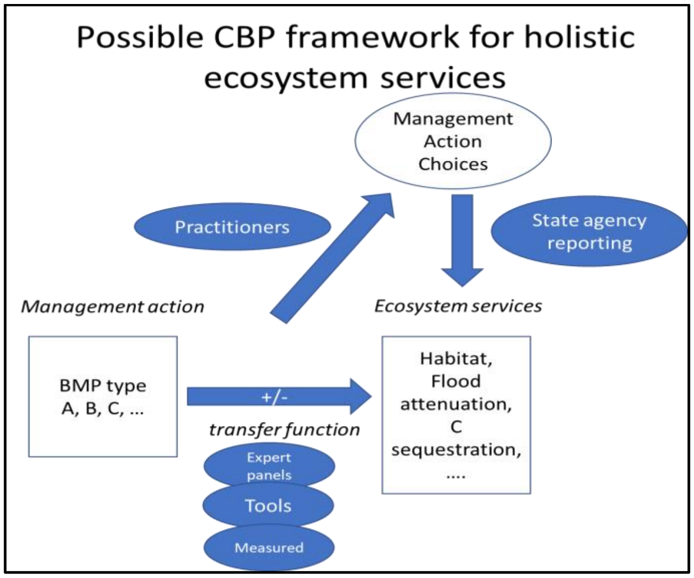


Figure 17. One possible suggested CBP framework for translating BMP implementation to an expected provisioning of various and multiple ecosystem services.

In the past, the CBP has been responsive to updating their goals and metrics based on emerging capabilities or needs. For example, sediment loads were not initially part of the development of the Chesapeake Bay TMDL, as described by Gary Shenk (USGS) at this workshop. Sediment was added to N and P loads TMDL in part because of interest and needs to understand and manage sediment as well as sufficient knowledge and capabilities to include sediment in the original Watershed Model. The implementation of wetland ecosystem services as a metric in the CBP is perhaps analogous – additional development in capabilities to measure and model ecosystem services, and continued interest by the Partnership, could lead to the addition of the ecosystem services of wetlands (and other ecosystems).

Recommendations

The following section identifies key findings from the workshop along with recommendations for consideration as options for the Chesapeake Bay Program to consider implementing in order to achieve its restoration goals:

1. **Key Finding:**

Wetland Projects are not accurately accounted for toward the wetlands goal or as BMPs. Efforts have focused only on wetlands for pollution load reduction. Wetlands in urban landscapes are not counted via this process.

Context

Chesapeake Bay restoration activity is mostly driven by the TMDL. However, the Chesapeake Bay Agreement includes multiple goals and outcomes related to improvements in habitat (wetlands, riparian forest buffers, stream health, SAV, etc.) that are separate from reductions in N, P, and sediment. Many of these habitat outcomes are far behind in their progress and will not reach their goal by the 2025 deadline. To meet the 2025 goals as they quickly approach, the Partnership would need to ensure that all Outcomes, especially habitat-based ones that are far behind, are making sufficient progress toward their goal. In order to address this issue, it is crucial to understand how the current system, focused on BMP load reductions, may undervalue habitat benefits, how restoration projects often compete for resources and credits, how some restoration designs may not support other habitat goals, and what alternatives or improvements there are for the current crediting system. Concerns over correct data entry and submission have arisen. Not all wetland acres restored or created are consistently included when water quality BMPs are reported. See Appendix C for a more detailed explanation of tradeoffs.

Immediate Needs:

- Create, initiate, and maintain a standing process to account for all wetlands restoration, creation, and enhancement projects.
- Provide training on data entry.
- Review and ensure BMPs reporting includes the area of wetlands restored or created.

Recommendations:

Proposed CBP Partner(s): Wetland habitat accounting database developers, data reporters, project proponents, funders.

1. Ensure all wetland projects are being counted regardless of whether they are a BMP or habitat or other service
2. Examine the existing accounting processes and identify approaches to account for awarding credit or incentive for ecosystem benefits that arise from all management

actions; suggest providing data to support CBP Wetlands and Black Duck data efforts.

Specific Considerations
Address on-going need to update data. Create a process for data input by jurisdiction/partners. Develop and implement an annual data update process. This accounting process does not serve as a Bay-wide wetlands status and trends monitoring. Additional efforts are necessary to address status and trends.

2. **Key Finding:**
   The benefits of Wetland Projects depend on landscape position and location, and the planning and implementation of wetland management actions can be integrated into larger scale systems thinking. Wetland projects could benefit from moving beyond opportunity driven restoration at a specific location that may be less suitable for holistic benefits to targeted restoration at suitable locations.

   Immediate Needs:
   - Investigate the synergistic value-added benefits of wetlands projects that are part of a larger scale multi-habitat or goal effort.
   - Investigate the unintended consequence of habitat trade-offs between wetlands and other habitats.
   - Create a multi-benefit geospatial decision support tool for wetland restoration and creation.

Recommendations:

Proposed CBP Partners: Water Quality Goal Implementation Team, Maintain Healthy Watersheds Goal Implementation Team, Fish Habitat Action Team, Forestry Workgroup, USGS, GIS Team

3. Seek systems level wetland restoration projects (as part of a larger wetland complex, or part of a multiple practice effort to include synergistic restoration such as stream, riparian buffers and fish passage) which avoid habitat tradeoffs by incorporating landscape level thinking into such projects and maximize multiple benefits.
4. Promote and incentivize restoration projects designed and constructed so that biological function is not negatively impacted while managing for water quality improvements.
5. Develop a process for project funders to include negative and positive indicator responses for habitat co-benefit and ecosystem services criteria when evaluating proposals (see Appendix D).

Specific Considerations
Develop a case study: Identify and implement wetland projects that are incorporated into larger scaled efforts to include stream restoration, forest buffers, SAV, floodplain connection and other habitat and living resources and that maximize the overall ecosystem health.

3. **Key Finding:**

Wetland Projects provide multiple benefits (i.e., ecosystem services) that are linked to multiple differing local, state, federal, and regional outcomes and goals. As such, assessing the net benefits for wetlands projects, especially in comparison to other habitat/water quality restoration efforts, is difficult.

Currently, restoration project proponents are more likely to make decisions on the projects they will pursue based on load reduction credits, cost, and land ownership criteria rather than ecosystem services offered by wetlands, stream restoration, and forest buffers. This leads to a choice between habitats rather than projects planned at a systems level to maximize habitat benefits. Projects implemented to generate single benefits may miss easily implemented modification to maximize co-benefits as best or result in adverse unintended consequences at worst. A focus on multiple ecosystem services of wetland and other associated ecosystem management actions could help shift planning and implementation towards holistic benefits.

Immediate Needs:

- Directed CBP effort to explore avenues for increasing the “credit” for wetland projects based on provision of co-benefits and linkages to other CBP outcomes (i.e., fish habitat, water quality, etc.)
- Develop a framework, such as multiple ecosystem services, to attribute multiple benefits credits for wetlands projects.

Recommendations:

Proposed CBP Partner(s): Water Quality Goal Implementation Team, Maintain Healthy Watersheds Goal Implementation Team, Fish Habitat Action Team, Forestry Workgroup

6. Investigate the possibility of adding or subtracting load reduction credit for wetland projects relative to habitat services provisioning, and expand to other types of habitat restoration BMPs (such as stream restoration and riparian forest buffers).
7. Support development of advances in understanding and predicting outcomes of multiple ecosystem services of wetland projects in addition to N, P, and sediment load reduction, such as habitat provisioning and flood reduction.
8. Support and encourage partners to consider multiple ecosystem services when evaluating wetland projects, such as rating proposals for funded efforts.

Specific Considerations
It is recommended that examples or case studies be developed to demonstrate systems level approaches that benefit multiple ecosystem services. Wetland projects potentially provide benefits for: habitat (aquatic and terrestrial), RTE species, water quality, erosion control, flood mitigation, food-web provision, blue carbon sequestration, recreation, and open space. Multiple ecosystem services are incorporated into larger scaled, landscape restoration efforts to include stream restoration, forest buffers, SAV, floodplain connection and other habitat and living resources in order to maximize the overall ecosystem health.

4. **Key Finding**:
Wetland project implementation could increase to better meet CBP goals by providing additional incentives and tools that properly capture and credit wetland co-benefits beyond water quality improvement.

One of the primary drivers of watershed project implementation throughout the Chesapeake Bay watershed is the Bay's TMDL for nutrients and sediments. Jurisdictions throughout the watershed have been tasked by the EPA to reduce nutrient and sediment loads to the Bay in order to achieve specific water quality standards for those pollutants. The EPA has been empowered to implement enhanced oversight and contingency actions if a state's progress is considered inadequate to meet the TMDL standards. To achieve these TMDL goals in nutrients and sediment, jurisdictions are prioritizing the implementation of practices that are the most cost-effective with large nutrient and sediment reductions per dollar spent. Such practices include agricultural cover crops, fencing livestock out of waterways, and stream restoration. Wetlands generally have low nutrient and sediment reductions compared to other practices and as such, are not the highest priority for implementation based on TMDL goals.

In order to increase the implementation of wetland projects to meet the additional acreage goals for wetlands, it is recommended that additional incentives could be explored that go beyond nutrient and sediment reduction. Such incentives could add economic value to other wetland benefits as described in these STAC workshop presentations, encouraging and incentivizing states to complete more wetland projects as practical and cost-effective to meet the Chesapeake Bay Agreement's specific wetland goals.

Immediate Need:

- Develop tools for use by project proponents to attribute multiple benefits from wetlands projects.

Recommendations:

Proposed CBP Partner(s): Water Quality Goal Implementation Team, Maintain Healthy Watersheds Goal Implementation Team, Fish Habitat Action Team, Forestry Workgroup

9. Investigate the development of an accounting system to track co-benefits and cross-outcome ecosystem services.
10. Develop a process for decision makers to plan and prioritize actions to address negative and positive indicator response for habitat co-benefit and ecosystem services criteria to include in decision making.
11. Investigate crediting for other ecosystem benefits which advance other Chesapeake Bay habitat and living resources outcomes.

Post Workshop Progress

Since the workshop convened in March 2022, there have been significant actions within the Bay Program partnership including the establishment of a 2023 Wetlands Action Plan identifying actions for nontidal and tidal wetlands, the roll-out of the Habitat Outcome and Attainment Tracking System ("Habitat Tracker"), the inclusion of two additional vice-chair positions within the Wetland Workgroup (WWG) membership in order to expand its capacity, and the convening of a "2022 Restoring Wetlands of the Chesapeake Bay Watershed Workshop" which informed the 2023 Action Plan. Minutes and more information on the aforementioned workshop can be found on the WWG webpage; direct link to meeting minutes and appendices can be accessed here.

Evaluation of the Outcome/Indicator

A review of the likely attainment of CBP outcomes was undertaken by the Outcome Attainability Team (OAT) in advance of the 2025 deadline for outcome attainment. The wetlands outcome was determined to be off-course for achievement by 2025.

Wetlands Project Tracker

The Habitat Outcome and Attainment Tracking System ("Habitat Tracker") is an online tool that collects and manages various habitat improvement projects implemented in the Chesapeake Bay watershed. The Habitat Tracker includes data from most of the jurisdictional partners and can produce reports helpful for ecosystem tracking and assessment as well as the assessment of project implementation goals through trend and targeting analyses. The tool was created with a specific focus on facilitating and guiding decision-making related to various wetland benefits, particularly habitat. The initial dataset, covering 2022, will be reported in late 2024.

Users can access the Habitat Tracker online or by downloading a pre-loaded Excel spreadsheet, which serves as a reporting and tracking template for habitat projects, containing various columns for project details including project information, wetland details, flood hazard, and environmental data, and additional information such as an environmental literacy component. The template assists data submitters in identifying projects that impact wetlands and black ducks and is then utilized to evaluate progress towards the 2014 Chesapeake Bay Agreement goals and outcomes.

Wetlands Action Plan

The determination by the OAT that the wetlands outcome was off-course for 2025 prompted the Management Board to direct the partnership, via the Habitat GIT, to develop and lead a process to create a Wetlands Action Plan. The effort included a 2-day workshop followed by office hours with each jurisdiction to collaborate on jurisdiction-specific action plans. Each jurisdiction (except for West Virginia which has very little wetland area in the Bay watershed) produced an action plan that was appended to the overall plan.

Outcomes from the August 2022 workshop informed the action plan, with recommendations for strategic planning, capacity building, landowner/community engagement, and sustainable funding. The document lists barriers as well as innovative approaches to overcome them, and potential funding opportunities with detail on match requirements and eligibility for a potential award. The Wetland Action Plan is available online for all interested users.

Wetland Workgroup (WWG) Reorganization

Following the recommendations from the August 2022 Wetlands Workshop, the WWG has re-organized by adding two Vice Co-Chair positions (one for tidal wetlands and one for nontidal wetlands) and seeking and securing additional participation following the Wetland Action Plan process. The new structure should provide additional capacity for engagement by the partnership working toward the wetlands outcome. WWG membership information is available on the group webpage.

Capacity Grant with Chesapeake Bay Trust

Specific interest of the combined WWG and the Climate Resiliency Workgroup in the promotion of efforts on tidal wetlands resilience and net increase via voluntary creation and restoration toward the wetlands goal led to the creation of a funding opportunity to add capacity for this work. A capacity grant was awarded to the Chesapeake Bay Trust and work on the grant kicked off in 2023. The primary task is to develop a single blueprint that outlines how to move forward with all the tools and priorities to develop coastal wetland siting criteria, including permit considerations. In addition, the purpose of the grant is to:

- assist the wetlands workgroup and CRWG in developing a landscape level strategic vision for the coastal wetland,
- work with the HGIT to develop an outreach plan to the Management Board, Principals’ Staff Committee,
- work across the Goal Implementation Teams and their workgroups to implement the blueprint, and
- work with the wetland’s workgroup, and CRWG and the Diversity Workgroup to develop an outreach plan to local communities conveying the local benefits of coastal wetland restoration and opportunities to collaborate/provide input on the blueprint and strategic vision.

Best Management Practice Verification Ad-Hoc Action Team (BMPVAHAT)

Another recent change around wetlands from the CBP perspective is an approved change regarding the verification requirements for wetlands as approved BMPs. Both tidal and nontidal wetlands can be eligible for load reduction credits for TMDL implementation. According to the traditional BMP verification process, BMP must be verified over the lifetime of the practice in order to maintain the pollution reduction credits for TMDL. WWG members have made the argument that wetlands are not comparable to other BMPs in that a successful wetland project results in a jurisdictional wetland. This means, once completed and verified by the permitting agencies engaged in implementation of the project, the wetland is protected legally from conversion into another landuse/ landcover. Given this protection, it is no longer required that wetland practices need verification over time, and wetland practices will no longer expire.

Comprehensive Evaluation of System Response (CESR)

The CBP advisory group, the Scientific and Technical Advisory Committee (STAC), published an independent consensus report in May 2023 entitled, “Comprehensive Evaluation of System Response” (CESR). CESR sought to evaluate progress made towards meeting the Bay Total Maximum Daily Load (TMDL) and assess why under this scheme, current and past efforts have not been successful in both achieving TMDL targets or reducing nutrient loads. The report evaluates the effectiveness of existing actions and provides considerations for accelerating progress towards partnership goals. The full report is available on the STAC website, as well as an Executive Summary and three resource documents that were foundational in identifying gaps and uncertainties in system response: Watershed, Estuary, and Living Resources.

One of the main findings assessed in the report related to wetlands is the following:

> “**Finding**: Significant enhancement of living resources can be achieved through additional management actions without complete achievement of water quality standards across all habitats.”
>
> “The living resource outcomes that can be expected from incremental attainment of water quality criteria depend greatly on a host of other factors. Structural aquatic habitat, nearshore habitat (wetlands, shoreline), commercial and recreational harvest, disease, and water conditions (temperature, salinity) are all significant drivers of the composition and abundance of living resources. Research points to the importance of specific habitats (particularly shallow water) and nearshore conditions for many important species.”

The CESR report calls for an acceleration of ecosystem restoration and recovery because living resource outcomes depend on nearshore habitats. Wetland conditions are important for the composition and abundance of many species of living resources, and the report concludes living resource benefits may be achieved without full attainment of water quality criteria across Bay habitats.

Further, legal requirements of the Clean Water Act disincentivize funneling management attention and resources to living resource outcomes as Water Quality is the only legally enforceable goal under the Clean Water Act (CWA). This causes attention to be focused on nutrient reductions rather than benefits to living resources; the advantages of wetland restoration or the establishment of living shorelines are frequently discussed in the context of TMDL rather than the enhancement of habitat. However, these investments can greatly enhance the living resources in the Bay.

References

Baker, M.E., D.E. Weller, and T.E. Jordan. 2006. Improved methods for quantifying potential nutrient interception by riparian buffers. Landscape Ecology 21(8): 1327-1345.

Baker, M.E., D.E. Weller, and T.E. Jordan. 2007. Effects of stream map resolution on measures of riparian buffer distribution and nutrient retention potential. Landscape Ecology 22: 973-992.

Baker, M.E., M.J. Wiley, and P.W. Seelbach. 2001. GIS - based hydrologic modeling of riparian areas: implications for stream water quality. Journal of the American Water Resources Association 37(6): 1615-1628.

Cahoon, D.R., D.J. Reed, A.S. Kolker, M.M. Brinson, J.C. Stevenson, S. Riggs, R. Christian, E. Reyes, C. Voss, and D. Kunz. 2009. Coastal wetland sustainability. Pages 57-72 *in*: Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington, D.C.

Ganju, N., Z. Defne,, M. Kirwan, S. Fagherazzi, A. D'Alpaos, and L. Carniello. 2017. Spatially integrative metrics reveal hidden vulnerability of microtidal salt marshes. Nature Communications 8(14156).

Hendricks, J., P. Mason, J. Herman and C. Hershner C. 2023. Prioritizing the protection and creation of natural and nature-based features for coastal resilience using a GIS-based ranking framework – an exportable approach. Frontiers Marine Science 10:1005827.

Kaushal, S., J. Reimer, P. Mayer, R. Shatkay, C. Maas, W. Nguyen, W. Boger, A. Yaculak, T. Doody, M. Pennino, N. Bailey, J. Galella, A. Weingrad, D. Collison, K. Wood, S. Haq, T. A. Newcomer-Johnson, S. Duan, and K. Belt. 2022. Freshwater salinization syndrome alters retention and release of chemical cocktails along flowpaths: From stormwater management to urban streams. Freshwater Science 41(3).

Kochel, R.C., B.R. Hayes, J. Muhlbauer, Z. Hancock, and D. Rockwell. 2016. Geomorphic response to catastrophic flooding in north-central Pennsylvania from Tropical Storm Lee (September 2011): Intersection of fluvial disequilibrium and the legacy of logging. Geosphere 12: 305-345.

Landry, J.B. and R.R. Golden. 2018. In Situ Effects of Shoreline Type and Watershed Land Use on Submerged Aquatic Vegetation Habitat Quality in the Chesapeake and Mid-Atlantic Coastal Bays. Estuaries and Coasts 41(1): 101-113.

Mayer, P., M. Pennino, T. Johnson-Newcomer and S. Kaushal. 2022. Long-term assessment of floodplain reconnection as a stream restoration approach for managing nitrogen in ground and surface waters. Urban Ecosystems 25: 1-29.

Nunez, K., T. Rudnicky, P. Mason, C. Tombleson, and M. Berman. 2022. A geospatial modeling approach to assess site suitability of living shorelines and emphasize best shoreline management practices. Ecological Engineering 179:106617.

Palinkas, C., M.C. Bolton, and L.W. Staver. 2023. Long-term performance and impacts of living shorelines in mesohaline Chesapeake Bay. Ecological Engineering 190:106944.

Patrick, C.J., D.E. Weller, D.E., X. Li, and M. Ryder. 2014. Effects of Shoreline Alteration and Other Stressors on Submerged Aquatic Vegetation in Subestuaries of Chesapeake Bay and the Mid-Atlantic Coastal Bays. Estuaries and Coasts 37:1516.

Rossi, R., C. Bisland, L. Sharpe, E. Trentacoste, B. Williams, S. Yee. 2022. Identifying and aligning ecosystem services and beneficiaries associated with Best Management Practices in Chesapeake Bay Watershed. Environmental Management 69: 384-409.

Thorp, J., M. Thoms and M. Delong. 2006. The riverine ecosystem synthesis: Biocomplexity in river networks across space and time. River Research and Applications 22: 123-147.

Van Appledorn, M. 2018. Complex interactions among river-valley morphology, basin size, and flow-event magnitude structure the physical template of floodplain ecosystems: Data: U.S. Geological Survey data release, https://doi.org/10.5066/P9ITQTNQ.

Ward J.V., K. Tockner, D.B. Arscott, and C. Claret. 2002. Riverine landscape diversity. Freshwater Biology, 47: 517-539.

Walker, R.H., M. J. Ashton, M. J. Cashman, R. M. Fanelli, K. P. Krause, G. B. Noe and K.O. Maloney. 2021. Time marches on, but do the causal pathways driving in stream habitat and biology remain consistent? Science Total Environment 789: 147985.

Weller, D.E. and M.E. Baker. 2014. Cropland riparian buffers throughout Chesapeake Bay watershed: spatial patterns and effects on nitrate loads delivered to streams. Journal of the American Water Resources Association 50(3): 696-710.

Williams, M.R., G. Bhatt, S. Filoso, and G. Yactayo. 2017. Stream restoration performance and its contribution to the Chesapeake Bay TMDL: Challenges posed by climate change in urban areas. Estuaries and Coasts 40: 1227-1246.

Wood, K., S. Kaushal, P. Vidon, P. Mayer, and J. Galella. 2022. Tree Trade-Offs in Stream Restoration: Impacts on Riparian Groundwater Quality. Urban Ecosystems 25: 1-23.

Appendix A: Workshop Agenda

Chesapeake Bay Program's (CBP)
Scientific and Technical Advisory Committee (STAC)

Evaluating an Improved Systems Approach to Crediting:
Consideration of Wetland Ecosystem Services
March 22-23, 2022
Location: Chesapeake Bay Program Philip Merrill Center
Workshop Webpage

{formerly known as 'Evaluating a Systems Approach to BMP Crediting'}

Tuesday, March 22, 2022

****Exact Times Are Subject to Change****

9:30 am Coffee & Light Breakfast (Provided)

10:00 am Welcome and Introductions – *Pamela Mason (VIMS)*

10:15 am Workshop Overview and Charge – *Pamela Mason (VIMS)*

10:30 am *Session 1*: Accounting
- **10:30 am Nonpoint Source TMDL Incentives and Impacts Other Goals** – *Jeff Sweeney (EPA)*
- **10:50 am Overview of Current BMP crediting** – *Olivia Devereux (Devereux Consulting, WQGIT)*
- **11:20 am Overview of Crediting from the Jurisdictional Perspective** – *Greg Sandi (MDE)*
- **11:45 am Q & A**

12:00 pm Lunch (Provided)

1:00 pm *Session 2*: Landscape/Systems Approach
- **1:00 pm Synergistic Bay Goals** – *Carin Bisland (EPA)*
- **1:25 pm Wetland Projects in Agricultural Landscapes** – *Steve Strano (NRCS)*
- **1:50 pm Coastal Wetlands Ranking for Co-Benefits** – *Pamela Mason (VIMS)*

2:15 pm Break

2:30 pm *Session 2 Continued*: Landscape/Systems Approach
- **2:30 pm Watershed Scale Restoration** – *Ben Hayes (Bucknell)*
- **2:55 pm Large Scale Projects** – *Rick Bennett (FWS)*
- **3:25 pm Watershed-level Effects of Nutrient Sinks: Lessons from analysis of riparian buffers** – *Matt Baker (UMBC)*
- **3:50 pm Q & A**

4:15 pm Break

4:20 pm Facilitated Discussion

5:00 pm Recess

Wednesday, March 23, 2022

8:30 am **Coffee & Light Breakfast (Provided)**

9:00 am ***Session 3*: Wetlands Projects and Co-Benefits**
Tradeoffs:
- **9:00 am MS4/urban Impacts** – *Sujay Kaushal (UMD)*
- **9:15 am Systems Degradation** – *Dave Goerman (PA)*
- **9:30 am Consequences of BMP Crediting, Resource Tradeoffs, and Need For an Ecosystem Approach** – *Denise Clearwater (MDE)*
- **9:45 am Unintended Consequences**– *Michael Williams (UMD)*
- **10:00 am Q & A**

10:15 am **Break**

***Session 3 Continued*: Wetlands Projects and Co-Benefits**
Co-benefits:
- **10:30 am SAV** – *Brooke Landry (MD DNR)*
- **10:45 pm Marine Fisheries** – *David O'Brien (NOAA)*
- **11:00 pm Waterfowl** – *Jake McPherson (DU)*
- **11:15 am Forestry and Streams** – *Anne Hairston-Strang (DNR)*
- **11:30 am Amphibians** – *Paula Henry (USGS)*
- **11:45 am Brook trout** – *Steve Faulkner (USGS)*
- **12:00 pm Q & A**

12:15 pm **Lunch (Provided)**

1:00 pm ***Session 4*: Management Implications and Recommendation Development**
Facilitation by Greg Noe (USGS) and Pamela Mason (VIMS)
- **1:00 pm Introduction and Overview of Where We Want to Go** – *Greg Noe (USGS)*
- **1:05 pm Fairfax Recovery Wheel** – *Meghan Fellows (Fairfax County)*
- **1:35 pm Ecosystem Services Quantification** – *Ryann Rossi (EPA)*

2:05 pm **Break**

2:15 pm Facilitated Discussion
Discussion will be split in two sections, first focusing on ecosystem services and then policy. Breakout groups will meet for 30-minutes to discuss each topic, followed by a 15-minute report out.
- **2:15 pm Ecosystem Services**
- **3:00 pm Policy**

3:45 pm **Conclusion and Next Steps**

4:00 pm **Adjourn**

Appendix B: Workshop Participants

Drew Atland, RK&K
Matt Baker, UMBC
Rick Bennett, US FWS
Alicia Berlin, USGS
Mark Biddle, Delaware DNREC
Carin Bisland, EPA
Taylor Blackman, PSU
Karl Blankenship, Bay Journal
Denise Clearwater, MDE
Meg Cole, CRC
Olivia Devereux, Devereux Consulting
Roman DiBiase, PSU
Kevin Du Bois, NAVFAC
Ari Engelberg, MD DNR
Steve Faulkner, USGS
Meghan Fellows, Fairfax County
Dave Goerman, PA DEP
Becky Golden, MD DNR
Chris Guy, US FWS
Anne Hairston-Strang, DNR
Jeremy Hanson, CRC
Jeff Hartranft, PADEP
Ben Hayes, Bucknell
Michelle Henicheck, VADEQ
Paula Henry, USGS
Sarah Hilderbrand, MD DNR
Elizabeth Hoffman, MDA
Gina Hunt, MD DNR
Bill Jenkins, EPA
Kelly Johnson, Conservation Corps
Sujay Kaushal, UMD
Michaella Kuykendall, MDA
Brooke Landry, MD DNR
Pam Mason, VIMS
Jake McPherson, DU
Greg Noe, USGS
David O’Brien, NOAA
Efeturi Oghenekaro, DOEE
Megan Ossmann, CRC
Tom Parham, MD DNR
Scott Phillips, USGS
Alison Rogerson, DNREC
Ryann Rossi, EPA
Greg Sandi, MDE
Alison Santoro, MD DNR
Kristin Saunders, UMCES
Gary Shenk, USGS
Steve Strano, NRCS
Brittany Sturgis, DNREC
Jeff Sweeney, EPA
Leon Tillman, USDA-NRCS
Jonathan Watson, NOAA
Michael Williams, UMD
John Wolf, USGS
Sarah Woodford, VA DEQ
Susan Yee, EPA
Beth Zinecker, UMD

Appendix C: Consequences of BMP Crediting, Resource Tradeoffs, and Need For an Ecosystem Approach – Expanded Presentation Description

Appendix and corresponding presentation compiled by Denise Clearwater, Special Projects Coordinator of the Wetlands and Waterways Program in the Maryland Department of the Environment, gave the above titled presentation on March 23, 2022.

Introductory Sections

The presentation noted that crediting for TMDL credit is only given for nutrient and sediment load reductions, without consideration of the living resources which are to be the beneficiaries of the load reduction. The importance of living resources and maintaining and improving their habitat is mentioned in numerous other Chesapeake Bay Agreement commitments. These commitments include goals for improving Submerged Aquatic Vegetation (SAV); wetlands; riparian forest; healthy streams, fish passage; and anadromous fish, brook trout, and other fisheries.

Outcomes of restoration projects are known to vary. There may be overall improvement, while only some components may benefit. Other elements of the ecosystem may be lost or perform at a lower level of functioning in services and processes.

This has led to debates about resource tradeoffs.

When considering ecosystems and restoration, the benefits and consequences to different system components depend upon their condition at project site prior to restoration; project design and implementation; and condition of upstream and downstream areas. The unintended or adverse consequences are potentially greater for existing sensitive and functioning resources and critical infrastructure.

The pertinent question for decision makers, stakeholders, regulators, reviewers and practitioners is: What are the benefits and consequences which should be considered to meet all relevant goals and achieve Net Ecological Uplift? It should also be recognized the term “Ecological Uplift” itself may have different interpretations depending upon perspective. A collaborative approach is essential to avoid or minimize adverse impacts.

Wetlands were presented as a resource which would particularly benefit from an ecosystem approach. Wetlands, being at the land/water interface, provide support for both adjacent upland and connected waters. Restoration projects which affect wetlands and fail to account for these connections may result in further degradation, rather than improvement, of certain ecosystem components, functions, and processes.

Restoration projects may affect wetlands either through construction within them or indirectly as a result of construction in or alteration of a connected resource. Restoration in a connected resource, such as an adjacent stream, may occur when wetland is still functioning. The level of degradation in wetland does not always match level of degradation in stream. This is particularly true for wetlands primarily supported by groundwater, rather than overbank flooding.

Wetlands provide numerous beneficial functions due to their ecosystem processes, including flood attenuation, water quality improvement, groundwater discharge and recharge, and habitat. The degradation of the wetland and its processes may thus lead to a “chain reaction” of other undesirable and adverse effects to connected resources, including to the stream which was intended to improve as a result of restoration.

The presentation gave examples of consequences and considerations related to wetlands and associated stream restoration. An understanding and acknowledgement of both benefits and consequences is necessary to avoid and minimize adverse effects.

It is important to note that the consequences described in the presentation do not occur at all sites. However, the consequences may occur when the design does not consider all functions and characteristics at the site.

Example Discussion of Ecosystem Approach for Streams Restoration and Wetlands

The presentation included a definition of “stream corridor” annotated from a definition in the Natural Resources Conservation Service (NRCS) to characterize the resources as part of an ecosystem which is affected by a stream restoration project:

“A stream corridor is an ecosystem that usually consists of three major elements:

Stream channel
Floodplain (often includes wetlands*)
Transitional upland fringe

Together they function as dynamic and valued crossroads in the landscape.”

*inclusion of wetlands added

(*Stream Corridor Restoration Principles, Processes, and Practices*, Federal Interagency Stream Restoration Work Group Part 653, National Engineering Handbook, NRCS, 1998 rev. 2001)

In order for a stream to be successfully restored, all associated components must be functioning. This includes both a stable stream channel, which is connected to its fully functioning riparian area, including wetlands.

A fully functioning riparian area is dominated by appropriate native vegetation, natural patterns of surface and groundwater inundation and saturation, and an intact, non-compacted soil profile.

Stream restoration for BMP credit typically attempts to increase connection of the stream channel to the floodplain by floodplain by:

1) Raising the streambed. This is accomplished by placing fill in the channel or structures to raise the water level; or

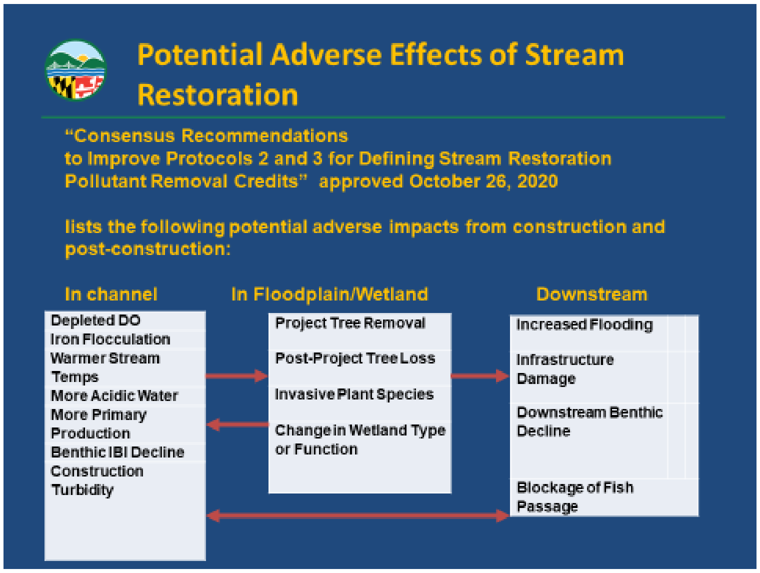
2) Lowering the floodplain. This is accomplished by excavation of the floodplain to bring its elevation closer to the water level in the stream, so that the water enters the floodplain more frequently.

Construction of stream restoration BMPs may range from limited to extensive. Construction activities include grading, vegetation removal, installation of berms, and building access roads. The extent of recovery in riparian areas with extensive disturbances is likely variable. More adverse impacts occur with extensive more extensive disturbance.

Operation of heavy equipment may result in soil compaction. Compaction results in smaller pore spaces, which restrict root growth and groundwater movement. There is also a loss of belowground habitat and reduced soil infiltration. These consequences adversely affect soil processes which contribute to belowground nutrient transformation and reduction of inputs to downstream waters.

Effects from new structures alter flows by diverting more water into floodplains and into bed and bank sediments. If too high or impermeable, structures may serve as blockages to aquatic life movement.

The presentation included the slide below, which shows a table from "Consensus Recommendations to Improve Protocols 2 and 3 for Defining Stream Restoration Pollutant Removal Credits," approved in October 2020 by the Chesapeake Bay Program Water Quality Goal Implementation Team for use in assigning credits for floodplain reconnection projects. Arrows were added to the tables for the presentation showing the interconnected relationships between riparian resources. For example, construction and installation of structures in stream channels may result in additional turbidity and a decline in IBI scores. Water level increases from the channel may result in loss of shade due to tree loss from excessive inundation, as well as from clearing of vegetation during construction in the riparian area. This in turn again affects the water chemistry in the channel, with increases in primary productivity, warmer temperatures, and lower DO when there is less flow due to impounding of water. These conditions may affect downstream resources, resulting in worse conditions for aquatic habitat. Instream structures may also result in blockages to aquatic life passage, if aquatic life cannot move over, through, or around the structure, so that the restored stream segment may have limited usage as habitat.



Potential Adverse Effects of Stream Restoration

"Consensus Recommendations
to Improve Protocols 2 and 3 for Defining Stream Restoration
Pollutant Removal Credits" approved October 26, 2020

lists the following potential adverse impacts from construction and post-construction:

In channel

- Depleted DO
- Iron Flocculation
- Warmer Stream Temps
- More Acidic Water
- More Primary Production
- Benthic IBI Decline
- Construction Turbidity

In Floodplain/Wetland

- Project Tree Removal
- Post-Project Tree Loss
- Invasive Plant Species
- Change in Wetland Type or Function

Downstream

- Increased Flooding
- Infrastructure Damage
- Downstream Benthic Decline
- Blockage of Fish Passage

<u>Adverse Effects and Unintended Consequences</u>

The presentation continued with more detail about adverse effects listed in the table.

1) In-Channel Changes from Structures
   a) Blockages to Passage to Aquatic Life. Blockages may be physical or chemical. Physical blockages are barriers to movement, when a structure does not allow movement over, through, or around it. Structures may add too much of a "drop" between upstream and downstream water levels for aquatic life to move beyond the structure. High discharges from undersized structures may also be too much for aquatic life to move upstream through it. However, structures with openings may allow for aquatic life movement.

   b) Less Effective Denitrification. Hyporheic exchange is the interaction between surface and groundwater. This may occur within the bed and banks of stream channels and can result in denitrification by microorganisms in the soils. Structures may either slow flow or force too rapid downwelling and reduce denitrification.

   c) Increased flooding. While increased connection to the floodplain is typically a goal of stream restoration projects, there may be increases on adjacent property which are not desirable.

   d) Failed structures. Failed structures may result in parts of the structure being transported downstream and damaging infrastructure. Pieces of the structures may strike the stream banks, resulting in more erosion and sediment deposition in the channel.

2) Harmful changes to water chemistry. Most of these are related to increases in water levels or other removal of streamside vegetation which result in loss of shade over nutrient-laden water.
   a) Potential chemical blockages. Temperatures are likely to increase and O decrease with loss of shade. Also, wetland soils in floodplains/riparian areas are often acidic.

Their disturbance during construction may result in discharges to the stream which result in lower pH. These may create conditions outside of ranges of tolerances for growth, propagation, and movement of aquatic life.

Changes to water chemistry resulting in changes outside of water quality standards may result in new impairment listings and TMDL requirements.

Designs which maintain shade or spring flow, or expose cold water springs may not have temperature increases.

b) Iron flocculation.

c) Decline in macroinvertebrate scores.

3) Direct removal of vegetation. If the riparian zone and streamside vegetation is forested, removal of the vegetation during construction typically results in loss of shade and inputs of the detrital inputs of leaves and wood. There will be a loss and/or change in plant communities. This may or may not be desirable, depending upon what was previously existing at the site and how it was valued; and what is likely to be the new plant community. Extensive clearing is also associated with increases in invasive species. Fragmentation of forested corridors from the tree loss has effects on wildlife species beyond the site.

   It may be difficult to successfully re-establish the desired and planned plant community. Repeated active management is often necessary to protect against herbivory; spread of invasive species, and replace of dead plantings.

4) Soil compaction. Soil compactions results from operation of heavy equipment. It results in reduction of soil pore spaces. This restricts root growth of both existing vegetation and new plantings. Groundwater movement is slower through smaller pores, resulting in lower infiltration rates as well as discharge to the stream. There is a loss of below ground habitat, which otherwise supports nutrient transformation.

   Soil compaction and channel alteration also may result in a reduction of hyporheic exchange. Hyporheic exchange depends upon flow; groundwater levels; hydraulic conductivity (heterogeneous sediments and bed complexity and topography; and features such as wood) and permeability in streambed; DOC; residence time; and microbial communities.

5) Potential loss/change in vegetation communities. Loss and change in plant communities may also occur without direct removal during construction, but also due to increased water levels. Plants require oxygen to roots, and are stressed by low oxygen and toxins in soil. Most tree species die with prolonged inundation and saturation. However, there is a broad range of tolerance to increased water levels, depending on the species. Tree seedlings are typically more sensitive.

   Soil redox potential is the capability of oxidation and reduction of elements in the soil. Nutrient and phosphorus uptake by trees may decrease in wetter soils with lower redox potential.

Water chemistry in the channel and riparian area are effected by loss of vegetation and shade. See item #2 above.

Changes in the plant community type as a result increased inundation and saturation in the riparian area affect aquatic resource type and habitats. This may or may not be desirable.

6) Other effect of water level changes. More water on the floodplain may increase hazards to upstream and downstream infrastructure.

Ecological Uplift and Minimizing Unintended Consequences

After the description of adverse impacts from some (but not all) stream restoration projects, the presentation discussed concepts of maximizing functional uplift and reducing unintended consequences.

It was suggested that "Maximizing uplift" means considering the range of ecological processes and ecosystem services which could be improved by a restoration project. The considerations for achieving uplift would be:

1) existing functions and other factors in site design;
2) potential adverse effects of altering floodplain/wetland and channel;
3) design and build for specific site conditions and retain natural system and processes where feasible; and
4) recognize that more modest alterations may be most beneficial overall when system has existing desired functions and condition.

There were numerous recommendations for how unintended consequences could be reduced. The presentation again noted that the consequences do not occur for all cases.

1) Address problems at source. While bank erosion is a major source of sediment, the discharges resulting in the erosion often originate in the upstream water outside of the project reach.

2) Maximize upland treatment. Management of stormwater for both quality and quantity outside of the stream network can reduce the extent of erosive discharges.

3) Properly size culverts and other crossings. Undersized crossings may result in higher discharges which may cause erosion.

4) Address the Unintended Consequences of projects with a design/construction which may not be appropriate for a specific site

5) Maintain or improve habitat conditions on sites with more limited degradation

6) Allow for adjusted credit toward TMDL as an incentive for reducing unintended consequences.

Needs for Implementation of an Ecosystem Crediting Approach

The presentation concluded with a list of elements for implementation of an ecosystem crediting approach.

1) An assessment of ecosystem condition, tailored to what is valued and part of larger ecosystem management goals. Interpretation and priorities may vary by jurisdiction.

2) Identification of functioning components which should not be reduced for a restoration project.

3) Identification of ecosystem improvements and potential tradeoffs.

4) Adjustments to databases which would allow for reporting of adjusted credit for and ecosystem approach.

5) Method for credit adjustments and documented rationale.

Credit Adjustments

Adjustments to a crediting approach for an ecosystem approach, rather than only nutrient and sediment reductions, can be accomplished through two different scenarios. These are:

1) Bonus credit for retention or restoration of desired components and processes. This would be a positive incentive for greater contribution toward a jurisdiction's load reduction allocation by protecting valuable, functioning, existing resources.

2) Credit reduction. This would be a debit from the reductions assigned through relevant protocols when existing valuable function and ecological processes are degraded. This would result in a greater amount of additional load reduction needed than if the resource was managed to maintain a suite of existing functions and a resource which still had fair-good condition.

References Related to Appendix C: Consequences of BMP Crediting, Resource Tradeoffs, and Need For an Ecosystem Approach – Expanded Presentation Description

Abernethy, V.J. and N.J. Willby. 1999. Changes along a disturbance gradient in the density and composition of propagule banks in floodplain aquatic habitats. Plant Ecology 140: 177-190.

Alexander, P., D.L. Nielsen and D. Nias. 2008. Response of wetland plant communities to inundation within floodplain landscapes. Ecological Management & Restoration 9: 187-195.

Amoros, C., G. Bornette and C. P. Henry. 2000. A vegetation based method for ecological diagnosis of riverine wetlands. Environmental Management 25: 211-227.

Angeler, D. G. and G. Garcı´a. 2005. Using emergence from soil propagule banks as indicators of ecological integrity in wetland: advantages and limitations. Journal of the North American Benthological Society 24: 740-752.

Angelov, M.N., S.J Sung, R.L. Doong, W.R. Harms, P.P. Kormanik, and C.C. Black Jr. 1996. Long-and short-term flooding effects on survival and sink–source relationships of swamp-adapted tree species. Tree Physiology 16(5): 477-484.

Bailey-Serres, J., and T.D. Colmer. 2014. Plant tolerance of flooding stress - recent advances. Plant, Cell and Environment 37: 2211-2215.

Baldwin, D.S., and A.M. Mitchell. 2000. The effects of drying and re-flooding on the sediment and soil nutrient dynamics of lowland river-floodplain systems: a synthesis. River Research and Applications 16: 457-467.

Banach, A.M., K. Banach, R.C.J.H. Peters, R.H.M. Jansen, E.J.W. Visser, Z. Stephniewska, J.G.M. Roelofs, and L.P.M. Lamers. 2000. Effects of long-term flooding on biogeochemistry and vegetation development in floodplains; a mesocosm experiment to study interacting effects of land use and water quality. Biogeosciences 6: 1325-1339.

Barrett, R., D.L. Nielsen and R. Croome. 2010. Associations between the plant communities of floodplain wetlands, water regime and wetland type. River Research and Applications 26: 866-876.

Boano, F., J.W. Harvey, A. Marion, A.I. Packman, R. Revelli, L. Ridolfi, and A. Wörman. 2014. Hyporheic flow and transport processes: Mechanisms, models, and biogeochemical implications, Review of Geophysics 52: 603-679.

Bodmer P, R. Freimann, S. von Fumetti, C.T. Robinson, and M. Doering. 2015. Spatio-temporal relationships between habitat types and microbial functions of an upland floodplain. Aquatic Sciences 78: 241-254.

Brock, M.A. and M.T. Casanova, 1997. Plant life at the edge of wetlands: ecological responses to wetting and drying patterns. Page 181-192 *in:* Klomp, N. & I. Lunt (eds), Frontiers in Ecology: Building the Links. Elsevier Science Ltd., Oxford.

Brock, M.A., D.L. Nielsen, R.J. Shiel, J.D. Green and J.D. Langley. 2003. Drought and aquatic community resilience: the role of eggs and seeds in sediments of temporary wetlands. Freshwater Biology 48: 1207-1218.

Bukaveckas, P.A. 2007. Effects of Channel Restoration on Water Velocity, Transient Storage, and Nutrient Uptake in a Channelized Stream. Environmental Science & Technology. 2007. 41(5): 1570-1576.

Casanova, M.T. and M.A. Brock. 2000. How do depth, duration and frequency of flooding influence the establishment of wetland plant communities? Plant Ecology 147(2): 237-250.

Chesapeake Bay Program. 2020. Consensus Recommendations to Improve Protocols 2 and 3 for Defining Stream Restoration Pollutant Removal Credits. Approved by Water Quality Goal Implementation Team. Annapolis, MD.

Ciszewski, D., and T.M. Grygar. 2016. A review of flood-related storage and remobilization of heavy metal pollutants in river systems. Water, Air, & Soil Pollution 227(7): 1-19.

Cramer, M.L. (managing editor). 2012. Stream Habitat Restoration Guidelines. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, Washington.

Drinkard, M.K., M. Kershner, A. Romito, J. Nieset, and F. Szalay. 2011. Responses of plants and invertebrate assemblages to water-level fluctuation in headwater wetlands. Journal of the North American Benthological Society 30(4): 981-996.

Duan, S., P.M. Mayer, S.S. Kaushal, B.M. Wessel, and T. Johnson. 2019. Regenerative stormwater conveyance (RSC) for reducing nutrients in urban stormwater runoff depends upon carbon quantity and quality. Science of The Total Environment 652: 134-146.

Duiker, S.W. 2004. Effects of Soil Compaction. Pennsylvania State University College of Agricultural Sciences Agricultural Research and Cooperative Extension
Federal Interagency Stream Restoration Work Group Part 653, National Engineering Handbook. *Stream Corridor Restoration Principles, Processes, and Practices*, NRCS, 1998 rev. 2001.

Filoso, S., S.M.C. Smith, M.R. Williams, and M.A. Palmer. 2015. The efficacy of constructed stream–wetland complexes at reducing the flux of suspended solids to Chesapeake Bay. Environmental Science & Technology 49(15): 8986-8994.

Garssen, A.G., A. Baattrup-Pedersen, L.A.C.J. Voesenek, J.T.A. Verhoeven, and M.B. Soons. 2015. Riparian plant community responses to increased flooding: A meta-analysis. Global Change Biology 21(8): 2881-2890.

Gibbs, J. and H. Greenway. 2003. Mechanisms of anoxia tolerance in plants. I. Growth, survival and anaerobic catabolism. Functional plant biology 30(1): 1-47.

Golladay, S.W., B.W. Taylor, and B.J. Palik. 1997. Invertebrate communities of forested limesink wetlands in southwest Georgia, USA: habitat use and influence of extended inundation. Wetlands 17(3): 383-393.

Hilderbrand, R.H., J. Acord, T.J. Nuttle, and R. Ewing. 2018. Quantifying the ecological uplift and effectiveness of differing stream restoration approaches in Maryland. Final Report Submitted to the Chesapeake Bay Trust for Grant #13141. 70 pp.

Jackson, M.B. and T. Colmer. 2005. Response and adaptation by plants to flooding stress. Annals of Botany 96(4): 501-505.

Song, K., M.E. Hernandez, J.A. Batson, and W.J. Mitsch. 2014. Long-term denitrification rates in created riverine wetlands and their relationship with environmental factors. Ecological Engineering 72: 40-46.

Knox, A.K., R.A. Dahlgren, K.W. Tate, and E.R. Atwill. 2008. Efficacy of natural wetlands to retain nutrient, sediment and microbial pollutants. Journal of environmental quality 37(5): 1837-1846.

Lammers, R.W. and B.P. Bledsoe. 2017. What role does stream restoration play in nutrient management? Critical Reviews in Environmental Science and Technology 47(6): 335-371.

Lukács, B.A., G. Sramkó, and A. Molnár, A., 2013. Plant diversity and conservation value of continental temporary pools. Biological Conservation 158: 393-400.

Merill, L. and D.J. Tonjes. 2014. A review of the hyporheic zone, stream restoration, and means to enhance denitrification. Critical Reviews in Environmental Science and Technology 44(21): 2337-2379.

Neckles, H.A., H.R. Murkin, and J.A. Cooper. 1990. Influences of seasonal flooding on macroinvertebrate abundance in wetland habitats. Freshwater biology 23(2): 311-322.

Nielsen, D.L., K. Podnar, R.J. Watts, and A.L. Wilson. 2013. Empirical evidence linking increased hydrologic stability with decreased biotic diversity within wetlands. Hydrobiologia 708(1): 81-96.

Palmer, M.A., H.L. Menninger, and E. Bernhardt. 2010. River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice? Freshwater biology 55: 205-222.

Palmer, M.A., K.L. Hondula, and B.J. Koch. 2014. Ecological restoration of streams and rivers: shifting strategies and shifting goals. Annual Review of Ecology, Evolution, and Systematics 45: 247-269.

Pezeshki, S.R., and R.D. DeLaune. 2012. Soil oxidation-reduction in wetlands and its impact on plant functioning. Biology 1(2): 196-221.

Pond, G. and K. Krock. 2018. *Macroinvertebrate responses to RSCs.* March 2017 Results. Presented to Urban Stormwater Work Group, Chesapeake Bay Program. June 19, 2018. Powerpoint presentation.

Raulings, E.J., K.A.Y. Morris, M.C. Roache, and P.I. Boon. 2010. The importance of water regimes operating at small spatial scales for the diversity and structure of wetland vegetation. Freshwater Biology 55(3): 701-715.

Shrestha, J., P.A. Niklaus, N. Pasquale, B. Huber, R.L. Barnard, E. Frossard, P. Schleppi, K. Tockner, and J. Luster. 2014. Flood pulses control soil nitrogen cycling in a dynamic river floodplain. Geoderma 228: 14-24.

Shuai, P., M.B. Cardenas, P.S. Knappett, P.C. Bennett, and B.T. Neilson. 2017. Denitrification in the banks of fluctuating rivers: The effects of river stage amplitude, sediment hydraulic conductivity and dispersivity, and ambient groundwater flow. Water Resources Research 53(9): 7951-7967.

Siebel, H.N. and I.M. Bouwma. 1998. The occurrence of herbs and woody juveniles in a hardwood floodplain forest in relation to flooding and light. Journal of Vegetation Science 9(5): 623-630.

Siebel, H.N. and C.W.P.M. Blom. 1998. Effects of irregular flooding on the establishment of tree species. Acta Botanica Neerlandica 47(2): 231-240.

Suchara, I., 2019. The impact of floods on the structure and functional processes of floodplain ecosystems. Journal of Soil Plant Biology 1: 44-60.

Teskey, R.O., T.M. Hinckley, and M.A. Walters. 1977. Impact of Water Level Changes on Woody Riparian and Wetland Communities: Plant and soil responses (Vol. 1). Fish and Wildlife Service, US Department of the Interior.

Teskey, R.O., T.M. Hinckley, and M.A. Walters. 1977. Impact of Water Level Changes on Woody Riparian and Wetland Communities: Southern forest region (Vol. 2). Fish and Wildlife Service, US Department of the Interior.

Teskey, R.O., T.M. Hinckley, and M.A. Walters. 1980. Impact of water level changes on woody riparian and wetland communities. Fish and Wildlife Service, US Department of the Interior.

Thapa, R., M.C. Thoms, M. Parsons, and M. Reid. 2016. Adaptive cycles of floodplain vegetation response to flooding and drying. Earth Surface Dynamics 4(1): 175-191.

Toogood, S.E. and C.B. Joyce. 2009. Effects of raised water levels on wet grassland plant communities. Applied Vegetation Science 12(3): 283-294.

Townsend, C.R. and A.G. Hildrew. 1994. Species traits in relation to a habitat templet for river systems. Freshwater Biology 31(3): 265-275.

van der Valk, A.G., L. Squires, and C.H. Welling. 1994. Assessing the impacts of an increase in water level on wetland vegetation. Ecological Applications 4(3): 525-534.

Ward, J.V., K. Tockner, and F. Schiemer. 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity1. River Research and Applications 15(1-3):125-139.

Warren, R.J., D.L. Potts, and K.M. Frothingham. 2015. Stream structural limitations on invasive communities in urban riparian areas. Invasive Plant Science and Management 8(3): 353-362.

Watson, J.A., M.B. Cardenas, S.B. Ferencz, P.S. Knappett, and B.T. Neilson. 2018. The effects of floods on the temperature of riparian groundwater. Hydrological Processes 32(9): 1267-1281.

Williams, M.R., B.M. Wessel, and S. Filoso. 2016. Sources of iron (Fe) and factors regulating the development of flocculate from Fe-oxidizing bacteria in regenerative streamwater conveyance structures. Ecological Engineering 95: 723-737.

Williams, M.R., G. Bhatt, S., Filoso, and G. Yactayo. 2017. Stream restoration performance and its contribution to the Chesapeake Bay TMDL: Challenges posed by climate change in urban areas. Estuaries and Coasts 40(5): 1227-1246.

Zimmer, M.A., and L.K. Lautz. 2015. Pre-and post restoration assessment of stream water–groundwater interactions: effects on hydrological and chemical heterogeneity in the hyporheic zone. Freshwater Science 34(1): 287-300.

Appendix D: Ecosystem Crediting Examples

Ecosystem crediting examples
Note: The descriptions and summary of pros and cons are presented in terms of the ecosystem service crediting which is part of the STAC effort, not as a criticism of the methods and documents from which language is excerpted or summarized.

Maryland Department of the Environment Forest Conservation Credit.

This is a credit under MS-4 permits. Below is an excerpt from "Maryland Department of the Environment. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Guidance for National Pollutant Discharge Elimination System Stormwater Permits November 2021."

pp. 17 - 18

a) Forest Conservation

EIA credit for forest conservation is available for the permanent conservation of existing acres of forest. Forest land cover has the lowest Phase 6 Model unit loads for nutrients and sediments, and conserving established forest acres that are vulnerable to development pressure is critical to ensuring that water quality does not worsen. Credit is available to MS4 jurisdictions that have implemented forest easements that limit development and go above and beyond the conservation programs incorporated into the Phase III WIP 2025 base land-use condition.

The Phase III WIP sets nutrient and sediment load reduction goals based on the projected growth in the State. *Maryland's Phase III Watershed Implementation Plan (August 2019)* utilizes the "Maryland Policy" Land Policy BMP scenario in the projected 2025 conditions, which includes assumptions about the continued conservation of forests due to existing policies in the State. State forest and agricultural conservation programs are estimated in projections out to the year 2025 using a trend of implementation of these programs in the past. The assumptions included in the Land Policy BMP scenario for Maryland are intended to reflect Maryland's continued implementation of the Forest Conservation Act, Critical Area Law, and other preservation programs. If an MS4 jurisdiction can establish that its forest conservation programs result in less development on forest than the WIP 2025 forecast, then it has successfully prevented a future load increase.

Requirements and Verification

Forest conservation credit is contingent upon the MS4 jurisdiction's ability to document that the easement exceeds the criteria described in Table 2 and is not part of a development required practice such as sheet flow to conservation area. Credit will only be available for the portion of the easement that goes above and beyond the conservation assumptions in Maryland's Phase III WIP. For example, if the Forest Conservation Act requires a minimum easement of 5 acres and a jurisdiction establishes a 10 acre easement, the forest conservation credit can be claimed for 5 acres.

Forest easements that are eligible for forest conservation credit should be proximate to a development in order to demonstrate that the easement is preventing a future load increase by preventing a loss of forest to an urban land use. Jurisdictions are required to submit locations and sizes of State-required forest conservation easements in order to verify the acres claimed for forest conservation credit do not overlap with State required mitigation. In addition, forest conservation easements should be demonstrably permanent, be at least 50% forest cover at the time of creation, and have a management plan that limits or restricts actions like mowing and tree removal.

Table 2. Easement Criteria based on the Phase III WIP Scenario Assumptions that must be Exceeded to Qualify for Forest Conservation Credit

Ea Easement cannot be an area under easement for State required mitigation.
Ea Easement cannot be a part of or reported to the following State programs: Program Open Space Rural Legacy Maryland Agricultural Land Preservation Foundation (MALPF) Maryland Environmental Trust (MET)
Ea Easement cannot be part of a sheetflow to conservation area BMP.
Ea Easement cannot be on a Land Use Conversion BMP.

To receive credit, MS4 jurisdictions must submit the following:

Documentation of forest conservation easements required by the Forest Conservation Act for mitigation within the jurisdiction.

Documentation of easements beyond State required forest conservation easements for which credit is requested, along with information on the development they are intended to prevent (e.g. development name, jurisdiction construction permit number).

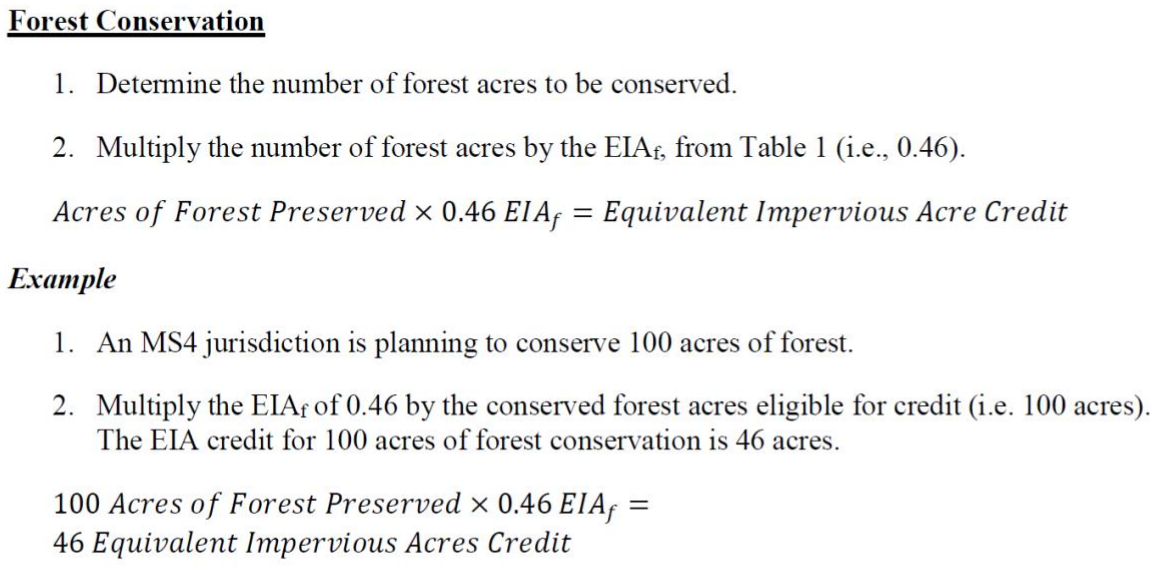
Documentation of tri-annual inspections to ensure compliance with easement requirements and retention of credit.

Load reductions are based on the difference between a total urban (inclusive of urban impervious and turf) unit load and the forest unit load (Table 3). An example credit calculation can be found in Appendix F.

Table 3. Load Reductions and EIAf for Forest Conservation BMPs.

Land Conservation BMP	**Load Reduced (lbs/acre/yr)**			**EIAf per Acre of Forest Conserved**
	TN	**TP**	**TSS**	
F Forest Conservation	10.57	1.10	2,465	0.46

Appendix F p. 63



Forest Conservation

1. Determine the number of forest acres to be conserved.
2. Multiply the number of forest acres by the EIA_f, from Table 1 (i.e., 0.46).

$$Acres\ of\ Forest\ Preserved \times 0.46\ EIA_f = Equivalent\ Impervious\ Acre\ Credit$$

Example

1. An MS4 jurisdiction is planning to conserve 100 acres of forest.
2. Multiply the EIA_f of 0.46 by the conserved forest acres eligible for credit (i.e. 100 acres). The EIA credit for 100 acres of forest conservation is 46 acres.

$$100\ Acres\ of\ Forest\ Preserved \times 0.46\ EIA_f =$$
$$46\ Equivalent\ Impervious\ Acres\ Credit$$

<u>Pros and Cons Of this Approach for Ecosystem Crediting:</u> The descriptions and summary of pros and cons are presented in terms of the ecosystem service crediting which is part of the STAC effort, not as a criticism of the methods and documents from which language is excerpted or summarized.
This is a useful starting consideration for conservation of an existing resource, rather than awarding credit for an actual change. The concept would need additional modification for ecosystem crediting. Stream restoration sites are not typically directly vulnerable to new impervious surface, but may have permanent access roads and often do involve a loss of existing forest cover. If forest is removed and re-planted, it would have different vegetated land cover before it progressed, if successful, to a more mature forest.

Other factors which would need to be addressed were the exclusions for other protective measures. Ecosystem crediting may need to allow for overlapping protective measures.

Nontidal Wetland Compensatory Mitigation – Preservation

Preservation of nontidal wetlands and associated resources, though rare, has been accepted on occasion to offset lost wetland acreage and function. The following is from "Components of a Compensatory Mitigation Plan - Guidance for Developing Wetland and Waterway Mitigation in Maryland" (MDE, 2022).

Preservation: Protecting high quality streams or wetlands under threat of development. o Preservation of aquatic resources may only be used to provide compensatory mitigation pursuant with the Federal Mitigation Rule, 33 CFR 332.3(h). Preservation should only be given mitigation credit when:

the proposed site provides important environmental functions for the watershed, the proposed site contributes significantly to the ecological sustainability of the watershed, the regulatory agencies determine preservation to be appropriate and feasible, and the site is under threat of destruction or degradation. Preservation is generally a less desirable form of mitigation than restoration, creation, or enhancement since in the mitigation context, it results in overall loss of acre and function. It should only be used in conjunction with aquatic resource restoration, establishment, and/or enhancement activities and should only contribute a small percentage of total mitigation credits. For PRM, preservation should not be considered unless acreage replacement has been met through 1:1 mitigation and there are no other desirable mitigation options. Preservation may be considered more favorably for systems that support highly unique resources, as determined by the regulatory agencies, but these sites must still meet the Federal Mitigation Rule requirements for preservation. Preservation generally receives much less mitigation credit than restoration or creation and should be limited to less than 10% of the total mitigation credits for the project.

Pros and Cons Of this Approach for Ecosystem Crediting: The awarding of credit to protect an existing high quality resource has some useful elements for an ecosystem crediting approach. The requirement to also perform other aquatic resource restoration, creation, or enhancement may or may not limit the utility of this approach and the concept would need additional modification for ecosystem crediting. Some forms of restoration, such as stream restoration sites are not typically directly vulnerable to new extensive new development, but may have permanent access roads and often do involve a loss of existing forest cover. Wetlands and their buffers adjacent to streams may be vulnerable to changes in land use which are adjacent or part of the contributing watershed.

Other factors which would need to be addressed are the extent of protective measures. Ecosystem crediting may need to allow for overlapping protective measures.

Vermont Lake Champlain TMDL

Vermont has an approved TMDL for phosphorus in Lake Champlain. Reductions from streambank erosion are important, but are expected to take many decades to occur, as the restoration strategy depends in part on actions that will facilitate natural stream evolution processes.

Vermont’s implementation plan lists river channel stability as a separate category for implementation, as are other categories for agriculture and stormwater management. Implementation for channel management is projected to be from 2015 – 2036. Another category is prevention of adverse channel modification. Again, the focus is on restoring stream channel equilibrium.

Credit is allowed for conservation/protection:

Restore channel roughness: add wood-vertical connectivity credit, with potential increases over time. Requires monitoring if desire to show change/increase from initial crediting over time.
River corridor easement for lateral connectivity, future vertical connectivity; protection, and buffer.
Protection bylaw or conserve wetlands-protection credit

Plant vegetation in buffer or stabilize streambank-lateral connectivity credit and storage credit
Replacement of bridges and culverts-vertical and longitudinal connectivity credit. May also get storage credit if floodplains re-form or are included in the design of the project.

Calculations begin with estimates for metrics as if the reach were fully functioning. The current condition uses actual metrics and subtracts from the "best" scores. The proposed improvements and resulting projected scores are then calculated for awarded credit.

The following factors are used:

1. Buffer viability and acres
2. Change in incision ratio / connectivity related to channel evolution stage
3. Floodplain acres reconnected
4. Protection

Below for "Vermont Phase I Lake Champlain Phosphorus TMDL Phase I implementation Plan" prepared by State of Vermont for U.S. Environmental Protection Agency. September 2016.

The above document makes the following statement:

"Reducing the need to channelize rivers in attempts to protect encroachments, allows rivers to evolve back and remain in their least erosive, equilibrium condition. Rivers have the energy to perform the work of restoration, with or without human intervention, and therefore, the nutrient load reduction sought through restoration is also achieved through corridor and floodplain protection."

The following summary is from "Standard Operating Procedures for Tracking and Accounting Of Natural Resources Restoration Project." Prepared by Clean Water Initiative Program, Department of Environmental Conservation, Vermont Agency of Natural Resources. June 28, 2022.

For inundation and storage processes, P removal credit is highest in year one, then awarded a lower constant value. Research has suggested that sediment and nutrient storage on the floodplain may be reduced over time. Vermont has used a 50% reduction after year 1 to be conservative in the assumption of amount of reduction of storage benefits over time, and by building this into the project accounting up front there is less need to try and actually monitor that possible reduction over time. Additional research in Vermont is being done to continue to look at amounts and type of sediment and nutrient storage that occurs on floodplains over time.

Credit for restoring channel roughness or large wood addition

May get vertical connectivity credit (aggradation of sediment to restore floodplain function and channel stability which increases over time; are currently given a standard value to use for determining phosphorus credits. If a project is one that an advocate feels may have an increase in sediment/nutrient storage over time, this would require monitoring and data to support changes in potential nutrient credits assigned to the project. Vermont does not currently require individual project monitoring for determining sediment / nutrient credit allocations; all values are determined using the Clean Water Service Provider Phosphorus Calculation tool. Verification monitoring will be done over at least a 10 year period to ensure the project is meeting the criteria for initial credits and if there are needs for maintenance to maintain the condition of the project for sediment/nutrient crediting.

Credit for removing constraints to lateral migration (lateral protection and increasing meanders)

If already connected, removing constraint gets storage credit since there is an expansion of accessible floodplain

Credit for river corridor easement

Lateral connectivity credit even if connected to floodplain. Credit for buffer and protection in this case; if vertical connection anticipated to occur over time can receive P storage credit.

Credit for river corridor by-law and wetland conservation

Credit for lateral connectivity.

Credit for Planting 50 for buffer or stabilizing stream bank; planting along entire corridor

Credit for lateral connectivity and improved storage from re-vegetated area. Credit can be given for areas beyond 50 feet.

Credit for replacing bridges and culverts. Includes bankfull span and steep channels.

Credit for longitudinal and temporal credits. If new downstream deposition results, may receive vertical credit for connection over time for storage credit.

Credit for stabilizing headcuts or gullies in perennial flow reaches

Credit for longitudinal improvement by arresting erosion process; minor vertical connectivity credit.

Credit for removal of ditch and tile drain in wetlands; Stabilize gully from intermittent or ephemeral flow; treat legacy forest trail/road drainage; disconnect municipal or private road ditch

Credit for temporal connectivity in watershed; wetland restoration credit for increased P storage;

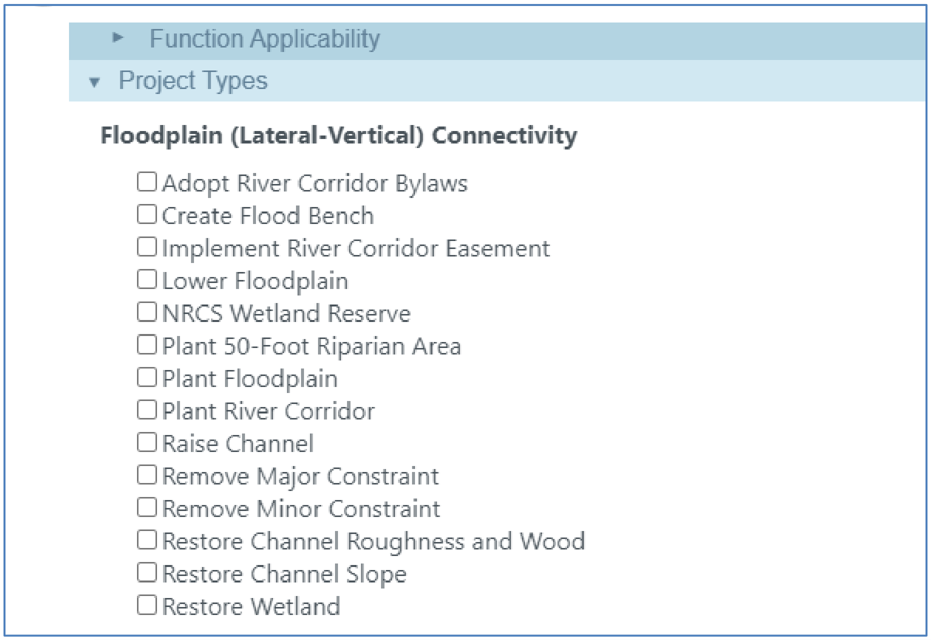
Credit for Removing or re-permitting stream diversions or water withdrawals; or remove groundwater extraction

Credit for improving longitudinal and temporal connectivity

For those that involved direct physical changes, “red-lined” plans are required in first year, then at year 5 evidence of buffer viability and floodplain storage. Some also require evaluation channel evolution and grade control. At year 10, evidence of buffer maturity and potential floodplain storage credit. After year 10, report on all 5 variables above; some also for potential new credits for floodplain function or storage.

Pros and cons: This approach considers a broader system than just an individual reach. Outcomes are designed to achieve an even distribution of transport and depositional reaches. The approach credits for conservation/protection of systems, allows for crediting of natural recovery after monitoring, including changes resulting from replacement of undersized culverts. Placement of large wood in streams may also be credited. However, measurements and calculations may be time consuming and adjustments may be necessary for implementation into the Chesapeake Bay Program crediting system. The concepts and types of practices and conservation measures are worth further consideration.

Project types shown in the FFI web tool below:

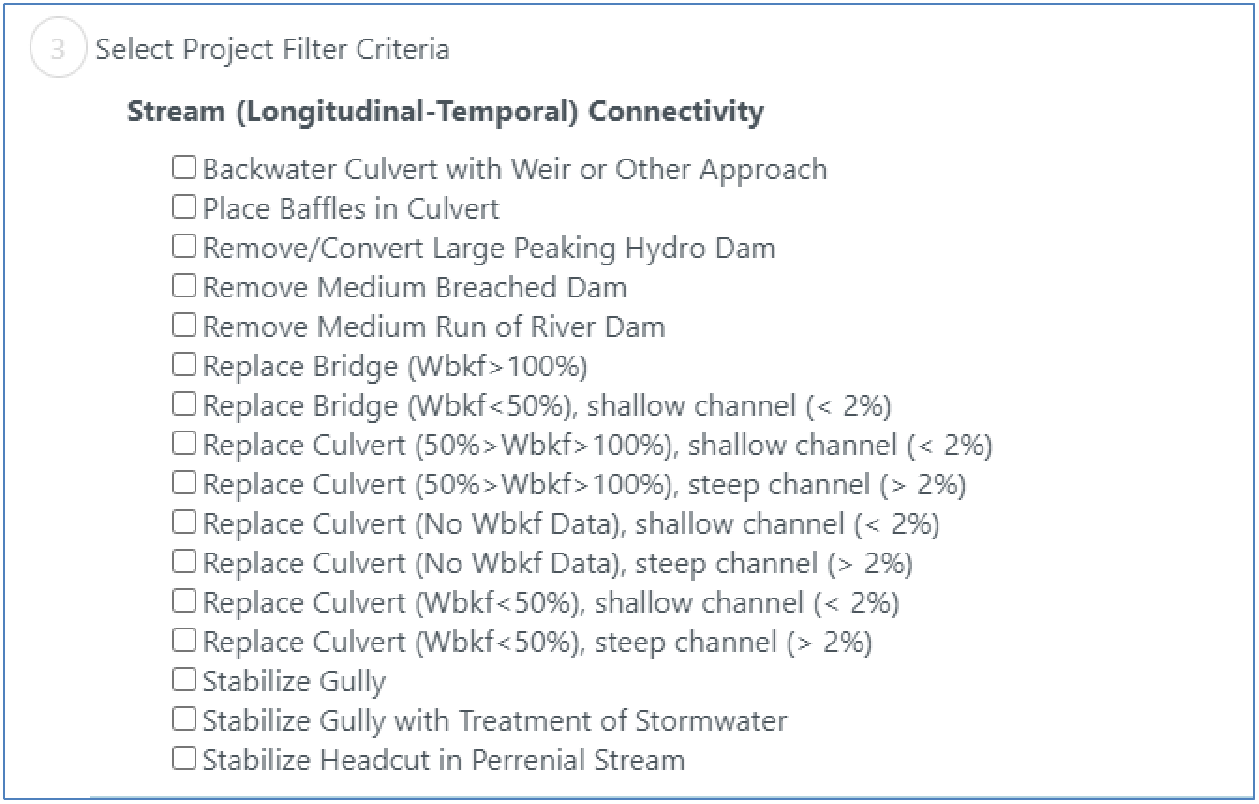


► Function Applicability

▼ Project Types

Floodplain (Lateral-Vertical) Connectivity

- ☐ Adopt River Corridor Bylaws
- ☐ Create Flood Bench
- ☐ Implement River Corridor Easement
- ☐ Lower Floodplain
- ☐ NRCS Wetland Reserve
- ☐ Plant 50-Foot Riparian Area
- ☐ Plant Floodplain
- ☐ Plant River Corridor
- ☐ Raise Channel
- ☐ Remove Major Constraint
- ☐ Remove Minor Constraint
- ☐ Restore Channel Roughness and Wood
- ☐ Restore Channel Slope
- ☐ Restore Wetland



③ Select Project Filter Criteria

Stream (Longitudinal-Temporal) Connectivity

- ☐ Backwater Culvert with Weir or Other Approach
- ☐ Place Baffles in Culvert
- ☐ Remove/Convert Large Peaking Hydro Dam
- ☐ Remove Medium Breached Dam
- ☐ Remove Medium Run of River Dam
- ☐ Replace Bridge (Wbkf>100%)
- ☐ Replace Bridge (Wbkf<50%), shallow channel (< 2%)
- ☐ Replace Culvert (50%>Wbkf>100%), shallow channel (< 2%)
- ☐ Replace Culvert (50%>Wbkf>100%), steep channel (> 2%)
- ☐ Replace Culvert (No Wbkf Data), shallow channel (< 2%)
- ☐ Replace Culvert (No Wbkf Data), steep channel (> 2%)
- ☐ Replace Culvert (Wbkf<50%), shallow channel (< 2%)
- ☐ Replace Culvert (Wbkf<50%), steep channel (> 2%)
- ☐ Stabilize Gully
- ☐ Stabilize Gully with Treatment of Stormwater
- ☐ Stabilize Headcut in Perrenial Stream

References for Ecosystem Examples

Maryland Department of the Environment. 2022a. Components of a Compensatory Mitigation Plan - Guidance for Developing Wetland and Waterway Mitigation in Maryland.

Maryland Department of the Environment. 2022b. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Guidance for National Pollutant Discharge Elimination System Stormwater Permits.

State of Vermont. 2016. Vermont Lake Champlain Phosphorus TMDL Phase I implementation Plan” prepared by State of Vermont for U.S. Environmental Protection Agency.

Vermont Agency of Natural Resources. Standard Operating Procedures for Tracking and Accounting Of Natural Resources Restoration Project.2022.

Vermont Dept. of Conservation. Personal communication 8/22/2022, 8/23/2022, 8/30/2022, 9/22/2022, 10/31/2022, 11/3/2022.

Appendix E: Breakout Questions

After hearing from the presenters on opportunities to incentivize habitat benefits in relation to TMDL and water quality outcomes, and that are part of Chesapeake Bay Agreement commitments; and the efficacy of a more holistic “systems approach” to BMP accounting, in-person and virtual participants met in breakout groups and answered the discussion questions listed below. Breakout questions were predetermined by the steering committee.

Discussion Question(s): Why are we getting these outcomes?

1. How have historical and present conditions been incorporated into restoration goals and approaches?

2. What regulatory/policy drivers led to different goals and approaches?

3. What are the stressors that led to stream impairment and to what degree have stream restoration approaches addressed them?

4. Has the monitoring of outcomes been effective and sufficient, including biotic uplift?

5. When outcomes have been successful, why were they successful? What has worked?

6. What do we do differently to get better outcomes?

Appendix F: Co-Benefit Matrix

Matrix on the following two pages.

Co-Benefits											
Habitat			**Flood**			**Socio-eco**			**Water Quality/ Quantity**		
Factor	**Data Source**	**Relevant CBP Group**	**Factor**	**Data Source**	**Relevant CBP Group**	**Factor**	**Data Source**	**Relevant CBP Group**	**Factor**	**Data Source**	**Relevant CBP Group**
RTE Species/ At Risk	https://dnr.maryland.gov/wildlife/Pages/plants_wildlife/rte/rteanimals.aspx, Virginia DCR		FEMA SFHA	FEMA NFIP		Accessible	Option- use state data on public lands		Erosion abatement		
Brook Trout			SFHA 0.1. and 0. 02	https://gis.chesapeakebay.net/wip/dashboard/		Demonstration			Load reduction	BMP Panels	
Black Duck			Flood benefits	Mapped for Virginia on Adaptva.com		Recreation	State Outdoors Plans		Nutrient/ sediment efficiencies	BMP Panels	
Connectivity: increasing corridors, enlarging existing features, filling in gaps	https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/		CRS Open Space	Where NWI or Virginia TMI intersect undeveloped landuses		Social Vulnerability	https://chesapeake-deij2-chesbay.hub.arcgis.com/		Legacy Sediment	https://www2.usgs.gov/water/southatlantic/projects/floodplains/; https://www.sciencebase.gov/catalog/item/5cae39c3e4b0c3b00654cf57	
Continuity: Re-connection to floodplain	https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/ https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/					Tribal Value			Residence Time	SCHISM	
Rarity/percent landuse (i.e. wetlands in urban landscapes)	https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/					Blue Carbon			Streamflow	https://sparrow.wim.usgs.gov/sparrow-northeast-2012/	
Complexity	different habitat types								OutFall	https://watershedresourcesregistry.org/	
Priority/Plan	State WIP3								Chemical/ Toxics	https://gis.chesapeakebay.net/wip/dashboard/	
SAV									TMDL waters	State data, WetCAT (Virginia)	

Co-Benefits											
Habitat			**Water Quality/ Quantity**			**Socio-eco**			**Water Quality/ Quantity**		
Fish nursery/refugia									Surface water - ground water exchange		
Plant community	Conserve Virginia								Slope/terrain/aspect/topography	Readily computed from digital elevation models in GIS	
Non-native species	https://nas.er.usgs.gov/viewer/omap.aspx										
Impervious surfaces and roads	https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/										
Historic land use change	https://www.usgs.gov/special-topics/lcmap/collection-12-conus-science-products										
Future predicted temperature and precipitation	https://www.sciencebase.gov/catalog/item/5cf6b2fbe4b0d63728b9b412										

Appendix G: Interactive Whiteboard Responses

Day 1:

1. How do landscape interactions influence ecosystem services around wetlands?
    a. the term ‘restoration potential’ comes to mind to track when outside factors continue to play a role in target ecosystem function
    b. I am not sure how landscape can be left out especially when considering wetlands in ag and urban areas
2. How would we account for landscape factors that influence ecosystem services?
    a. hyper res hydrography, hi res LU/LC, GIS
3. How do we account for things other than water quality (‘accounting system’)?
    a. grouped by CBP outcomes and goals?
    b. indicator species response?
    c. Agree w/ focus on CBP outcomes and goals. Consider prioritizing based on community wants/needs?
    d. Are there good indicator species that respond at the scale of these projects? It seems to me birds might be affected by way more landscape than any individual project
    e. diamondback terrapin use of the shoreline or ‘beach’
    f. start with a simpler ‘system’ (probably not NEIEN)
    g. Is there a push for a monetary accounting system? Do we have a sense of that at all?
4. How do we track unintended consequences?
    a. allow for the possibility of positive and negative consequences
    b. it would be great to use CAST but not what it was intended for.. dare I say we need a new different system to calculate +/- consequences
    c. specifically related to ecosystem services? Then I would say we need to monitor the proposed metrics used to quantify those as BMPs are implemented
    d. Are ‘unintended consequences’ results that were unknown before restoration or negative effects of restoration?
    e. An interactive approach could help in identifying the negative ones (or even the positive unintended consequences) and work that information to move forward in the same of alternative direction
    f. applicable as both ‘iterative’ and ‘interactive’
5. What habitat services should receive extra credit if they are improved or restored?
    a. Is climate sequestration considered a habitat benefit since it mitigated for future climate impacts? If so, that’s one that should get extra credit
6. What other services should receive extra credit if they are improved or restored?
    a. carbon sequestration

Day 2:

1. What habitat services should receive extra credit if they are improved or restored?
    a. BMP credits for SAV...if SAV also got credits/was a BMP there would be more incentive to maintain/protect/restore SAV either independently or in combo with shoreline projects that might impact SAV

2. What other services should receive extra credit if they are improved or restored?
    a. consider using UN millennial goal framework
3. Where and how could an improved systems approach to accounting/incentive/framework protocol be applied?
    a. ladder, pay people adequately, build trust with landowners
    b. State implementation Plans for milestones, more details to either restore or protect swatches of wetlands
    c. NRCS and Soil and Water communications
    d. NFWF project review
    e. Accountability for WIP commitment wetland projects
    f. Checklist for funders
    g. Template for funder
    h. habitats, can we enhance TMDL crediting for conserving existing habitat? It was mentioned earlier today that creating habitat was worth more TMDL-worse than preserving habitat. We should change that
    i. Consider all wetland actions not just WQ BMPs
    j. Consider peer pressure-case studies
    k. the floodplain restoration via reconnection in the wetland goals, because we've been implementing most of this work under ACEP-WRE, rather than under stream restoration programs.
    l. NRCS CPPE and CART
    m. CBP sets priorities for management actions to achieve multiple outcomes to promote greatest ES (Nature based solutions)
    n. Greater participation in WWG
    o. Build in capacity to address futures
    p. Better outreach/communication to the public for wetlands (e.g. dollars, habitat?), have to have a 'reason'
    q. BMP credits for SAV...if SAV also got credits/was a BMP there would be more incentive to maintain/protect/restore SAV either independently or in combo with shoreline projects that might impact SAV

Appendix H: List of Figures

Appendix I: List of Tables