



# The Final Ecosystem Goods and Services (FEGS) Document Reader

## A Tool to Extract, Identify, and Prioritize Ecosystem Services and their Beneficiaries from Documents

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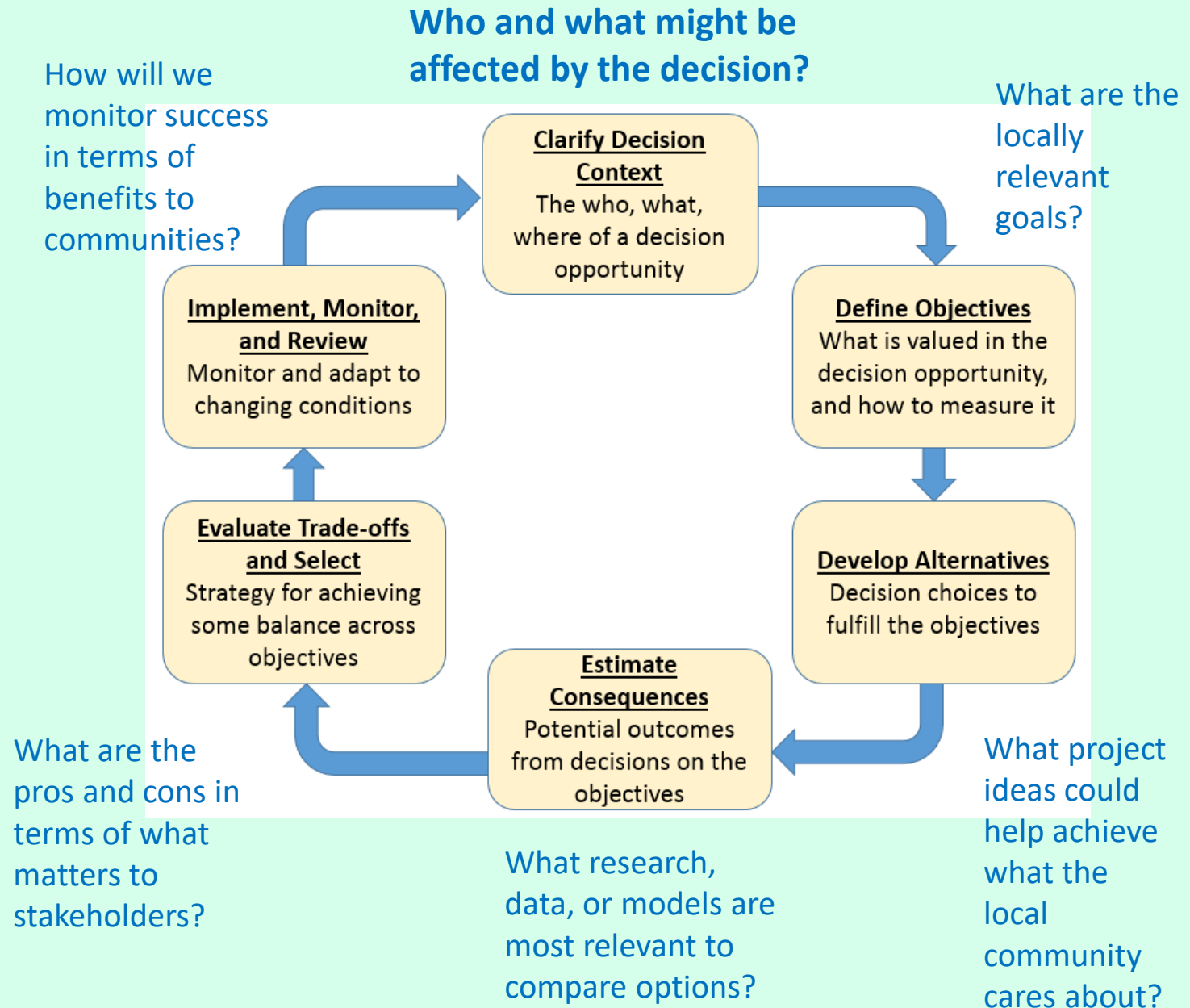
*The views expressed in this presentation are those of the authors and do not necessarily represent the views or the policies of the U.S. Environmental Protection Agency.*

# Challenge

Essential first step to effectively integrating ecosystem services into environmental management decisions is to:

- Identify the key stakeholders
- Understand what is important to them

Forms the foundation for steps in a decision process



# Tools to Help Identify and Prioritize Ecosystem Services

## National Ecosystem Services Classification System (NESCS) Plus

- Organize and structure
- Classify ecosystems, users who benefit, attributes they care about
- Comprehensive – make sure key users or ecosystem services are not overlooked

[www.epa.gov/eco-research/nescs-plus](http://www.epa.gov/eco-research/nescs-plus)



Beneficiary
Agricultural
Commercial/Industrial
Government/Residential
Transportation
Subsistence
Recreational
Inspirational
Learning
Non-use
Humanity

Ecological End Product
Atmosphere
Soil
Water
Fauna
Flora
Fungi
Other Natural
Components
Composite

Environment
Rivers and Streams
Lakes and Ponds
Near-coastal/Estuarine
Open Ocean and Seas
Woody Wetlands
Herbaceous Wetlands
Deciduous Forest
Evergreen Forest
Pasture/Hay
Cultivated Crops
Grassland
Shrubland/Scrubland
Lichens
Moss
Sedge
Dwarf Scrub
Perennial Ice/Snow
Developed Open Space
Developed Low/Med/High
Intensity
Barren Land

# Tools to Help Identify and Prioritize Ecosystem Services



## Final Ecosystem Goods & Services (FEGS) Scoping Tool

- Transparent, repeatable, & defensible
- Grounded in multi-criteria decision analysis
- Formal deliberative approach toward stakeholder and ecosystem services prioritization
- User use best/expert judgment to score relative importance

[www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-scoping-tool](http://www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-scoping-tool)

**Beneficiaries**

Identify the types of beneficiaries making up each stakeholder group by percentage. Select your stakeholder from the drop down and enter the percentages in the input boxes. Each stakeholder must have beneficiary percentages which sum to 100.

Once you have entered your beneficiary data proceed to the Attribute page.

**Notes**

Select a Stakeholder Group

Herb Nolan/Solomon Foundation

This stakeholder group does not directly benefit from the ecosystem

Select Beneficiaries

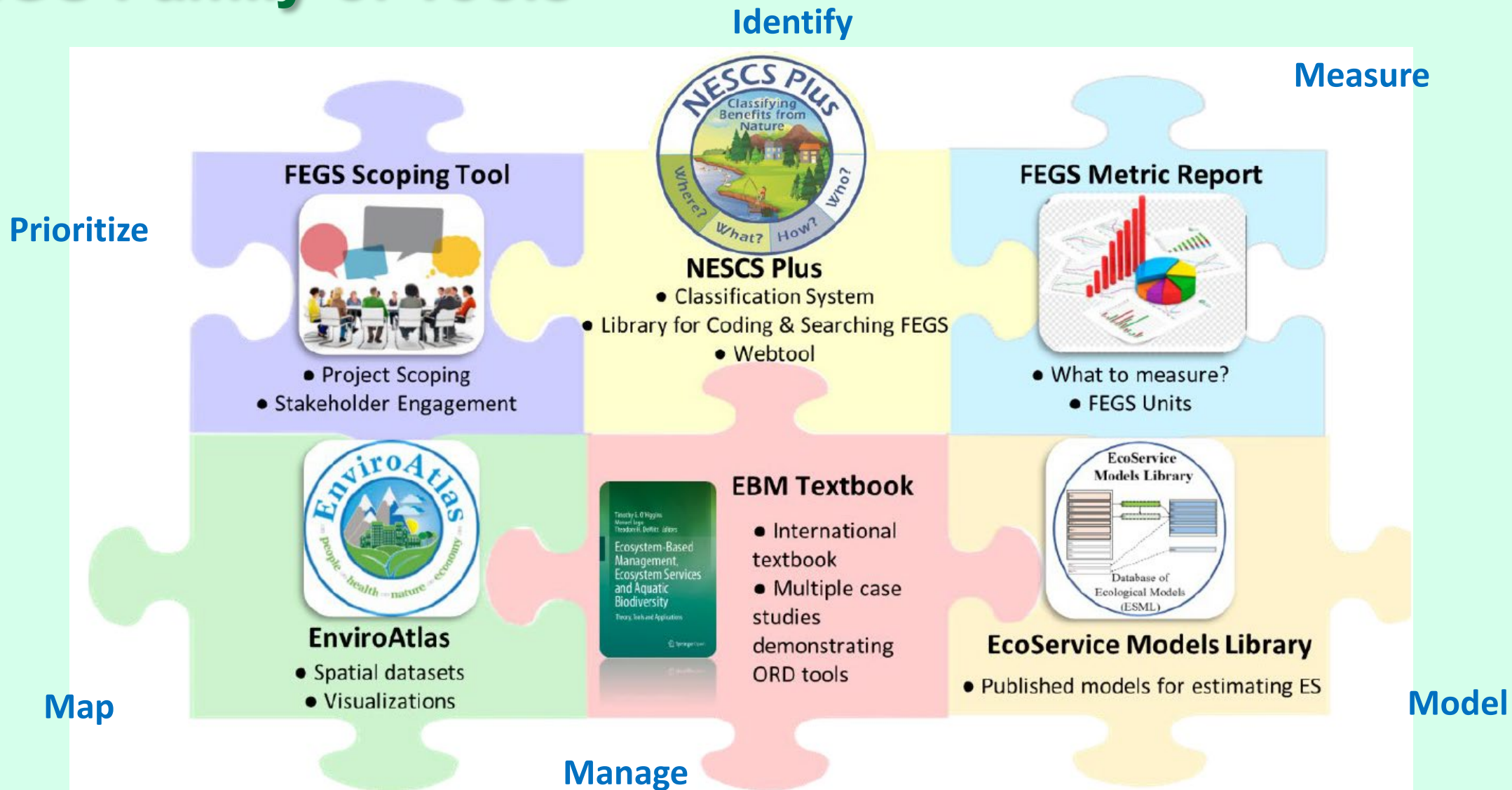
**Agricultural** **Commercial / Industrial** **Governmental / Municipal / Residential**

**Transportation** **Subsistence** **Recreational** **Inspirational** **Learning** **Non-Use**

Category	Subcategory	Definition	Priority
	<b>Hide Definitions</b>		
	Experiencers / Viewers	Views and experiences the environment as an activity (e.g., bird, wildlife, or fauna watching; nature appreciation; hiking, biking, camping, climbing, outings, sunbathing, sightseeing, beach combing)	9
	Food Pickers / Gatherers	Recreationally collects or gathers edible flora, fungi, or fauna (does not include hunting or trapping) (e.g., berry picking, mushroom	9



# FEGS Family of Tools



Sharpe et al. 2023. *Frontiers*. <https://doi.org/10.3389/fevo.2023.1290662>

# Why FEGS?

## Final Ecosystem Goods and Services (FEGS)

“[biophysical] components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

Environmental  
Context



Mangroves

Where?

+

Beneficiary



Recreational Birdwatchers

Who?

+

Ecological  
Attribute



Charismatic bird species

What?

# Why FEGS?

- Clarify what is meant and reduce ambiguity
- Directly relevant to stakeholders

## Intermediate Ecosystem Services

Water quality

What?

Where?

For who?

## Final Ecosystem Goods & Services

**Water salinity** in **groundwater** that local **farmers** depend on for irrigating crops

**Water temperature** in **local streams** used by **industrial processors** for cooling

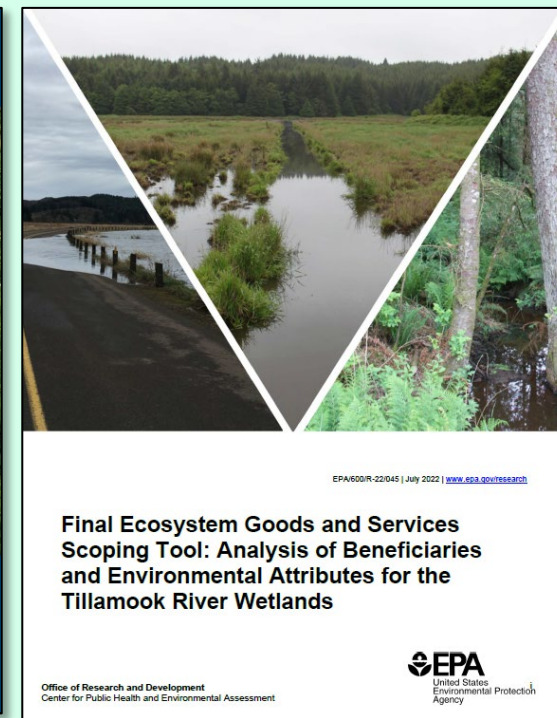
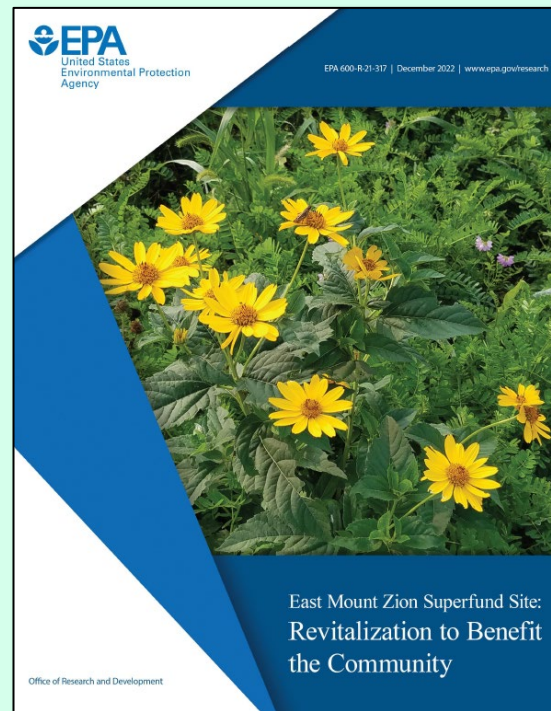
**Water turbidity** in **coastal waters** that are visited by **snorkelers**



# Scoping Priority FEGS

## NESCS Plus and FEGS Scoping Tool

- Rely on user to identify and classify important beneficiaries and ecosystem services
- Ideally user works directly with decision-makers and other organizational representatives to elicit their opinions and priorities
- Have been used as part of stakeholder engagement in several case studies



## But...

- Learning curve to understanding and applying a classification system
- Stakeholder engagement can be challenging and time consuming
- Importance scoring can be subjective



# FEGS Document Reader

## New addition to FEGS Tool Family

A deep learning, text-mining technology to accelerate the identification and prioritization of ecosystem services when written information is available

Provides an assessment of:

- the relative importance of different ecosystems mentioned in documents
- the types of beneficiaries who use or care about those ecosystems
- the most relevant ecosystem services important to those users

### FEGS Document Reader Tool

This tool is intended to help identify and prioritize ecosystem services attributes and the beneficiaries who use or care about them based on a search for keyword terms in pdf documents.

**Upload Document(s)**  
Browse... No file selected  
Find Matches Cancel

**Choose figure type:**  
 Bar Chart  
 Pie Chart

**Display which ecosystem?**  
[Dropdown menu]

**Export results as:**  
 .xlsx  
 .fegs  
Export

**Export which figures:**  
 All Ecosystems  
 Select from list  
Export

Documents Environment Profile Beneficiary Profile Attribute Profile Word Cloud

**Instructions for the FEGS Document Reader:**  
Step 1: Upload pdf documents  
Step 2: Find keyword matches in sentences  
Step 3: Create and view figures

**Uploaded Document(s):**  
No documents uploaded  
Remove selected file(s)

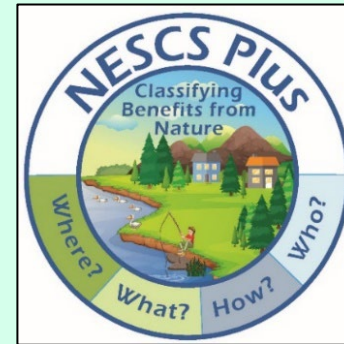
**Keyword Matches:**  
Upload documents then click 'Find Matches' to search for keyword matches. Finding Matches can take 10-30 seconds per document, or >60 seconds for large documents.

**R Shiny Application**

# Tool Overview

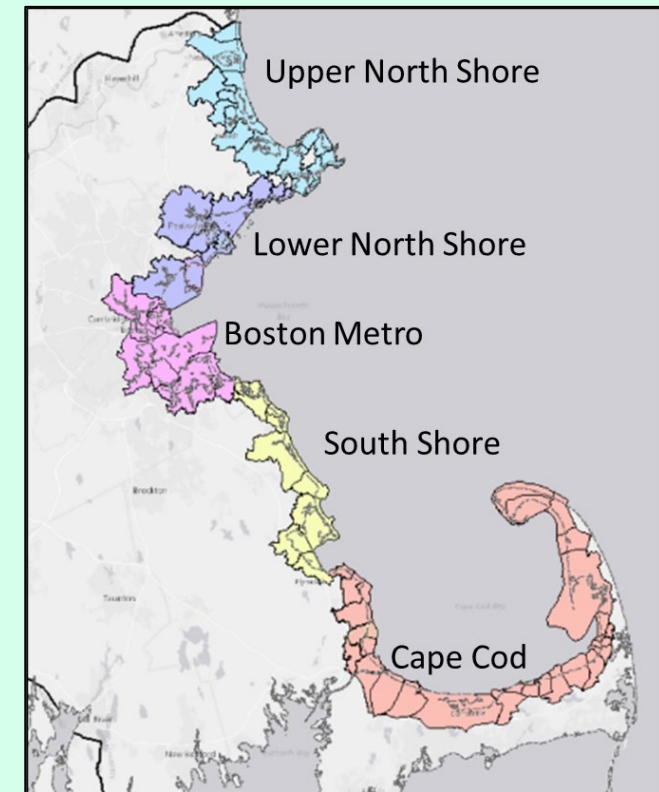
- Leverages NESCS Plus to classify text
  - the **Environment** providing the service
  - the **Beneficiary** who uses or cares about it
  - the **Ecosystem Attribute** the user cares about
- Classes/SubClasses are defined by >5000 keyword search terms
- Searches sentences for keywords and counts class/subclass frequencies
- Considered a “FEGS” if all 3 (Beneficiary, Ecosystem Attribute, Environment) mentioned in same sentence ( $\pm 1$ )

Beneficiary	Ecosystem Attribute	Environment
Agricultural Commercial/Industrial Government/Residential Transportation Subsistence Recreational Inspirational Learning Non-use Humanity	Atmosphere Soil Water Fauna Flora Fungi Other Natural Components Composite	Rivers and Streams Lakes and Ponds Near-coastal/Estuarine Open Ocean and Seas Woody Wetlands Herbaceous Wetlands Deciduous Forest Evergreen Forest Pasture/Hay Cultivated Crops Grassland Shrubland/Scrubland Lichens Moss Sedge Dwarf Scrub Perennial Ice/Snow Developed Open Space Developed Low/Med/High Intensity Barren Land



# Tool Overview

- Keywords originally developed and refined for coastal case studies
  - Who Benefits from National Estuary Programs (Yee et al. 2019)
  - Community Profiles of Coastal Habitat Use in Massachusetts Embayments (Yee et al. 2023)
  - Regional Differences in Tidal Wetland Management Priorities (Jackson et al. 2024)



Organization Categories	Pacific Northwest	Mid-Atlantic	Northern Gulf of Mexico	Total
Federal Agencies	5	5	10	20
State and Local Agencies	13	18	14	45
Land Stewards	17	23	16	56
Wetland Conservation Organizations	10	4	6	20
<b>Total</b>	<b>45</b>	<b>50</b>	<b>46</b>	<b>141</b>

# Tool Steps

- Follows the same steps as the FEGS Scoping Tool

Step 1: Documents represent “Stakeholders”

Step 2a: Generate a Beneficiary Profile for each “Stakeholder”

2b: Generate an Average Beneficiary Profile across All Documents

Step 3a: Identify Ecosystem Attributes Relevant to each Beneficiary

3b: Generate an Average Attribute Profile across All Documents

Step 4: Prioritization can be Filtered by Ecosystem and exported as output files (.xls, .fegs)

## FEGS Scoping Tool



*importance weights are based on frequencies of mentions in documents*



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## **Kinds of documents that may contain ecosystem services information**

ADAPTATION PLANS OR STRATEGIES  
BROCHURES OR GUIDES  
CLIMATE, RESILIENCE, OR VULNERABILITY PLANS  
COMMUNITY OR TOWN REPORTS  
CONSERVATION OR RESTORATION PROJECTS/PLANS  
ECONOMIC PLANS  
ENVIRONMENTAL IMPACT REPORTS OR STATEMENTS  
FEASIBILITY REPORTS OR STUDIES  
HARBOR PLANS  
OPEN SPACE OR RECREATION PLANS  
MITIGATION PLANS  
HABITAT ASSESSMENTS  
LANDSCAPE OR RESOURCE INVENTORIES  
RECOVERY OR IMPROVEMENT PLANS  
SCIENTIFIC JOURNAL ARTICLES  
STORMWATER OR WILDLIFE MANAGEMENT PLANS  
SUSTAINABILITY OR STEWARDSHIP PLANS  
WATERSHED PLANS OR REPORTS  
WATER QUALITY ASSESSMENTS OR REPORTS  
WEBSITE CONTENT  
WORKSHOP DISCUSSION NOTES OR SUMMARIES

# Tool Steps

- Follows the same steps as the FEGS Scoping Tool

Step 1: Documents represent “Stakeholders”

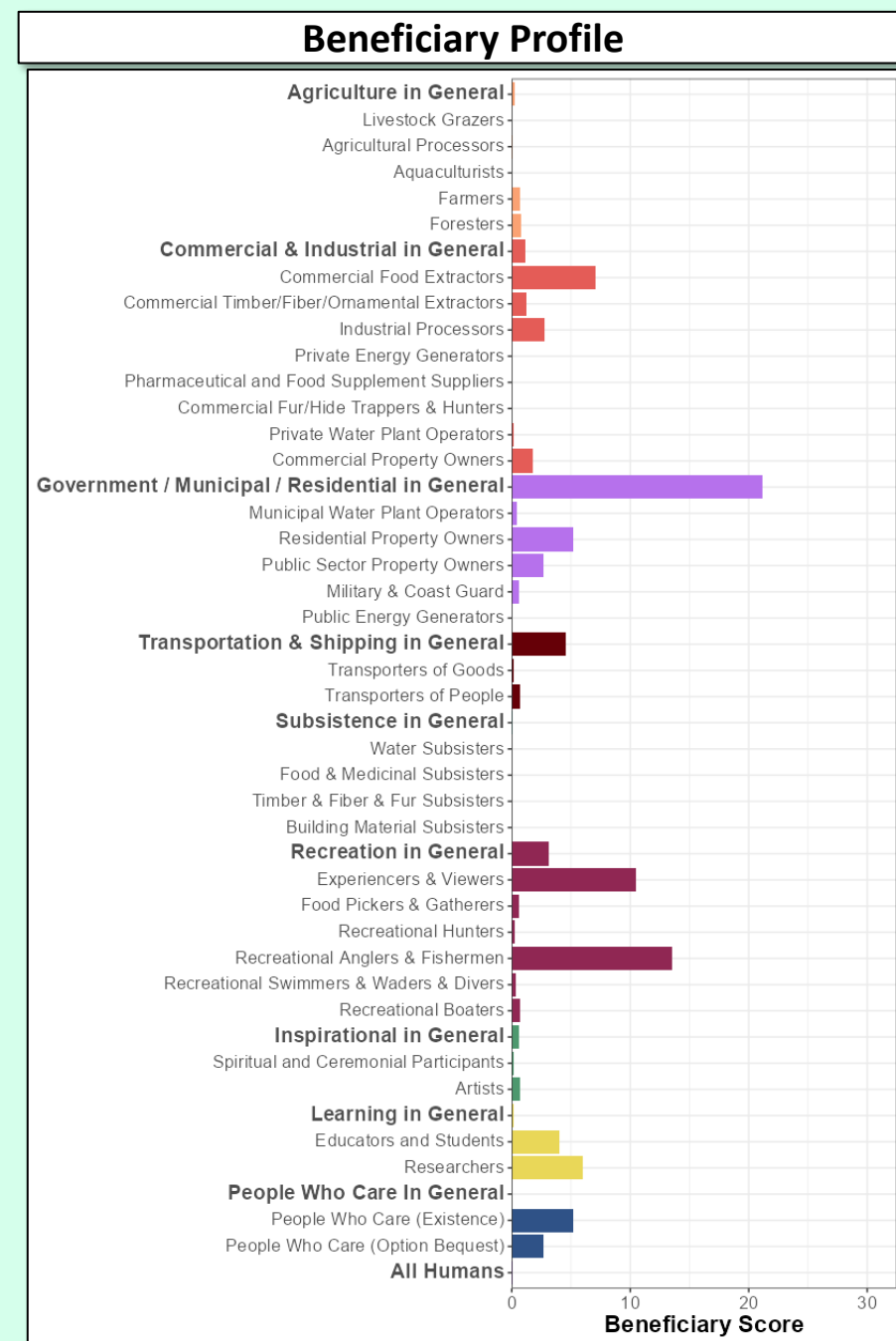
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**2b: Generate an Average Beneficiary Profile across All Documents**

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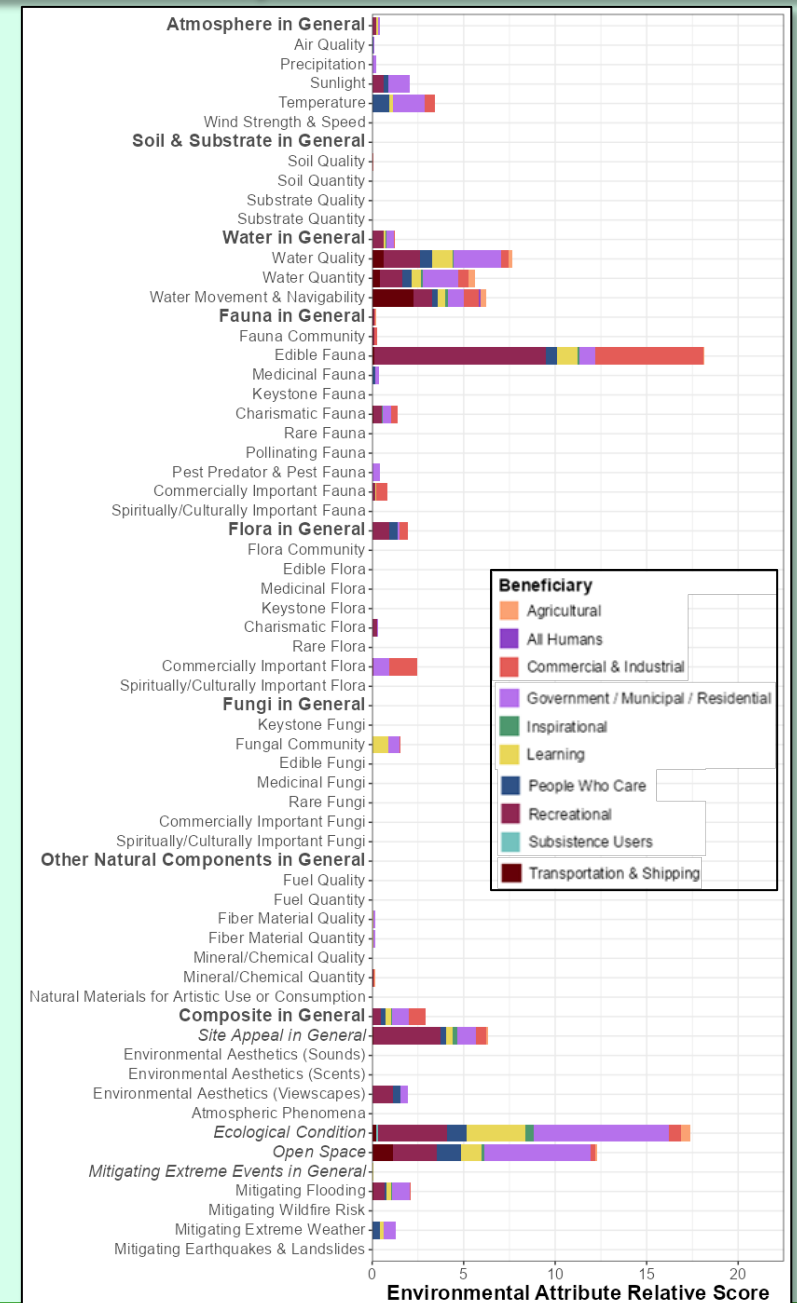
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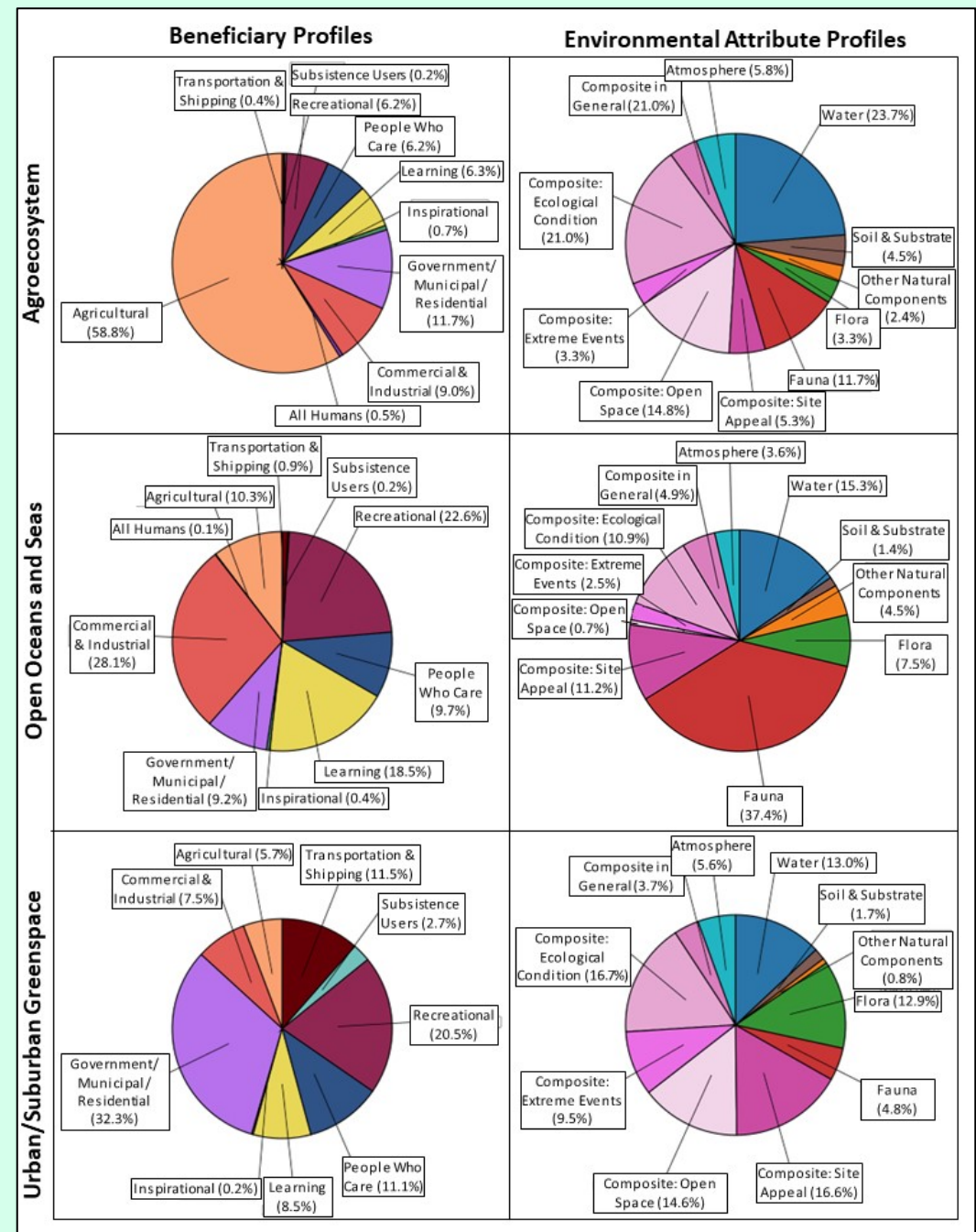




# Demonstration 1

## Identifying Common Themes in EPA Ecosystem Services Case Study Research

- Around 40 EPA case studies that have conducted ecosystem services assessments
- Characterize ecosystems and associated ecosystem services recent EPA case studies investigated



# Demonstration 2

## Soliciting Stakeholder Input on Benefits of Nature-Based Solutions in Crisfield, MD

- Living shorelines, dune restoration, salt marsh restoration, living breakwaters, oyster reefs
- Can NBS reduce storm-related flooding?
- What are the co-benefits?

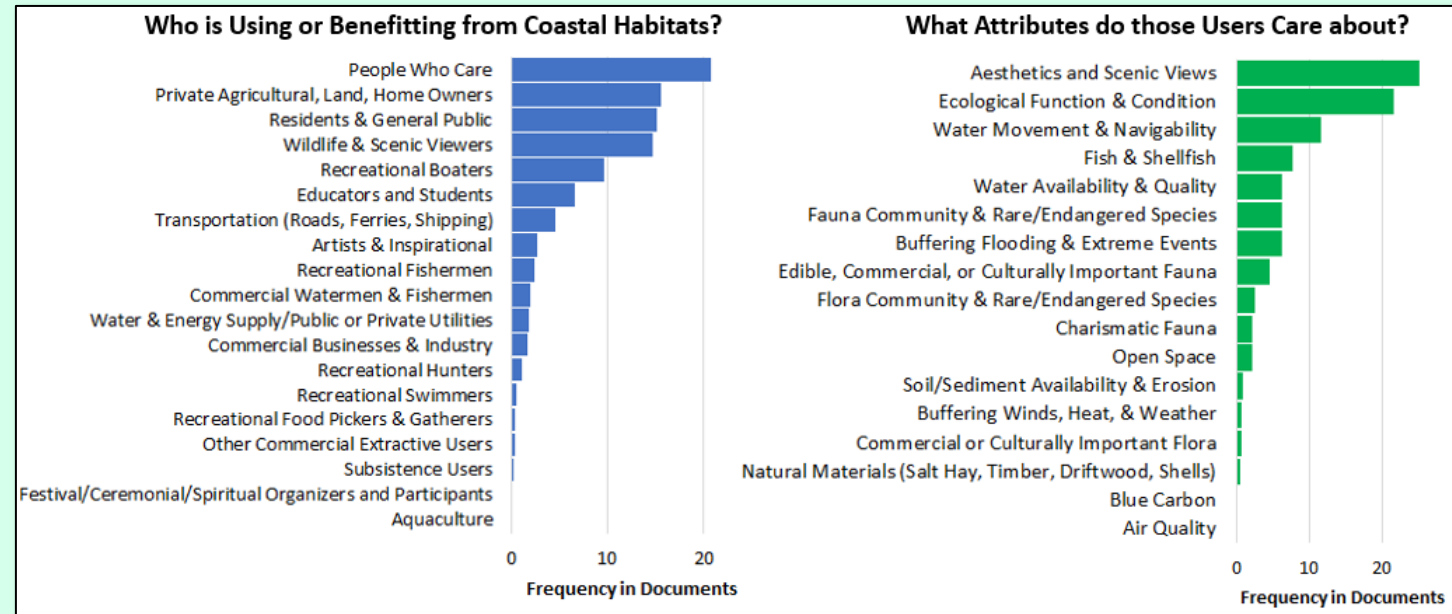




# Demonstration 2

## Soliciting Stakeholder Input on Benefits of Nature-Based Solutions in Crisfield, MD

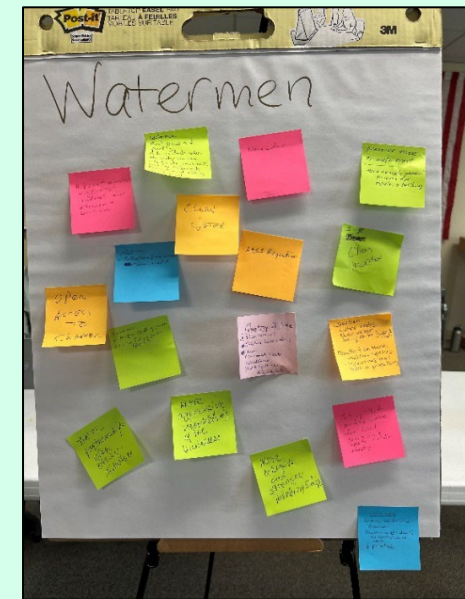
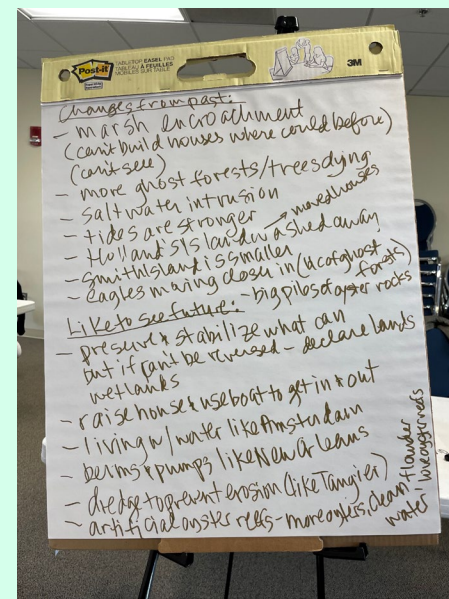
- Analyzed 30+ Documents
- Example to explain co-benefits based on existing knowledge
- Strawman to react to at meeting with institutional representatives



# Demonstration 2

## Soliciting Stakeholder Input on Benefits of Nature-Based Solutions in Crisfield, MD

- Public meeting free-response breakout groups & activities
- Synthesize notes to generate priority list for quantitative assessment



Natural Beauty	26.3
Ecological Condition	20.5
Target Species for Fishing/Hunting/Seafood Industry	15.0
Water Movement & Navigability	9.0
Flora Community	4.9
Flood Protection	4.2
Water Access	3.3
Charismatic Fauna	3.3
Water Quality	3.1
Fauna Community	2.7
Water in General	2.5
Mold	2.0
Natural Open Spaces	1.0
Natural Materials	0.8
Air Quality	0.6
Weather	0.3
Nuisance & Invasive Species	0.2

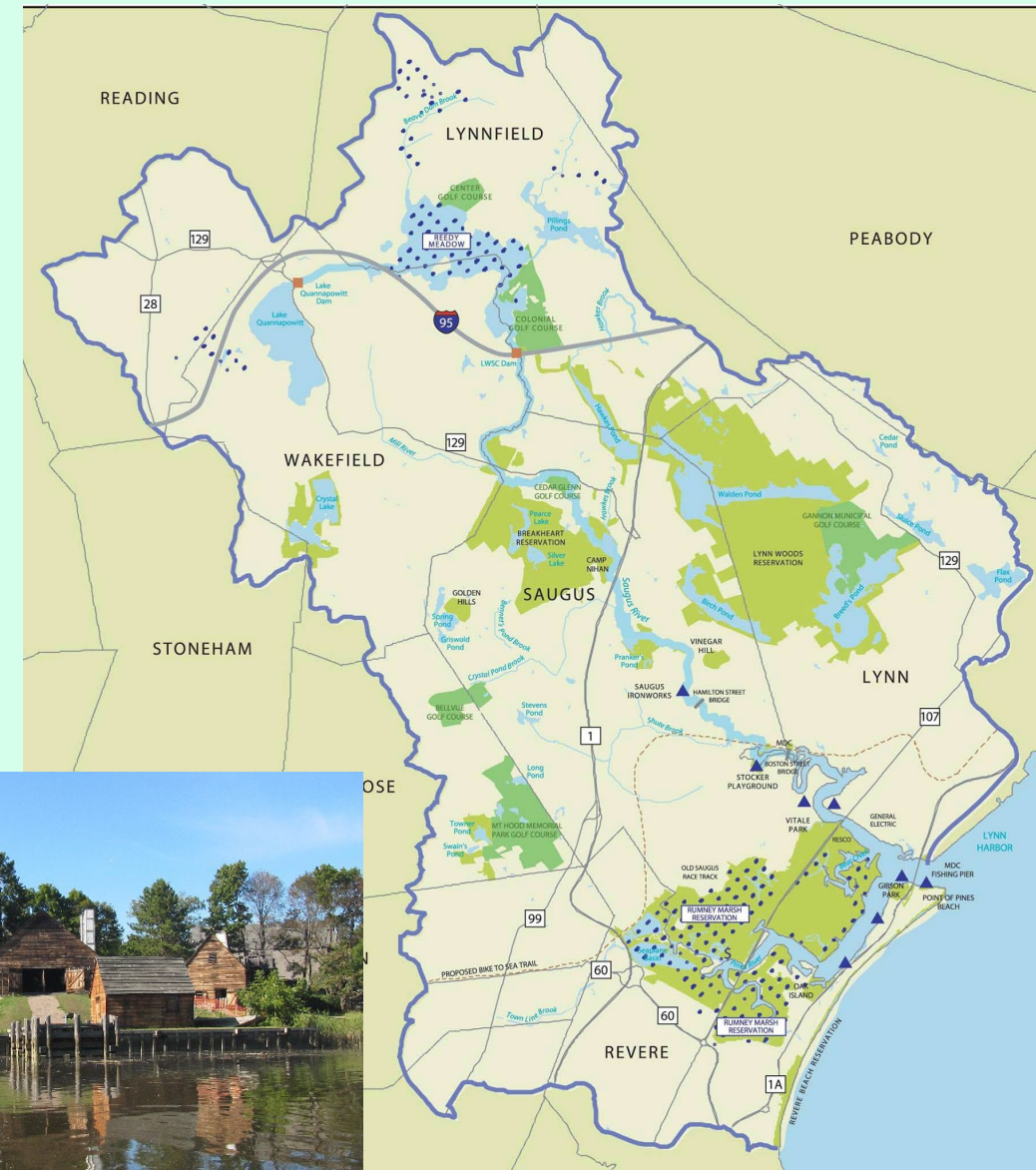
Now working to identify metrics & models to compare co-benefits of NBS options



# Demonstration 3

## Scoping Benefits of Restoration to Key Stakeholders for Saugus River Watershed, MA

- Identify, compare, and communicate potential benefits of restoration options
- Motivate action and funding

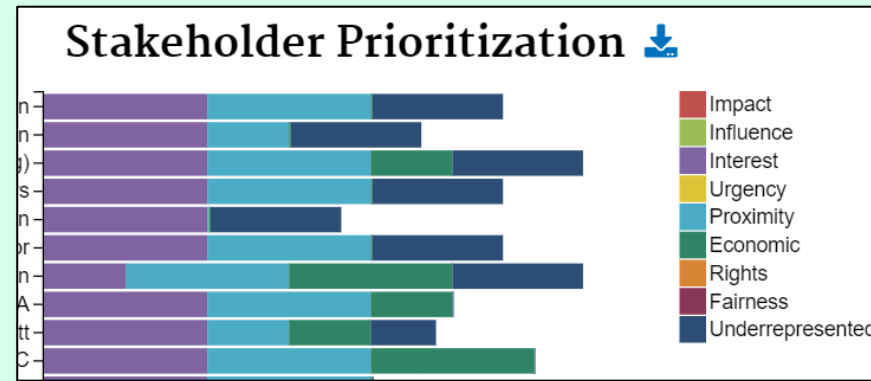


# Demonstration 3

## Scoping Benefits of Restoration to Key Stakeholders for Saugus River Watershed, MA

Two Parallel efforts:

- Used FEGS Scoping Tool directly with partners
- ~60 stakeholders
- Worked through FST steps over several weeks



### Beneficiaries

Select a Stakeholder Group  
Herb Nolan/Solomon Foundation  This stakeholder group does not directly benefit from the ecosystem

Select Beneficiaries

**Agricultural** Commercial / Industrial Governmental / Municipal / Residential Transportation Subsistence

Recreational Inspirational Learning Non-Use

Category	Subcategory	Definition	Herb Nolan/Solomon Foundation
	<b>Hide Definitions</b>		Prioritization Result: 73.9
	Experiencers / Viewers	Views and experiences the environment as an activity (e.g., bird, wildlife, or fauna watching; nature appreciation; hiking, biking, camping, climbing, outings, sunbathing, sightseeing, beach combing)	9

### Attributes

Identify the types of attributes making up each beneficiary group by percentage. Identify how much each beneficiary group cares about the listed environmental attributes by percentage. Each beneficiary group must have attributes which sum to 100.

Notes [✎](#) [^](#)  
Your notes here...

Select a Beneficiary Group  
Recreational

Select Attributes

**Atmosphere** Soil Water Fauna Flora Fungi Other Natural Components Composite (and Extreme Events)

Attribute Tier 1	Attribute Tier 2	Recreational					
		Experiencers / Viewers	Food Pickers / Gatherers	Hunters	Anglers	Waders / Swimmers / Divers	Boaters
Beneficiary Result		8.16	6.94	1.36	6.97	7.59	8.02
Atmosphere	Air Quality	4	6		5	4	4
	Wind Strength / Speed	4	6	7	5	4	4
	Precipitation	4	6	7	5	4	4
	Sunlight	4	6	7	5	4	4

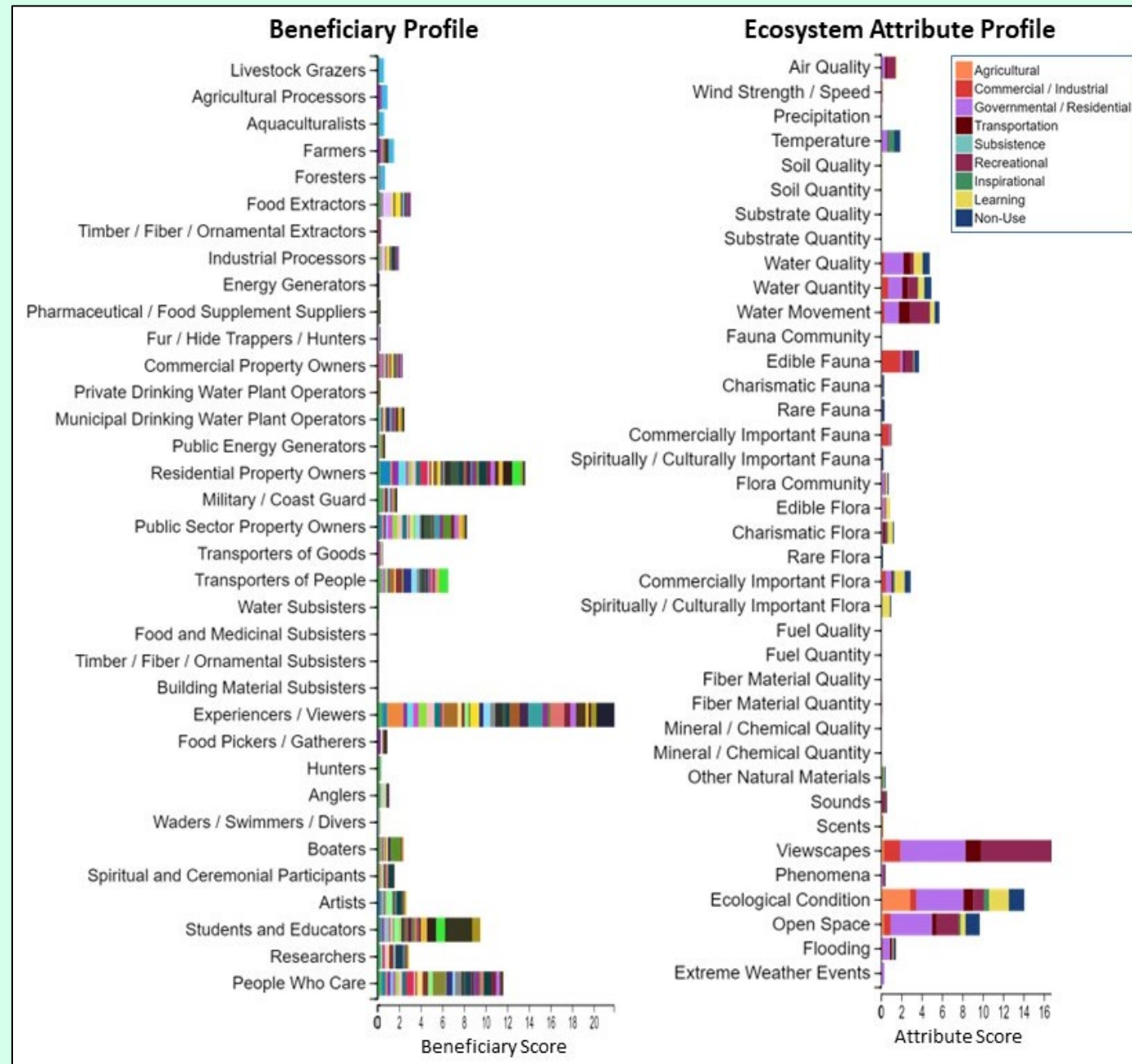
# Demonstration 3

## Scoping Benefits of Restoration to Key Stakeholders for Saugus River Watershed, MA

Two Parallel efforts:

- Identified documents for those same stakeholders
- Investigated whether document analysis provided additional insights over FST

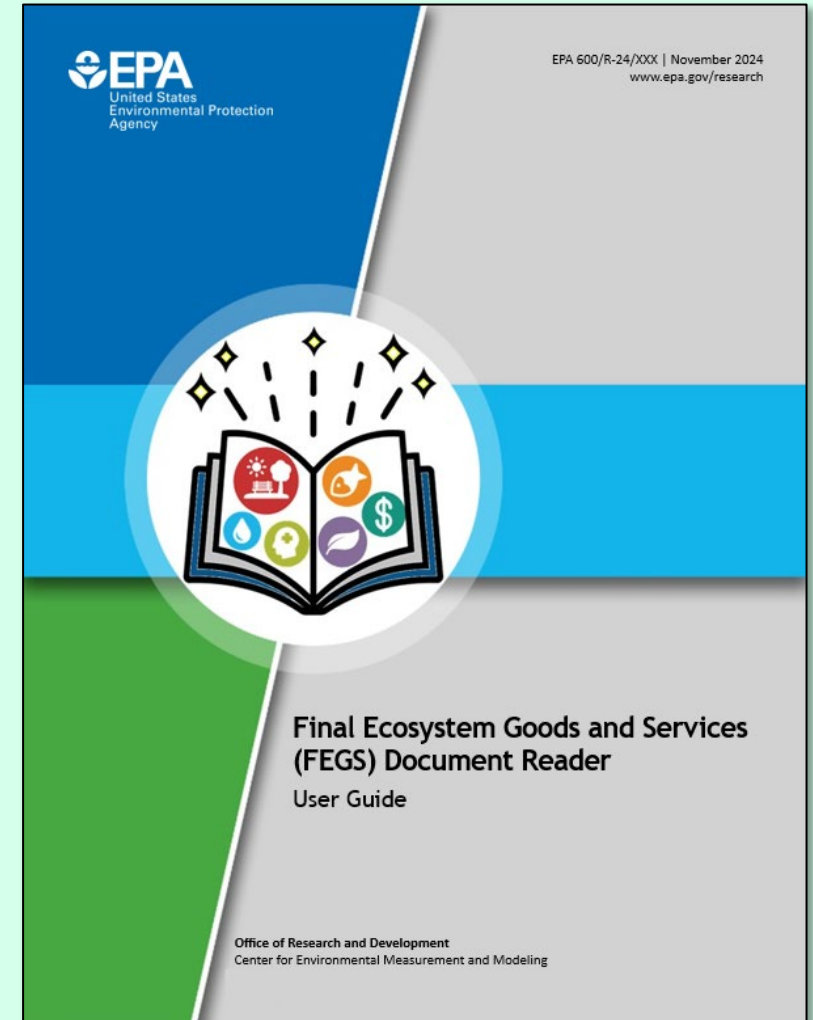
Next steps – comparing benefits of different restoration options



# Summary

- Ready to go 'live'
- Not intended to be a substitute for thoughtful stakeholder engagement
- Can serve as a starting point for more efficient or targeted engagement
- For some applications, a 'fast' assessment of existing information may be adequate
- Can provide a consistent approach for investigative analysis of documents (spatial, temporal comparisons)

[https://shiny.epa.gov/FEGS\\_Document\\_Reader](https://shiny.epa.gov/FEGS_Document_Reader)  
yee.susan@epa.gov





# Thank you!

## FEGS Document Reader



## FEGS Scoping Tool



- Project Scoping
- Stakeholder Engagement



## NESCS Plus

- Classification System
- Library for Coding & Searching FEGS
- Webtool

## FEGS Metric Report

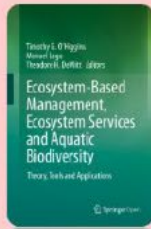


- What to measure?
- FEGS Units



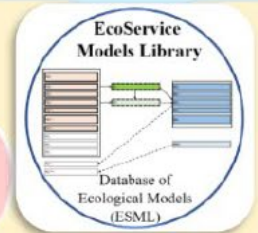
## EnviroAtlas

- Spatial datasets
- Visualizations



## EBM Textbook

- International textbook
- Multiple case studies demonstrating ORD tools



## EcoService Models Library

- Published models for estimating ES

## Acknowledgments

- Co-authors on previous publications using earlier versions of document analysis
- Collaborators on FEGS family of tools
- Collaborators on Crisfield, MD research project
- City of Crisfield, MD
- Collaborators on Saugus River, MA research project
- Saugus River Watershed Council