Working Towards a Robust Monitoring Framework for Natural and Nature-Based Features in the Mid-Atlantic Using Citizen Science

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The Mid-Atlantic Regional Council on the Ocean (MARCO) recognizes that information on sustaining wetlands, nature-based shoreline management and climate change is rapidly evolving, and continued research is important to understand the systems affected by the environment and management efforts. The information in this report will inform MARCO activities, but nothing in this document should be construed as a MARCO endorsement or MARCO policy. MARCO hopes that others find the information in this report useful to their climate adaptation efforts.

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Background

On February 15th and 16th, 2017, the National Wildlife Federation (NWF) convened a small group of experts in natural and nature-based features (NNBF) to begin the development of a regionally standardized and coordinated approach to post-implementation performance monitoring. This workshop built upon over a year of work identifying the most important challenges and solutions to improving the use and understanding of NNBF in the Mid-Atlantic[14]. Through this previous work, regional stakeholders identified the creation of a standardized and coordinated approach to monitoring NNBF projects using citizen science as one of the most needed solutions.

These stakeholders felt that one of the biggest challenges in the field of NNBF was the short timelines and low level of funding associated with post-implementation monitoring. The limitations inherent in most projects make it nearly impossible to collect data on long-term project performance.

Citizen science monitoring represents a viable way to overcome this challenge. Citizen scientists not only represent an opportunity for low to no-cost monitoring, but leveraging existing volunteer groups can help ensure periodic collection of long term data as monitoring activities can be integrated within existing programs. This is especially important in the field of NNBF, as these projects often require one to five years for vegetation to mature and to realize their full effectiveness. Additionally, long-term monitoring helps to ensure that any necessary repairs or modifications are caught in a timely and cost efficient manner.

Introduction

The following report represents an initial step in the development of a standardized and coordinated approach to citizen science monitoring of NNBF

[14] Schrass, K. and A.V. Mehta. 2017. Improved Use and Understanding of NNBF in the Mid-Atlantic. Annapolis, MD: National Wildlife Federation. Available at: http://midatlanticocean.org/wp-content/uploads/2017/03/Improved-Use-and-Understanding-of-NNBF-in-the-Mid-Atlantic.pdf

projects in the Mid-Atlantic[15]. While the following report outlines the outcomes of a two-day workshop, it builds upon a large body of existing monitoring programs and frameworks. In preparation for the workshop and development of the following methods and metrics, NWF reviewed and assessed a number of existing monitoring frameworks developed within and beyond the Mid-Atlantic region. Based upon that review, the workshop and this report followed the goal-based monitoring framework advanced by other example programs, such as the one developed by the Partnership for the Delaware Estuary, The Nature Conservancy, and a suite of partners in New Jersey[16]. The goal-based structure was selected to allow participants to look across different types of NNBF and focus on the core metrics common to different features and goals.

The identification of these methods and metrics was accomplished in three phases. In Phase 1, participants developed a list of potential project performance goals, e.g. shoreline stabilization, habitat creation and/or nutrient reduction, representing the perspectives of a broad group of stakeholders involved in the NNBF field, e.g. property owners, conservation organizations, and local governments. Following the identification of these goals, the participants identified a wide range of habitat types associated with coastal NNBF projects. These two lists formed the axes of Table 1, which was subsequently used as the framework for the development of goal-based metrics. After populating this table with metrics, in Phase 2 participants identified both citizen science and intensive methods for measuring each metric. In this paper, the methods, along with the metrics they measure are grouped by goal. In Phase 3 participants identified the next steps that will be required to refine, pilot, and improve the methods and metrics developed during their workshop.

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[15] For an overview of natural and nature-based features, please refer to the United States Army Corps of Engineer's "Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience" (2015) at http://www.dtic.mil/dtic/tr/fulltext/u2/a613224.pdf

[16] Yepsen, M., Moody, J., Schuster, E., editors (2016). A Framework for developing monitoring plans for coastal wetland restoration and living shoreline projects in New Jersey. A report prepared by the New Jersey Measures and Monitoring Workgroup of the NJ Resilient Coastlines Initiative, with support from the NOAA National Oceanic and Atmospheric Administration (NOAA) Coastal Resilience (CRest) Grant program (NA14NOS4830006).

Phase 1: Identification of Goal-Based Core Metrics

The first phase of the workshop focused on developing a robust list of goal-based metrics along with a list of NNBF habitat types. The participants' diverse list of goals and habitats makes the resulting monitoring frameworks appropriate for a wide range of traditional and non-traditional stakeholders.

The complete list of goals is:

- Improve water quality/mitigate stormwater
- Erosion reduction/shoreline stabilization
- Monetary benefit
- Increase habitat value
- Carbon sequestration/climate amelioration
- Improve aesthetics/increase environmental stewardship
- Embrace cultural heritage
- Improve recreational opportunities
- Reduce storm surge/flood impacts
- Structural integrity

These goals were then applied to a range of features or habitat types, including:

- Submerged aquatic vegetation (SAV)
- Wetlands
- Riparian buffer
- Dunes
- Beaches
- Shellfish reefs
- Maritime forests[17]
- Mudflat[17]
- Urban retrofit[18]

[17] These habitat types were identified by stakeholders after the workshop was completed, therefore this report will not include them in the following tables. More research is needed to identify the most appropriate metrics and methods for maritime forest and mudflats habitat types.

[18] In addition to these natural habitats we found that an additional habitat type was required to encompass projects that are situated in highly developed areas with little to no remaining natural habitat. We settled on the name "urban retrofit" for these projects.

These lists were then used to develop a matrix that was subsequently populated with metrics for each goal in each feature type[19].

Table 1 summarizes the core metrics identified for each goal and habitat type identified in Phase 1. For each habitat type (x-axis) and each goal (y-axis) the participants identified up to three core metrics to measure project performance. These lists of one to three core metrics were condensed from a wider brainstorm of project metrics with participants discussing and agreeing to the combination, substitution, and/or removal of any metrics from this longer list. *Needs more research* identifies those topics fell outside of the participants' expertise and could be better addressed by experts in those specific fields. This workshop found that in using a goal-based approach core metrics were often identical across the various habitat type. Our participants found that certain parameters were important among multiple types of NNBF, although the measurable metric and interpretation of findings might vary. However, in many circumstances the habitat type will determine the type of method used to measure the metric.

It is expected that individuals or organizations monitoring a project using this framework would collect data pertaining to each core metric related to their specific goal(s) and feature type(s). The long-term performance of coastal NNBF can be dependent on actions undertaken on adjacent and upland areas. Therefore, it is strongly recommended that monitoring should take effects of natural processes, ecological communities, and adjacent areas into account. Finally, for NNBF to perform successfully in the long-term, property owner goals should be cognizant and inclusive of the priorities of both the regulatory agencies as well as the wider community. Success for these projects is a function of both ecological and societal value and therefore approaching NNBF with as wide a perspective as possible will help to highlight potential challenges in the planning and goal-setting stage.

[19] See Table 1

Table 1: Goal-Based Core Metrics

Project Goal	SAV	Wetlands	Urban Retrofit	Riparian Buffer	Dunes	Beaches	Shellfish Reefs
Water quality & Stormwater mitigation	Sediment load Nutrient reduction (e.g. nitrogen/unit area)	Sediment load Nutrient reduction (e.g. nitrogen/unit area) Toxic/pathogens removal	Sediment load Nutrient reduction (e.g. nitrogen/unit area) Toxic/pathogens removal	Sediment load Nutrient reduction (e.g. nitrogen/unit area) Toxic/pathogens removal	Sediment load Nutrient reduction (e.g. nitrogen/unit area) Toxic/pathogens removal	*Needs more research*	Sediment load Nutrient reduction (e.g. nitrogen/unit area) Toxic/pathogens removal
Erosion reduction & Shoreline stabilization	Wave attenuation Rate of shoreline change Sediment elevation & stability	Wave attenuation Rate of shoreline change Sediment elevation & stability	Wave attenuation Rate of shoreline change Sediment elevation & stability	Wave attenuation Rate of shoreline change Sediment elevation & stability	Wave attenuation Rate of shoreline change Sediment elevation & stability	Wave attenuation Rate of shoreline change Sediment elevation & stability	Wave attenuation Rate of shoreline change Sediment elevation & stability
Monetary impacts (e.g. reduced tax, increased property values)	Preferred use/value *Needs more research*	Preferred use/value *Needs more research*	Preferred use/value *Needs more research*	Preferred use/value *Needs more research*	Preferred use/value *Needs more research*	Preferred use/value *Needs more research*	Preferred use/value *Needs more research*
Habitat Value	Species composition (flora & fauna) & density (indicator species, density indices[20], change) Vegetated area & cover	Species composition (flora & fauna) & density (indicator species, density indices, change) Vegetated area & cover	Species composition (flora & fauna) & density (indicator species, density indices, change) Vegetated area & cover	Species composition (flora & fauna) & density (indicator species, density indices, change) Vegetated area & cover	Species composition (flora & fauna) & density (indicator species, density indices, change) Vegetated area & cover Dune dimension	Species composition (flora & fauna) & density (indicator species, density indices, change) Beach/Veg area & cover	Species composition (flora & fauna) & density (indicator species, density indices, change) Reef dimension

[20] While participants did discuss the use of biodiversity indices here it was ultimately determined that more flexibility was important, and that biodiversity for this purpose was covered by composition and density.

Project Goal	SAV	Wetlands	Urban Retrofit	Riparian Buffer	Dunes	Beaches	Shellfish Reefs
Carbon sequestration & Climate Amelioration	Carbon storage potential Buffering capacity (water chemistry)	Carbon storage potential Buffering capacity (water chemistry)	Carbon storage potential Buffering capacity (water chemistry *Needs more research*	Carbon storage potential Buffering capacity (water chemistry)	N/A[21]	N/A[21]	Carbon storage potential Buffering capacity (water chemistry)
Aesthetics & Environmental Stewardship	Perception Community engagement	Perception Community engagement	Perception Community engagement	Perception Community engagement	Perception Community engagement	Perception Community engagement	Perception Community engagement
Cultural Heritage	Sense of place Cultural/tribal value	Sense of place Cultural/tribal value	Sense of place Cultural/tribal value	Sense of place Cultural/tribal value	Sense of place Cultural/tribal value	Sense of place Cultural/tribal value	Sense of place Cultural/tribal value
Recreation	Usage rate Type of use	Usage rate Type of use	Usage rate Type of use	Usage rate Type of use	Usage rate Type of use	Usage rate Type of use	Usage rate Type of use
Storm surge & flood reduction	Water retention Energy absorption Change in flood insurance premiums *Needs more research*	Water retention Energy absorption Change in flood insurance premiums *Needs more research*	Water retention Energy absorption Change in flood insurance premiums *Needs more research*	Water retention Energy absorption Change in flood insurance premiums *Needs more research*	Water retention Energy absorption Change in flood insurance premiums *Needs more research*	Water retention Energy absorption Change in flood insurance premiums *Needs more research*	Water retention Energy absorption Change in flood insurance premiums *Needs more research*

[21] Participants felt that dunes and beach have no substantial connection to carbon sequestration due to the limited presence of woody vegetation in these habitats.

Project Goal	SAV	Wetlands	Urban Retrofit	Riparian Buffer	Dunes	Beaches	Shellfish Reefs
Structural implementation & integrity (if applicable)	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials	Placement within habitat (permit compliance) Dimensions of structure and its components Condition of materials

Phase 2: Identification of Methods

For each metric in Table 1 the participants developed a number of methods that could be employed by volunteers and citizen scientists to attain measurements for each metric. In addition to the citizen science methods, the participants identified a corresponding intensive method that could be used to verify the accuracy and suitability of data collected by citizen scientists. The path towards a better understanding on the performance of NNBF is not solely through citizen science action, but through greater collaboration between citizen scientists and experts. In particular, citizen scientists and volunteers can increase the amount of data that is collected on projects while qualified experts are necessary to scope essential performance data and to interpret, analyze, and verify the citizen collected data, leading to better project management, siting and design decisions in the future. As discussed earlier, the emphasis on citizen science was an effort to overcome financial and timeline constraints that frequently prevent the collection of project performance data.

Tables 2 – 11 describe potential methods grouped by goal. Tables 8 – 11 specifically address social, cultural and economic metrics and methods. Again, areas marked as *needs more research* represent collective gaps in knowledge of the workshop participants and do not represent an absence of relevant methods.

Table 2 Goal: Increase Habitat Value[22]

Habitat Value Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Dune dimension	Geotagged aerial imagery (drone)	Measure dune height/length/width/slope using tape measure & simple laser-level, or hand-held analogue tool (clinometer); use distance from stable feature(s) to prevent damage to dunes	Training; supplies
	Real Time Kinematic (RTK) GPS	Measure dune height/length/width/slope using tape measure & simple laser-level, or hand-held analogue tool (clinometer)use distance from stable feature(s) to prevent damage to dunes	Training; supplies
	Numerical modeling	Measure dune height/length/width/slope using tape measure & simple laser-level, or hand-held analogue tool (clinometer) use distance from stable feature(s) to prevent damage to dunes	Training; supplies
Reef dimension	RTK GPS	Tape measure survey	Supplies
	3D laser scan	Measure reef height/length/width/rugosity (chain-measure, photographs)	Training; supplies; *needs research for measuring rugosity*
	Sonar Survey (Side-Scan Sonar kayak or boat mounted)	*Needs more research*	*Needs more research*
	Laser levels	Laser levels	Training; supplies
Spp composition & density (flora & fauna)	Shannon Diversity and other absence, abundance, and richness measures	Transect method for species count and richness	Training; supplies (e.g. quadrat, transect-tape, tape measure, scale, calipers/fish boards, Spp Chart/Guide)

[22] In order to put habitat values into context it is import to compare a NNBF to native ecosystem conditions. Any deviation too far outside of the range of normal habitat conditions can actually be detrimental to overall system function although that may not be obvious when looking at data solely from the project site scale.

Spp composition & density (flora & fauna		Quadrat method for species count and richness Identifying presence/absence of organism-groups/guilds (very broad categories) Bioblitz w/ use of phone-apps for photo-capture and identification purposes (e.g. Inaturalist) Benthic cores Seining, dip net, or sieving Surveys collected from angelers, birders, etc.	
	Aerial imagery (id, diversity, coverage)	Photo observation	Training; supplies
	Horsehoe crab survey	Horseshoe crab survey	Outreach; training; supplies
	Index of Biological Integrity (IBI) or variations		
	Acoustic/Satellite tagging	*Needs more research*	*Needs more research*
	Flora/Fauna growth and survivorship		
Vegetated area & cover	RTK GPS	Quadrat Sampling	Training, supplies
Woody or vegetative debris (presence, density)	*Needs more research*	*Needs more research*	*Needs more research*

Table 3 Goal: Improve Water Quality[23]

Water Quality Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Sediment load	Total suspended solids (TSS)/Suspended sediment concentration (SCC)	Evaluation of water clarity (e.g. disappearance of Secchi Disk/feet by depth - "Wade-in") Mail-in sample kit (e.g. chlorophyll A)	Training, supplies, research needed for rapid-assessment techniques
Toxic/pathogens removal	Fecal Coliform or Entero	Mail-in sample kits Reporting beach closures	Training; supplies; research needed for low-cost, rapid-assessment techniques
	Tissue Samples of Vegetation (toxics)		
	Using Literature Values	*Needs more research*	*Needs more research*
	Heavy Metal Analysis in Fish/Sediment	Submit caught-fish	*Needs more research*
Nutrient reduction (e.g. nitrogen/unit area	Water sampling (lg scale)	Report occurrences of algal blooms	Training; supplies; research needed for low-cost, rapid-assessment techniques
	Filtration capacity of shellfish (small-scale)	Measure oyster density and size	Training; supplies
	Nutrient load measurements (pre/post project or control/reference)	Mail-in sample kits	Outreach & awareness; training; supplies; research needed for low-cost, rapid-assessment techniques
	Modeled reduction based on literature and/or approved protocols and NNBF feature + area	*Needs more research*	*Needs more research*
	Combined Sewer Overflow (CSO) discharge frequency or volume	Report occurrences of CSO discharges or sewage infrastructure issues Report fish or wildlife kills	Outreach & awareness
	N Load Modeling (land use in watershed or GW N x precip)	*Needs more research*	*Needs more research*
	Multimeters (e.g. YSI)	Multimeters (e.g. YSI)	Training; supplies

[23] As much as possible, it is important to control for external effects on water quality either through the use of a control site against which to compare changes in metrics or other means.

Table 4 Goal: Erosion Reduction

Erosion Reduction Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Wave attenuation	Live buoys	Leo forms	Training, supplies
	Wave energy (wave pressure sensors)	Observation of boat traffic and storms (e.g. Record videos) Use Google earth to measure fetch	Outreach & awareness; training; research needed for correlation
	Side Scan Sonar (SSS) - bedform morphology	Anecdotal evidence from recreational fishermen/boaters	Outreach & awareness; training
	Structural integrity	*Needs more research*	*Needs more research*
	Engineering survey	*Needs more research*	*Needs more research*
Sediment elevation & stability	Digital Elevation Model (DEM)	Laser-level to benchmark Share recreational drone video and photo content	Outreach & awareness, training
	Sediment Elevation Table (SET)	*Feldspar clay markers*	Training, supplies
	Photographs	Photographs (pre/post storm)	Outreach & awareness, training
	Marker layers	Survey rod and transit Feldspar markers (measure sediment accretion) Permanent monument (e.g. steel rod) App that submits phone GPS data	Outreach & awareness, training, supplies
	Bulk density	Fill known volume containers	Training, supplies
	Drone survey - topo (3D)	Share recreational drone video and photo content	Outreach & awareness, training
	Nearshore survey - surface sonar	*Needs more research*	*Needs more research*
	SSS - grain type (e.g. LIDAR)	*Needs more research*	*Needs more research*
	RTK-GPS Survey	*Needs more research*	*Needs more research*
	Bearing capacity (stability)	Movement of sediment surface relative to permanent benchmark	Outreach & awareness, training, supplies
Rate of shoreline change	RTK-GPS	Stable marker measurements, 3 points (1 seaward of marsh, 1 in marsh, and 1 landward of marsh)	Outreach & awareness, training, supplies
	GIS	*Needs more research*	*Needs more research*
	Engineering survey	*Needs more research*	*Needs more research*
	Drone survey (measure feature change temporally/spatially)	Submit/share time-lapsed, geotagged phone photos	Outreach & awareness; training

Table 5 Goal: Carbon Sequestration/Climate Amelioration

Carbon Sequestration Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Carbon storage potential	Biomass measurements	Organic matter content (e.g. LOI) *Needs more research*	Training, facility, equipment
	Change in below- and/or above-ground biomass		
	Change in soil organic carbon		
	Organic matter x conversion		
	Standing stock (veg cover x conversion)		
	Lead 210 Carbon dating to get at sequestration rate (P)		
	Bulk diversity (P)		
Buffering capacity (water chemistry)	pH	Water sampling *Needs more research*	Training, supplies
	CO2		
	Carbonate		
	Dissolved Oxygen		
	Water quality		
	Multimeters		
	Change in shellfish community (small scale)		
	Water chemistry metrics (large scale)		

Table 6 Goal: Reduce Storm Surge/Flood Impacts[24]

Storm Surge & Flood Impact Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Water retention	Aerial imagery (HWL/flood mark), RTK (HWL/flood mark)	Geo-tagged Cell Phone Image	Outreach & awareness, training
	Marsh Area and Porosity	Estimate marsh area	Training, supplies
	Water Volume (hydrodynamic change model)	Flow Rate (m/s), Observed High Water Mark	Training, supplies
	GIS	Smartphone app	Outreach & awareness, training
Energy absorption	Pressure sensor array (ADCP)	Movement of Proxy Material within and adjacent to project *Needs more research*	Training, supplies
	Wave height models		
	Run up		
	Property damage prevented (% reduction attributable to NNBF)		

Table 7 Goal: Structural Implementation/Integrity

Structural Integrity Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Placement within habitat (permit compliance)	RTK-GPS	*Needs more research*	*Needs more research*
	As built documents		
	Aerial drones		
	Bathymetry/SSS	Kayaks/Hikes w/ geotagged photos	Outreach & awareness, training, supplies
	Photogrammetry of Feature	Wide view photo of site	Outreach & awareness, training
		Photo documentation pre/post storm	Outreach & awareness, training
		Position relative to MHW/MLW	Outreach & awareness, training
		Position relative to existing natural feature	Outreach & awareness, training

[24] In understanding the impact of NNBF on storm surge and flood related damages it is necessary to compare the site to either similar unprotected shorelines, similar structurally protected shorelines, or both. Alternatively, performance can be measured against a specific goal established during the design or pre-implementation phase.

Placement within habitat (permit compliance)		Tie down distance (measure distance to fixed marks)	Outreach & awareness, training
		Video of time-lapse of flow through structure	Outreach & awareness, training
	Hydrodynamic modeling DEM	Measure buffer or setback distances	Training, supplies
	Aerial imaging	Flow rates w/ dissolution	Training, supplies
		Measure depth/water marks	Training, supplies
		Measure distance moved from original placement	Training, supplies
		GPS structures based on permitted plans	Training, supplies
		Ponding of water	Outreach & awareness, training
Condition of materials	Engineering survey-laser level	Photo documentation	Outreach & awareness, training
		Relative Integrity (missing components, % missing components, soil loss, overtopping)	Training, supplies
	Photogrammetry	Quadrant survey	Training, supplies
	RTK or Laser Scan of Structure	Measure material size (component)	Training, supplies
		Observation of Material Condition	Training, supplies
	Aerial imaging	Visual damage assessment	Training, supplies
Dimensions of structure and its components	RTK-GPS	*Needs more research*	*Needs more research*
	Drone survey		
	Bathymetry		
	SSS		
	Photogrammetry		
	Engineering Survey	Photo documentation of structure, barnacle line	Training, supplies
		Rock/grain size	
		Height/width/length/volume	
		Number of features (breakwater units, gaps, boxes)	

Table 7 Goal: Improve Recreation Opportunities

Recreational Opportunity Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Usage rate	Remote-sensed counts Surveys Number of hunting licenses sold in the year Number of visitors Number of rentals	Presence/Absence Landing surveys via FIN numbers Outreach event attendance *Needs more research*	Training, supplies
Type of use	Expert panel interviews	*Needs more research*	*Needs more research*
	Use surveys (type and amount)	Number of public access sites and observations of use Cameras Car counts Entrance survey *Needs more research*	Training, supplies

Table 8 Goal: Monetary Benefits

Monetary Benefit Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Lifetime project costs[25]	Accounting of costs across the entire project life cycle	*Needs more research*	*Needs more research*
Preferred use/value	Survey of resident perceived-value Real estate values Interviews on perceptions of NNBF benefit to sense of protection Online sharing	*Needs more research*	*Needs more research*

[25] Includes capital costs and maintenance over lifetime of project.

	Online hits		
Change in flood insurance	Flood insurance claims	*Needs more research*	*Needs more research*
	NNBF related CRS points attained		
	Intensive numerical modeling		
	Interviews		
	Real estate transactions		
Impact on local economy[26]	Ecotourism revenue	*Needs more research*	*Needs more research*
	Quantify additional co-benefits	*Needs more research*	*Needs more research*

Table 9 Goal: Embrace Cultural Values

Cultural Value Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Restoration of historic uses	*Needs more research*	Interviews	Training, supplies
Sense of place	*Needs more research*	Interviews	Training, supplies
		Survey of books, etc.	*Needs more research*
Cultural/tribal value	Surveys of value	Interviews	Training, supplies
		Number of historic sites	
		Registry	
		Number of public access points	

Table 10 Goal: Improve Aesthetics/Environmental Stewardship

Aesthetic & Stewardship Metric	Intensive Method(s)	Citizen Science Method(s)	Need(s) for Use by Citizen Scientists
Perception (survey)	Survey	Survey (online)	Training, supplies
	Interviews	*Needs more research*	*Needs more research*
	Change in littering/dumping	Tracking of amount of trash gathered at clean up events	Training, supplies
Community engagement	Willingness to pay	*Needs more research*	*Needs more research*
	Visits/People counts	# volunteers @ event	Training
		# of events	Training
		Online sharing	Training
	NGO Priorities for Funding	Donations	Training

[26] Includes non-owner monetary benefits such as community quality of life, commerce, and tourism.

Phase 3: Next Steps and Research Needs

The most immediate and critical next step, identified by the workshop participants, is to reach out to a larger group of experts to identify and fill in gaps in these current frameworks, especially those knowledge gaps marked with *needs more research* above. Coordination and collaboration with other groups and individuals who are experts in either specific habitats or focus on particular goals will aide in vetting and improving this monitoring framework.

In addition to coordination with specific expert groups, receiving input from citizen monitoring efforts from across the country could help identify gaps in this current framework as well as methods and metrics that have been proven especially effective or ineffective. Across the region there are volunteer groups that are already involved in some monitoring or other aspect of NNBF. These groups include Master Gardeners, Master Naturalists, Watershed Stewards, and volunteers for organizations like Audubon, among many others. Engaging these groups in a discussion of their successes and challenges could help to identify what has worked in different parts of the Mid-Atlantic and narrow and focus the current list of metrics and/or methods. Synthesizing inputs from these monitoring practitioner groups with additional input from subject area experts would be a significant step forward in refining and furthering the monitoring framework outlined in this report.

The other side of a citizen science monitoring program, which this workshop and report did not have a chance to explore, is the development of a data clearinghouse that can serve as a repository for the data; allowing citizen scientists to upload data and allowing professionals and experts to access the data for research and analysis. This data will also need to be subjected to a quality assurance/quality control process. How this data collection and sharing process is established in the Mid-Atlantic should be discussed among a variety of federal, state, local and non-profit stakeholders.

Currently, in Maryland the Chesapeake Bay National Estuarine Research Reserve, together with partners from the Alliance for the Chesapeake Bay, Chesapeake Environmental Communications, Izaak Walton League of America, the Alliance for Aquatic Resource Monitoring (ALLARM) and the University of Maryland Center for Environmental Science's Integration and Application Network (UMCES-IAN) team are developing a database and web application to integrate citizen-based and nontraditional environmental monitoring programs located throughout the Chesapeake Bay. The database and web application is served at the Virginia Institute of Marine Science and will allow individual groups to upload monitoring results to a central database, while also providing public-facing data visualizations and download features. Monitoring data will also be submitted to the Chesapeake Bay Program's Chesapeake Environmental Data Repository (CEDR) database. Beta testing of the database and web-application with a small group of citizen monitors is set to begin in mid-June 2017. The goal is to provide not only a readily available and easily usable web portal for data submission, but a way for citizens to see how their monitoring efforts and results are included in the overall monitoring effort, as well as provide direct positive feedback for their efforts.

Understanding where there are similar data repositories in existence or in development across the region could identify those networks that could promote and disseminate a standardized and coordinated citizen science monitoring framework.

Finally, it is of critical importance that the data citizen scientists collect is accurate and useful. Therefore, workshop participants suggested identifying a network of pilot sites and pairing volunteer groups with experts to simultaneously employ both the intensive and citizen scientist methods outlined in this framework. If appropriate funding was identified, this project would provide us with a better understanding of the quality and reliability of the data that is being collected by citizen scientists and would reveal those methods and/or metrics that are feasible for citizen scientists to measure and those that are not. The pilot projects would also help in designing standardized data collection protocols as well as establish the frequency with which monitoring efforts should be undertaken. Dedicated funding and support is also needed to develop and test the approaches that best motivate citizen scientists and volunteers to participate in monitoring efforts.

We understand that citizen science monitoring may not be suitable in every situation for every metric, but we feel that it is feasible in many scenarios. Where it is not appropriate for citizen science, certain monitoring requirements may need to be coordinated between regulators, property owners and science advisors. It is our hope and intention that, through these next steps, this framework will continue to evolve. We hope that other organizations involved in improving the state of NNBF monitoring will find this report valuable in undertaking their own work and that through regional collaboration a coordinated and standardized monitoring framework can be co-developed.