Quantifying Ecosystem Services and Co-Benefits of Nutrient and Sediment Pollutant Reducing BMPs

STAC Workshop Report
March 29-30, 2017
Annapolis, MD

STAC Publication 17-008

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 www.chesapeake.org/stac.

Workshop Steering Committee

Beth McGee
Director of Science & Agricultural Policy
Chesapeake Bay Foundation

Mark Bryer
Director, Chesapeake Bay Program
The Nature Conservancy

Rich Batiuk
Associate Director for Science, Analysis and
Implementation
U.S. EPA Chesapeake Bay Program Office

James Davis-Martin
Chesapeake Bay Coordinator
Virginia Department of Environmental
Quality

Jennifer Greiner
Habitat Goal Team Coordinator
U.S. Fish and Wildlife Service (USFWS)

Steve Newbold
U.S. Environmental Protection Agency

Lisa Wainger
Professor, University of Maryland Center
for Environmental Science – Chesapeake
Biological Lab

Kristin Saunders
Chesapeake Bay Program Cross Program
Coordinator, University of Maryland Center
for Environmental Sciences

Scott Phillips
Chesapeake Bay Coordinator
U.S. Geological Survey (USGS)

Rachel Dixon
Scientific and Technical Advisory
Committee Coordinator
Chesapeake Research Consortium

Table of Contents

Executive Summary

On March 29-30, 2017, approximately 50 people representing a range of interests and perspectives met in Annapolis, MD for the *Quantifying Ecosystem Services and Co-Benefits of Nutrient and Sediment Pollutant Reducing BMPs* STAC workshop. The purpose was to identify the "ecosystem service" benefits of implementing best management practices (BMPs) designed to improve water quality and discuss how they could be integrated into existing decision-making tools. Another desired outcome was a shared understanding by workshop participants of the opportunities for, and constraints on, quantifying these benefits. This underlying premise proposes that if local decision makers better understand additional benefits of BMPs they are already working to implement for water quality improvement—benefits such as flood risk reduction, air pollution treatment, and enhanced recreational opportunities—they may be able to better coordinate their investments and meet multiple objectives for their communities.

The presentations and discussions during the two-day workshop demonstrated that the identification, quantification, and valuation of ecosystem service benefits are distinct, but related, activities. That is, benefits must be identified before they can be quantified, and quantified before they can be valued. Furthermore, each of these three separate activities—identification, quantification, and valuation—can be useful for local decision makers, depending on the context. Just understanding that an additional benefit to a management action exists, and is positive, may be enough for some decisions/decision makers, while others may want a more rigorous quantification or determination of value. For example, knowing that a wetland may reduce local flooding and provide downstream water quality may be helpful for some to know, whereas others would like quantified benefits for both.

Another insight coming from the workshop is that benefits accruing from a particular action often vary locally and geographically, therefore, scale and location are important. For example, benefits of carbon sequestration are global whereas flood protection benefits would be very site specific.

Presentations by recognized experts highlighted existing tools/quantification approaches that could, with additional effort, be leveraged by the Chesapeake Bay Program (CBP) Partnership. These approaches included: estimating benefits of green infrastructure practices in the Chesapeake Bay watershed, the social cost of carbon to quantify and monetize benefits of reducing greenhouse gases, and the i-Tree tool that can be used to quantify benefits of trees on air pollutant treatment and soon will be modified to include reduced heat related illnesses.

Through a workshop participant voting process, the following five benefits were identified as the recommended highest priority benefits on which the Partnership should focus future actions on:

- Ecosystem sustainability: benefits to fish and other aquatic resources in local streams and rivers
- Hazard mitigation: flood, drought and fire risk reduction
- Recreation and aesthetics: hunting, fishing, swimming, boating, nature watching, outdoor education
- Drinking water: improvements to both quantity and quality
- Human health: improved air quality, reduced heat related illnesses, fewer water borne illnesses

There were five key findings/observations heard multiple times throughout the workshop which should directly influence Partnership decisions on the next steps in this process:

- Uncertainty is okay, just be upfront about it and clearly communicate about it.
- The location of the BMP will have direct implications in terms of the quantification and valuation of its benefits.
- We need to simplify our language and be clear on definitions of benefits.
- Level of quantification/valuation needed for the BMP benefits depends on the user.
- Keep focused on what local elected officials are concerned about.

The following recommendations came from the workshop participants' discussions on the second day of the workshop, benefitting from the presentations and two rounds of breakout groups:

Recommendation 1: Pick the low hanging fruit and move forward. The CBP Partnership should build upon the Tetra Tech report[1], an evaluation of effects of BMP implementation on each of the CBP's management strategies, capturing both benefits and unintended consequences, if applicable, for each BMP. The product was a matrix that cross-walked the full list of CBP-approved BMPs with our current best understanding of additional benefits. This information could be made more accessible and user-friendly, possibly by incorporating results directly into the CBP Partnership's Chesapeake Assessment and Scenario Tool (CAST) so that it could support short-term decisions and be used to prioritize further work on quantification of benefits besides water quality (see Recommendation 2 below).

Recommendation 2: Pursue efforts for more quantification. For a clearly defined subset of practices and their respective benefits, the workshop participants recommended assembling the appropriate experts to examine methods to quantify additional benefits. The outcome would be a proposed framework and approach by which the quantification of these and other future

---

[1] "Estimation of BMP Impact on Chesapeake Bay Program Management Strategies". Accessed here: http://www.chesapeake.org/stac/presentations/274_TetraTech_BMPImpactScoringReport_20170428.pdf

identified benefits from implementation of the BMPs could be measured and incorporated into Partnership's CAST tool. Sources of funding and mechanisms for soliciting research should be considered simultaneously to promote likelihood of future action. An RFP and funding to initiate and sustain this effort should be pursued.

Recommendation 3: <u>Keep the CBP approval process for benefits simple</u>. Having a formal CBP process for approval of new additional benefits from Partnership approved BMPs adds visibility, transparency, and confidence to the resultant use and application of these additional benefits by the partnership and individual partners. However, we don't need the same level of effort nor the same level of scrutiny, review and decision making as we have in place with the Partnership's BMP expert panels operating under the CBP BMP Protocol. Therefore, based on the BMPs, the respective lead Goal Implementation Team will be responsible approving new additional BMP benefits prior to them being added to the CBP partnership's BMP benefits matrix.

Recommendation 4: <u>Seek input from broader set of stakeholders</u>. Though attempts were made to include a diversity of stakeholders at the workshop, the participants still recognized that representation was incomplete. Therefore, additional targeted outreach efforts, listening sessions or focus groups to solicit broader input should be initiated. Specifically, input from a broader array of stakeholders on the following is needed:

- What specific ecosystem services/additional benefits are of the most importance/relevance to them;
- Their recommendations for a more understandable set of terminology to be adopted and used by the Partnership; and
- Feedback on the relative importance of identification versus quantification versus valuation across the range of priority benefits.

Recommendation 5: <u>Factor existing understanding of additional benefits into Partnership's documents.</u> At the request of the CBP Partnership, Virginia Tech is drafting summary narrative and graphical descriptions of logical groupings of the hundreds of CBP-approved BMPs within a larger *CBP Quick Reference Guide to BMPs* to be published in 2018. For those BMPs for which CBP Goal Implementation Teams have already identified additional benefits beyond nutrient and sediment pollutant load reductions, we would add short narrative descriptions of those additional benefits within the forthcoming *CBP Quick Reference Guide to BMPs*.

Introduction

This report summarizes a two-day STAC workshop held on March 29-30, 2017 at the Crowne Plaza Hotel in Annapolis, Maryland. The purpose of the workshop was to identify the "ecosystem service" benefits of implementing best management practices (BMPs) designed to improve water quality and discuss how they could be integrated into existing Chesapeake Bay Program (CBP) Partnership decision-making tools (see **Appendix A** for the workshop agenda). Another desired outcome was a shared understanding by workshop participants of the opportunities for, and constraints on, quantifying these benefits. The underlying premise is that if local decision makers better understand additional benefits of BMPs they are already working to implement for water quality improvements—benefits such as flood risk reduction, air pollution treatment, and enhanced recreational opportunities—they may be able to better coordinate their investments and meet multiple objectives for their communities. The workshop was attended by approximately 50 people representing a diverse range of interests and perspectives, including economists, ecologists, state and federal agency representatives, local government officials, and non-profit environmental organizations (see **Appendix B** for the full list of workshop participants).

The specific workshop objectives were:

1. A shared understanding by workshop participants of the opportunities for, and constraints on, quantifying and valuing ecosystem services and additional benefits associated with water quality improvement-focused BMPs.

2. A list of ecosystem services and other additional benefits and the associated BMPs for which quantification is a priority.
    o   A subset of these priority ecosystem services/additional benefits and the associated BMPs that are "ready to go"—data/analyses exist to support quantification—and next steps for how to incorporate these into existing Partnership management tools (e.g., CAST).
    o   A subset of these priority ecosystem services/additional benefits and associated BMPs for which data gaps exist along with a prioritized list of next steps to be taken to close these data gaps.

3. A framework for a collaborative institutional system (structure, procedures and governance) needed to sustain continued quantification of ecosystem services and collateral benefits resulting in Partnership review and approval.

4. A plan and schedule for implementation of the workshop's recommendations.

Workshop Summary

What are Ecosystem Services?

The workshop began with a "Wordle Poll" of attendees' answers to the question: What does the term "ecosystem services" mean to you? Common responses (see report cover graphic) included words such as: benefits, nature, natural, people, society, humans, ecosystem, functions, value, flows. From the ensuing discussion, we quickly learned that participants defined the term "ecosystem services" very differently. In fact, one response to the question was: "depends on who is defining." Some participants suggested that the term "bonus benefits" might be less confusing in this context, but still there is an obvious need for understandable definitions and clear communication on what is meant by this term.

> *The most common definition of ecosystem services broadly defines the term as "the benefits gained by humans from ecosystems."*
> *- Millennium Ecosystem Assessment*

Dr. Lisa Wainger, UMCES and Chair of the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC), set the stage for the rest of the workshop with her presentation entitled "Setting the Context: Ecosystem Service Analysis." Wainger emphasized that economic value is anything that contributes to human well-being, including "use values" and "non-use" values.

Case Studies

A few experts provided a series of case study presentations to give context for how ecosystem services and other additional benefits can be identified, quantified, and valued and the challenges therein. Three recognized experts in their respective fields, illustrated real working examples of ecosystem services:

- Carbon Sequestration from Forests - *Kate Zook (USDA)*
- Methodology to Quantify Heat-Related Health Effects Due to Tree Cover - *Paramita Sinha (RTI)*
- Pollinator Habitat Valuation **-** *Dan Hellerstein (USDA-ERS)*

Narrative summaries of and links to these workshop presentations can be found in **Appendix C**. Collectively, these four presentations demonstrated that the identification, quantification, and valuation of ecosystem service benefits are distinct, but related, activities. That is, benefits must be identified before they can be quantified, and quantified before they can be valued. For example, one "bonus benefit" of urban trees is the cooling effect that shade provides. One could estimate the reductions in air temperature due to urban tree canopy, quantify the resulting

reductions in heat related illnesses, then monetize or value these health related benefits. Furthermore, each of these three activities—identification, quantification and valuation—can be useful for decision making, depending on the context. Simply understanding that an additional benefit to a management action exists, and is positive, may be enough for some decisions/ decision makers while others may want a more rigorous quantification or even determination of the actual value.

Another insight from the case studies was that benefits accruing from a particular action often vary locally and geographically, therefore, scale and location are important. For example, benefits of carbon sequestration are global whereas flood protection benefits would be very site specific. In the CBP Partnership, we are dealing with both upstream—the overall watershed and its rivers and streams that contribute to the Chesapeake Bay—and downstream—the Bay's tidal waters—ecosystems. Therefore, the ecosystem service types and beneficiaries vary by location.

These case study presentations highlighted existing tools/quantification approaches that could, with some additional effort, be used by the CBP partnership. These included the approaches used by Wainger et al. (2013) for estimating benefits of green infrastructure practices in the Chesapeake Bay watershed,[2] the social cost of carbon to quantify and monetize benefits of reducing greenhouse gases,[3] and the i-Tree tool[4] that can be used to quantify benefits of trees on air pollutant treatment. The i-Tree tool will soon be modified to include reduced heat related illnesses.

Cross Walk of BMPs and Chesapeake Watershed Agreement Commitments
To narrow down the list of BMPs and possible additional benefits that would be considered by workshop participants, the Workshop Steering Committee used a recent evaluation by Tetra Tech funded through the Partnership's Goal Implementation Team (GIT) project funding. The evaluation analyzed the effects of the implementation of BMPs on each of the CBP's management strategies, capturing both benefits and unintended consequences, if applicable, for each BMP. The evaluation produced a matrix that assigned an impact score to each BMP (or BMP group) for each management strategy or outcome. The scores range from 5 to negative 5, with a score of zero indicating the BMP has no impact on the management strategy[5]. Using this matrix as a starting point, the Workshop Steering Committee developed a *simplified* matrix with a shortened list of practices providing the most benefits and categories of benefits typically used in ecosystem service studies (see the narrowed down matrix in **Appendix D, Table 1**).

---

[2] Wainger, et al. 2013. Accessed here:
http://ageconsearch.tind.io//bitstream/148408/2/ARER%202013%2042x1%20WaingerEtal.pdf
[3] http://www.cfare.org/UserFiles/file/Chapter3-EstimatedValuesofCarbonSequestrationResultingfromForestManagementPolicyScenarios_v1.pdf
[4] http://www.itreetools.org/
[5] URL Link to final impact scores accessible here: http://www.chesapeake.org/stac/workshop.php?activity_id=274

Prioritizing Practices and Benefits

Workshop participants were separated into two breakout groups, based on background and expertise: "ecologists/economists" and "policy/implementation representatives." Each group was asked to review the shortened list of BMPs and associated additional benefits noted above.

The ecologists/economists' breakout group was asked to focus on the current state of the science: where are there well known and established links between BMP implementation and these benefits and where are there gaps in the needed information? This breakout group also worked to answer the following questions:

- Which ecosystem services/additional benefits and associated BMPs are essentially "ready to go" in terms of management application?
- What additional work, if any, would be needed to directly incorporate these quantified services/benefits into the Chesapeake Bay Program partnership suite of decision support tools? Who is best suited to do this work and who could fund it?
- What are the recognized limitations/uncertainties of the sub-set of quantified services/benefits?
- Which ecosystem services/additional benefits have just a few data gaps?
- What are those data gaps and what steps could the Chesapeake Bay Program Partnership take to address them?
- What scales of analysis are most feasible?
- Which benefit estimates are likely to have the lowest error (e.g., because causal chains between actions and benefits are shorter)?

The policy/implementation representatives' breakout group was asked to focus on what's missing and their priorities as they also considered answers to the following questions:

- What important ecosystem services/additional benefits or BMPs are missing from the current matrix?
- How does one envision information about these ecosystem service benefits being used in decision making?
- By high, medium and low categories, what is the relative priority you would place on the list of ecosystem services and associated BMPs?
- For the high priority ecosystem service benefit categories: How important is it for these benefits be expressed quantitatively vs. qualitatively? How important is it for those benefits to be monetized (i.e., expressed in terms of dollars) so that one can compare/contrast across different benefit categories? (e.g., tons of carbon sequestered versus $ value of carbon sequestered that can then be compared to other monetized benefits).

- What is the desired level of certainty about the ecosystem service benefits needed for decision-making? Does this vary depending on the situation?

Summaries of the breakout group's discussion and evaluations of the original twelve ecosystem services are documented in facilitator Lara Fowler's day two presentation which summarizes the discussions during day one of the workshop (see **Appendix C** for a link to the presentation). The twelve ecosystem services discussed were:

- Drinking water (water supply/regulation)
- Wastewater/bacteria/water purifications
- Hazard mitigation (flooding)
- Recreation
- Spiritual, cultural, education
- Aesthetics
- Food production
- Local air quality
- Climate/carbon sequestration/global air quality
- Energy production and efficiency
- Health
- Ecosystem sustainability (biodiversity, habitat)

The breakout group exercise illuminated confusion over terminology, uncertainty about the target audience(s) and drivers for decision-making. That said, the workshop participants did make progress on prioritizing practices and bonus benefits. Through "dot voting" on day two of the workshop, the initial list of twelve additional benefits was reduced to five which, in turn, were identified as priorities by workshop participants.

Top Five Priority Additional Benefits
On the second day of the workshop, the breakout groups were organized by the top five priority additional benefits identified during the first day. The following summarizes the discussions during each of breakout groups.

Water Supply and Regulation
Participants prioritized practices that provide the benefit of clean and abundant drinking water supply. Practices, such as afforestation, forest conservation, forest buffers, and urban infiltration practices, can affect both water quantity and water quality. Practices such as nutrient management that directly reduce or prevent nitrate from leaching into groundwater or flowing overland into local streams and rivers also provide this benefit.

There are examples of valuation of this benefit, one of the best being New York City protecting forests in the Catskill Mountains to avoid costs associated with drinking water treatment.[6] There are some existing tools that can help quantify these benefits, including models that can estimate pollutant removal of sediments or volume of infiltration and valuation approaches to estimate costs to treat drinking water and, therefore, cost avoidance/savings. Complexities include: some BMPs are additive and some are multiplicative; these benefits would be relatively "local"; and there could be a "mismatch" between the location where the practice is implemented and where the benefits of reduced costs to treat drinking water are gained.

Hazard mitigation

Practices that help reduce the impacts of natural hazards such as flooding, drought, and fire were identified as one of the top priorities, although the focus of the workshop discussions was on reduced inland flooding and coastal flooding. Practices that provide these benefits include anything that allows infiltration and retention of water e.g., afforestation, forests, buffers and urban stormwater BMPs (e.g., green infrastructure) as well as practices that would increase the distance between flooding and human habitats e.g., buffers, wetlands, and living shorelines.

Quantification of inland flooding benefits can include estimates of storage volume of water, particularly in urban areas. Participants noted the INVEST model might be able to estimate flood retention ability e.g., via metrics of water storage and infiltration. The Federal Emergency Management Agency (FEMA) has tools to value infrastructure in flood plains e.g., through crop loss claims and flood claims. A challenge is that benefits of flood reduction do not necessarily accrue in the same areas as where implementation occurs, so it is important to consider geographical location and impact on who may be implementing the practice versus who may be benefiting from it.

For coastal flooding, studies in New England and Jamaica Bay, New York were cited as attempts to quantify benefits of coastal wetlands, as well as work on the Gulf Coast evaluating their effectiveness. Benefits can be quantified through estimates of wave reduction and changes in the likelihood or degree of flooding in local areas (e.g., number of houses affected). Valuation can include changes in insurance premiums (e.g., communities that set aside green space can qualify for lower premiums through the National Flood Insurance Program). Valuation can also be made in terms of avoided flood damages: a recent study showed that coastal wetlands avoided $625 Million in direct flood damages during Hurricane Sandy (Barbier et al. 2013; Narayan et al. 2017). Unlike riverine flooding, where implementation may be geographically separate from those that benefit, there is a more direct locational connection for coastal flooding. In terms of linking practices to benefits, quantifying and valuing them, more is known about coastal flooding than riverine flooding.

---

[6] https://www.nrdc.org/experts/eric-goldstein/decision-time-nycs-upstate-drinking-water-supply.

Ecosystem sustainability
Different people in the breakout groups were allowed to make their own interpretation of "ecosystem sustainability". Some viewed it in terms of the intrinsic value of biodiversity and habitats. For others, it represented the link to the biotic health of local waterways and streams. This benefit was ranked as a high priority by the policy/implementation break-out group, in part, because of the link to upstream waters and habitats. In this context, all BMPs would have benefits, as water quality is linked to improved stream habitats and diversity. It is possible to quantify stream health via biotic stream surveys. However, quantification will be challenging as the link between BMP implementation, reduced pollution and biotic responses in terms of healthier and more diverse aquatic communities is complicated and influenced by many factors.

Recreation
Workshop participants prioritized benefits to recreation from the implementation of practices intended to improve water quality. As discussed, recreation included: fishing, hunting, swimming, boating, nature watching, canoeing, and kayaking. Participants agreed that benefits accrue to both land and water-based recreation, and that quantification of these benefits is possible for some areas. Recreation demand models are useful and available, but additional work is needed to relate the amount of a particular BMP implemented to changes in site quality that would yield additional recreational opportunities. Valuation can be estimated using a "willingness to pay" approach that incorporates the number of visits to a recreation site and the cost per visit. Location considerations are important, include urban and rural settings, and proximity of access points on both public and private lands provide important data for modeling. For example, site distance (e.g., from an access point) and quality (e.g., aesthetics, abundance of fish, water clarity) are important factors in quantification of benefits.

Quantification opportunities are similar to those described previously for water-based recreation, but data to show site-specific benefits are lacking. The breakout group noted that further investigation is needed to define the relationship between urban BMPs and aesthetics/home values, to differentiate conditions under which substantial benefits are produced.

Human Health Support
Workshop participants also identified benefits to human health as a priority, but they were unable to further this discussion in a break-out group. These benefits could include improved air quality that would lead to less illness, especially in urban areas; reduced heat-related illnesses due to more urban trees and associated shading and reduced ambient temperatures; safer places to swim and fewer water-borne illnesses. One recommendation of the workshop is to vet this list of priority services to a broader variety of stakeholders to obtain more specific information regarding stakeholder priorities around human health outcomes.

Other Key Findings/Messages Coming from the Breakout Groups' Discussions:

- Need to clearly communicate what is meant by "ecosystem services"
- It was largely agreed that the BMPs on the list have known ecological and societal benefits, but placing them within a quantification/valuation framework would be difficult
- There was a perceived disconnect between the presumed "positive" benefits of the ecological services provided by the BMPs and hard-and-fast nutrient/sediment pollutant load reduction values of the different BMPs
- It would be easier to quantify and value certain ecological services, such as carbon sequestration, habitat impacts and flooding, whereas services such as cultural, spiritual and educational values would be extremely difficult to quantify
- Participants struggled with assessing the certainty and credibility threshold of the currently available models/data and how useful that potentially uncertain data would be to evaluating the causal chains between actions and benefits and the values of those benefits
- It would be useful to get the stakeholder perspective regarding which ecological services and/or BMPs they value most, as a tool for evaluating where future studies, models and data should be developed, and how they would re-define different terminology throughout this process
- The second breakout group of ecologists/economists spent a lot of time looking at the matrix and denoting BMPs and ecological services that they felt could be quantified and valued at the present time
- Need a clear definition of the audience for the outcomes from this workshop
- It's going to take more than one BMP to achieve some of these ecosystem services like ecosystem sustainability—participants struggled with quantifying ecosystem services without seeing them as a suite of BMPs
- Participants raised the question about how to quantify the loss of an ecosystem service as also being important to consider
- Building on the discussion of single practices versus systems of practices–to estimate cumulative effects on a larger scale is a challenge because of the impact of additive benefits and trade-offs
- Need more detailed information on quantifying the specific co-benefits of taking these specific actions, not a general set of messages from implementing these BMPs leading to these generic co-benefits
- Need a matrix that cross walks the list of CBP-approved BMPs with the best understanding of co-benefits at this time, leading to further work on quantification of the co-benefits

Several workshop participants expressed the importance of understanding benefits like economic development and job creation associated with implementing BMPs. These types of economic impact indicators, unfortunately, were not within the scope of this workshop. Also not addressed

yet is avoided costs–for example, many practices implemented to reduce nutrient and sediment pollutant loads also reduce flooding or provide drinking-water treatment. Therefore, by implementing practices, other costs can be avoided.

Missing BMPs

During the breakout group discussions, the following BMPs were cited as missing from the larger matrix presented to the workshop participants:

- Land use management/land use ordinance related best management practices
- Land conservation and preservation (beyond just a focus on restoration)
- Services targeted to avoiding future nutrients - nutrient management and manure storage
- Reforestation (tree planting)
- Cover crops, or conversion to pasture/carbon sequestration
- No-till or conservation tillage
- Oyster restoration

Framework for a Common Valuation System

Over the past two decades, the CBP Partnership has had significant success in developing and formally approving over 400 different BMPs with underlying definitions, nutrient and sediment reduction efficiencies, and agreement on how each BMP will be tracked, verified, reported and then credited as well as costs, including up-front capital investments and costs for continued operation and maintenance. The ecosystem services addressed have been mainly focused on water quality. The overall question for discussion here was what does the framework for supporting identification/ quantification/ valuation of ecosystem services/additional benefits beyond this workshop look like. The following are the key points made during discussion of the need for a common valuation system, based on asking for feedback from every workshop participant before going into a general discussion:

- Work first to gain acceptance of the matrix as a tool to be used by the Partnership and then build from there—keep it simple as we don't want to over complicate the process
- Assume that the same level of scrutiny is not necessary as with other BMP expert panels
- Build off the Tetra Tech matrix as it has already been reviewed by different committees within the Partnership
    - Work to make it more user-friendly, more graphically oriented
    - Realistically, have it in place to support development of the jurisdictions' Phase III Watershed Implementation Plans (winter 2017-2018)
    - Focus on big picture usage—more detailed quantification will be difficult on this timeline
    - But don't stop there – A move towards more quantification or even valuation of BMPs in regards to local benefits should be the goal.

- Focus on a couple of practices first, then go deeper–look at a couple BMPs and work to better visualize/quantify a range of benefits rather than working across the benefits back towards the BMPs
- Select some practices with well recognized existing supporting quantification and valuation assessment tools and use them to help develop a longer term process for the Partnership
- Need to decide whether to go forward with individual BMPs or groups of BMPs
- Don't need to set up a parallel expert panel process for benefits—build from the matrix developed by Tetra Tech
  - Continue to add new information over time, relying on the existing Goal Implementation Teams to oversee that updating process and approving future updated versions of the matrix when needed
- Work to forge a stronger connection with the 2014 *Chesapeake Bay Watershed Agreement's* goals and outcomes
- Keep it simple so that our local partners can message easily with their constituents.
- "Conserving natural benefits" might be a different nomenclature that the Partnership should adopt in place of "ecosystem services"

Based on these discussions, participants reached agreement on the following points on the framework for a common valuation system:

- There is a need for a framework within the CBP partnership for accepting/ approving newly identified additional benefits.
- Having a formal CBP approval process for these new additional benefits adds visibility, transparency, and confidence to the resultant additional benefits.
- The responsibility for accepting and approving the addition of new BMPs and corresponding benefits should continue to reside with the respective Goal Implementation Teams.
- There is a need to work deeper into a small set of additional benefits and prove what can be done by the Partnership before we go forward with a larger scale effort directed towards further quantification and valuation of benefits.
- Need to more fully consider the local needs and specific geographies to prioritize the co-benefits to focus on.
- Map out the interconnections between a select set of BMPs and a select set of additional benefits all the way to the end for a series of working examples to build from.
- There are clearly opportunities for bringing in others with expertise in economics and other social sciences to help in this process to support the work of the Goal Implementation Teams.
- Begin with the Tetra Tech derived matrix developed working with the Partnership's various Goal Implementation Teams. This will ensure there is something in place for the

jurisdictions to start using to support development of their Phase III Watershed Implementation Plans in the winter of 2017.

Workshop Findings

During the break-out sessions and ensuing discussion, there were a number of important observations that will influence next steps in this process. Summarized below are key findings the Workshop Steering Committee members heard several times throughout the workshop, during the breakout groups as well as during discussions with all workshop participants.

Uncertainty is okay, just be upfront about it. It's okay if our estimates about benefits are uncertain if we provide a way to represent and convey that uncertainty in all the communications about achieving these additional benefits.

Location, location, location. For many of the additional benefits, the impact will be at the local scale, therefore, somehow incorporating more local specificity into the decision-making tools and more quantification of the connection between the amount of benefit and the location of the practice may be important. There seems to be a clear distinction between upstream, Bay watershed versus tidal areas as well as rural versus urban areas in terms of quantification and valuation of benefits.

Need to simplify our language and be clear on definitions of benefits. Given the opportunity for the identification of a multitude of additional benefits from the implementation of practices originally designated for nutrient and sediment pollutant load reductions, clear communication as to what benefits are derived from which practices is essential. Agreement on a set of shared terms, each with clearly defined meanings, for use in future communications is also critical.

Level of quantification/valuation needed depends on the user. For some audiences/potential users of this information, simply knowing that there is a positive or negative relationship with an additional benefit of interest is sufficient for decision-making e.g., something analogous to the narrowed-down Tetra Tech matrix (see **Appendix D, Table 1**). For others, a more refined quantification of benefits is desired e.g., flood mitigation in Washington, D.C. or a specific cost valuation of the resultant flood damage avoided. In this context, the ability to discriminate among BMPs in a quantitative way was of interest, but most workshop attendees did not express a strong interest in or need for valuation of benefits.

Keep focused on what local elected officials are concerned about. A recent report by Ecologix requested by the CBP's Local Leadership Workgroup[7] identified the top three priorities for local officials – public safety, infrastructure and economic development. Economic development and job creation should be considered additional benefits along with ecosystem services and other natural benefits.

Recommendations

Recommendation 1
Pick the low hanging fruit and move forward. For some stakeholders, simply knowing that a practice provided additional benefits (i.e., "yes or no"), particularly those linked to outcomes of the 2014 *Chesapeake Watershed Agreement*, may be enough. Therefore, the CBP Partnership should build upon the Tetra Tech report and the supporting spreadsheet that provides qualitative measures of benefits by making this information more accessible and user-friendly, possibly by incorporating results directly into the CBP Partnership's Chesapeake Assessment and Scenario Tool (CAST). A matrix that crosswalks the full list of CBP-approved BMPs with our current best understanding of additional benefits can support short-term decisions and be used to prioritize further work on quantification of benefits besides water quality (see Recommendation 2 below).

Recommendation 2
Pursue efforts for more quantification. Other stakeholders desired more robust and quantifiable information on bonus benefits. There was agreement among workshop participants that some benefits/ecosystem services had enough existing information that they could be fairly readily incorporated into decision-making tools (e.g., i-Tree tool that estimates benefits of trees on reducing air pollution, carbon sequestration benefits of vegetation). For a clearly defined subset of practices and their respective benefits, the workshop participants recommended assembling the appropriate experts to examine methods to quantify additional benefits. However, workshop participants stressed that a 'full-blown' expert panel review process is not necessary; see Recommendation #3. The outcome would be a proposed framework and approach by which the quantification of these and other future identified benefits from implementation of the BMPs could be measured and incorporated into Partnership's CAST tool. Sources of funding and mechanisms for soliciting research should be considered simultaneously to promote likelihood of future action. An RFP and funding to initiate and sustain this effort should be pursued.

---

[7] Accessed here:
https://www.chesapeakebay.net/documents/EcoLogix_Group_final_report_Strategic_Outreach_Education_Program_for_Local_Elected_Officials__8-17.pdf

Recommendation 3
Keep the CBP approval process for benefits simple. Having a formal CBP process for approval of new additional benefits for Partnership-approved BMPs adds visibility, transparency, and confidence to the resultant use and application of these additional benefits by the Partnership and individual partners. However, we don't need the same level of effort nor the same level of scrutiny, review and decision making as we have in place with the Partnership's BMP expert panels operating under the CBP BMP Protocol. Therefore, based on the BMPs, the respective lead Goal Implementation Team will be responsible for approving new additional BMP benefits prior to them being added to the CBP partnership's BMP benefits matrix.

Recommendation 4
Seek input from broader set of stakeholders. Though attempts were made to include a diversity of stakeholders at the workshop, the participants still recognized that representation was limited. Participants suggested targeted outreach efforts, listening sessions or focus groups to solicit broader input on what benefits and practices are important. This could also help educate a broader group of stakeholders about the concept of "bonus benefits." Mary Gattis, Coordinator of the CBP's Local Government Advisory Committee (LGAC) offered to help facilitate this effort with local government officials. In addition, workshop participants also thought outreach to farmers, urban residents and other groups representing more diverse backgrounds and socio-economic classes was also important. Input from this broader array of stakeholders should include:

- What ecosystem services/additional benefits are of the most importance/relevance to them;
- Their recommendations for a more understandable set of terminology to be adopted and used by the Partnership; and
- Feedback on the relative importance of identification versus quantification versus valuation across the range of priority benefits.

Recommendation 5
Factor existing understanding of additional benefits into Partnership's documents. At the request of the CBP Partnership, Virginia Tech is drafting summary narrative and graphical descriptions of logical groupings of the hundreds of CBP-approved BMPs within a larger *CBP Quick Reference Guide to BMPs* to be published in 2018. For those BMPs for which CBP Goal Implementation Teams have already identified additional benefits beyond nutrient and sediment pollutant load reductions, we would add short narrative descriptions of those additional benefits within the forthcoming *CBP Quick Reference Guide to BMPs*.

References

Barbier, E.B., I.Y. Georgiou, B. Enchelmeyer, and D.J. Reed. 2013. The Value of Wetlands in Protecting Southeast Louisiana from Hurricane Storm Surges. PLoS ONE 8, e58715. doi:10.1371/journal.pone.0058715

Narayan, S., M.W. Beck, P. Wilson, C.J. Thomas, A. Guerrero, C.C. Shepard, B.G. Reguero, G. Franco, J.C. Ingram, and D. Trespalacios. 2017. The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. Scientific Reports 7, 9463. doi:10.1038/s41598-017-09269-z

Wainger, L.A., G. Van Houtven, R. Loomis, J. Messer, R. Beach, and M. Deerhake. 2013. Tradeoffs among Ecosystem Services, Performance Certainty, and Cost-efficiency in Implementation of the Chesapeake Bay Total Maximum Daily Load. Agricultural and Resource Economics Review 42(1): 196-224.

Appendix A: Workshop Agenda

**Quantifying Ecosystem Services and Co-Benefits of
Nutrient and Sediment Pollutant Reducing BMPs**
Scientific and Technical Advisory Committee Workshop

March 29th-30th, 2017
Workshop Location: Crowne Plaza Hotel, 173 Jennifer Rd., Annapolis, MD 21401
http://www.chesapeake.org/stac/workshop.php?activity_id=274

Workshop Objective: It's no secret that the Chesapeake Bay Program Partnership is focused on improving water quality of the Bay and its tributaries by reducing nutrient and sediment runoff. A massive effort is underway to implement management practices throughout the watershed to achieve clean water. These management practices also have benefits beyond just clean water, benefits that are valued by citizens across the watershed and at more local levels. Understanding the significance of these benefits can lead to enhanced support, coordination and funding for our collective conservation efforts.

This workshop will identify opportunities to value the diverse benefits resulting from implementation of best management practices focused on improving water quality. The workshop will address the suite of ecosystem services benefits – such as more and better recreation opportunities, reduction in natural hazards such as flood risk, and providing food – that can result in local watersheds from actions that are focused on reducing nutrient and sediment runoff.

Participants in this workshop will identify a set of ecosystem services that are a high priority for the partners and stakeholders responsible for implementation (e.g., state and local governments) and that are feasible to value using monetary units or non-monetary metrics. Invited participants have expertise in evaluating the effectiveness of best management practices (BMPs) for producing beneficial outcomes and/or expertise in how those outcomes are valued by partners and stakeholders. Most importantly, partners and stakeholders will work together on identifying how benefits can be integrated into existing decision processes and what actions can be taken to fill gaps in understanding.

Workshop Outcomes:
5. A shared understanding by workshop participants of the opportunities for and constraints on quantifying and valuing ecosystem services associated with water quality-focused BMPs.

6. A list of ecosystem services/other benefits and associated BMPs for which quantification is key.
    - A subset of these priority ecosystem services/collateral benefits and the associated BMPs that are "ready to go"—data/analyses exist to support quantification—and next steps for how to incorporate these into existing Partnership management tools (e.g., CAST)
    - A subset of these priority ecosystem services/collateral benefits and associated BMPs for which data gaps exist and a prioritized list of next steps to be taken to close these data gaps

7. A framework for a collaborative institutional system (structure, procedures and governance) needed to sustain continued quantification of ecosystem services and collateral benefits resulting in Partnership review and approval.

8. A plan and schedule for implementation of the workshop's recommendations

Participants Preparation for Workshop:
To take maximize our short time together, we ask that each participant:

1) Review a preliminary list of BMPs and corresponding ecosystem services/collateral benefits – Accessible [here](#).

2) Watch pre-workshop presentation by Jim Boyd (RFF) - The webinar will provide participants with a basic, working knowledge of ecosystem service benefit concepts and measurement approaches necessary to engage fully in the workshop.
   a. Part I (14 mins): https://www.youtube.com/watch?v=n8XtS6BTWFU&feature=youtu.be
   b. Part II (13 mins): https://www.youtube.com/watch?v=liArq3xPjuc

Workshop Agenda

Day 1:
9:30 am   **Sign-In and Coffee (provided)**

10:00 am   **Getting Started –** *Workshop co-chairs: Beth McGee (CBF) /Mark Bryer (TNC)*
- Welcome and review of workshop objectives, outcomes, agenda
- Introductions
- Questions to consider

10:20 am   **Framework; introductory exercise –** *Facilitators: Lara Fowler (PSU)/Christine Gyovai*
(D+D)

- Framework for discussions
- Interactive Polling Exercise

10:50 am   **Setting the Context: Ecosystem Service Analysis -** *Lisa Wainger (UMCES)*
A summary of ecosystem service concepts and analyses that builds on the Boyd webinar and provides additional information about valuation techniques, what tools are available, and some pros and cons on how they can be applied.

11:20 am   **Case Studies: Working Examples of How Quantified Ecosystem Services Can Help Support Implementation Decision Making**
- **Agricultural Case Study**: Carbon Sequestration from Forests - *Kate Zook (USDA)*
- **Urban Case Study**: Methodology to Quantify Heat-Related Health Effects Due to Tree Cover - *Paramita Sinha (RTI)*
- **Pollinator Habitat Valuation:** *Dan Hellerstein (USDA-ERS)*

12:30 pm   **Lunch (provided) & informal discussions**

1:20 pm   **Directions to the Breakout Groups**
Brief review of the matrix as a starting point for the break out groups followed by the charges and questions posed to each of the breakout groups.

1:40 pm   **Breakout Groups (Session 1): Review and Prioritize Potential BMPs and Associated Ecosystem Services**

- **Policy/implementation perspectives**
- **Economist/ecosystem service perspectives**

3:10 pm   **Break**

3:30 pm   **Reconvene larger group:**
- **Report out from Policy/implementation group(s)**
- **Report out from economists/ecosystem service group(s)**
- **Discussion**

5:00 pm   **Adjourn**

5-6:00 pm   **Workshop Steering Committee meeting**
Crosswalk priorities and availability; develop short list of BMPs/services for Day 2.

6:15 pm   **Informal dinner** – Anyone interested can meet at a local restaurant to continue
discussion

Day 2:
8:30 am   **Coffee and light continental breakfast (provided)**

9:00 am   **Reflections: things that went bump in the night? --** *Lara Fowler/Christine Gyovai*

9:15 am   **Presentation of the Crosswalk between the Priority Ecosystem Services/BMPs and Availability of Tools/Data/Approaches for Quantification -** *Mark Bryer/Beth McGee*
- Facilitated discussion
- **Voting (with dots)** on priority ecosystem services/collateral benefits

10:15 am   **Breakout Groups (Session 2): How, and what is needed, to incorporate priority practices and services into our decision-making tool?** Focusing on the prioritized list, groups will identify what is needed to incorporate Tier 1 practices/services into existing decision-making tools, and for Tier 2 and 3, critical data gaps, and how to address them.

11:30 am   **Report out from Breakout groups**

12:00 pm   **Lunch (provided)**

12:45 pm   **Framework for a Common Valuation System -** *Kristin Saunders (UMCES)/Rich Batiuk*
(EPA-CBP)

The what: The Chesapeake Bay Program Partnership has had significant success in developing and formally approving over 400 different BMPs with underlying definitions, nutrient and sediment reduction efficiencies, and agreement on how each BMP will be tracked, verified, reported and then credited. The overall question for discussion here is what does the framework for supporting quantification/valuation of ecosystem services/collateral benefits beyond this STAC workshop look like.

1:45 pm   **Next Steps -** *Lara Fowler/Christine Gyovai*
The how: By September 2017, we want to present to the Chesapeake Bay Partnership's Management Board a comprehensive set of recommendations for how the Partnership should proceed from here well into the future in supporting quantification of ecosystem services and factoring them into its shared decision support tools and collaborative decision-making processes. In the next 5 months, how do we get from this workshop to a proposal for the full Chesapeake Bay Program partnership to consider?

2:45 pm   **Final thoughts -** *Mark Bryer/Beth McGee*
3:00 pm   **Adjourn**

Appendix B: Workshop Participants

Batiuk, Rich	US EPA-CBPO	Batiuk.Richard@epa.gov
Bennett, Erin	Blue Water Baltimore	ebennett@bluewaterbaltimore.org
Bisland, Carin	US EPA-CBPO	bisland.carin@epa.gov
Blackburn, Jessica	Alliance for the CB - CAC	jblackburn@allianceforthebay.org
Blankenship, Karl	Bay Journal	kblankenship@bayjournal.com
Bryer, Mark	TNC	mbryer@tnc.org
Busch, Greg	MDE	gregory.busch@maryland.gov
Campbell, Elliot	MD DNR	elliott.campbell@maryland.gov
Davis-Martin, James	VA DEQ	James.Davis-Martin@deq.virginia.gov
Devereux, Olivia	Devereux Environmental Consulting	olivia@devereuxconsulting.com
Dixon, Rachel	STAC Coordinator/CRC	dixonr@chesapeake.org
Duriancek, Lisa	USDA	lisa.duriancik@wdc.usda.gov
Filoso, Solange	UMCES	filoso@umces.edu
Fowler, Lara	PSU/STAC	lbf10@psu.edu
Franke, Emilie	NOAA/ERT	emilie.franke@noaa.gov
Gattis, Mary	Alliance for the CB - LGAC	mgattis@allianceforthebay.org
Gilbeau, Gaby	PSU	gmg205@psu.edu
Greiner, Jennifer	USFWS	jennifer_greiner@fws.gov
Gyovai, Christine	Dialogue + Design	christine@dialogueanddesign.com
Hartley, Chris	USDA	chartley@oce.usda.gov
Hartman, Alana	WV DEP	alana.c.hartman@wv.gov
Hellerstein, Daniel	USDA	danielh@ers.usda.gov
Hinrichs, Elaine	STAC Staff/CRC	hinrichse@chesapeake.org
Hogan, Dianna	USGS	dhogan@usgs.gov
Jasinski, Paula	CAC	paula@chesapeakedata.com
Johnson, Zoe	CBP-NOAA	zoe.johnson@noaa.gov
Kasi, Nicki	PA DEP	vbkasi@pa.gov
Hopkins, Krissy	USGS	khopkins@usgs.gov
Mason, Pam	VIMS	mason@vims.edu
Massey, Matt	NCEE	massey.matt@epa.gov
Matuszeski, Bill	CAC	bmat@olg.com
McCarty, Greg	USDA-ARS	Greg.McCarty@ars.usda.gov
McGee, Beth	CBF	BMcgee@cbf.org
Newbold, Steve	EPA/STAC	newbold.steve@epa.gov
O'Neil, Kelly	CBF	KONeill@cbf.org
Peters, Mark	USDA-NRCS	mark.peters@wdc.usda.gov
Phillips, Don	LGAC	hdonpj47@gmail.com
Phillips, Scott	USGS	swphilli@usgs.gov
Ribaudo, Marc	USDA-ERS/STAC	mribaudo@ers.usda.gov

Saari, Steve	DC DDOEE	steve.saari@dc.gov
Saunders, Kristin	UMCES	ksaunders@ca.umces.edu
Shenk, Gary	USGS-CBPO	gshenk@chesapeakebay.net
Sievers, Mark	Tetra Tech	mark.e.sievers@tetratech.com
Simpson, David	EPA	rdsimpson3@live.com
Sinha, Paramita	RTI	psinha@rti.org
Sturgis, Brittany	DE DNREC	brittany.sturgis@state.de.us
Thompson, Lindsey	Thompson Ag Consulting	lindsay.mdag@gmail.com
Traut, Ashley	Blue Water Baltimore	atraut@bluewaterbaltimore.org
Wainger, Lisa	UMCES/STAC	wainger@umces.edu
Zook, Kate	USDA	kzook@oce.usda.gov

Appendix C: Presentation Summaries and Links to Presentations

Setting the Context: Ecosystem Service Analysis - *Lisa Wainger (UMCES)*
http://www.chesapeake.org/stac/presentations/274_Wainger_Ecosystem_Services_Intro_032817.pdf

Dr. Wainger reviewed some of the economic principles relevant to the measurement of benefits from BMP implementation and provided some practical examples of benefit measurement approaches that generated either non-monetary benefit indicators or monetary values. She began her review of economic principles by defining economic benefits as anything that contributes to human well-being. Many think that economic benefits are limited to direct financial gain, but economists define benefits as a wide range of uses such as enhanced enjoyment of a recreational activities or an increase in property protection. Benefits also include so-called *nonuses* or the satisfaction that people derive from protecting species and ecosystems for others or future generations. In a recent review of economic values estimated for the Chesapeake Bay (Wainger et al. 2017, Table 1), non-use values were the largest values compared to any single use value. She also clarified that, although these benefits enhance social well-being, they cannot necessarily be turned into a funding stream to restore or preserve ecosystems.

She differentiated monetary values that are sometimes attributed to ecosystems on a per acre basis from economic values that reflect what someone would be willing to pay to restore or retain a benefit in a specific location. When values do not reflect local conditions, they are not likely to be meaningful for targeting BMP implementation. For example, an average value of ecosystem services per wetland acre could reflect (in part) the value derived from a location where the wetland prevented costs associated with drinking water treatment. However, if no drinking water intakes are present, that value does not reflect the benefit of wetland restoration at that location.

Dr. Wainger further explained the distinction between *economic impacts* and *economic benefits*. Economic impacts are the economic activity, including business sales and jobs, generated by restoration spending. These impacts can have substantial benefits for local economies by invigorating businesses and providing employment. However, economic impacts are not used to judge whether benefits exceed costs of a program because *any* money spent generates jobs and economic activity, regardless of the social importance of the investment. Therefore, money can be moved among different types of spending with similar effects, although measured impacts depend on the economic structure.

Dr. Wainger then transitioned to a description of the components that must be measured in an economic analysis. A conceptual diagram was used to show the step connecting an action to non-monetary benefit indicators (or benefit-relevant indicators) or to monetary values (Figure 1). The goal with economic analysis is to consider how important changes are to stakeholders, in order to inform decisions about how money is best spent to enhance societal well-being. For that reason, non-monetary benefit indicators that resonate immediately with stakeholders (and require little explanation) are best for communicating benefits. For example, rather than report stream temperature, report whether conditions are met to allow brook trout reproduction. In this way,

the metric reflects that the change was sufficient to generate an outcome that matters to people concerned with the long-term viability of brook trout populations.
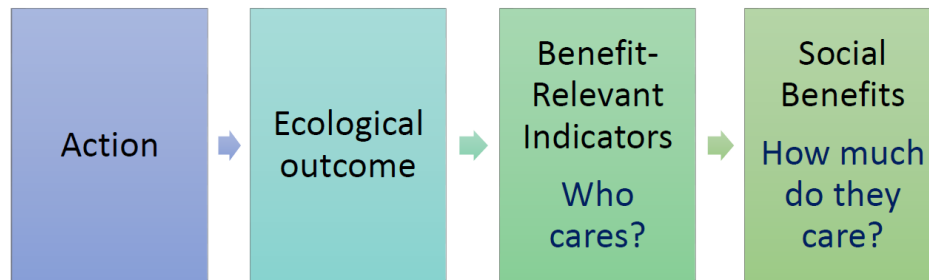

Figure 1. Conceptual diagram showing links that must be made to measure benefits of environmental restoration.

1. An action, such as riparian buffer restoration, must be linked to an ecological outcome, such as an increase in brook trout abundance.
2. That ecological outcome can then be measured in terms of a benefit-relevant indicator such as fishing catch increases (a benefit to anglers) or an increase in brook trout reproduction extent (a benefit to those who value knowing brook trout are likely to persist for future generations).
3. In the last step, benefit-relevant indicators can be monetized using methods to quantify how much people would be willing to pay for those changes.

Finally, Dr. Wainger showed results of a prior study that demonstrated how some straightforward GIS analysis can be used to quantify non-monetary benefit indicators and monetary values for a range of ecosystem services due to Chesapeake Bay Watershed restoration (US EPA 2011 and Wainger et al. 2013). Services included increases in recreational and aesthetics, flood risk mitigation, brook trout habitat, air quality, and weather risk mitigation (associated with a changing climate). Some of the services were measured as monetary values and others only as non-monetary benefit indicators. She referred any listeners who want to know more about monetary valuation techniques (Wainger et al. 2014).

References
US EPA. 2011. An Optimization Approach to Evaluate the Role of Ecosystem Services in Chesapeake Bay Restoration Strategies. US EPA/600/R-11/001. ORD.

Wainger, L.A., Van Houtven, G., Loomis, R., Messer, J., Beach, R., Deerhake, M., 2013. Tradeoffs among Ecosystem Services, Performance Certainty, and Cost-efficiency in Implementation of the Chesapeake Bay Total Maximum Daily Load. Agricultural and Resource Economics Review 42, 196–224.

Wainger, L. A., D. Secor, C. Gurbisz, M. Kemp, P. M. Glibert, J. Richkus, and M. Barber. 2017. Resilience indicators support valuation of estuarine ecosystem restoration under climate change. *Ecosystem Health and Sustainability* 3(4):e01268.

Wainger, L. A., R. J. Johnston, K. J. Bagstad, C. F. Casey, and T. Vegh. 2014. Social Impact Analysis: Monetary Valuation. In: The Federal Resource Management and Ecosystem Services Guidebook (Olander, L. et al. eds.). National Ecosystem Services Partnership. https://nespguidebook.com/assessment-framework/monetary-valuation.

Case Studies: Working Examples of How Quantified Ecosystem Services Can Help Support Implementation Decision Making

- **Agricultural Case Study**: **Carbon Sequestration from Forests -** *Kate Zook (USDA)* http://www.chesapeake.org/stac/presentations/274_Zook_Carbon%20Valuation_STAC%20Mtg.pdf

R. Bluffstone, J. Coulston, R.G. Haight, J.D. Kline, S. Polasky, D.N. Wear, and K. Zook.

USDA policy includes an intention to lead efforts to mitigate and adapt to climate change, drought, and extreme weather in agriculture and forestry by encouraging conservation of sensitive lands, private forest growth and retention, and federal forest stewardship (U.S. Department of Agriculture 2014). Approaches for meeting these goals could involve increasing stored carbon via USDA incentive programs to retain land in agriculture and forest, increasing afforestation of especially marginal agricultural lands, and altering the management of nonindustrial forestlands, among other policy and program alternatives. Evaluating the potential effects of such incentive programs thus is of growing interest as policies for increasing carbon storage are being proposed for both public and private lands (e.g., Lewandrowski et al. 2004, McKinley et al. 2011). Evaluating potential USDA policy and program effects on stored carbon, however, depends on developing suitable and consistent performance metrics for tracking progress toward meeting USDA goals. This includes metrics for characterizing the amount of stored carbon increase (or decrease) resulting from Agency policies and programs. This talk presents a conceptual framework and demonstrates a method for evaluating stored carbon in response to USDA policies and programs, with a focus on restoration of public forestlands, enhanced management of private forestlands, and afforestation of private agricultural lands. The associated analysis draws on existing data and models to develop a national-level measure of forest carbon and its value (in dollars). This measure is used to estimate future changes in forest carbon and its value likely to result land use and forest disturbance (e.g., wildfire) policy scenarios, including (1) reduced development, (2) private land afforestation and public land restoration, and (3) reduction in high severity wildfire.

Our results demonstrate that there is a high value in forest carbon terms associated with both current (reference) and the three modeled policies. Regardless of the modeled scenario, our results show that changes in USDA policy can have large effects on the value of carbon stored in U.S. forests. Our estimates suggest that the greatest carbon gains would be obtained from afforestation and reforestation policies, followed by reduced development, and then reducing wildfire. Given that such policies have long played a role in USDA conservation efforts, they would seem to offer a potentially viable approach should the USDA choose to pursue opportunities for increasing stored carbon in the U.S. Our analysis has not considered the fiscal costs associated with the policies and programs that define our scenarios. A full cost-benefit analysis would provide a more complete policy recommendation.

References
Lewandrowski, J., M. Peters, C. Jones, R. House, M. Sperow, M. Eve, and K. Paustian. 2004. Economics of sequestering carbon in the U.S. agricultural sector. Technical Bulletin No. 1909. U.S. Department of Agriculture, Economic Research Service, Washington, DC. 61 p.

McKinley, D.C., M.G. Ryan, R.A. Birdsey, C.P. Giardina, M.E. Harmon, L.S. Heath, R.A. Houghton, R.B. Jackson, J.F. Morrison, B.C. Murray, D.E. Pataki, and K.E. Skog. 2011. A synthesis of current knowledge on forests and carbon storage in the United States. Ecological Applications 21(6):1902-1924.

U.S. Department of Agriculture [USDA]. 2014. Strategic plan: fiscal year 2014-2018. Office of Chief Financial Officer, U.S. Department of Agriculture, Washington, DC. 45 p.

- **Urban Case Study: Methodology to Quantify Heat-Related Health Effects Due to Tree Cover - *Paramita Sinha (RTI)***
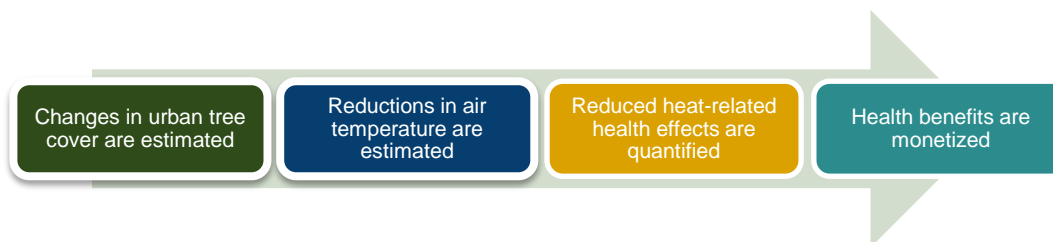 http://www.chesapeake.org/stac/presentations/274_Sinha_STAC_UrbanCaseStudy.pdf

P. Sinha, J. Richkus and B. Lim
Acknowledgements: David Nowak, U.S. Forest Service

Assessing the full suite of benefits of best management practices (BMPs) involves considering ancillary ecosystem service benefits or "co-benefits" in addition to improved water quality that can result in the Chesapeake Bay watershed from such management practices. USEPA (2012) provides an analytic framework that incorporates such ecosystem service impacts to assist policymakers in evaluating BMPs. Some of the key co-benefits of BMPs include water storage, greenhouse gas mitigation and improved habitats for fish, animal and waterfowl. This case study includes an additional source of benefits – air temperature reductions. Temperature regulation is a critical ecosystem service provided by trees and quantifying and valuing these services is an important step in assessing the benefits of BMPs that increase tree cover (e.g. reforestation). Reductions in temperatures can reduce heat-related health effects including: respiratory, as seen in Lin et al. 2009); cardiovascular illnesses, as seen in Lin et al. (2009); heat stroke, as seen in Bobb et al. (2014); and mortality, as seen in Madriagano et al. (2015).

Figure 1

We describe a four-step approach (shown in Figure 1) to quantify and value tree impacts on air temperature and its subsequent impacts on human health. We have developed this approach to expand the existing US Forest Service model (i-Tree)8 to include impacts of reduced temperatures on human health. The first step quantifies tree cover (using high resolution tree cover maps included in i-Tree Landscape). The second step estimates changes in air temperatures

---

[8] The i-Tree suite of urban forest modeling tools currently quantifies and values many of the benefits provided by urban forests, including reductions in building energy use and associated power plant emissions, stormwater runoff reduction control, carbon sequestration, and improvements in public health due to air pollution reduction (e.g., Nowak et al. 2008, 2013, 2014).

(using the i-Tree Cool model currently under development). The third step involves applying estimated relationships (from epidemiological literature) between temperature and different health effects to the exposed population. The fourth step involves applying value estimates (from non-market valuation literature) to the change in health effects to obtain the total monetized benefits of the avoided health effects. Expansions to include other benefits of tree cover such as comfort values of avoiding extreme summers, aesthetic impacts of trees, etc. are also under development. We demonstrate where these ecosystem services can augment information currently being used by the Bay Program by identifying relevant cells in the BMP matrix provided prior to the workshop.

References
Bobb, J. F., Obermeyer, Z., Wang, Y., and Dominici, F. (2014). Cause-specific risk of hospital admission related to extreme heat in older adults. *JAMA, 312*(24), 2659-2667. doi:10.1001/jama.2014.15715.

Lin, S., Luo, M., Walker, R. J., Liu, X., Hwang, S. A., & Chinery, R. (2009). Extreme high temperatures and hospital admissions for respiratory and cardiovascular diseases. *Epidemiology, 20*(5), 738-746. doi:10.1097/EDE.0b013e3181ad5522

Madrigano, J., Ito, K., Johnson, S., Kinney, P. L., & Matte, T. (2015). A case-only study of vulnerability to heat wave-related mortality in New York City (2000-2011). *Environmental Health Perspectives 123*(7), 672-678. doi: http://dx.doi.org/10.1289/ehp.1408178.

Nowak, D. J., Hirabayashi, S., Bodine, A., & Hoehn, R. (2013). Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. *Environmental Pollution, 178*, 395–402.

Nowak, D. J., Hoehn, R. E., Crane, D. E., Stevens, J. C., Walton, J. T., & Bond, J. (2008). A ground-based method of assessing urban forest structure and ecosystem services. *Arboriculture & Urban Forestry*, *34*(6), 347–358.

Nowak, D. J., Hirabayashi, S., Bodine, A., & Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. USDA Forest Service / UNL Faculty Publications. Paper 284. http://digitalcommons.unl.edu/usdafsfacpub/284

U.S. EPA, 2012. *An Optimization Approach to Evaluate the Role of Ecosystem Services in Chesapeake Bay Restoration Strategies.* U.S. EPA/600/R-11/001

- **Pollinator Habitat Valuation:** *Dan Hellerstein (USDA-ERS)*
  http://www.chesapeake.org/stac/presentations/274_Hellerstein_Valuing%20pollinator%20habitats.pdf

Estimates of the annual value of honeybee, and native, pollinators in the United States range from $150 million to $19 billion; with honeybees providing ~ $350 million in pollination services annually (for example, almonds). However, pollinators are under increasing stresss; with losses in honeybee colonies averaging over 30% of the last decade. While a number of factors contribute to this stress (such as pest, pathogens, and pesticides), good forage can help pollinators overcome these problems – where good forage means land covers that provides nectar, pollen, nesting sites (for native pollinators). Best management practices (BMPS) can incorporate beneficial forage.

Calculating the social value of BMPS with beneficial forage requires multiple steps:
- What is the impact on the landscape
- What is the impact on pollinators
- How does this impact translate into changes to goods and services people care about
- What is the value of these goods and services

However, none of the goods and services have values that one can pull off the shelf. A recent CFARE working group considered this issue, focusing on the values of tweaking CRP parcels (installing pollinator habitat instead of simple grass mixes). Questions considered in this analysis include:

Forage improvement (more forbs)	What is the "per parcel" benefit - extra pollen, nectar, etc.?
Honeybee direct effects	Will honeybees utilize? Are there honeybees nearby who will "forage" on an improved parcel?
Honeybee mid-term effects	How does forage translate into more brood, or longer lifespan, or greater activity, of bees in the colony?
Colony impacts	Will the colony be "stronger"? Can better forage help a colony withstand the various stressors?
Survival	How more likely will a stronger colony survive the winter?
More colonies	Beekeepers have more colonies to offer to farmers (they can avoid the expense of creating new colonies)
Lower costs to farmers	More ag profit, more production (lower consumer prices)

Takeaways from this exercises include:

- Conceptually, it isn't that difficult to measure the "social value" from healthier pollinator populations due to land use changes

- But the devil is in the myriad details – such as the value of an x% increase in overwinter survival of N colonies

- We have some models that get us part way there, but they are all best thought of as exploratory

- Benefit relevant indicators can proxy for changes, providing a means of comparing the "effectiveness" of different policies

- **Quantifying Ecosystem Services and Co-benefits of Nutrient and Sediment Pollution Reducing BMPs—Recap from March 29, 2017:** *Lara Fowler (PSU)*
  http://www.chesapeake.org/stac/presentations/274_Fowler_Day%201%20Recap.pdf

Comprehensive summary of the workshop discussions as well as the report outs from the morning and afternoon breakout groups from the first day of the workshop.

Appendix D: Additional Resources

Workshop Relevant Published Reports and Papers
The following list was provided by workshop participants

- ❖ The Council on Food, Agricultural and Resource Economics (CFARE) and the USDA Office of the Chief Economist Office of Environmental Markets partnered on a project to develop a conceptual framework for valuing ecosystem service benefits from U.S. farms and forests. The report chapters (below) are available on C-FARE's website.
    - Synthesis Chapter: The Valuation of Ecosystem Services from Farms and Forests: Informing a systematic approach to quantifying benefits of conservation programs
    - Chapter 1: Assessing Pollinator Habitat Services to Optimize Conservation Programs
    - Chapter 2: Ecosystem Service Benefits Generated by Improved Water Quality from Conservation Practices
    - Chapter 3: Estimated Values of Carbon Sequestration Resulting from Forest Management Policy Scenarios

- ❖ Center for Neighborhood Technology. 2010. The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits. 73 p. https://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf
    - *A broad analysis that is the first to place an economic value on the numerous benefits provided by green infrastructure. Goals: 1- Inform decision-makers and planners about the multiple benefits green infrastructure delivers to communities, 2- guide communities in valuing the benefits of potential green infrastructure investments.*

- ❖ Coutts, A.M., N.J. Tapper, J. Beringer, M. Loughnan, M. Demuzere. 2012. Watering our cities: The capacity for Water Sensitive Urban Design to support urban cooling and improve human thermal comfort in the Australian context. Progress in Physical Georgraphy 37(I) 2-28. doi: 10.1177/0309133312461032
    - *Outlines benefit of urban stormwater management to urban cooling*

- ❖ Gómez-Baggethun, E., D.N. Barton. 2013. Classifying and valuing ecosystem services for urban planning. Ecological Economics 86: 235-245.
    - *Table 1 provides an overview of the types of indicators and proxies that can be used to assess urban ecosystem service functions*

- ❖ Moore, T.L.C., and W.F. Hunt. 2012. Ecosystem service provision by stormwater wetlands and ponds – A means for evaluation? Water Research 46: 6811-6823.
    - *Assessed carbon sequestration, biodiversity, and cultural services for 20 stormwater ponds and 20 stormwater wetlands in North Carolina*

❖ Palmer, M.A., S. Filoso, R.M. Fanelli. 2014. From ecosystems to ecosystem services: Stream restoration as ecological engineering. Ecological Engineering 65: 62-70.
  - *Environmental costs and benefits of urban stream restoration*

❖ Philips, S. and B. McGee. 2016. Ecosystem Service Benefits of a Clean Chesapeake Bay. Coastal Management 44(3): 241-258. doi: 10.1080/08920753.2016.1160205

❖ U.S. EPA. 2014. The Economic Benefits of Green Infrastructure: A Case Study of Lancaster, PA. Developed under EPA Contract No. EP-C-11-009 as part of the 2012 EPA Green Infrastructure Technical Assistance Program. https://www.epa.gov/green-infrastructure/economic-benefits-green-infrastructure-lancaster-pa
  - *This case study estimates the value of several of the benefits of Lancaster's Green Infrastructure Plan. It highlights the importance of including: the multiple benefits of green infrastructure in cost-benefit assessments; and adding green infrastructure into planned improvement projects.*

❖ Ziter, C. 2016. The biodiversity-ecosystem relationship in urban areas: a quantitative review. Oikos 125: 761-768. doi: 10.1111/oik.02883
  - *Review of studies looking at urban biodiversity as an ecosystem service*

Table 1. Using the Tetra Tech matrix as a starting point, the Workshop Steering Committee developed the following *simplified* matrix with a shortened list of practices providing the most benefits and categories of benefits typically used in ecosystem service studies

Sector	BMP Group	Ecosystem sustainability	Water Supply and Regulation	Hazard Mitigation	Recreation Supply	Cultural, Spiritual and Educational support	Aesthetics	Food Provisions	Water Purification& Waste Treatment to Protect Human Health	Climate Regulation, carbon sequestration	Human Health Support (other than water)
Agriculture	Ag Forest Buffer										
Agriculture	Grass Buffers										
Agriculture	Ag Stream Restoration										
Agriculture	Wetland Restoration and Streamside Wetland Restoration										
Agriculture	Ag Shoreline Management (incl. Non-Vegetated and Vegetated)										
Agriculture	Stream Access Control with Fencing										
Agriculture	Alternative Water System (Off Stream Watering Without Fencing)										
Agriculture	Alternative Crops and Alternative Crop/Switchgrass (RI)										
Forestry	Forest Conservation										
Forestry	Forest Harvesting Practices										
Forestry/ Urban	Dirt/Gravel Roads										
Urban	Urban Forest Buffers										
Urban	Urban Stream Restoration										
Urban	Urban Growth Reduction										

Urban	Urban Shoreline Management										
Urban	Abandoned Mine Reclamation										
Urban	Bioretention										
Urban	Urban Tree Planting										
Urban	Impervious Surface Reduction										
Urban	Wet Ponds										
Urban	Grass Buffers										
Urban	Runoff Reduction										
Urban	Infiltration Practices										
Urban	Permeable Pavement										
Urban	Filtering Practices										
Urban	Erosion and Sediment										