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Operationalizing Ecosystem Services Endpoints and Assessment Tools for Supporting Risk Assessments in Contaminated Site Cleanups

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Operationalizing Ecosystem Services Endpoints and Assessment Tools for Supporting Risk Assessments in Contaminated Site Cleanups[1]

By

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Abbreviations and Symbols

Acronyms and abbreviations used in this report include the following:

BERA	Baseline Ecological Risk Assessment
CCTE	Center for Computational Toxicology and Exposure
CEMM	Center for Environmental Measurement and Modeling
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (referred to as Superfund)
CESER	Center for Environmental Solutions and Emergency Response
CICES	Common International Classification of Ecosystem Services
COPC	Contaminants of Potential Concern
CPHEA	Center for Public Health and Environmental Assessment
EGS	Ecosystem Goods and Services
EM	Ecological Models
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ERAF	Ecological Risk Assessment Forum

ERAF EGS WG	Ecological Risk Assessment Forum's Ecosystem Goods and Services for Directing and Communicating Ecological Risk Workgroup
ERT	Environmental Response Team
ESML	EcoService Models Library
FEGS	Final Ecosystem Goods and Services
FST	FEGS Scoping Tool
FYR	Five-Year Reviews
GAP	Gap Analysis Project
GEAE	Generic Ecological Assessment Endpoint
GIS	Geographic Information Systems
GLWQA	Great Lakes Water Quality Agreement
HUC	Hydrological Unit Code
NAICS	North American Industrial Classification System
NARPM	National Association of Remedial Project Managers
NESCS Plus	National Ecosystem Services Classification System Plus
OSC	On-Scene Coordinator
OECA	Office of Enforcement and Compliance Assurance
OLEM	Office of Land and Emergency Management
OMB	Office of Management and Budget
ORD	Office of Research and Development
ORM	Office of Resource Management
OSAPE	Office of Science Advisor, Policy, and Engagement
OSRE	Office of Site Remediation Enforcement
OSRTI	Office of Superfund Remediation and Technology Innovation
P&S	Planning and Scoping
PRP	Potentially Responsible Party
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPM	Remedial Project Manager
SAB	Science Advisory Board
SHC	Sustainable and Healthy Communities
SLERA	Screening-Level Ecological Risk Assessment
STLR	Superfund and Technology Liaison Research
USGS	United States Geological Survey
VRD	Variable Relationship Diagram

Table of Contents

Notice and Disclaimer iii
Citation for this Report iii
Acknowledgments iii
Abbreviations and Symbols iii
Executive Summary 2
Introduction 3
Background 3
EPA's Ecosystem Services Tools 7
Relevant EGS Tools at EPA 7
Workshop 20
Logistics 20
Workshop Introduction 20
Workshop Case Study 27
Conclusions and Future Directions 29
References 31
Appendix 1 – Overview Presentations 33
Appendix 2 – Theoretical Case Study Presentation 80
Appendix 3 – EGS Tool Outputs Based on Workshop's Hazardous Site Case Study 86

Executive Summary

Cleanup of contaminated sites focuses on activities needed to minimize risks of contaminants to human health and the environment. As part of necessary efforts during contaminated site cleanups, an ecological risk assessment (ERA) is conducted to examine the extent of potential contamination and evaluate risks to the environment. In the Superfund context, an ecological risk assessment is a qualitative or quantitative appraisal of the actual or potential impacts of contaminants from a hazardous waste site on plants and animals other than humans and domesticated species (USEPA, 1997).

The U.S. Environmental Protection Agency (EPA) has been applying ecosystem goods and services (EGS) concepts – the benefits we get from nature – in contaminated site cleanups for more than a decade. Recently, an EPA Superfund Technical Liaison Research (STLR) project focused on the incorporation of existing EPA/Office of Research and Development (ORD) EGS tools and concepts into the established ERA process. This effort examined potential strategies for employing EGS tools and concepts to enhance potential ERA outputs.

Although ecological and human health risk assessments are largely separate undertakings, one distinctive feature of EGS is that they are able to crosswalk ecosystem quality to human health and well-being. As such, EGS can provide a profound enhancement to any assessment because they bridge the ecosystem-human health divide. Thus, incorporating EGS into the ERA process has the potential to improve the environmental and socio-economic outcomes of contaminated site cleanup. As such, there is a need for site-specific examples that incorporate EGS into the ERA process for risk assessors and other technical staff to be able to routinely incorporate nature's benefits to humans into the investigation, analysis, risk assessment, and remedial decisions of hazardous waste sites. In order to effectively incorporate EGS into the hazardous waste site remedial process, risk assessors will need the buy-in, support, and understanding of their project managers and upper management, and in some cases, resources provided by federal and private contractors.

Overall, these tools and approaches could be useful for ERAs in contaminated sites to achieve better outcomes and enhance community engagement and support. Until recently, there had been no EGS-focused coordination or training for ERA practitioners, Remedial Project Managers, Community Involvement Coordinators, etc. Future work should focus on providing site-specific examples of incorporating EGS concepts and tools into ERAs focused on: (1) developing real site examples of operationalizing certain EGS-based tools, models, and assessment endpoints in ERAs conducted at Superfund fund-lead sites; and (2) providing evidence and framework for others, including state and tribal environmental agencies, to potentially utilize these examples at Responsible Party (RP)-led Superfund sites and regional Resource Conservation and Recovery Act (RCRA) sites. Additional outreach to relevant local, state, and federal stakeholders on EGS tools development and application at hazardous waste sites should be conducted. Additionally, trainings and informational webinars should be developed and conducted to provide more awareness of EGS tools, their potential benefits, and examples of their applications.

Introduction

Background

The U.S. Environmental Protection Agency (EPA) has been applying ecosystem goods and services (EGS)[1] concepts in contaminated site cleanups for more than a decade. The EPA's Science Advisory Board (SAB) in 2009 identified potential connections between the use of EGS concepts and approaches and steps in remediation and redevelopment processes (USEPA, 2009). As summarized in Harwell et al. (2021), the SAB recommended integrating EGS assessments into multiple stages of a contaminated site cleanup effort. In 2015/2016, EPA efforts focused on developing generic guidelines for incorporating EGS into ecological risk assessments (ERA) through the development and application of Generic Ecological Assessment Endpoints that incorporate EGS in ERA (USEPA, 2015; Munns et al., 2016). Other work has applied EGS concepts in contaminated site cleanups, including in Beneficial Use Impairment Assessments for the Great Lakes Areas of Concern (Angradi et al., 2016; Williams and Hoffman, 2020), and the development and retrospective application of a generalizable framework for considering EGS in contaminated cleanups (Harwell et al., 2021), and the value-added aspects that EGS consideration can bring to monitoring design and subsequent assessments (Harwell et al., 2022). These advancements provide inspiration and opportunities to explore options for operationalizing EGS in risk assessments of hazardous waste sites.

An EPA (2016) report, *Generic Ecological Assessment Endpoints (GEAE) for Ecological Risk Assessment (2nd Edition) with Generic Ecosystem Services Endpoints*, was developed "to assist EPA risk assessors conducting ecological risk assessments in considering ecosystem services when selecting assessment endpoints. Incorporating ecosystem services endpoints in ecological risk assessments can make the assessments more relevant to decision makers and stakeholders with concerns more oriented toward societal outcomes. Ecological risk assessments that include ecosystem service endpoints provide more useful information to economists who perform benefit-cost analyses, relative to conventional endpoints alone. Assessing risks to ecosystem services can highlight potential assessment endpoints that are not considered in conventional risk assessments such as flood control, nutrient cycling, carbon sequestration, and soil formation."

In April 2022, Executive Order 14072, *Strengthening the Nation's Forests, Communities, and Local Economies*[2] was signed, focusing on identifying "key opportunities for greater deployment of nature-based solutions across the Federal Government, including through potential policy, guidance, and program changes." Notably, EO 14072 Section (b) charges the Office of Management and Budget (OMB) with issuing "guidance related to the valuation of ecosystem and environmental services and natural assets in Federal regulatory decision-making." Such OMB guidance will increase the relevance and significance of efforts to use EGS in contaminated site ERAs by providing concrete ways of incorporating the value of EGS during decision-making points of the cleanup process.

Although EGS-based tools have been used to produce environmental benefits at Superfund sites (e.g., Coeur d'Alene River and Lower Darby Creek; Harwell et al., 2021), currently no examples or applications exist that demonstrate how EGS-based tools, models, and assessment endpoints can be used in ERAs at

[2] *See* https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/

Superfund fund-lead sites. Further, there is no guidance or legal requirement that the potentially responsible parties (PRPs) for PRP-led Superfund or RCRA Corrective Action sites incorporate EGS concepts and tools into any aspect of site investigation and remediation. Thus, at present EPA can only encourage PRPs to incorporate EGS concepts and tools by explaining the benefits of their use and application.

Contaminated Site Cleanups and Ecological Risk Assessments

Fundamentally, cleanup of contaminated sites focuses on activities needed to minimize risks of contaminants to human health and the environment. As part of necessary efforts during contaminated site cleanups, an ERA is conducted to examine the extent of potential contamination and evaluate risks to the environment. In the Superfund[3] context, an ERA is a qualitative or quantitative appraisal of the actual or potential impacts of contaminants from a hazardous waste site on plants and animals other than humans and domesticated species (USEPA, 1997).

Ecological risk assessments for contaminated site cleanups are generally conducted using a phased approach – a screening-level ecological risk assessment (SLERA) often followed by a baseline ecological risk assessment (BERA). In SLERAs, the potential for adverse effects to ecological entities are evaluated using conservative, site-specific exposure scenarios (e.g., maximum measured media concentrations) and generic screening benchmark values. The exposure and effects of site related stressors (contaminants for Superfund contexts) on ecological entities are also evaluated in BERAs but they are analyzed using more refined, detailed, and/or targeted site-specific physical, chemical, and biological data and field and/or laboratory studies (USEPA, 2008).

The risk assessment team decides that either the SLERA is adequate to determine that ecological threats are negligible, or that the process should continue to a more detailed BERA. In the latter case, the SLERA serves to identify exposure pathways and preliminary contaminants of concern for the BERA, and it reduces the scope of the BERA by eliminating those contaminants and exposure pathways that pose negligible risks (USEPA, 1997). The results of the baseline risk assessment inform remedial alternatives development during the Feasibility Study by helping establish acceptable exposure levels.

Superfund Technical Liaison Research Project

An FY21 Superfund Technical Liaison Research (STLR) project examined the incorporation of existing EPA/Office of Research and Development (ORD) EGS tools into the established ERA process. The potential for employing EGS tools to enhance potential ERA outputs was explored through a facilitated, EPA workshop held on February 28, 2022.

The workshop focused on:

[3] 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 U.S.C. § 9601 *et seq*.)

1) Enhancing Superfund ERA output usefulness (as well as ERA outputs for other EPA hazardous waste cleanup programs under Resource Conservation and Recovery Act (RCRA)[4], Brownfields[5], and Great Lakes Water Quality Agreement (GLWQA)[6]) during remediation decision-making through incorporating EGS approaches and assessments into the existing ERA process; and
2) Demonstrating EGS concepts and tools and discussing of operationalization of EGS-based concepts and tools in the ERA process.

As recommended in the Executive Summary of USEPA (2015), "In addition to research, training opportunities for ecological risk assessors and risk managers are necessary to enable them to understand better how ecosystem services can be used in the ERA and decision-making processes." The STLR workshop, along with two informational webinars held separately for project managers and risk assessors, helped to serve that purpose.

The STLR workshop was devised and planned by the Ecological Risk Assessment Forum's (ERAF's)[7] *Ecosystem Goods and Services for Directing and Communicating Ecological Risk Workgroup* (ERAF EGS WG). This workgroup is composed of USEPA regional ecological risk assessors from EPA Regions 1, 2, 3, 7, and 9 and ORD scientists and managers from the Center for Environmental Measurement and Modeling (CEMM), Center for Environmental Solutions and Emergency Response (CESER), Center for Public Health and Environmental Assessment (CPHEA), Center for Computational Toxicology and Exposure (CCTE), Office of Science Advisor, Policy, and Engagement (OSAPE), Office of Resource Management (ORM), and Sustainable and Healthy Communities (SHC) National Research Program. The goals of this workgroup were to provide information and resources on EGS-based concepts and tools to Superfund and RCRA human health and ecological risk assessors, project managers, and other support teams (e.g., Community Involvement Coordinators) and to delineate how EGS-based tools and assessment endpoints can be incorporated in the ERAs of hazardous site investigations. For this workshop, four EPA EGS tools were examined in greater detail: National Ecosystem Services Classification System Plus (NESCS Plus); Final Ecosystem Goods and Services Scoping Tool (FST); EnviroAtlas; and EcoService Models Library (ESML).

The objective of the STLR workshop was to help fill information gaps and establish nexuses between ERA and EGS by introducing new and innovative approaches to develop EGS-specific tools and apply them to hazardous waste site ERAs. These approaches will help promote the overall goal of incorporation of EGS in the ERA and decision-making processes used in contaminated sites remediation and redevelopment. Site examples of operationalizing certain EGS-based tools, models, and endpoints in ERAs can provide reference examples and frameworks for others (e.g., regional or state site managers, risk assessors, PRPs) to utilize. The aggregated and organized ERA/EGS information and highlighted major nexuses will facilitate the generation of example applications of EGS enhanced ERAs at contaminated sites. These

[4] 1976 Resource Conservation and Recovery Act (RCRA; 42 U.S.C. 82 § 6901 *et seq*.)
[5] 2002 Small Business Liability Relief and Brownfields Revitalization Act (Brownfields; Pub. L. 107–118, 115 stat. 2356)
[6] 1987 US-Canada Great Lakes Water Quality Agreement (GLWQA) identified Areas of Concern and Beneficial Use Impairments.
[7] The ERAF is a group of EPA risk assessors from Regional and Headquarters Offices that addresses ecological issues pertaining to hazardous waste sites.

examples will then serve as references or case studies that will illustrate how EGS can be incorporated and will demonstrate the resulting enhanced socio-economic ERA relevance. This should lead to wider usage of EGS models, assessment methodologies, and other tools. It is important to acknowledge that there are numerous other ecosystem services tools (e.g., Bagstad et al. 2013), EGS classification systems (e.g., Finisdore et al. 2020), and related biodiversity tools (e.g., the Map of Biodiversity[8]) available for consideration. While this workshop examined USEPA tools, the approach presented would work for other tools, frameworks, and decision support systems, such as the US Fish and Wildlife Service's Information for Planning and Consultation tool[9].

Researchers provided workshop presentations on:

- Generic Ecological Assessment Endpoints (GEAEs);
- A crosswalk of EGS and ERA;
- An ORD EGS Tool Portal (currently under development); and
- Four publicly available ORD tools:
    - the National Ecosystem Services Classification System Plus (NESCS Plus)[10];
    - the Final Ecosystem Goods and Services (FEGS) Scoping Tool (FST)[11]
    - the EnviroAtlas[12]; and
    - the EcoService Models Library (ESML)[13].

Workshop participants included EPA Superfund and RCRA ecological risk assessors and project managers from all 10 EPA Regions, as well as Regional Brownfields project officers, Superfund On-Scene Coordinators, and Community Involvement Coordinators. Participants from EPA Headquarters included scientists from Office of Superfund Remediation and Technology Innovation (OSRTI) and Environmental Response Team (ERT), both within Office of Land and Emergency Management (OLEM) and from Office of Site Remediation Enforcement (OSRE) within Office of Enforcement and Compliance Assurance (OECA). Participants from ORD included representatives from CEMM, CESER, CPHEA, CCTE, OSAPE, ORM, and the SHC National Research Program.

[8] *See* https://www.natureserve.org/map-biodiversity-importance
[9] *See* https://ipac.ecosphere.fws.gov/
[10] *See* https://www.epa.gov/eco-research/national-ecosystem-services-classification-system-nescs-plus
[11] *See* https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-scoping-tool
[12] *See* https://www.epa.gov/enviroatlas
[13] *See* https://www.epa.gov/eco-research/ecoservice-models-library

EPA's Ecosystem Services Tools

Relevant EGS Tools at EPA

Over the past two decades, EPA researchers have led the development and application of a number of EGS-related tools (for overview of EPA EGS research, see Harwell and Jackson, 2021). While an individual tool may have been developed for a specific purpose/application, researchers are exploring how to translate both EGS concepts and tools for applications across a range of decision-making contexts. From this perspective, a crosswalk between EGS tools and steps in a contaminated site ERA framework can advance ERA science. An initial crosswalk table examining EPA EGS tools (Table 1) was developed by Maurice et al. (2019). The Decision Questions column includes example questions that might be asked for any given decision context. They are intended to prompt discussion with the decision makers/stakeholder groups to both increase thinking about what types of EGS are relevant to consider and to translate that information to understand which tool might be most relevant.

ERA Phases	Example EGS Topics and Activities	Some Potential EPA EGS Tools	Decision Questions
Planning and Scoping	• Identify EGS in site landscape	• FEGS Scoping Tool • FEGS Classification System • National Ecosystem Services Classification System-Plus (NESCS-Plus)	• Who are the stakeholders and what are their relative standings and levels of impact? • Do EGS classification systems help with selection, completeness, and comparability across assessment endpoints? • Would inclusion of EGS facilitate broader conversation with stakeholders and include ecosystem structure, function and benefits they had not considered?
Problem Formulation	• Describe EGS benefits • Estimate magnitudes of EGS benefits • Incorporate EGS into conceptual site model (CSM)	• FEGS Scoping Tool • EcoService Models Library (ESML) • Eco-Health Relationship Browser • EnviroAtlas • Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)	• What resources have stakeholders indicated are important for protection? • What health concerns do they have? • Has there been prioritization by stakeholders? • What do spatial data-layers tell us about the site and it's surrounding area?
Analysis	• Evaluate potential EGS/site contaminants connectivity • Evaluate potential effects of site contaminants on EGS • Evaluate EGS condition (functionality, impairment level) • Evaluate EGS resilience/vulnerability to site contaminants • Calculate EGS cost savings and other benefits • Assess EGS capacity (type, temporal, seasonal) • Assess EGS importance to stakeholders • Assess EGS maintenance effort and cost • Identify key features or parameters to protect EGS benefits	• EcoService Models Library (ESML) • EnviroAtlas • EPA H2O Tool • Rapid Benefit Indicators (RBI) Approach • Visualizing Ecosystem Land Management Assessments (VELMA) Model • Causal Analysis/Diagnosis Decision Information System (CADDIS)	• Are EGS attributes quantifiable (i.e., can they be measured or modeled)? • Which indicators might serve as proxy for assessing classes of EGS? • What spatial and temporal factors need to be considered? • Can EGS related ecological receptors be aggregated in space or across contaminants? • What are the estimated differences in benefits between multiple future scenarios? • How do upstream and downstream areas affect or are affected by the site? • How might benefits be valued?
Risk Characterization	• Compare costs and benefits of EGS • Characterize site contaminant threats to EGS • Characterize EGS impairment level by site contaminants	• EcoService Models Library (ESML) • EnviroAtlas • EPA H2O Tool • Rapid Benefit Indicators (RBI) Approach	• Would EGS help with risk characterization of aggregate and cumulative risk? • Can costs and benefits be compared using similar units of measure? • Where are the beneficiaries? • Which beneficial uses might be impacted or restored?
Risk Communication	• Articulate EGS benefits and costs	• All of the above	• What EGS do decision makers and stakeholders care about? • How do EGS contribute to human health and wellbeing?

Table 1. *Crosswalk between EGS Topics/Activities/Tools and ERA Phases. From Maurice et al. (2019)*

While there are many EPA EGS tools available, including many developed outside of EPA, the STLR project examined four EGS tools for their utility in advancing ERA science: NESCS Plus; FEGS Scoping Tool (or FST); EnviroAtlas; and ESML. Information about the tools and their use in relation and relevance to ERA is presented below.

National Ecosystem Services Classification System Plus (NESCS Plus)

The EPA has developed the NESCS Plus for classifying benefits to human communities from nature (Newcomer-Johnson et al., 2020). A well-defined framework for classifying EGS is essential for

systematically identifying and tracing these linkages. The NESCS Plus includes a suite of definitions and a classification system that can:

- identify and classify what matters directly to people;
- be applied at multiple spatial scales;
- promote interdisciplinary communication about the nature of EGS; and
- facilitate development of biophysical metrics that could be measured to link EGS to human well-being.

As solely a classification system, the NESCS Plus only provides the framework for analyzing how, and how much, changes to ecosystems impact human welfare, rather than being a tool used to conduct such analyses. Through establishing the framework for analyses, the NESCS Plus enables the analyses for various types of environmental management actions, policies, and regulations.

From the start, quantifying (and where feasible, valuating) how much changes in an ecosystem can impact human well-being requires identification of the relevant final EGS (those that directly benefit people). The NESCS Plus facilitates these analyses by enabling the analyst to answer four questions about the final EGS: Where? What? How? and Who? Through a user navigating these questions for their given decision context/location, the NESCS Plus generates a list of potential final EGS that are applicable to that decision context/location.

The first step in using the NESCS Plus is determining how to query the tool. The user has two initial choices, i.e., “Browse Core Options” (Figure 3a-c) or “Query All Options” (Figure 4a-b).

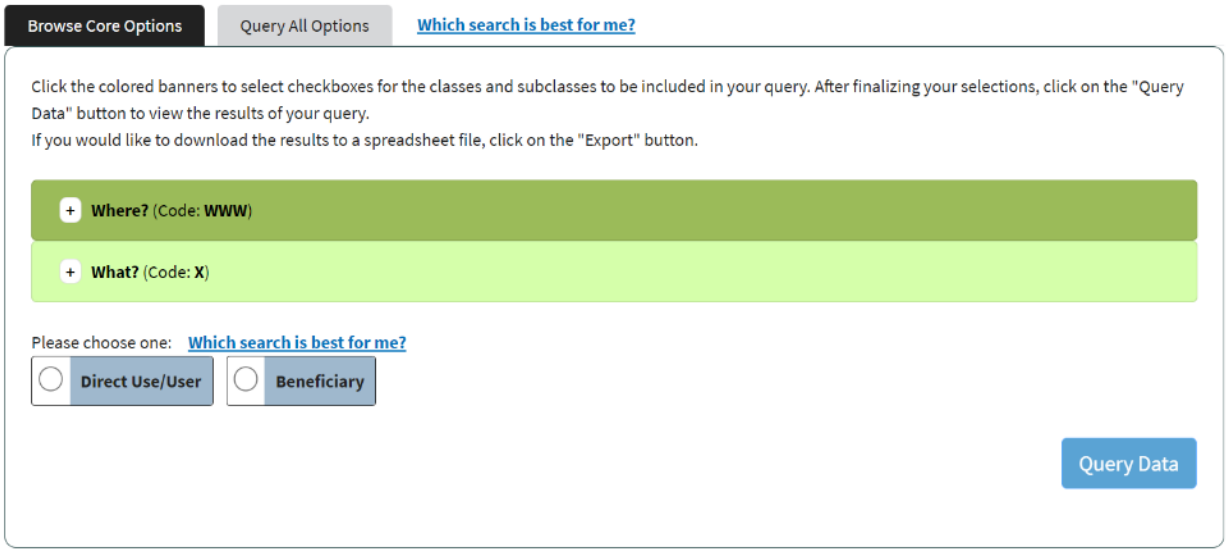

FIGURE 3A

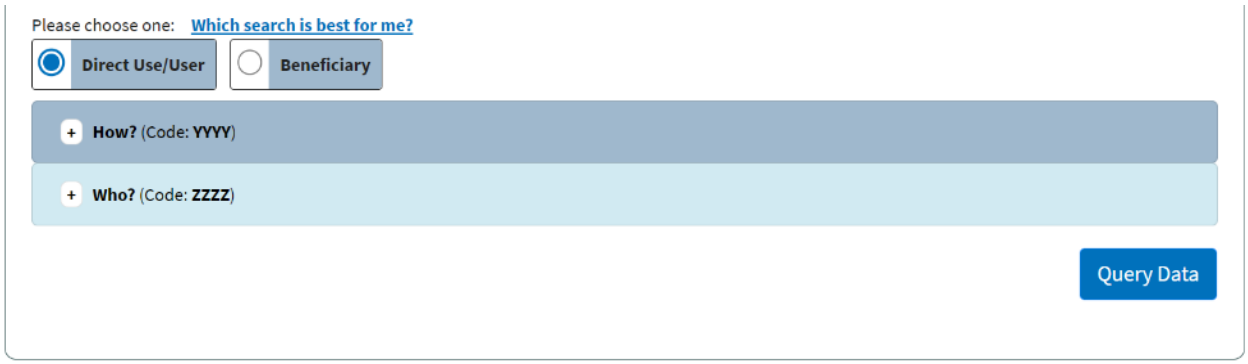

FIGURE 3B

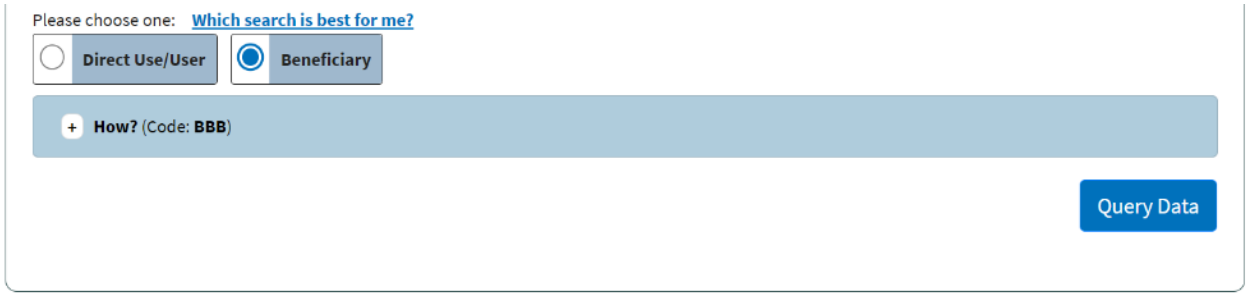

FIGURE 3C

Figure 3. *The NESCS Plus query option of "Browse Core Options" (A) allows the user to navigate a core set of potential results by selecting among a suite of options for Where?" and "What?", followed by (B) choosing the path of a "Direct Use/User" allowing the user to choose among "How?" and "Who?", or choose the path of a (C) "Beneficiary" to complete the query for a different coding of "How?" From Newcomer-Johnson et al. (2020).*

Both approaches in (B) and (C) are designed to support a comprehensive accounting of the different ways in which humans benefit from ecosystems. Regardless of the search selected, you will receive results for Direct Use, Direct User, and Beneficiary classes.

The "Direct Use/User" approach (B) uses the North American Industrial Classification System (NAICS) system - the standard used by U.S. federal statistical agencies in classifying business establishments - to classify Who?" (i.e., identify the Direct User) and offers an easy link to other information systems that use NAICS categories or codes to classify economic or other data.

The "Beneficiary" approach (C) is simpler because it only contains one component, and thus it may be more intuitive, especially for users that have less experience with NAICS.

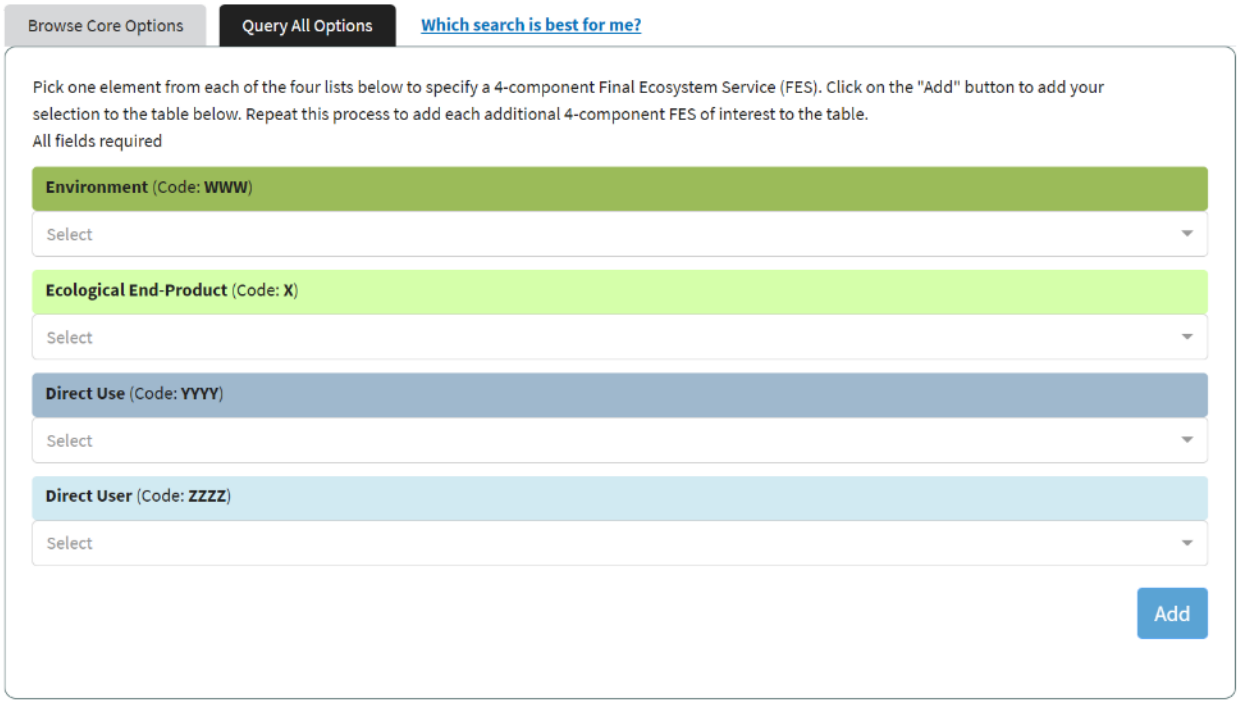

FIGURE 4A

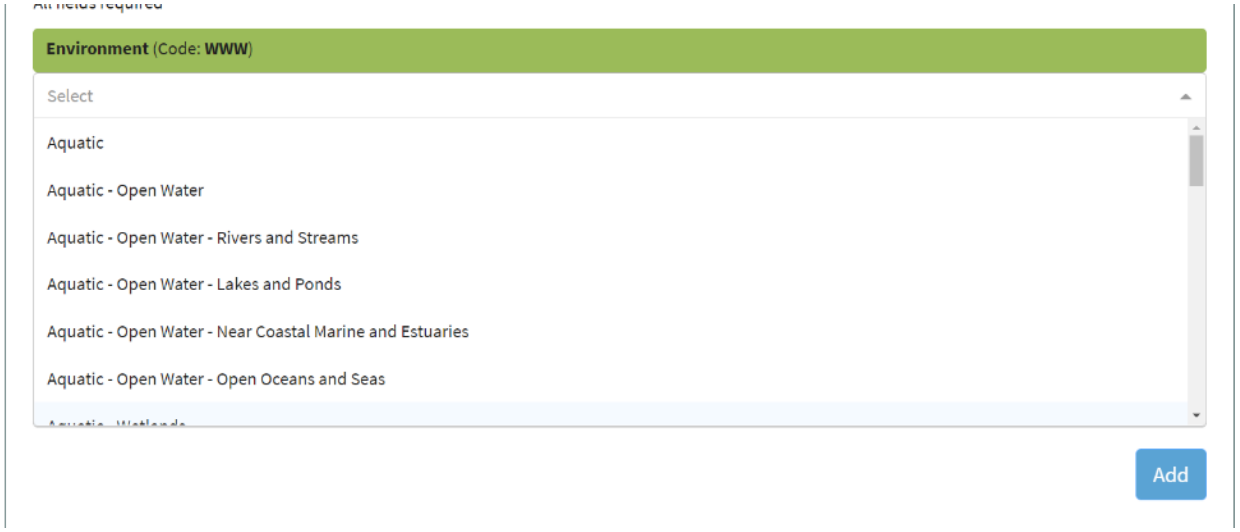

FIGURE 4B

Figure 4. *The NESCS Plus query option of "Query All Options" allows the user to (A) navigate the full suite of potential results by selecting drop-down options among a series of four lists: Environment (shown in B), Ecological End-Product, Direct Use, and Direct User.*

A more detailed description is provided in Newcomer-Johnson et al. (2020).

An example of the NESCS Plus output is shown in Figure 5. The structure of the NESCS Plus output is intended to help the user trace a chain of interest. This is the results of the Workshop case study described below and in Appendix 2.

NESCS Plus ID (WWW.X.YYYY.ZZZZ)	Environment Class (W)	Environment Subclass I (WW)	Environment Subclass II (WWW)	Ecological End-Product Class (X)	Direct Use/Non-Use Class (Y)	Direct Use/Non-Use Subclass I (YY)	Direct Use/Non-Use Subclass II (YYYY)	Direct User Class (Z)	Direct User Subclass I (ZZ)	Dir Use Sul II (Z
111.3.110Y.1531	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Protection of human property	All Direct Use Subclass IIs	Industry	Real Estate Rental and Leasing	Real
111.3.110Y.1532	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Protection of human property	All Direct Use Subclass IIs	Industry	Real Estate Rental and Leasing	Rent Leas Servi
111.3.110Y.2111	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Protection of human property	All Direct Use Subclass IIs	Households	Households	Hous
111.3.111Y.2111	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Recreation/tourism	All Direct Use Subclass IIs	Households	Households	Hous
111.3.111Y.2111	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Recreation/tourism	All Direct Use Subclass IIs	Households	Households	Hous
111.4.109Y.2111	Aquatic	Open Water	Rivers and	Fauna	Direct Use	Support of human health and life or	All Direct Use	Households	Households	Hous

Figure 5. Example of NESCS Plus output for the Workshop case study (Appendix 2).

Final Ecosystem Goods and Services Scoping Tool (FST)

Successful ecosystem-based assessment, protection, and revitalization approaches have advanced both a social-ecological approach to systems thinking and the application of principles of structured decision making. The FST tool is a decision support tool designed to help decision makers in the early stages of their efforts by providing a transparent, repeatable, defendable approach for identifying and prioritizing stakeholders, the ways in which they use the environment (their beneficiary roles), and the most relevant environmental attributes necessary to realize those uses. Once decision makers know how stakeholders are benefiting from the environment, they can be included as part of a larger set of decision criteria (e.g., measures of cost, human health impacts, etc.) for evaluating tradeoffs across mitigation and remediation options. This scoping tool uses a tiered multi-criteria decision analysis approach (Sharpe, 2021) in which an initial prioritization of stakeholder groups is used to prioritize their beneficiary roles and environmental attributes of interest. The tool can be used with stakeholders for a given decision context and thus help with stakeholder communication and engagement.

When users open the FST, they are shown a set of criteria for use in prioritizing stakeholder groups (Sharpe et al., 2021). Users are asked to weight each criterion for their relative importance for distinguishing among stakeholder groups. They are then asked to score each stakeholder group on that criterion. Weighting the criteria is a subjective decision, scoring the groups on those criteria should not be. For example, although different decision makers may disagree on how influential the criterion of economic interest should be in distinguishing among groups, it should be clear whether any given group has an economic interest in the outcome of a decision. The tool provides definitions and scoring metrics

for the criteria. The combination of the weights and the scores are responsible for the first output – a chart showing the relative priority of the stakeholder groups as well as information on how each criterion is influencing that prioritization (Figure 6). See Sharpe et al. (2021) for an in-depth description.

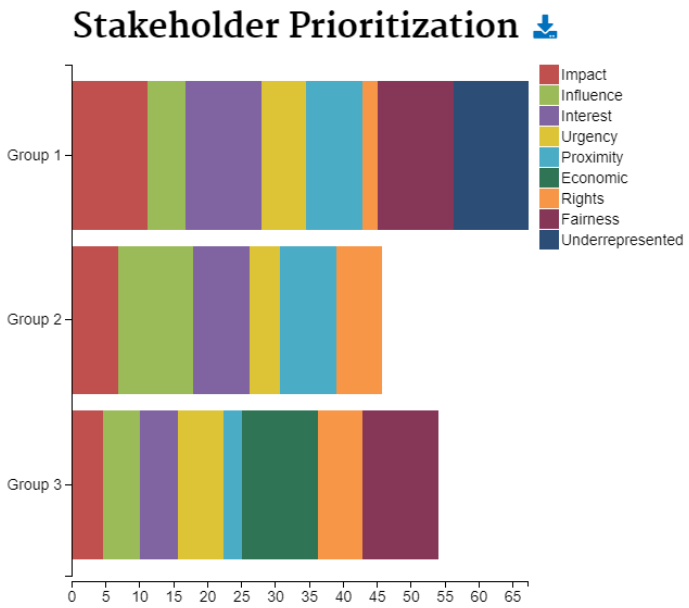

***Figure 6**. Example of the FST stakeholder prioritization output for three different stakeholder groups (Group 1, 2, and 3). The length of each bar reflects the relative priority of each stakeholder group as a result of how each criterion was weighted and each stakeholder group scored. The x-axis indicates the relative priority of each group. Each color represents a different prioritization criterion (see legend). The width of each color reflects how much the group's score for that criterion contributes to the group's overall priority.*

In the second portion of the tool, users are asked to identify, by percentage, the ways in which each stakeholder group benefits from the environment. This step uses the defined beneficiary classes and subclasses from NESCS Plus as options to choose from. The output is a beneficiary profile, weighted by the stakeholder prioritization, for the decision context (Figure 7). This allows users to capture a comprehensive set of site benefits, identify priority uses, and find common interests across stakeholder groups. A more detailed description is provided in Sharpe et al. (2021).

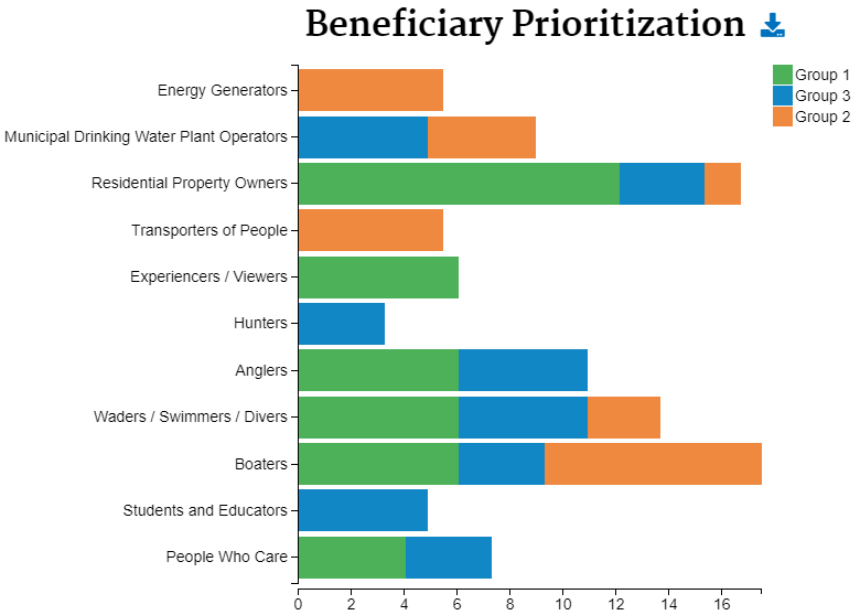

Figure 7*. Example of the FST beneficiary prioritization output for the stakeholder groups in Figure 6. The width of each bar reflects the relative priority of each beneficiary group as a result of how much that beneficiary group is represented in each stakeholder group (see legend). For example, stakeholder Group 2 includes the beneficiary groups energy generators, municipal drinking water plant operators, residential property owners, transporters of people, waders/swimmers/divers, and boaters. The x-axis indicates the relative priority of each beneficiary group.*

In the final portion of the tool, users are asked to identify, by percentage, the aspects of the environment that each beneficiary group relies upon. This step uses the defined environmental end-product classes and list of environmental attributes from the NESCS Plus as options to choose from. The output identifies key environmental attributes, weighted by the beneficiary prioritization, for the decision context (Figure 8). This allows users to identify the most relevant aspects of the environment and why those aspects are valued. This allows decision makers to choose meaningful ways of incorporating those valued uses in decision making. For example, although agricultural beneficiaries and recreational beneficiaries may both be concerned with water quality, the meaningful metric when tracking the impacts of a project on water quality would likely be different between those beneficiaries. From a project team/management perspective, these differences might change which endpoints to look at (e.g., different GEAE), inform the consideration of remediation options (e.g., Harwell et al., 2021), or influence how to think about EGS-related monitoring elements (e.g., Harwell et al. 2022).

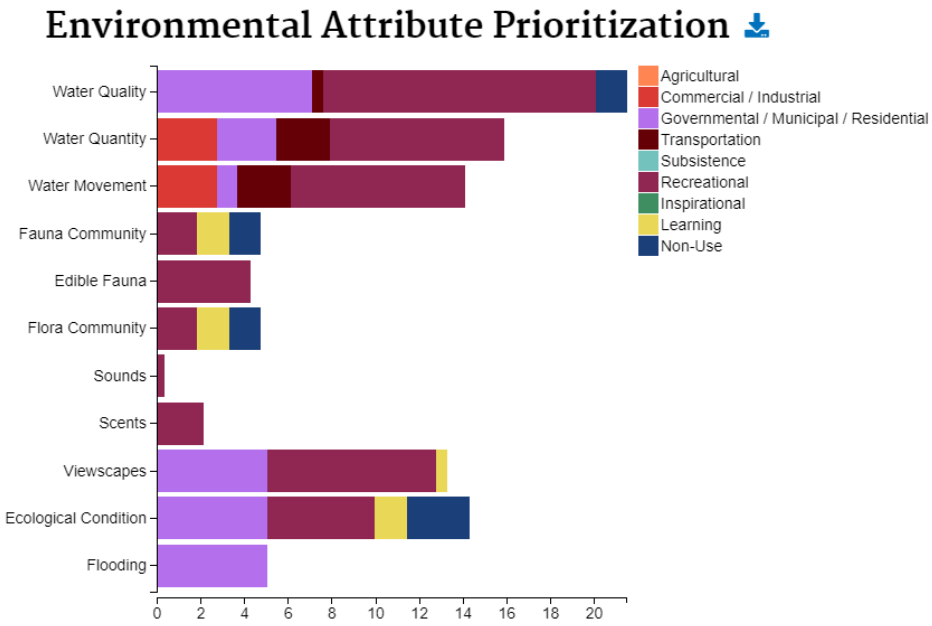

Figure 8. *Example of the FST environmental attribute prioritization output for the beneficiary groups in Figure 7. The width of each bar reflects the relative priority of each attribute as a result of how much that attribute is valued by each beneficiary group. The results are displayed as the aggregated beneficiary classes (see legend) rather than then subclasses used in Figure 8 to improve the figure's legibility. For example, the commercial/industrial beneficiary class relies upon two of the 11 identified environmental attributes (water quality and water movement). The x-axis indicates the relative priority of each attribute.*

The FEGS Scoping Tool provides an essential methodology to sort, organize, and evaluate the complex array of stakeholders, their respective interests and priorities, and environmental resources and attributes, in order to identify meaningful and actionable EGS decision criteria.

EnviroAtlas

The EnviroAtlas is a data-rich, web-based decision support tool that provides geospatial data, easy-to-use tools, and other resources related to EGS and their chemical and non-chemical stressors (Pickard et al. 2015). It also demonstrates the linkages between EGS and human health and allows users to assess equity related to the provisioning of EGS. It can be used by federal and state agencies, tribes, non-profit organizations, communities, industry, and individuals to help inform policy and planning decisions related to the ERA paradigm. It can also be used by academics and educators as a source of data and as a teaching tool. The tool can be used with stakeholders for a given decision context and thus help with stakeholder communication and engagement for a given decision context.

Many of the data sets contained within the EnviroAtlas have been developed specifically for the EnviroAtlas. The EnviroAtlas contains two primary tools: An *Interactive Map*, which provides access to 500+ environmental and demographic maps and an *Eco-Health Relationship Browser,* which displays

evidence from hundreds of scientific publications on the linkages between ecosystems, the services they provide, and human health.

In addition to the two main tools, the EnviroAtlas website contains an abundance of background information on EGS, tutorials and guides on how to use the EnviroAtlas, educational modules designed for use in the classroom, more information about the EnviroAtlas data, and technical resources for more experienced users.

The *Eco-Health Relationship Browser* (Figure 9) contains a literature review of over 1,000 articles investigating the relationships between ecosystems, EGS, and human health. The user can start their investigation with a human health outcome, an EGS, or an ecosystem. Designed with utility in mind, the Eco-Health Relationship Browser is an informational tool that can help researchers find articles and inform decision-makers about possible public health outcomes associated with their decisions. Users can click on the bubbles or the linkages, learn about the relationships, and view the supporting literature. The bubbles and lines provide a way for the user to better focus on potential causal chains of interest. A more detailed description is provided in Jackson et al. (2013).

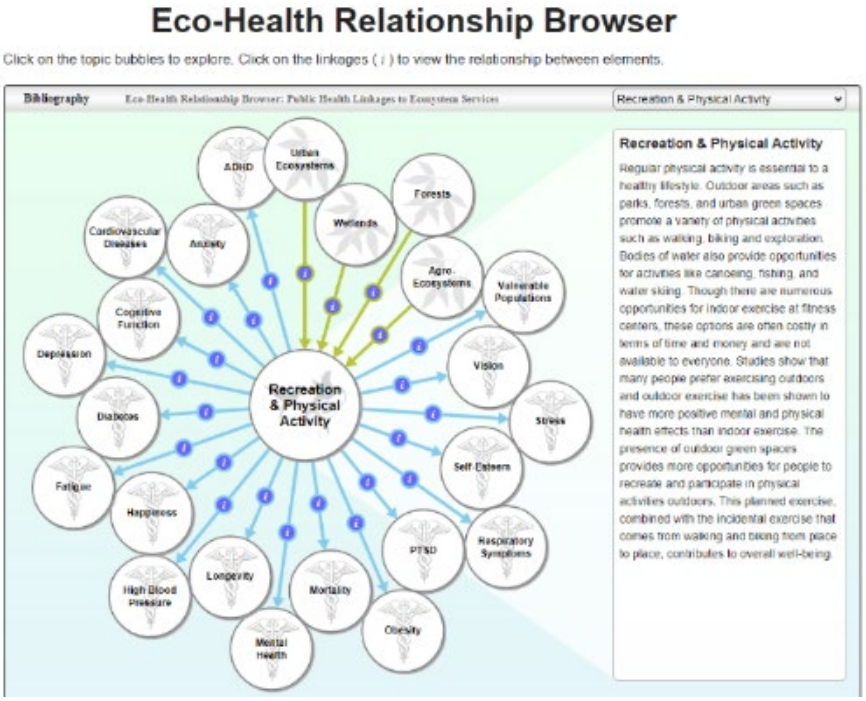

Figure 9. *EnviroAtlas EcoHealth Relationship Browser*

The *Interactive Map* (Figure 10) is an easy-to-use data discovery and display tool providing users easy access to over 500 environmental and demographic maps (data layers) within EnviroAtlas. The map layers are organized into themes: EGS and Biodiversity (green background in map table of contents); Pollution Sources and Impacts (mauve background); People and Built Spaces (blue background); and Boundaries (grey background). Each of the map layers in the EGS and Biodiversity theme is tagged with one or more of their related EGS benefit categories: Clean Air; Clean and Plentiful Water; Natural Hazard Mitigation; Climate Stabilization; Recreation, Culture, and Aesthetics; Food, Fuel, and Materials; and/or

Biodiversity Conservation. The Pollution Sources and Impacts theme includes sites such as RCRA and Superfund sites regulated by EPA. A demographic widget provides access to many data layers derived from U.S. Census data. These data layers provide a means to assess equity.

The data available includes data for multiple extents and resolutions including many data layers available for the conterminous United States at either a 30 x 30 square meters resolution or summarized by medium sized watersheds. Finer resolution data are also available for over 1,400 municipalities and towns across the United States and are based on one-by-one square meter land cover (meaning there is a data point for every square meter on the ground).

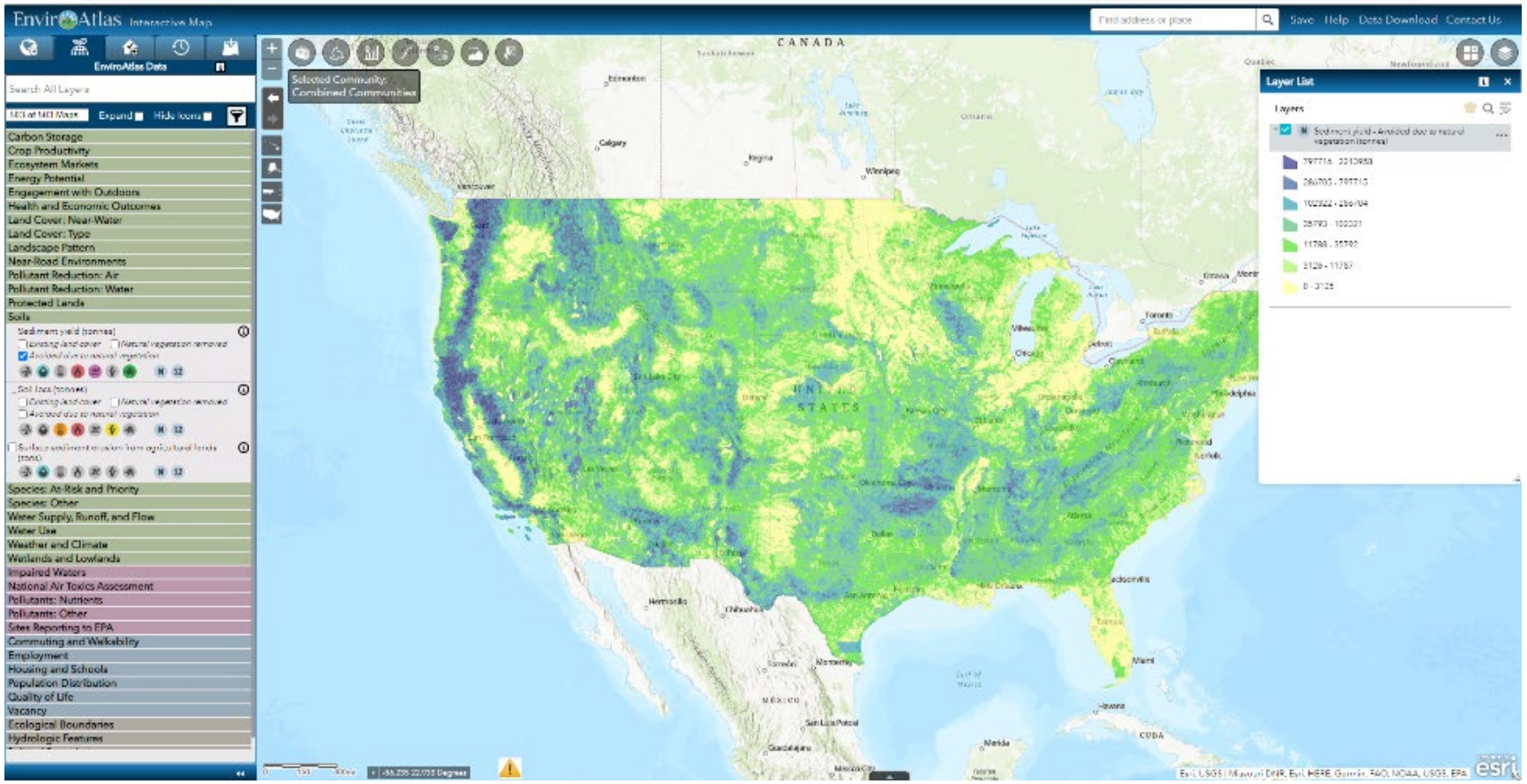

Figure 10. *EnviroAtlas Interactive Map, map displayed is showing soil loss avoided due to natural vegetation.*

The Interactive Map includes a tour, featured collections of data for targeted uses, two time series widgets for investigating climate change scenarios, analysis tools, and more. A Dynamic Data Matrix provides another way to browse data layers and documentation via a table format. Both the Interactive Map and the Dynamic Data Matrix can be sorted, searched, and filtered to make it easier for user to find their data of choice. A more detailed description is provided in the resources on the EnviroAtlas home page.

EcoService Models Library (ESML)

The ESML is an online database of more than 270 ecological models for estimating the production of ecosystem goods and services. The ESML contains detailed descriptions for each model to helps users find, examine, and compare models so that they can understand how the models work and decide if they want to use them. Scientists across government, academia, and business develop computational models that describe ecosystem processes that yield EGS. The ESML compiles information about ecological models in a single, easy-to-use location providing detailed model descriptions to help users identify the best model for a given situation. The ESML contains >50 individual descriptors for each model, covering purpose, approach, and environmental use (such as EGS) using the NESCS Plus and the Common International Classification of Ecosystem Services (CICES) systems, and is searchable by the type of environment modeled, location, or EGS. The ESML also includes variable relationship diagrams that show logical relationships between variables. A more detailed description is provided in the resources on the ESML home page.

Recently, a "Hazardous Waste Site ERA" filter was added to the ESML to provide hazardous waste site ecological risk assessors as well as interested project managers and stakeholders, a guide to navigate the ESML. This filter helps facilitate incorporation of EGS (using the Generic Ecological Assessment Endpoints) into ERA by enabling streamlined identification of applicable EGS-related models. Application examples of the filter include supporting context establishment for revitalization or reuse plans development and supporting identification of potential community benefits associated with, and created or enhanced by, some remedial options. The goal of the ESML Hazardous Waste Site ERA filter is to maximize ecosystem generated community benefits gained during cleanup activities.

The ESML allows the user several starting options (yellow highlighted menu buttons toward the top of the ESML home page depicted in Figure 11), consisting of:

- Searching for models;
- Creating a receptacle to collect user-defined ESML model information;
- Learning resources; and
- Viewing of the full ESML data map.

The "Hazardous Waste Site ERA" filter can be accessed by navigating to the Search Ecological Models (EMs) webpage by selecting "Search EMs" followed by selecting "Hazardous Waste Site ERAs" in the left-side drop-down menu (highlighted in yellow in Figure 12).

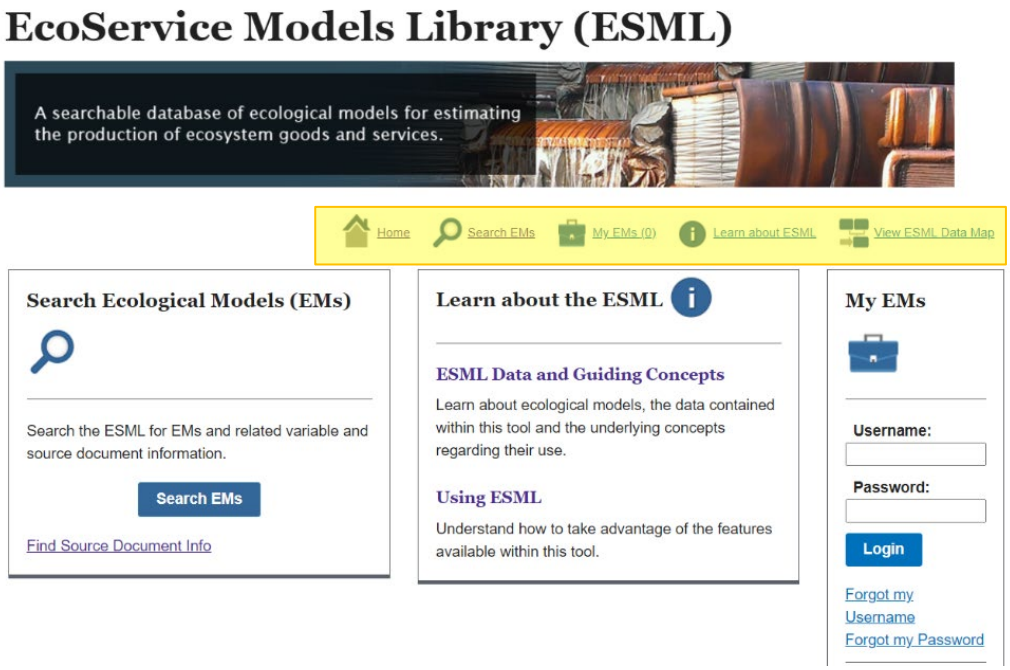

Figure 11. *The starting screen (yellow highlight added) for the EcoService Models Library.*

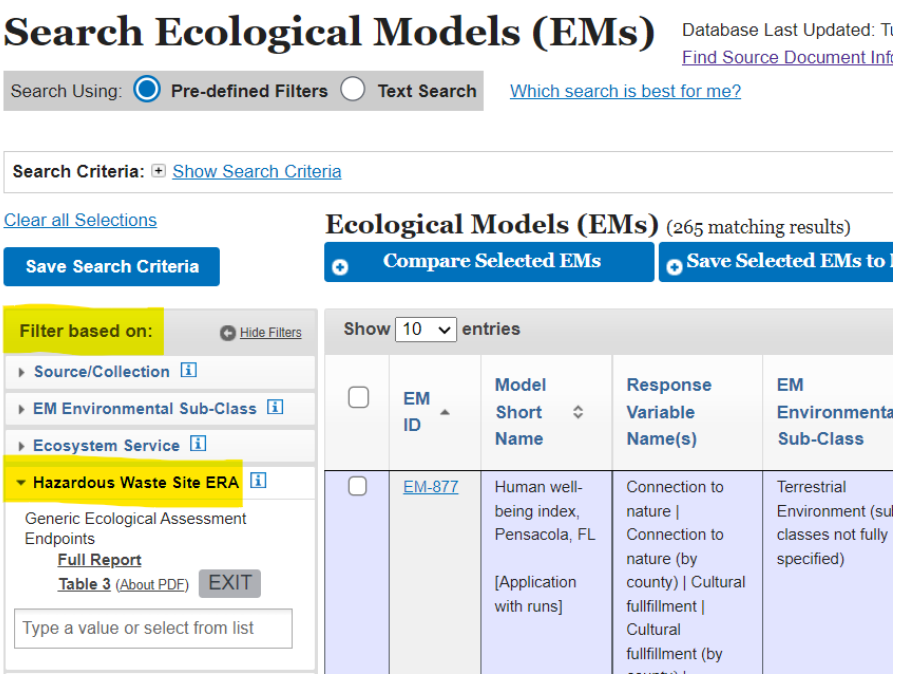

Figure 12. *The "Hazardous Waste Site ERA" filter (yellow highlight added) that can be used to help screen candidate models in the EcoService Models Library.*

Workshop

Logistics

The workshop brought together environmental risk assessors at EPA headquarters and within the Regions along with ORD scientists and staff with expertise in EGS. The workshop planning group identified the following desired outcomes for the workshop:

- Convincingly articulate the value of incorporating EGS in contaminated site SLERA and BERA;
- Increase awareness and understanding of EGS relevant tools available;
- Explore potential insertion or leverage points to incorporate EGS into a SLERA and BERA; and
- Illustrate the potential use and value of EGS tools and outcomes via a concrete and realistic contaminated site case study.

To achieve these outcomes, the workshop planning group identified several needs and activities:

1. Describe how the workshop fits within the larger effort to incorporate EGS into remedial efforts across the remedial programs from site investigation to remedial design and construction.
2. Explicitly state the value of incorporating EGS into ERA and explicitly crosswalk the ideas between EGS generally and ERA specifically and share possible EGS endpoints for human well-being.
3. Bring risk assessors and EGS tool experts together to make crosswalks explicit and tangible by discussing how four EGS tools might be applied to steps in the ERA process.
4. Explore how an individual tool might be useful in ERAs by employing breakout groups to allow risk assessors to interact with the EGS tool expert.
5. Walk the workshop audience through a hypothetical urban, contaminated sediment site with minimal human health risks but significant ecological risks. Participants were asked how the tools might be applied at each stage of the ERA process, from early site investigation to developing the baseline ecological risk assessment (BERA).

Workshop Introduction

About 40 individuals across ten EPA Regions, headquarters, and ORD participated. Program offices represented included Superfund, RCRA, OECA, and Brownfields.

The Workshop began with an overview of EGS, the many life-sustaining benefits we receive from nature – clean air and water, fertile soil for crop production, pollination, and flood control (nature's benefits to humans). Incorporating EGS into ERA can have many benefits, with the two most prominent being: 1) linking human well-being into the ERA process; and 2) improving communication to the public of EGS – (nature's benefits) – when describing the problem being addressed and the reasons/benefits for selected remedies.

Ecosystem services assessment endpoints were introduced. Assessment endpoints are explicit expressions of the environmental values to be protected, operationally defined as ecological entities (e.g., an important fish species such as coho salmon) and their attributes (e.g., fecundity and recruitment of coho salmon). For ERAs, assessment endpoints have traditionally been selected by ecological risk assessors in consultation with decision makers. These endpoints often have not been clearly linked with broader societal values and benefits in a way that is most meaningful to the public. It

has become clear over time that for ERA results to be relevant, consideration of the environmental and community settings and contexts should be considered. In such a manner, these endpoints can help with: illuminating the reasons for actions taken and decisions made; considering financial implications; and bridging currently disparate assessment and decision approaches.

To advance development of generic ecological assessment endpoints (GEAEs), EPA identified a suite of GEAEs that: could be useful in decisions; were measurable; definable; and responsive to society's needs (USEPA 2016). By considering these endpoints early in problem formulation in ERA and tailoring them to the specific site, risk estimates could be derived for these during the assessment process. These GEAE included such endpoints as food production and recreational opportunity.

The chart below (Table 2) gives examples of how GEAEs based on EGS can supplement traditional EPA risk assessment endpoints; the "Benefit" column in Table 2 captures the supplementary benefits that GEAEs can provide. The reader is pointed to the 2016 EPA report, *Generic Ecological Assessment Endpoints (GEAE) for Ecological Risk Assessment (2nd Edition) with Generic Ecosystem Services Endpoints* for more information (USEPA 2016). The full suite of EGS GEAE are reproduced in Table 3.

Generic Ecosystem Service	Conventional Assessment Endpoint	Measurement Endpoint	Benefit
Food Production	Fish population vitality	Fish abundance, size structure, and species number	Nutrition, recreation, income, and enjoyment
Recreation	Bird species diversity	Bird abundance, species number	Recreation, enjoyment

Table 2: *Example Ecosystem Service Assessment Endpoints*

Earlier efforts to develop a crosswalk between the ERA process and EGS topics and tools (Table 1) was also presented, along with example decision questions that could be addressed by such a linkage. Examples were provided for each of the four ERA phases (Planning and Scoping, Problem Formulation, Analysis, and Risk Characterization) and the interphasic Risk Communication which is operative during the entire ERA process. For instance, the EnviroAtlas and NESCS-Plus could be used to identify EGS in the site landscape during ERA Planning and Scoping to help establish an assessment framework by organizing the types of ecosystems, benefits, and beneficiaries present. Such EGS activities could allow the ecological risk assessor to be better positioned to start to answer questions such as:

- What ecosystems and EGS are present?
- Who are the stakeholders?
- What benefits do the stakeholders receive from the EGS?
- How are EGS benefits being impacted and by how much?
- Would inclusion of EGS facilitate a broader conversation with stakeholders, including discussion of environmental benefits they previously had not considered?

Conventional Ecological Assessment Endpoint	GEAE	Possible Generic Ecosystem Service Assessment Endpoint	Ecological Benefit	Potential Valuation Methods
• Population abundance • Population size structure • Recruitment • Presence/absence of game species • Mortality, morbidity, or survival • Tissue contaminants • Growth, production, or extirpation • Taxa richness	Population abundance and production	Food production (e.g., catchable, edible fish for recreational, commercial and subsistence uses)—a final service	• Nutrition • Recreation • Income • Enjoyment of catching/preparing food • Survival	• Market value and rents for commercial fisheries • Recreational demand modeling • Stated preference • Household production
• Ecosystem functions (e.g., nutrient and flood water retention, organic matter degradation)	Ecosystem function	Water purification for drinking, domestic, industrial, and agricultural uses—a final service	Support for life, health, and commerce	• Extraction and treatment costs • Water rights trading values • Stated Preference • Hedonic values for industry and agriculture production
• Plant community uptake and deposition of pollutants	Ecosystem function	Air purification (for breathing and visibility) – a final service	Support for life and health	• Pollution control costs • Stated preference • Replacement cost
• Plant community net production • Carbon sequestration	Ecosystem function	Climate stabilization—a final service	Support for life and health	• Greenhouse gas control avoided costs (or damages) • Stated preference • Benefits transfer
Water retention	Ecosystem function	Flood and storm surge regulation—a final service	Protection of life and property	• Avoided damage costs of flooding • Hedonic (Insurance or costs of structural mitigation) • Replacement cost
• Yellow pine production • Standing biomass of trees • Cotton production	• Population abundance and production	Raw material production—a final service	• Support for life • Survival • Products • Trade	Market value

Conventional Ecological Assessment Endpoint	GEAE	Possible Generic Ecosystem Service Assessment Endpoint	Ecological Benefit	Potential Valuation Methods
	• Assemblage production		• Income and wealth	
• Population abundance • Pollinator abundance	• Population abundance • Assemblage function	Pollination—an intermediate service	• Food • Nutrition • Survival • Products • Trade and income	• Market value • Stated preference
Soil formation	Ecosystem function	• Soil formation—an intermediate service	• Food • Nutrition • Survival • Products • Trade and income	• Market value • Pollution control costs • Stated preference
• Water quality • Soil quality	Ecosystem function	Waste assimilation—an intermediate service	• Waste treatment • Detoxification	• Pollution control costs • Stated preference
• Wilderness quality. • Endangered species • Habitat area and quality	Area or quality of ecosystem or special place	Provision of aesthetic, scientific, recreational, educational cultural, medical, genetic, ornamental, and spiritual resources—final services	• Enjoyment of nature • Cultural fulfillment • Medical value	• Stated preference • Hedonic pricing • Benefits transfer

Table 3: *Examples of the relationships among conventional ecological assessment endpoints, GEAEs, generic ecosystem service assessment endpoints, ecological benefits and valuation (reproduced from USEPA 2016).*

For example, engagement on these questions could amplify and expand the benefits of ERA and work at contaminated sites so that both ecological and societal benefits are increased. This type of engagement is one potential way to increase the benefits of the investment of staff time/expertise/partnership development at contaminated sites (e.g., more benefits per investment of agency & community partner resources).

Presentation slides can be found in **Appendix 1**.

Following the introductory presentations, ORD scientists shared background information on four EPA EGS tools for further consideration by the workshop participants. The four tools' potential role in ERA phases and actions are noted in Table 4.

ERA Phase	EGS Tool Names	Activity
1 - Planning & Scoping	EnviroAtlas	Map EGS and biodiversity
	FEGS Scoping Tool	Identify and prioritize stakeholders and EGS
	NESCS Plus	Identify potential EGS using clearly defined terms and a comprehensive list
2 - Problem Formulation	EnviroAtlas	Map EGS and biodiversity
	FEGS Scoping Tool	Identify and prioritize stakeholders and EGS
	NESCS Plus	Identify potential EGS using clearly defined terms and a comprehensive list
3 - Analysis	EnviroAtlas	Map EGS and biodiversity
	ESML	Find models for estimating EGS
4 - Risk Characterization	EnviroAtlas	Map pollution sources and impacts
	ESML	Find models for estimating stressors and impacts on EGS
5 - Risk Communication	FEGS Scoping Tool	Framework for identifying priority EGS for stakeholders
	NESCS Plus	Identify potential EGS using clearly defined terms and a comprehensive list

Table 4: *Phases of ERA, EGS Tools, and EGS-related Activity associated with each tool.*

The workshop participants then were divided into breakout groups which were moved through round-robin sessions to discuss each of the four tools. The following are summaries compiled of the discussions, organized by tool.

National Ecosystem Services Classification System (NESCS) Plus

What steps in the ERA framework and cleanup process do you see this tool as being most beneficial?

- 1. Planning & Scoping: The NESCS Plus lets one a cast of a wide net then filter down to see what is relevant.
- 2. Problem Formulation: It is important to identify the tool and items for your specific site instead of going straight to the community and possibly getting hopes up.
- 5. Risk Communication: The NESCS Plus would let stakeholders understand how ES is incorporated in decisions.
- Cleanup process: Throughout the whole cleanup process, especially when you start early you can measure how many benefits you get and how they change over time.

What would be needed to utilize the NESCS Plus?

- A hands-on effort to walk through and understand the thinking process for how to use NESCS Plus.
- Examples of how the NESCS Plus has been used and what works and what does not to help document failure.
- Develop case studies and site examples to provide real-world scenarios.
- Demonstrations and virtual trainings.

FEGS Scoping Tool (FST)

What steps in the ERA framework and cleanup process do you see the FST as being most beneficial?

- 1. Planning & Scoping: Most useful in the scoping phase. Important to consider ecosystem services at the beginning of a project.
- 2. Problem Formulation: Helpful for not only identifying stakeholders but also understanding which stakeholders we should be investing more time and communication with.
- 5. Risk Communication: Could be useful when talking to communities and human health risk assessors as well.
- Cleanup process: Tool is more social science based which could help bridge the gap between risk assessment and ecosystem service thinking and community involvement.
- Cleanup process: Could be useful at multiple stages of the Superfund process. At the beginning, while trying to determine which remedial action to take, and when making risk management decisions.
- Cleanup process: This could be helpful to Brownfields grantees' efforts to make sure those groups are focused on the stakeholders and benefits while still maintaining that enthusiasm for moving forward.
- Cleanup process: Could be useful for retrospective analyses on their assessment and cleanup sites.

- Cleanup process: From an enforcement perspective it could be helpful early in the decision-making process and engaging all the team members. Gives an end goal for the project which would help review or consultation.
- Community Outreach: Great for outreach (community involvement departments and RPMs).
- Community Outreach: Illustrates the link between what one is trying to do on the cleanup side and ecosystem services – this tool could help show the link to multiple stakeholders.
- Other: Could be useful for projects involving tribal elements to ensure tribal interests are included.

What would be needed to utilize the FST?

- Case studies using the FST to compare the differences in monetary values or other obvious human benefits to enhance community understanding.
- Trainings: This presentation or a demonstration with other partners.
- Information on when to use/not use (e.g., it may be hard to see a use for the FST in emergency response actions).

EnviroAtlas

What steps in the ERA framework and cleanup process do you see the EnviroAtlas as being most beneficial?

- Step 1. Planning & Scoping: EnviroAtlas can be useful in planning and scoping especially.
- Step 2. Problem Formulation: EnviroAtlas can be helpful in all ERA phases, especially problem formulation in the SLERA.
- Step 4. Risk Characterization. EnviroAtlas can be helpful in risk investigation (e.g., wetlands, floodplains, and threatened and endangered species).
- Cleanup process: EnviroAtlas can be helpful at all different stages, including: RI/FS; remedial design; Five Year Reviews (FYRs); capturing successful remedies and reuse.
- Cleanup process: The EnviroAtlas can be useful for informing a clean-up as well as how the clean-up will help in the redevelopment process.

What would be needed to utilize the EnviroAtlas?

- Hydraulic connectivity (National Hydrography Data and tool that does overland flow based on 30 m digital elevation model) and habitat connectivity (30 m pixel).
- Land-cover change over time.
- Virtual trainings and expand the training to other federal agencies. Presenting at NARPM (National Association of Remedial Project Managers).
- Add an “Ecological Risk Assessment Featured Collection” to help the user to find data easily.
- An example site and demo.
- While EnviroAtlas provides information on high priority species (natural heritage data), cannot get a list of those species easily.
- Individual species lists.

EcoService Models Library (ESML)

What steps in the ERA framework do you see this tool as being most beneficial?

- Step 1. Planning & Scoping: More involved in early stages of planning and scoping because can search the library for key words to see what models are available based on the habitats/receptors of the project.
- Step 2. Problem Formulation: helpful for thinking pre-planning/ahead.
- Step 4. Risk Characterization: ESML could be helpful at the analysis stage.
- Step 5. Risk Communication: Useful for both modeling and communicating the value of environmental assessment/cleanup work.
- It is important for each stage to understand full spectrum of risk and what can be done to alleviate risk, then looking at remedies, and even further to reuse potential.

What would be needed to help you utilize the ESML?

- Information on how to use on a very rural site (e.g., an old mine/acidic stream that is not suitable for fishing but there is general support based on public recreation activities/forest services).

Workshop Case Study

The last part of the workshop focused on a conversation around a hypothetical case study (**Appendix 2**) to explore how the EGS tools might be used during phases of an ERA. The case study site is an abandoned hazardous waste site located in central New Jersey along the Raritan River. Polychlorinated biphenyls (PCBs) and metals (arsenic and mercury) were found at elevated concentrations in shallow surface sediments of the stream channel and at lower concentrations within the marsh itself and at deeper sediments. Examples of ecological receptors for measures of effects at the site include: Aquatic macroinvertebrates (blackworm: *Lumbriculus variegatus*); terrestrial invertebrate community (earthworm: *Eisenia fetida*); estuarine fish population in the Raritan River; and bird and mammal population abundance in the marsh and the river.

The slides from the presentation of the case study are presented in **Appendix 2**. The following summarizes the discussion that was focused on several key questions.

From the four EGS tools discussed, which can be applied and utilized during the Planning & Scoping phase of the site?

- Tool: Participants mentioned that the FEGS Scoping Tool, the EnviroAtlas, and the NESCS Plus could be used in the SLERA.
- Tool: The tools can produce a large amount of information for RPMs/contractors to process. A quick run (less than 10 min) of NESCS Plus for the site identified 69 potential EGS. The next step would be to determine what the classical risk assessment endpoints are for the site and how they would connect to potential services (e.g., fish consumed by people and fishable waters).

- Tool: The EnviroAtlas could be used for land use and cover in order to figure out what the conditions are adjacent to the site, whether water is moving through the site, and the impact on threatened and endangered species.
- Tool: The EnviroAtlas could be used to help with formulating more direct precise questions for the SLERA. It may be possible to import other local datasets for the BERA (more recent and/or better resolution).
- Other: Some Regions are short-staffed and, therefore, rely on contractors for tasks during the planning and scoping phase. EPA teams could potentially utilize contractors to use the tools during Planning & Scoping. It is important to train contractors in the tools being used and provide guidance about how they should be integrated.
- Other: The balance between ideal and reality varies from EPA Region to Region and, even RPM to RPM. External support for use of EGS tools might not necessarily align with what is being done in a given Region.

Post-workshop, the four EGS tools were applied to this theoretical case study. Results of those exercises are presented in **Appendix 3**.

A SLERA was conducted for the site to determine which contaminants and exposure pathways presented ecological risks based on conservative assumptions. Three primary contaminants of potential concern (COPCs) identified in the marsh and associated drainage ways were PCBs, arsenic, and mercury. The SLERA endpoints are the protection of the survival, growth, and reproduction of certain ecological receptors including aquatic invertebrates, forage fish, the short-tailed shrew, marsh birds, and amphibians. What generic EGS endpoints can be created for the SLERA? How can the EGS tools discussed today be applied and utilized for the SLERA?

The generic EGS endpoints identified and discussed included:

- The protection of fish and the benefits for subsistence and recreational fishers;
- The presence of the green frog and the benefits for recreational opportunities for enjoying charismatic wildlife;
- The presence of red-tailed hawks and recreational birdwatching;
- The presence of crabs and potential crab consumption; and
- The presence of amphibians and their role in insect control (mosquitoes).

BERA endpoints in the marsh and river ecosystems include aquatic and terrestrial macroinvertebrate community abundance and population production in marsh sediment/soil, estuarine fish population abundance and community structure in the Raritan River, and Wildlife population abundance in the marsh and the river. What site-specific EGS assessment endpoints might be relevant?

The site-specific EGS endpoints identified and discussed included:

- Subsistence and recreational fishing;
- Vector (mosquito) control;
- Flood management;
- Carbon sequestration;
- Bank stabilization;

- Other: At a base level, things like climate mitigation can be considered relevant EGS even though they are not necessarily directly applicable to the risk assessment. They could still be considered during the baseline phase, rather than solely as endgame concepts.

What site-specific GEAEs might assist with risk management decisions and remedy selection?

- Can relate benefits to humans from ecological risk-driven remedies such as remediating large scale sediment sites.
- Can use EGS context to support the selected remedy based on the context of our programs.
- Focus on what is important to people in the SLERA and BERA and the surrounding environment.

How can the EGS tools discussed be applied and utilized for the BERA?

The discussion focused on the need for continual efforts on translation of EGS information for contaminated site cleanup practitioners:

- It is unclear whether the tools presented make things easily understandable. For example, should benthic organisms be considered directly or indirectly (as the base of the food chain)? (Information about why you should care about benthic organisms (and other ecological receptors) is available in the EnviroAtlas' Eco-Health Relationship Browser).

What are the biggest challenges to getting RPMs to incorporate EGS tools? What would be helpful going forward?

The discussion focused on several themes (examples, value added information, training, awareness, acceptance):

- Examples: Site-specific examples of the tools being used.
- Value Added Information: A deeper understanding of the added value of incorporating these tools, beyond just regulatory mandates or other external reasons.
- Training: Training in using the tools for new RPMs who may be unfamiliar with ecological health concepts (particularly for the Eco-Health Relationship Browser).
- Awareness: Raising awareness about the existence of tools (for example, presenting at the National Association of Remedial Project Managers' conference).
- Acceptance: Building buy-in among RPMs first then managers, as opposed to the other way around.

Conclusions and Future Directions

Conclusions related to incorporating EGS into ERAs, and ultimately the remedial process, illustrate that there is a real need for site-specific examples of this process for risk assessors and other technical staff to be able to routinely incorporate nature's benefits to humans into the investigation, analysis, risk assessment, and remedial decisions at hazardous waste sites. Also evident is the value of incorporating EGS into the risk assessment process, and how that can be used to supplement current risk assessment methodologies, although it was recognized that this area still needs further development and explanation. To effectively incorporate EGS into the hazardous waste site remedial process, risk

assessors need the buy-in, support, and understanding of their project managers (and upper management) and, in some cases, federal and private contractors.

The ERAF EGS workgroup had reviewed the existing EGS literature and found that there may be many benefits to incorporating EGS into the ERA process. Primarily, EGS concepts can incorporate human well-being into the process, which is especially important for those sites where remedy decisions are based primarily on risks to ecological receptors such as large-scale sediment remediation sites. Using EGS assessment endpoints enables a clearer explanation of the problem being addressed and provides obvious linkages to human well-being, providing a stronger basis for decision making. Further, risk communication is improved by including EGS into the ERA process since ecosystem services are readily translated into benefits that society understands and cares about. In summary, based on the existing literature cited herein, and the outcomes of the workshop discussions, incorporating EGS into the ERA process has the potential to improve the environmental and socio-economic outcomes of contaminated site cleanups.

During presentation and discussion of the ORD EGS Tools in the STLR workshop, it was apparent that some tools are best used in the Planning & Scoping phases (e.g., the FEGS Scoping Tool and the NESCS Plus) and others are useful in the screening level and baseline ecological risk assessment phases (e.g., the EnviroAtlas and the ESML). Workshop participants stated many times that just a list of ORD EGS tools makes it difficult for risk assessors to know how to use them without specific examples, case studies, and assistance in navigating EGS tool selection. Risk assessors and other technical staff will likely need additional training and technical assistance to learn about, apply, and effectively use the EGS tools. Creative approaches need to be developed for helping stakeholders with using tools. Access and support for the tools will need to be more specific to cleanups to be utilized effectively.

Overall, these tools and approaches could add value to the use of ERAs at contaminated sites by achieving better outcomes and enhancing community engagement and support. Until recently, there had been no EGS-focused coordination or training for ERA practitioners, Remedial Project Managers, Community Involvement Coordinators, etc. Future work will focus on providing site-specific examples of incorporating EGS concepts and tools into ERAs, this can be done through a retrospective analysis (e.g., Harwell et al. 2021) or looking forward with existing projects. The ERAF EGS workgroup will work on developing real site examples of operationalizing certain EGS-based tools, models, and assessment endpoints in ERAs conducted at Superfund fund-lead sites. The workgroup will also look to provide evidence and framework for others, including state and tribal environmental agencies, to potentially utilize these tools at PRP-led Superfund sites, regional RCRA sites, and hazardous waste sites in general. The ERAF EGS workgroup will also collaborate with the EnviroAtlas tool lead to create an ERA-featured collection. Additional outreach to relevant local, state, and federal stakeholders on EGS tools development and application at hazardous waste sites will also be conducted at internal and external meetings as well as at national and international conferences. Moreover, trainings and informational webinars will be developed and conducted to provide further awareness and examples of EGS tool applications to site project managers, risk assessors, contractors, and other technical staff working on hazardous waste sites.

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Appendix 1 – Overview Presentations

EPA

Operationalizing Ecosystem Services Endpoints and Assessment Tools for Supporting Risk Assessments and Contaminated Site Cleanups

2/28/2022

Superfund Technology Liaison Research (STLR) – Funded Workshop

by Ecological Risk Assessment Forum (ERAF) Ecosystem Goods and Services (EGS) Workgroup

Co-chairs: Gina Ferreira and Steph Kim

CBI Facilitators: Pat Field and Brandon Chambers

Disclaimer: The views expressed are those of the author(s) and do not necessarily represent the views or policies of the U.S. EPA.

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Slide

ERAF Workgroup: EGS for Directing & Communicating Ecological Risk

- Co-chairs (Gina Ferreira & Steph Kim)
- Members (ORD & Regional Colleagues)
  - Ned Black
  - Abby DeBofsky
  - Paulina Do
  - Kelly Garbach
  - Jim Harvey
  - Matt Harwell
  - Michael Kravitz
  - Venessa Madden
  - Charles Maurice
  - Wayne Munns
  - Tammy Newcomer-Johnson
  - Bruce Pluta
  - Marc Russell
  - Leah Sharpe
  - Cody Schumacher

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WHAT ARE ECOSYSTEM GOODS & SERVICES (EGS)?

EGS are the many life-sustaining benefits we receive from nature - clean air and water, fertile soil for crop production, pollination and flood control (nature's benefits to humans).

EGS Milestones

- Millennium Ecosystem Assessment 2005
- ORD Ecosystem Services Research Program 2007
- 2015 Draft OPM Directive (M-06-01 Memorandum Incorporating Ecosystem Services into Federal Decision Making)
- 2015/2016 – Initial ORD work connecting ES and risk assessments – Wayne Munns, et al.
- 2021 Translational Ecosystem Services workshop series

Benefits of Incorporating EGS into the ERA

- Incorporates human well-being into the ecological risk assessment (ERA) process
- Improves communication to the public of EGS – (nature's benefits) - when describing the problem being addressed and the reasons/benefits for selected remedies

STLR Workshop Agenda

Overview of incorporating EGS tools and ecosystem service assessment endpoints into ecological risk assessment framework

Facilitated breakout discussions of EGS tools application: National Ecosystem Services Classification System (NESCS) PLUS, Final EGS (FEGS) Scoping, EnviroAtlas, and EcoService Models Library (ESML)

Discuss applications of EGS tools and ecosystem service assessment endpoints in a case study

Teams Instruction

- Turn VPN off for best bandwidth
- Need to be on Teams computer audio to participate in breakout group sessions
- Option to turn video on/off when speaking
- "Mute" on your end when not speaking
- Zoom in on presented information using (1) focus on content option in "…" settings on Teams and/or (2) two fingers to zoom in/out on the laptop's mouse track
- Use "hand raising" button to speak during breakout sessions and case study and/or use chat throughout the entire workshop

Virtual Workshop Instruction

- Listen and learn
- Engage please!
- Engage across disciplines and offices
- Leave your emails, laundry, napping and other work for another time please.
- Feel free to snack while we work
- One person speak at a time
- Park other issues in a parking lot as needed

Mentimeter Poll

- **Mentimeter** link and code: Provided in chat
- CLICK on the URL and the questions will appear
- RESULTS will be shown by us on screen after

- INITIAL QUESTIONS
  - What's your region?
  - What's your tenure at EPA?
  - Which program do you work under?

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Presenter Bio: Wayne Munns, PhD

Wayne R. Munns, Jr. is Director of US EPA's Atlantic Coastal Environmental Sciences Division, an acknowledged expert in the fields of ecosystems services and ecological risk assessment, a past member of US EPA Risk Assessment Forum, and past Chair of the Society of Environmental Toxicology and Chemistry's (SETAC) Ecological Risk Assessment Advisory Group. Wayne was a principal author of the Agency's Ecological Benefits Assessment Strategic Plan, a core contributor to the development and oversight of US EPA's Ecosystem Services Research Program and has supported several national and international efforts to advance methods to inform environmental protection and management policy and decisions. He has presented concepts and approaches for population risk assessment and ecological benefits assessment at annual risk assessors' meetings and regional risk assessors' meetings and provided training to the ERAF on assessing risks to populations. His current interests include ecological risk assessment, ecosystem services, and applying the tenants of translational science to encourage solutions driven research that yields fit-for-purpose solutions meeting stakeholder needs.

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Generic Ecosystem Services Assessment Endpoints

Wayne R. Munns, Jr.
US Environmental Protection Agency
Office of Research and Development

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Ecological Risk Assessment

- Well developed process to inform environmental protection & restoration decisions
- Focus on assessment endpoints (AE) – explicit expressions of the environmental values to be protected, operationally defined as ecological entities & their attributes
- AEs traditionally selected by risk assessors (ecologists) in consultation w/decision makers

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Context

- AEs typically reflect ecologists' values, often disconnected from broader societal values & benefits
- Growing awareness that environmental management is improved by considering explicitly how decisions affect well-being of people & society
- "Societally relevant" AE that resonate most w/the public
  - –demystify actions & decisions
  - –might have financial implications
  - –can help to bridge currently disparate assessment & decision approaches (e.g., Superfund & NRDA)

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Ecosystem Services

- Functioning ecosystems contribute to well-being of ecological, social & economic components of the larger social-ecological system (aka sustainability)
- Structural components & processes interact functionally to benefit all life
- Contributions of ecological systems to vitality of human & non-human species alike can be considered ***ecosystem services*** **(ES)**
- ES complement traditional assessment endpoints by communicating benefits & costs of decisions

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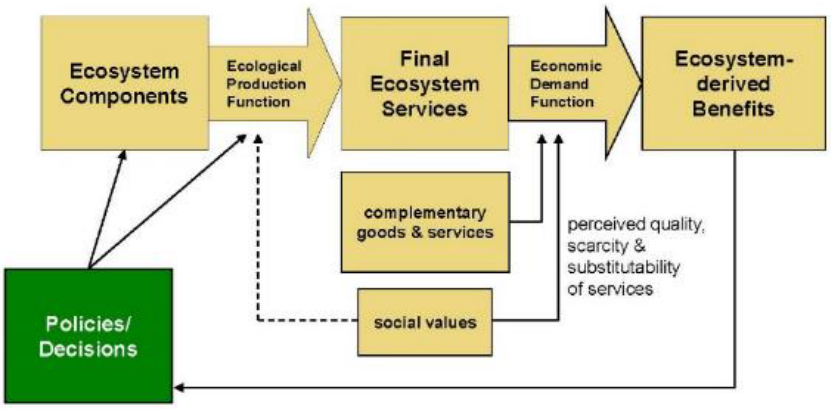
Conceptually



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Advantages of ES Assessment Endpoints

- More complete assessment of composite values of ecosystems & tradeoffs associated w/alternative decisions
- Enhanced social relevance, clarity & communication of decisions & rationale
- Decreased likelihood of unintended consequences
- Quantitative input to benefit-cost analysis

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Considering Generic Endpoints

- Generic ecological assessment endpoints (GEAE)
  - –broadly described assessment endpoints for ERA (US EPA 2003)
  - –applicable in a variety of environmental management contexts
  - –considered in problem formulation
- 15 originally described to guide planning of ERAs based on:
  - –usefulness in informing EPA decisions
  - –practicality of their measurement
  - –clarity with which they can be defined
  - –responsiveness to society's needs

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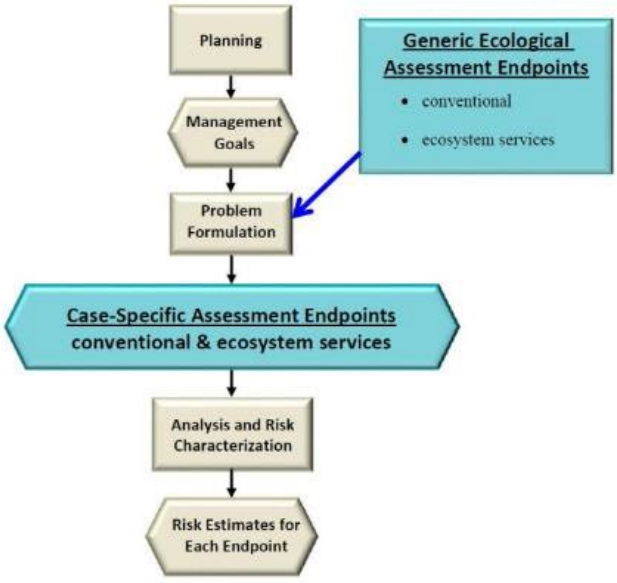
GEAE Use in ERA



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US EPA Risk Assessment Forum Technical Panel

- Provided rationale for generic ES assessment endpoints
- Described linkages among traditional endpoints & ecosystem services
- Offered generic ES assessment endpoints for use in ERA & other assessments
- Evaluated value added in case studies
- Prepared guidelines in 2016*

* Generic Ecological Assessment Endpoints (GEAEs) For Ecological Risk Assessment: Second Edition With Generic Ecosystem Services Endpoints Added (2016)

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Example Generic ES Assessment Endpoints*

Generic Ecosystem Service	Conventional Assessment Endpoint	Measurement Endpoint	Benefit
Food production	Fish population vitality	Fish abundance Size structure Species number	Nutrition Recreation Income Enjoyment
Recreational opportunity	Bird species diversity	Bird abundance Species number	Recreation Enjoyment Nutrition Income

*Additional ES-GEAE given in 2nd edition

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Case Study Evaluations

- Highlight use of ES assessment endpoints spanning spatial scales & types of decisions
  - –hazardous waste sites
  - –conductivity in Appalachian streams
  - –national scale assessments for setting air quality standards
  - –threatened & endangered species
- Focus on value added by ES assessment endpoints

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A Crosswalk between EGS Tools and the ERA Framework

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ERA Phases x EGS Activities Crosswalk

ERA Phases	Example EGS Topics and Activities	Some Potential EPA EGS Tools	Decision Questions
Planning and Scoping	• Identify EGS in site landscape	• FEGS Scoping Tool • FEGS Classification System • National Ecosystem Services Classification System-Plus (NESCS-Plus)	• Who are the stakeholders and what are their relative standings and levels of impact? • Do EGS classification systems help with selection, completeness, and comparability across assessment endpoints? • Would inclusion of EGS facilitate broader conversation with stakeholders and include ecosystem structure, function and benefits they had not considered?
Problem Formulation	• Describe EGS benefits • Estimate magnitudes of EGS benefits • Incorporate EGS into conceptual site model (CSM)	• FEGS Scoping Tool • EcoService Models Library (ESML) • Eco-Health Relationship Browser • EnviroAtlas • Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)	• What resources have stakeholders indicated are important for protection? • What health concerns do they have? • Has there been prioritization by stakeholders? • What do spatial data-layers tell us about the site and it's surrounding area?
Analysis	• Evaluate potential EGS/site contaminants connectivity • Evaluate potential effects of site contaminants on EGS • Evaluate EGS condition (functionality, impairment level) • Evaluate EGS resilience/vulnerability to site contaminants • Calculate EGS cost savings and other benefits • Assess EGS capacity (type, temporal, seasonal) • Assess EGS importance to stakeholders • Assess EGS maintenance effort and cost • Identify key features or parameters to protect EGS benefits	• EcoService Models Library (ESML) • EnviroAtlas • EPA H2O Tool • Rapid Benefit Indicators (RBI) Approach • Visualizing Ecosystem Land Management Assessments (VELMA) Model • Causal Analysis/Diagnosis Decision Information System (CADDIS)	• Are EGS attributes quantifiable (i.e., can they be measured or modeled)? • Which indicators might serve as proxy for assessing classes of EGS? • What spatial and temporal factors need to be considered? • Can EGS related ecological receptors be aggregated in space or across contaminants? • What are the estimated differences in benefits between multiple future scenarios? • How do upstream and downstream areas affect or are affected by the site? • How might benefits be valued?
Risk Characterization	• Compare costs and benefits of EGS • Characterize site contaminant threats to EGS • Characterize EGS impairment level by site contaminants	• EcoService Models Library (ESML) • EnviroAtlas • EPA H2O Tool • Rapid Benefit Indicators (RBI) Approach	• Would EGS help with risk characterization of aggregate and cumulative risk? • Can costs and benefits be compared using similar units of measure? • Where are the beneficiaries? • Which beneficial uses might be impacted or restored?
Risk Communication	• Articulate EGS benefits and costs	• All of the above	• What EGS do decision makers and stakeholders care about? • How do EGS contribute to human health and wellbeing?

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ERA Phases x EGS Activities Crosswalk

ERA Phases | Example EGS Topics and Activities | Some Potential EPA EGS Tools | Decision Questions

Planning and Scoping | • Identify EGS in site landscape | • FEGS Scoping Tool • FEGS Classification System • National Ecosystem Services Classification System-Plus (NESCS-Plus) | • Who are the stakeholders and what are their relative standings and levels of impact? • Do EGS classification systems help with selection, completeness, and comparability across assessment endpoints? • Would inclusion of EGS facilitate broader conversation with stakeholders and include ecosystem structure, function and benefits they had not considered?

Problem Formulation | • Describe EGS benefits • Estimate magnitudes of EGS benefits • Incorporate EGS into conceptual site model (CSM) | • FEGS Scoping Tool • EcoService Models Library (ESML) • Eco-Health Relationship Browser • EnviroAtlas • Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES) | • What resources have stakeholders indicated are important for protection? • What health concerns do they have? • Has there been prioritization by stakeholders? • What do spatial data-layers tell us about the site and it's surrounding area?

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• FEGS Classification System
• National Ecosystem Services Classification System-Plus (NESCS-Plus) | • Who are the stakeholders and what are their relative standings and levels of impact?
• Do EGS classification systems help with selection, completeness, and comparability across assessment endpoints?
• Would inclusion of EGS facilitate broader conversation with stakeholders and include ecosystem structure, function and benefits they had not considered?

Problem Formulation | • Describe EGS benefits
• Estimate magnitudes of EGS benefits
• Incorporate EGS into conceptual site model (CSM) | • FEGS Scoping Tool
• EcoService Models Library (ESML)
• Eco-Health Relationship Browser
• EnviroAtlas
• Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES) | • What resources have stakeholders indicated are important for protection?
• What health concerns do they have?
• Has there been prioritization by stakeholders?
• What do spatial data-layers tell us about the site and it's surrounding area?

Analysis | • Evaluate potential EGS/site contaminants connectivity
• Evaluate potential effects of site contaminants on EGS
• Evaluate EGS condition (functionality, impairment level)
• Evaluate EGS resilience/vulnerability to site contaminants
• Calculate EGS cost savings and other benefits
• Assess EGS capacity (type, temporal, seasonal)
• Assess EGS importance to stakeholders
• Assess EGS maintenance effort and cost
• Identify key features or parameters to protect EGS benefits | • EcoService Models Library (ESML)
• EnviroAtlas
• EPA H2O Tool
• Rapid Benefit Indicators (RBI) Approach
• Visualizing Ecosystem Land Management Assessments (VELMA) Model
• Causal Analysis/Diagnosis Decision Information System (CADDIS) | • Are EGS attributes quantifiable (i.e., can they be measured or modeled)?
• Which indicators might serve as proxy for assessing classes of EGS?
• What spatial and temporal factors need to be considered?
• Can EGS related ecological receptors be aggregated in space or across contaminants?
• What are the estimated differences in benefits between multiple future scenarios?
• How do upstream and downstream areas affect or are affected by the site?
• How might benefits be valued?

Risk Characterization | • Compare costs and benefits of EGS
• Characterize site contaminant threats to EGS
• Characterize EGS impairment level by site contaminants | • EcoService Models Library (ESML)
• EnviroAtlas
• EPA H2O Tool
• Rapid Benefit Indicators (RBI) Approach | • Would EGS help with risk characterization of aggregate and cumulative risk?
• Can costs and benefits be compared using similar units of measure?
• Where are the beneficiaries?
• Which beneficial uses might be impacted or restored?

Risk Communication | • Articulate EGS benefits and costs | • All of the above | • What EGS do decision makers and stakeholders care about?
• How do EGS contribute to human health and wellbeing?

Office of Research and Development
Sustainable and Healthy Communities (SHC) Research Program

Incorporation of EGS into ERA Workshop
28 February 2022

EPA United States Environmental Protection Agency

ERA Phases x EGS Activities Crosswalk

ERA Phases	Example EGS Topics and Activities	Some Potential EPA EGS Tools	Decision Questions
Planning and Scoping	• Identify EGS in site landscape	• FEGS Scoping Tool • FEGS Classification System • National Ecosystem Services Classification System-Plus (NESCS-Plus)	• Who are the stakeholders and what are their relative standings and levels of impact? • Do EGS classification systems help with selection, completeness, and comparability across assessment endpoints? • Would inclusion of EGS facilitate broader conversation with stakeholders and include ecosystem structure, function and benefits they had not considered?
Problem Formulation	• Describe EGS benefits • Estimate magnitudes of EGS benefits • Incorporate EGS into conceptual site model (CSM)	• FEGS Scoping Tool • EcoService Models Library (ESML) • Eco-Health Relationship Browser • EnviroAtlas • Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)	• What resources have stakeholders indicated are important for protection? • What health concerns do they have? • Has there been prioritization by stakeholders? • What do spatial data-layers tell us about the site and it's surrounding area?
Analysis	• Evaluate potential EGS/site contaminants connectivity • Evaluate potential effects of site contaminants on EGS • Evaluate EGS condition (functionality, impairment level) • Evaluate EGS resilience/vulnerability to site contaminants • Calculate EGS cost savings and other benefits • Assess EGS capacity (type, temporal, seasonal) • Assess EGS importance to stakeholders • Assess EGS maintenance effort and cost • Identify key features or parameters to protect EGS benefits	• EcoService Models Library (ESML) • EnviroAtlas • EPA H2O Tool • Rapid Benefit Indicators (RBI) Approach • Visualizing Ecosystem Land Management Assessments (VELMA) Model • Causal Analysis/Diagnosis Decision Information System (CADDIS)	• Are EGS attributes quantifiable (i.e., can they be measured or modeled)? • Which indicators might serve as proxy for assessing classes of EGS? • What spatial and temporal factors need to be considered? • Can EGS related ecological receptors be aggregated in space or across contaminants? • What are the estimated differences in benefits between multiple future scenarios? • How do upstream and downstream areas affect or are affected by the site? • How might benefits be valued?
Risk Characterization	• Compare costs and benefits of EGS • Characterize site contaminant threats to EGS • Characterize EGS impairment level by site contaminants	• EcoService Models Library (ESML) • EnviroAtlas • EPA H2O Tool • Rapid Benefit Indicators (RBI) Approach	• Would EGS help with risk characterization of aggregate and cumulative risk? • Can costs and benefits be compared using similar units of measure? • Where are the beneficiaries? • Which beneficial uses might be impacted or restored?
Risk Communication	• Articulate EGS benefits and costs	• All of the above	• What EGS do decision makers and stakeholders care about? • How do EGS contribute to human health and wellbeing?

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EGS Tools Presenters & Bios

National Ecosystems Classification System-Plus (NESCS Plus) **- Matt Harwell, PhD**

Dr. Matthew Harwell is a Supervisory Ecologist and leads ORD's research laboratory in Newport, Oregon. Matt's areas of specialization include ecosystem services, ecosystem assessment, integration and communication of science for decision makers, adaptive management, and ecosystem restoration. Over the past decade, Matt has worked with a science leadership team to co-lead a significant portion of ORD's national research portfolio on ecosystem services, most recently including developing connections between ecosystem services and different processes in contaminated cleanups including risk assessments.

Final EGS Scoping (FEGS) Tool **– Leah Sharpe, PhD**

Leah Sharpe is a Decision Scientist with the Gulf Ecosystem Measurement and Modeling Division of ORD's Center for Ecosystem Measurement and Modeling. She joined EPA in 2016 and, since then, has been working to incorporate ecosystem service thinking into decision making processes and developing tools and approaches for doing so. Prior to her time at the EPA she worked for NOAA Fisheries where she focused on decision support, science communication, and policy analysis. She received her MS and her PhD from University of Minnesota.

EnviroAtlas **– Anne Neale, PhD**

Anne Neale leads the EnviroAtlas, a web-based interactive tool that integrates over 450 mapped data layers and helps users understand the implications of planning and policy decisions on community assets and vulnerabilities. Anne has a background in landscape ecology and ecosystem services and has been with EPA since 1991. One of her primary research interests has been examining relationships between spatial patterns of landscape characteristics and ecological resources, ecosystem services, and human health outcomes. One of her goals with EnviroAtlas is to translate science into tools and data that can be readily understood and used by a broad audience.

EcoService Models Library (ESML) **– Tammy Newcomer-Johnson, PhD**

Tammy Newcomer-Johnson is an ecologist with the Office of Research and Development in Cincinnati, Ohio. Tammy leads the EcoService Models Library and the National Ecosystem Services Classification System (NESCS Plus (NESCS rhymes with Texas)).

Disclaimer: The views expressed are those of the author(s) and do not necessarily represent the views or policies of the U.S. EPA.

STLR Workshop for Potential Incorporation of EGS into ERA

Description of the ES Tools Portal (Currently Under Development)

Tammy Newcomer-Johnson, Matt Harwell, Leah Sharpe

February 28, 2022

Featured Tools for today's workshop:

NESCS Plus	EnviroAtlas
FEGS Scoping Tool	EcoService Models Library

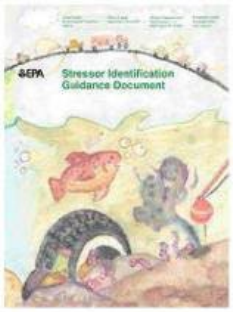
Outline

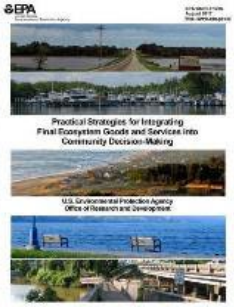
- EPA ES Tools
- ERA Phase and Activities Crosswalk
- ES Portal Demo
- ERA Phases Vs. Today's Featured Tools

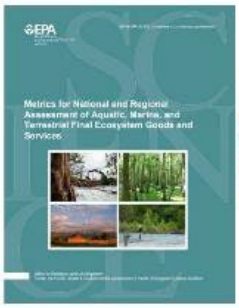
Featured Tools for today's workshop:

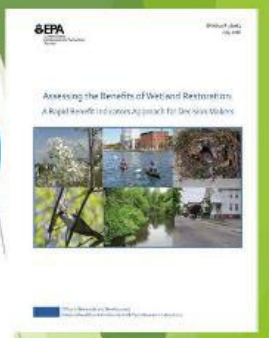
NESCS Plus	EnviroAtlas
FEGS Scoping Tool	EcoService Models Library

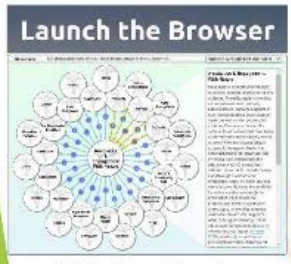
EPA ES Tools

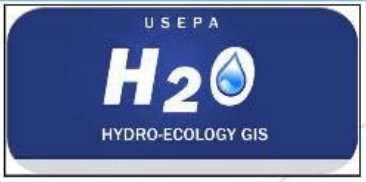






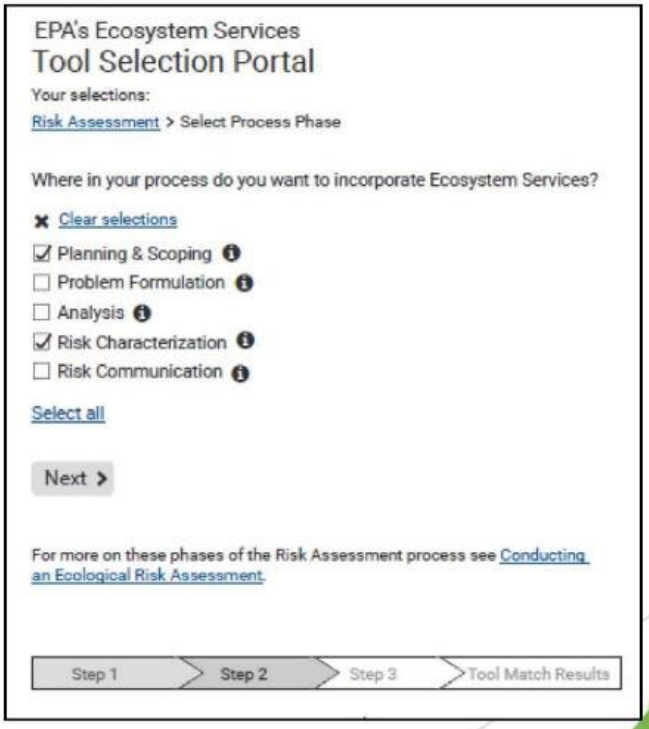




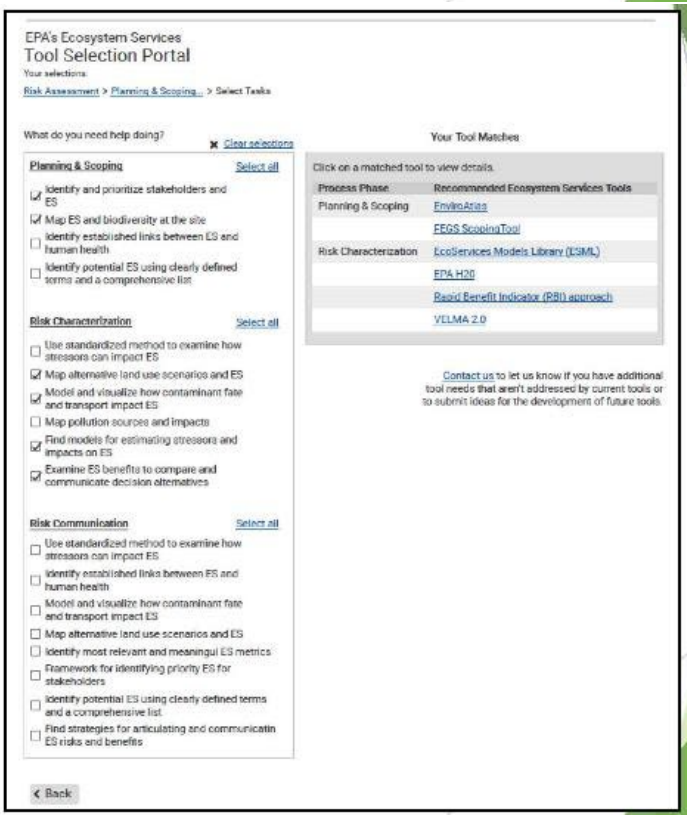


ERA Phases and Activities	NESCS Plus	FEGS Scoping Tool	EnviroAtlas	EcoService Models Library	CADDIS	EPA H2O	VELMA 2.0	Eco-Health Browser	Rapid Benefit Indicator (RBI)	FEGS Metrics Report	Practical Strategies
1 - Planning & Scoping	■	■	■					■			
Identify and prioritize stakeholders and ES		■						■			
Identify established links between ES and human health											
Identify potential ES using clearly defined terms and a comprehensive list	■										
Map ES and biodiversity			■								
2 - Problem Formulation	■	■	■		■						
Create conceptual model for how stressors impact ES					■						
Identify and prioritize stakeholders and ES		■									
Identify potential ES using clearly defined terms and a comprehensive list	■										
Map ES and biodiversity			■								
3 - Analysis			■	■	■	■	■	■			
Find models for estimating ES				■							
Map alternative land use scenarios and ES impacts						■					
Map ES and biodiversity			■								
Model and visualize how contaminant fate and transport impact ES							■				
Use standardized method to examine how stressors can impact ES					■						
4 - Risk Characterization			■	■	■	■	■	■	■		
Examine ES benefits to compare and communicate decision alternatives									■		
Find models for estimating stressors and impacts on ES				■							
Map alternative land use scenarios and ES						■					
Map pollution sources and impacts			■								
Model and visualize how contaminant fate and transport impact ES							■				
Use standardized method to examine how stressors can impact ES					■						
5 - Risk Communication	■	■			■	■	■	■	■	■	■
Examine ES benefits to compare and communicate decision alternatives									■		
Find strategies for articulating and communicating ES risks and benefits											■
Framework for identifying priority ES for stakeholders		■									
Identify established links between ES and human health								■			
Identify most relevant and meaningful ES metrics										■	
Identify potential ES using clearly defined terms and a comprehensive list	■										
Map alternative land use scenarios and ES						■					
Model and visualize how contaminant fate and transport impact ES							■				
Use standardized method to examine how stressors can impact ES					■						

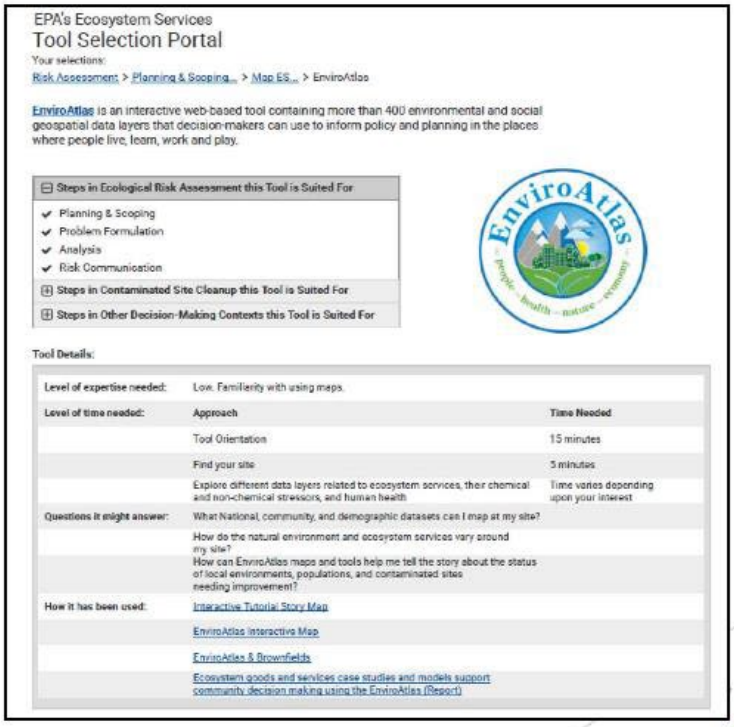
ES Tools Portal Mock-Ups for your Feedback



ES Tools Portal Mock-Ups for your Feedback



ES Tools Portal Mock-Ups for your Feedback



U.S. Environmental Protection Agency

ERA phases vs. today's featured tools

ERA Phase	Tool Names	Activity
1 - Planning & Scoping	EnviroAtlas	Map ES and biodiversity
	FEGS Scoping Tool	Identify and prioritize stakeholders and ES
	NESCS Plus	Identify potential ES using clearly defined terms and a comprehensive list
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	ESML	Find models for estimating stressors and impacts on ES
5 - Risk Communication	FEGS Scoping Tool	Framework for identifying priority ES for stakeholders
	NESCS Plus	Identify potential ES using clearly defined terms and a comprehensive list

Questions will be discussed in breakout session

- Tammy: Newcomer-Johnson.Tammy@EPA.gov
- Matt: Harwell.Matthew@epa.gov
- Leah: Sharpe.Leah@epa.gov

Up next – Today's featured tools:

Slide

ERAF EGS STLR Workshop:

National Ecosystem Services Classification System (NESCS Plus)

Presenter: **Matt Harwell**

Facilitator: Marc Russell

Recorder: Brooke Mastervich

Tool lead: Tammy Newcomer-Johnson

40

Outline

- What is this tool?
- Why bother with it?
- How does it work?
- Examples of how it could be used

41

What is this tool?

NESCS Plus is an organizer. It aids identifying and classifying what matters directly to people.

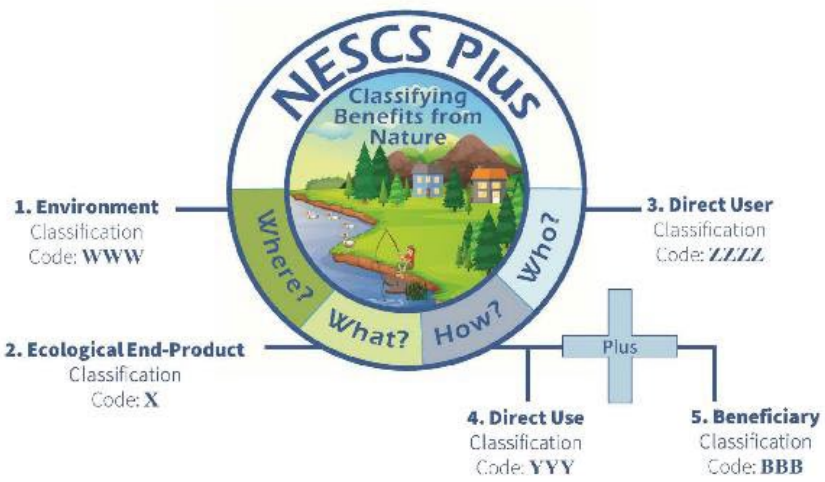
people & codes

5. Integration with ORD tools

42

What is this tool?

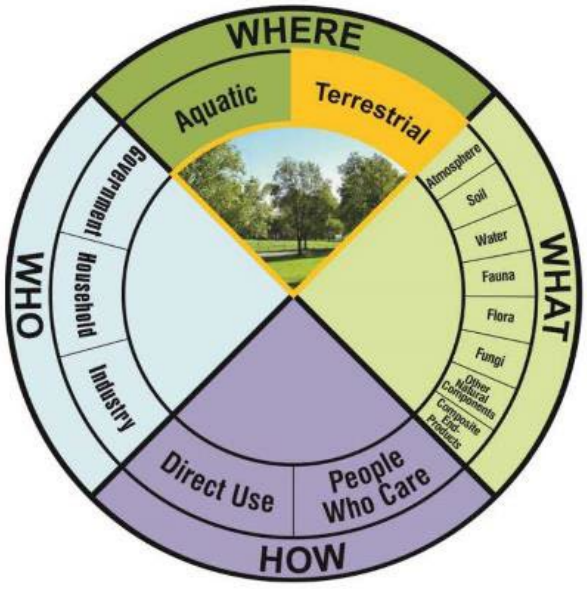
5 Components; Flexible Hierarchies; & Discrete Classes and Codes



43

What is this tool?

Visualizing the Components of FEGS Classification



44

EPA United States Environmental Protection Agency

What is this tool?

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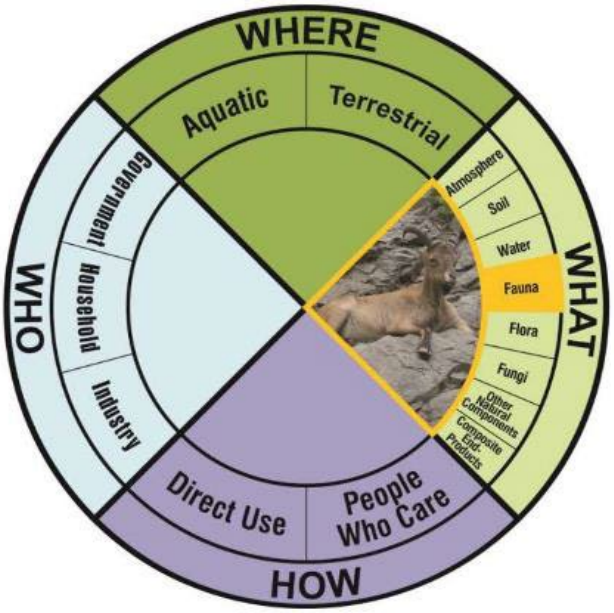
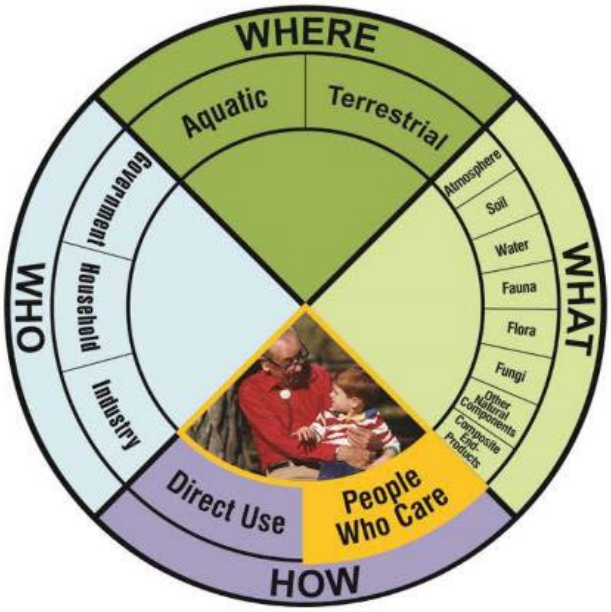


45

EPA United States Environmental Protection Agency

What is this tool?

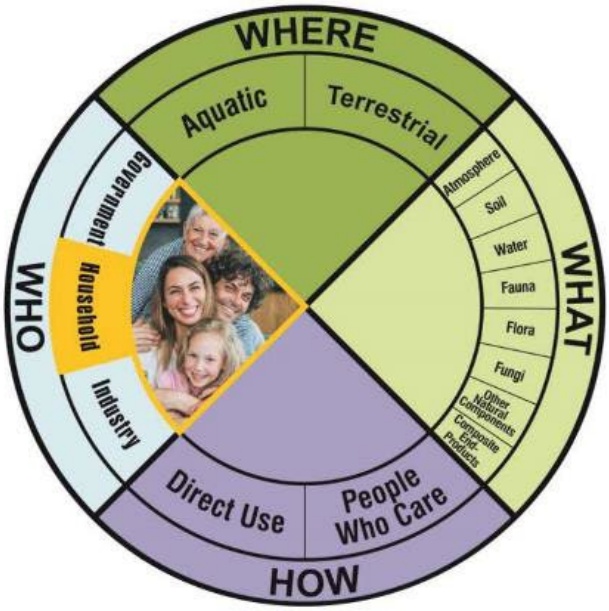
Visualizing the Components of FEGS Classification



46

What is this tool?

Visualizing the Components of FEGS Classification



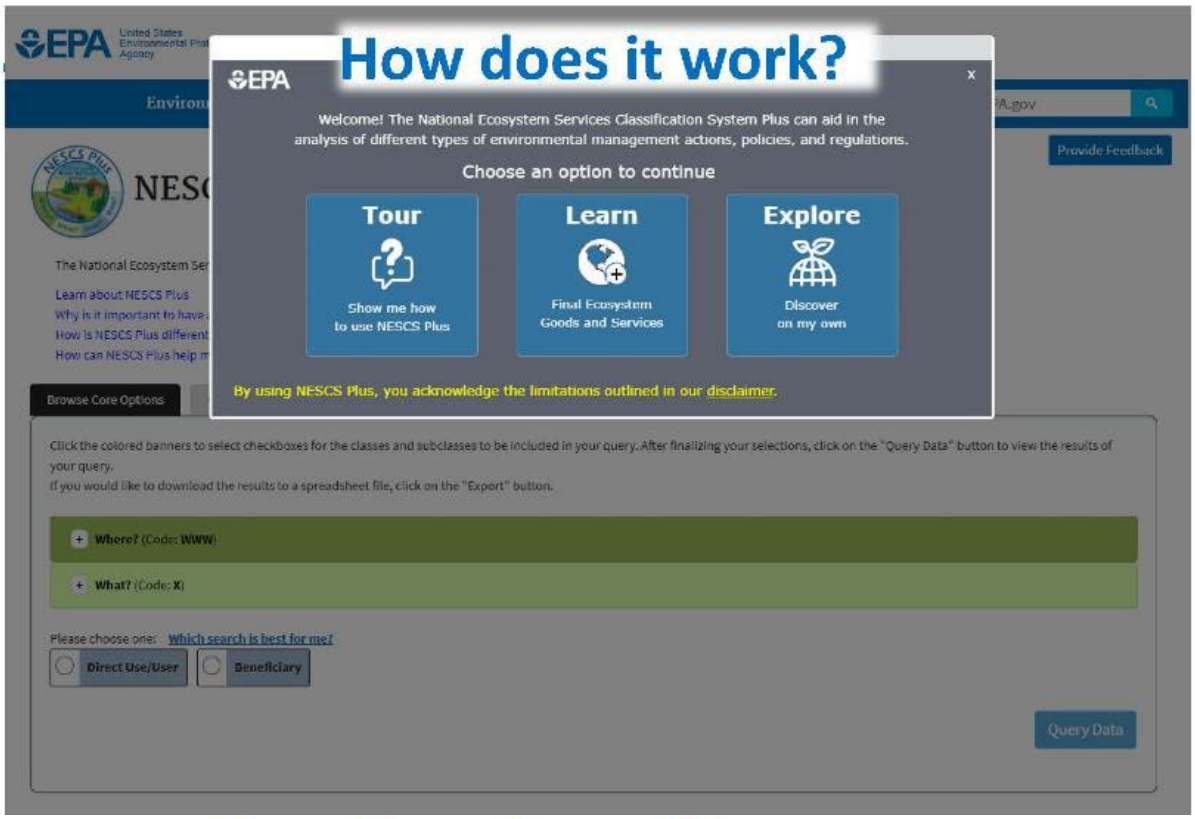
47

Why bother with NESCS Plus?

1. Need for <u>common language</u> across <u>multiple disciplines</u> to reduce miscommunication and redundancy
2. Need for <u>standardized approaches</u> for <u>assessing ecosystem services</u>

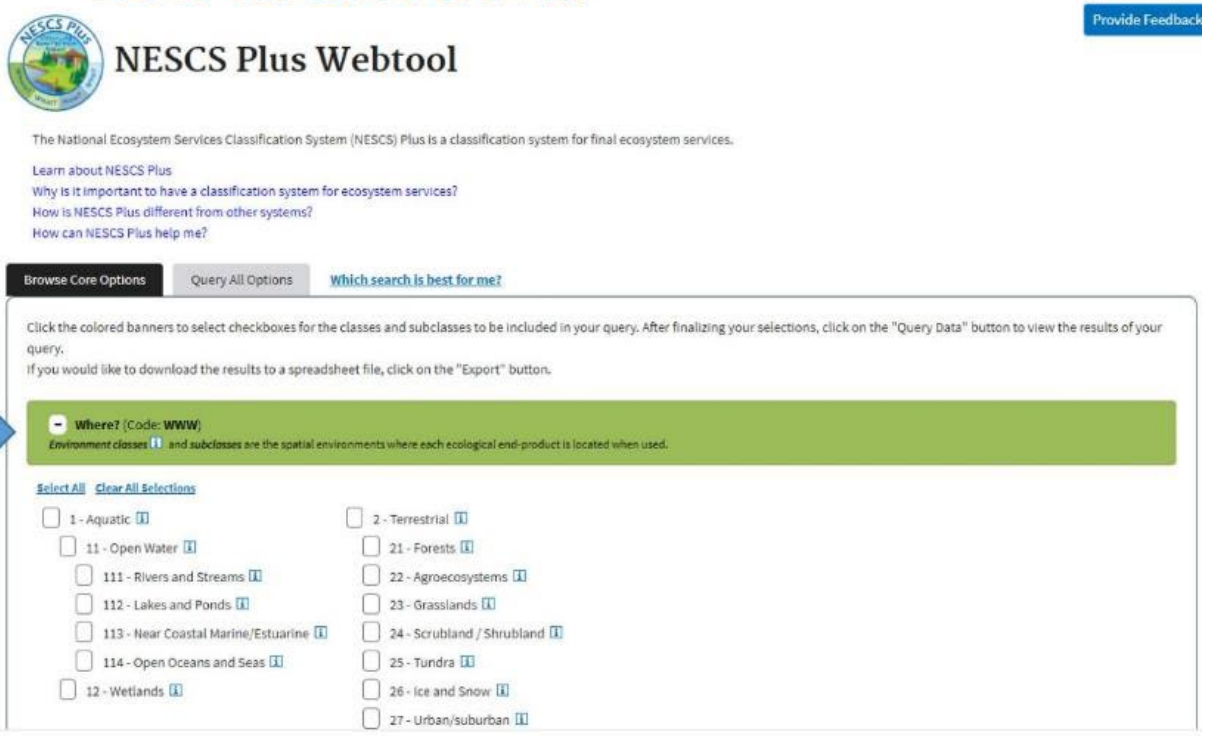
48

How does it work?



49

How does it work?



Can do this for:

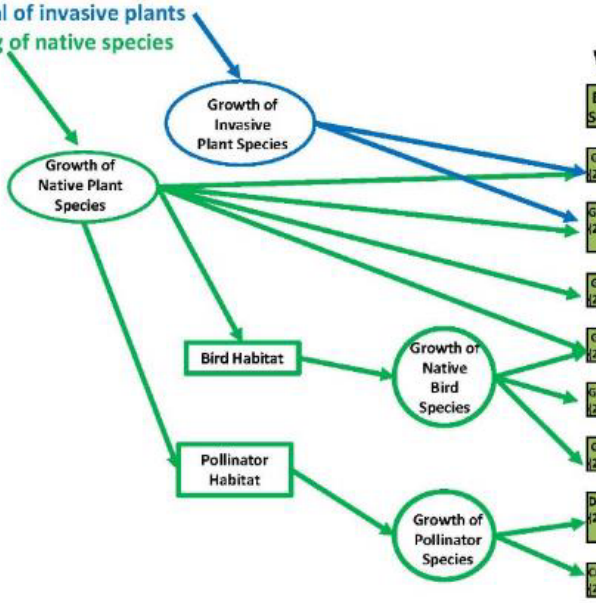
- **Where?**
- **What?**
- **How?**
- **Who?**

50

Examples of how it could be used

Grassland Restoration

- Removal of invasive plants
- Planting of native species



LIST OF AFFECTED FINAL ECOSYSTEM SERVICES (FES)

Where?	What?	How?	Who?	
Environment Subclass II (WWW)	Ecological End-Product Class (X)	Direct Use/Non-Use Subclass II (YYYY)	Direct User Subclass II (ZZZZ)	NESCS Plus ID (WWW.X.YYYY.ZZZZ)
Grassland/Herbaceous (231)	Flora (5)	Aesthetic appreciation; in-situ (1062)	Households (2111)	231.5.1062.2111
Grassland/Herbaceous (231)	Flora (5)	Property protection; in-situ (1102)	Administration of Environmental Quality Programs (3924)	231.5.1102.3924
Grassland/Herbaceous (231)	Flora (5)	Recreation; in-situ (1112)	Households (2111)	231.5.1112.2111
Grassland/Herbaceous (231)	Composite (8)	Information/Education; in-situ (1132)	Education services (1611)	231.8.1132.1611
Grassland/Herbaceous (231)	Fauna (4)	Aesthetic appreciation; in-situ (1062)	Households (2111)	231.4.1062.2111
Grassland/Herbaceous (231)	Fauna (4)	Recreation; in-situ (1112)	Households (2111)	231.4.1112.2111
Developed Open Space (271)	Fauna (4)	Plant cultivation; in-situ (1082)	Households (2111)	271.4.1082.2111
Cultivated Crops (222)	Fauna (4)	Plant cultivation; in-situ (1082)	Crop Production (1111)	222.4.1082.1111

51

ERA phases vs. today's featured tools

ERA Phase	Tool Names	Activity
1 - Planning & Scoping	EnviroAtlas	Map ES and biodiversity
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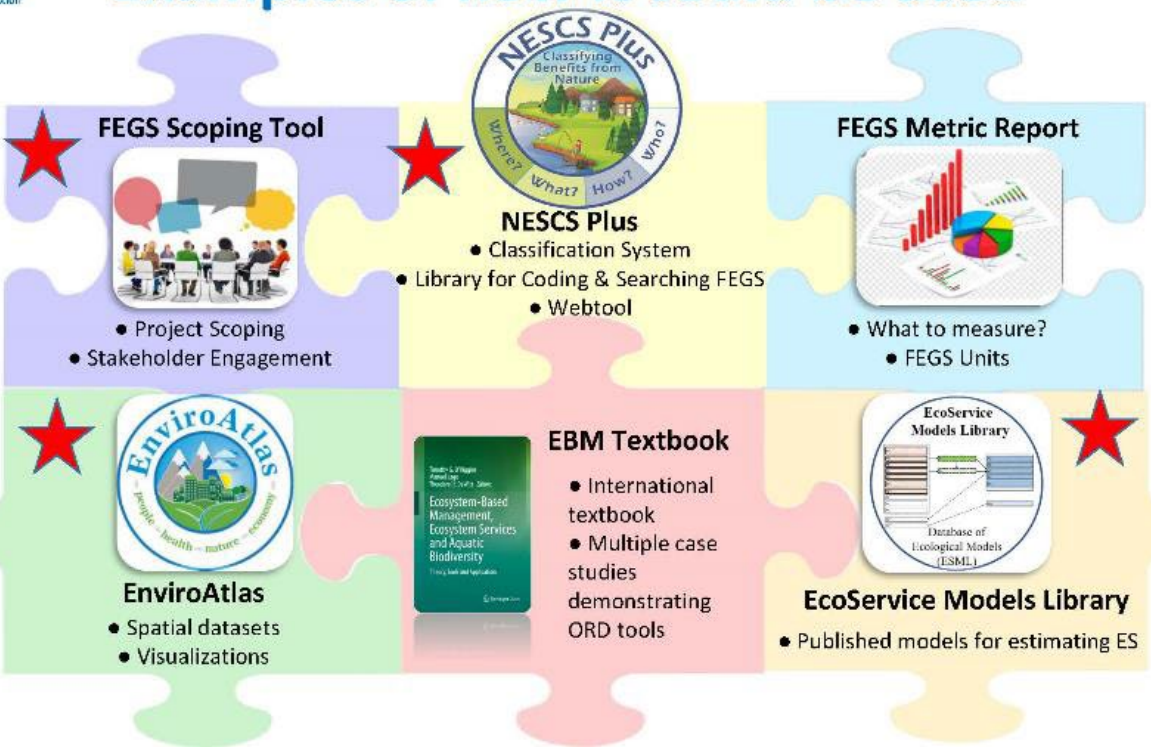
Examples of how it could be used



Thank you!
Questions will be discussed in breakout session

- Matt: Harwell.Matthew@epa.gov
- Marc: Russell.Marc@epa.gov
- Brooke: Mastervich.Brooke@epa.gov
- Tammy: Newcomer-Johnson.Tammy@epa.gov

ERAF EGS STLR Workshop:

Final Ecosystem Goods and Services Scoping Tool

Tool Lead: **Leah Sharpe**

Facilitator: Bruce Pluta

Recorder: Katelyn Barrett

EPA United States Environmental Protection Agency

Outline

- What is this tool?
- Why bother with it?
- How does it work?
- Examples of how it could be used

- Designed for community decision-makers
- Used at an early project scoping stage of decision-making
- To help identify and prioritize:
  - *Stakeholders*,
  - *The ways they are benefiting from the ecosystem*, and
  - *The environmental attributes necessary to realize those benefits*

58

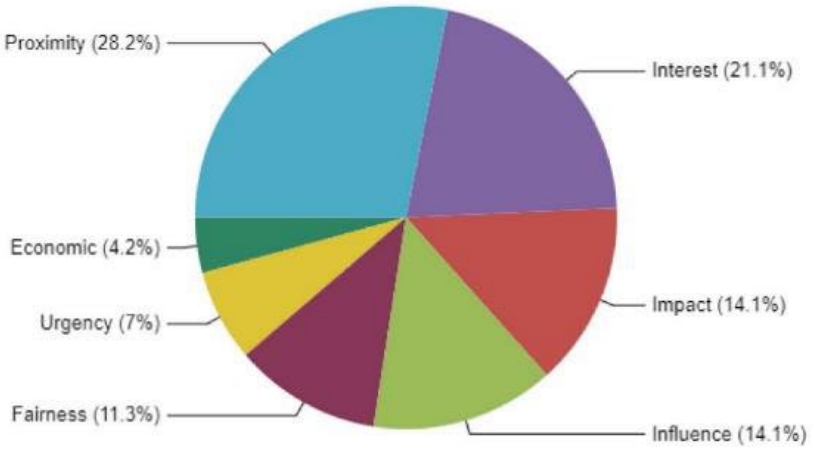
Why bother with the Scoping Tool?

- Considering ecosystem services is important in decision making for the environment and public health
- Identifying **more relevant ecosystem services** ensures they are considered in the decision-making process
- Uses final ecosystem goods and services (FEGS), the elements of nature that **directly benefit humans**, used in other ORD tools
- Decision makers are already doing *ad hoc* prioritizations, this tool makes the process transparent, the priorities explicit, and the results explainable

59

Stakeholder Prioritization

Color	Criterion	Weight
	Magnitude & Probability of Impact	50
	Level of Influence	50
	Level of Interest	75
	Urgency & Temporal Immediacy	25
	Proximity	100
	Economic Interest	15
	Rights	0
	Fairness	40
	Underrepresented & Underserved	0



Screenshots from tool: weighting step

Stakeholder Prioritization

Stakeholders

Identify your stakeholder groups. Enter the name of the group and press **Add stakeholder group**.

Notes

Your notes here...

Stakeholder group name | Add Stakeholder Group

Screenshots from tool: scoring step

61

Stakeholder Prioritization

Level of Influence

Does this stakeholder group have any formal or informal influence over the decision making process?

Please enter a number 0 to 100.

- 100 = This group has formal influence over the decision-making process (i.e. can have the project stopped, must be consulted with).
- 50 = This group has informal influence over the decision-making process.
- 0 = This group has no influence over the decision-making process.

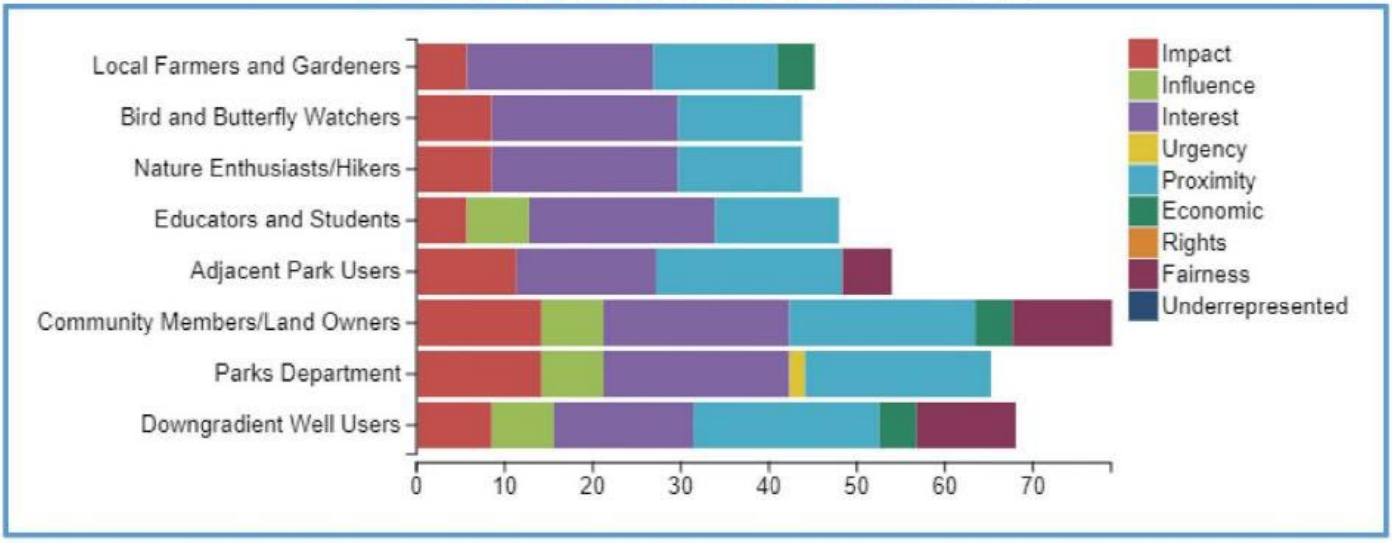
Group 1 [ ]
Group 2 [ ]

- Score each stakeholder group using the provided metrics as a guide
- **Objective!**

Screenshots from tool: scoring step

62

Stakeholder Prioritization



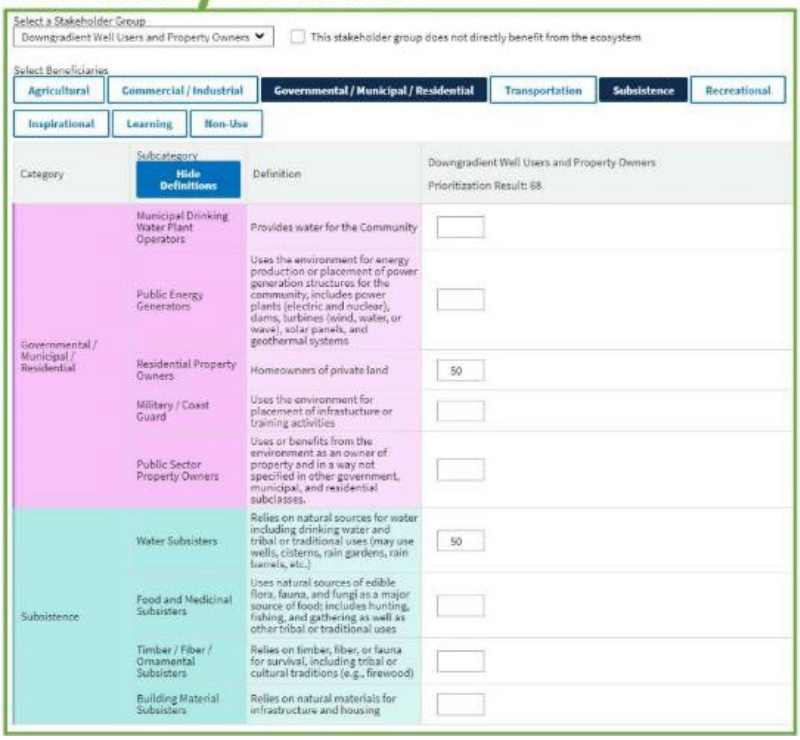
- Bar chart shows relative priority of stakeholder groups and what criteria are driving that prioritization
- East Mount Zion landfill revegetation (simplified and tweaked)

Screenshot from tool: prioritization results

63

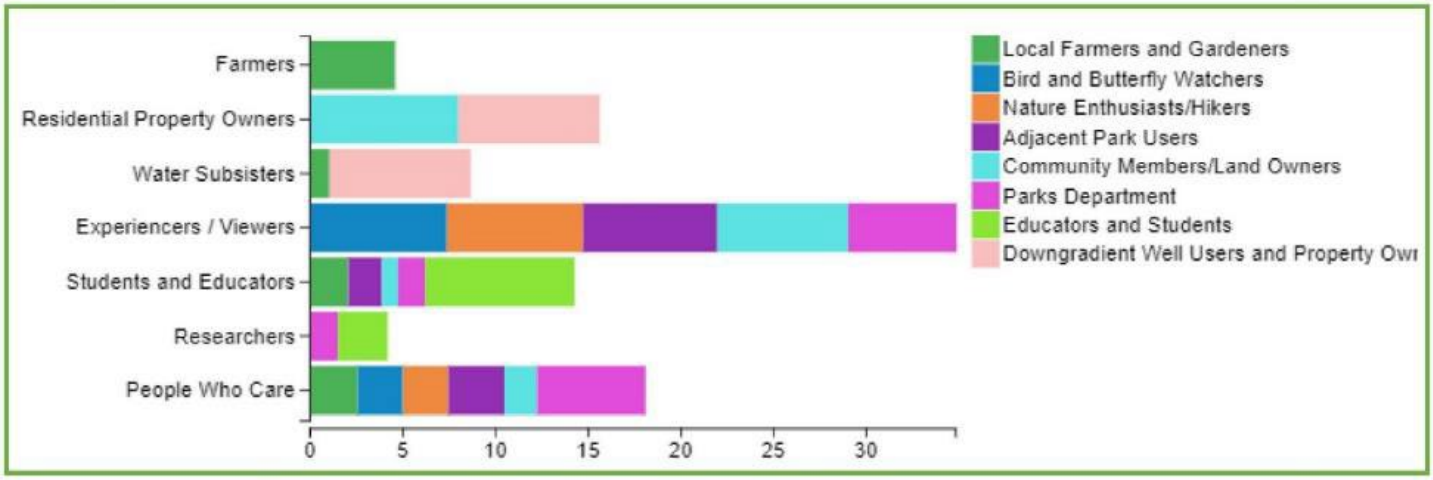
Beneficiary Profile

- Identify, by %, how each stakeholder group benefits from the site



Screenshot from tool – beneficiary step

Beneficiary Profile



- Bar chart shows relative priority of different types of beneficiaries and which stakeholder groups are receiving that benefit

Screenshot from tool: beneficiary results

65

Key Attribute Identification

- Identify, by %, what each beneficiary group needs from the site

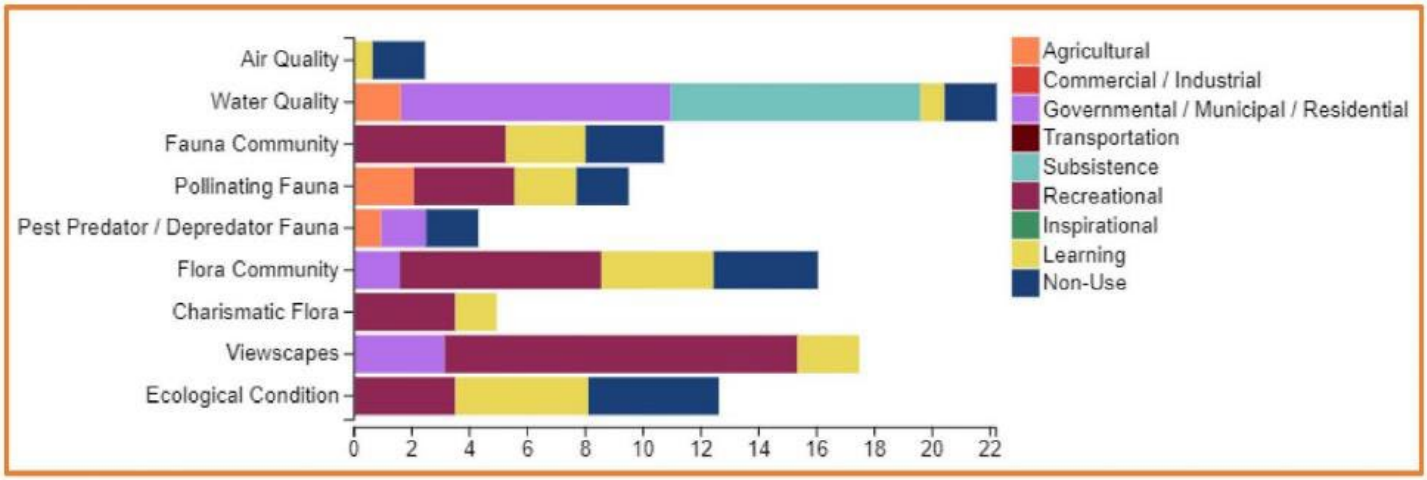
Select a Beneficiary Group: Agricultural

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

Attribute Tier 1	Attribute Tier 2 (Hide Definitions)	Definition	Agricultural Farmers
Beneficiary Result			4.55
Water	Water Quality	The suitability of water for use based on physical, chemical, and/or biological characteristics	35
	Water Quantity	The amount of water present, could be measured in terms of volume, depth, total yield, and/or peak flow	
	Water Movement	The amount of water flowing per unit of time, includes aspects such as surface water movement through watersheds, wave action, etc	
Fauna	Fauna Community	The interacting animal life present in the area	
	Edible Fauna	Fauna fit to be eaten by humans	
	Medicinal Fauna	Fauna that has healing properties as is or after processesing	
	Keystone Fauna	Fauna on which other species depend, its absence would significantly alter the ecosystem	
	Charismatic Fauna	Fauna with symbolic value or widespread popular appeal	
	Rare Fauna	Fauna that are uncommon or infrequently encountered	
	Pollinating Fauna	Fauna that moves pollen from plant to plant	45
	Pest Predator / Depredator Fauna	Fauna that prey upon pest species	20

Screenshot from tool – user input attribute step

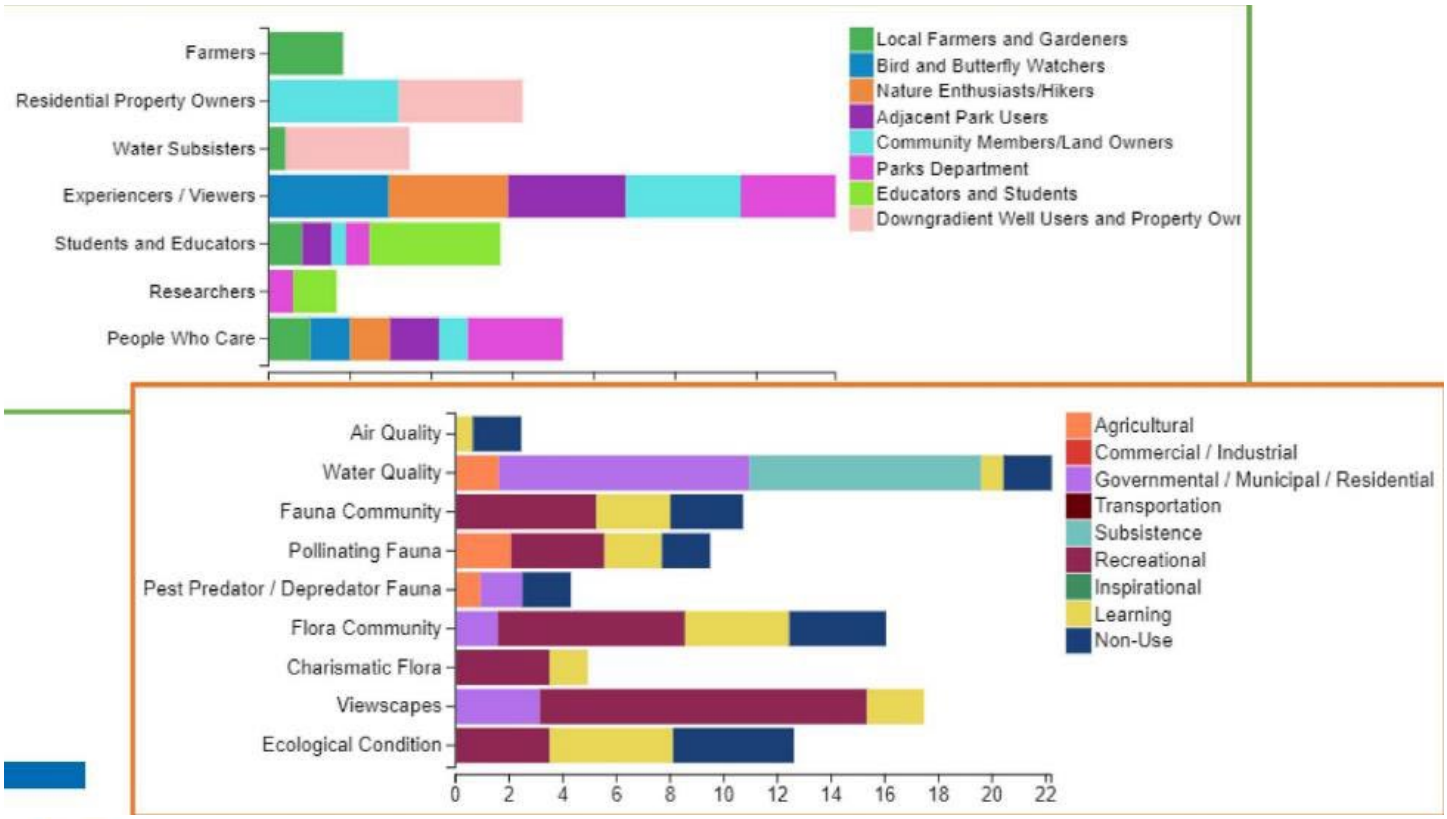
Key Attribute Identification



- Bar chart shows relative priority of different environmental attributes and the beneficiaries who value them

Screenshot from tool: attribute results

67



EPA United States Environmental Protection Agency

Applications

- To identify ways in which stakeholders could benefit from a project
- To find common interests among stakeholder groups
- To identify goals and metrics for restoration or remediation sites
- To identify ecosystem services for consideration in land use decisions
- To explicitly lay out an understanding of the stakeholder context and have an opportunity to correct misconceptions

69

ERA phases vs. today's featured tools

ERA Phase	Tool Names	Activity
1 - Planning & Scoping	EnviroAtlas	Map ES and biodiversity
	FEGS Scoping Tool	Identify and prioritize stakeholders and ES
	NESCS Plus	Identify potential ES using clearly defined terms and a comprehensive list
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3 - Analysis	EnviroAtlas	Map ES and biodiversity
	ESML	Find models for estimating ES
4 - Risk Characterization	EnviroAtlas	Map pollution sources and impacts
	ESML	Find models for estimating stressors and impacts on ES
5 - Risk Communication	FEGS Scoping Tool	Framework for identifying priority ES for stakeholders
	NESCS Plus	Identify potential ES using clearly defined terms and a comprehensive list

Thank you!
Questions will be answered in breakout session

- Leah: Sharpe.Leah@epa.gov
- Bruce: Pluta.Bruce@epa.gov
- Katelyn: Barrett.Katelyn@epa.gov

- Tool URL: https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs-scoping-tool

71

Outline

- What is this tool?
- Why bother with it?
- How does it work?
- Examples of how it could be used

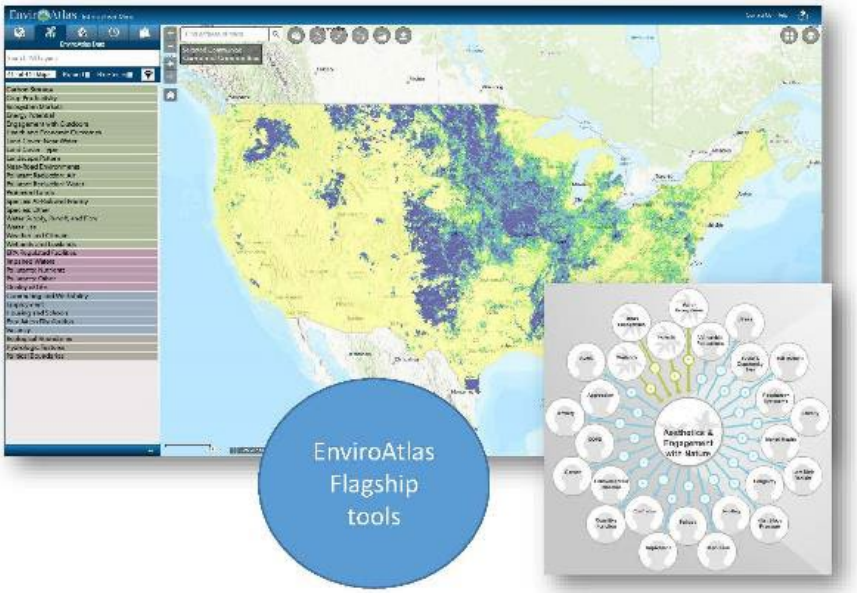
72

What is this tool?

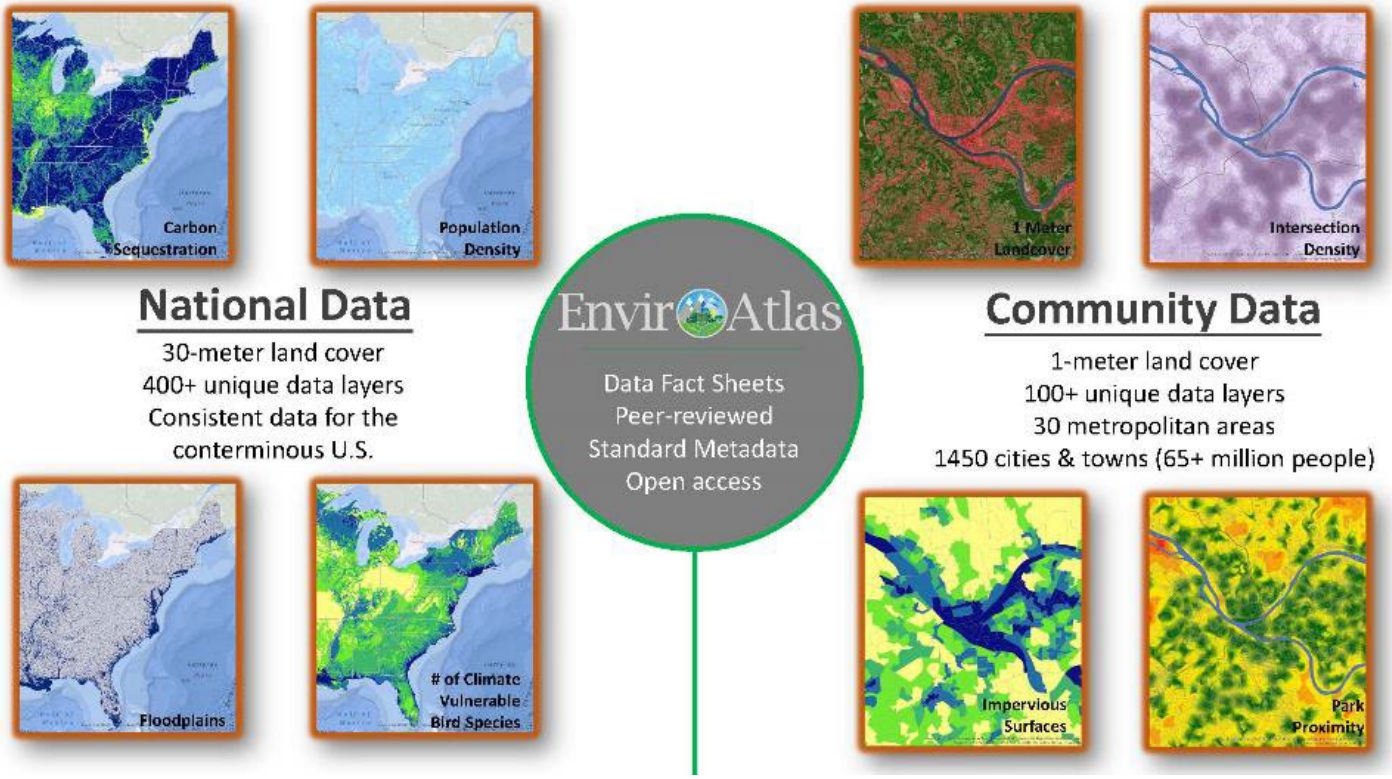
EnviroAtlas is an online resource providing geospatial data, easy-to-use tools, and other resources related to ecosystem services, their chemical and non-chemical stressors, and connections to human health and equity.

Includes:

- Over 500 map layers
- **Interactive Mapping Application**
- **Eco-Health Relationship Browser**
- Analytic and Interpretive Tools
- GIS Toolboxes
- Guides, Use Cases, Tutorials

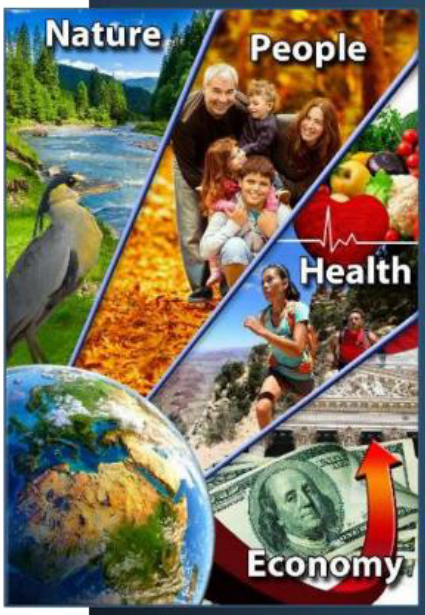


Clean Air
Clean & Plentiful Water
Biodiversity Conservation
Food, Fuel, & Materials
Natural Hazard Mitigation
Climate Stabilization
Recreation, Culture & Aesthetics
Ecosystem Services Benefit Categories


Carbon Sequestration
Population Density
1 Meter Landcover
Intersection Density
National Data
30-meter land cover
400+ unique data layers
Consistent data for the conterminous U.S.
EnviroAtlas
Data Fact Sheets
Peer-reviewed
Standard Metadata
Open access
Community Data
1-meter land cover
100+ unique data layers
30 metropolitan areas
1450 cities & towns (65+ million people)
Floodplains
# of Climate Vulnerable Bird Species
Impervious Surfaces
Park Proximity

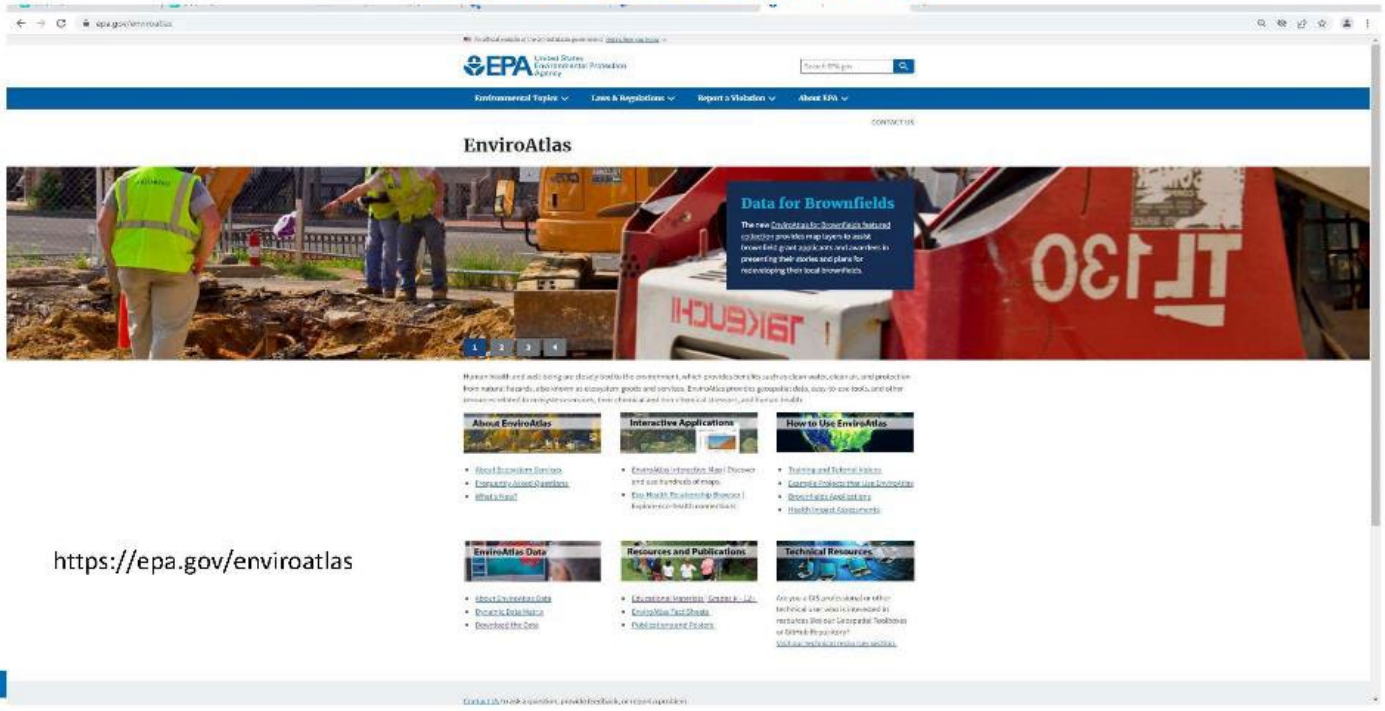
Why bother with EnviroAtlas?

- May have just the data you have been searching for
- Contains many data sets that are unique to EnviroAtlas
- Consistently documented and vetted
- Don't need GIS experience to use
- Many data layers summarized to common geographic units (i.e., watersheds, census block groups)
- Relatable to the other EGS tools in this presentation
- Provides multiple ways to interact with the data
  - Interactive Map
  - Published web services
  - All data are downloadable



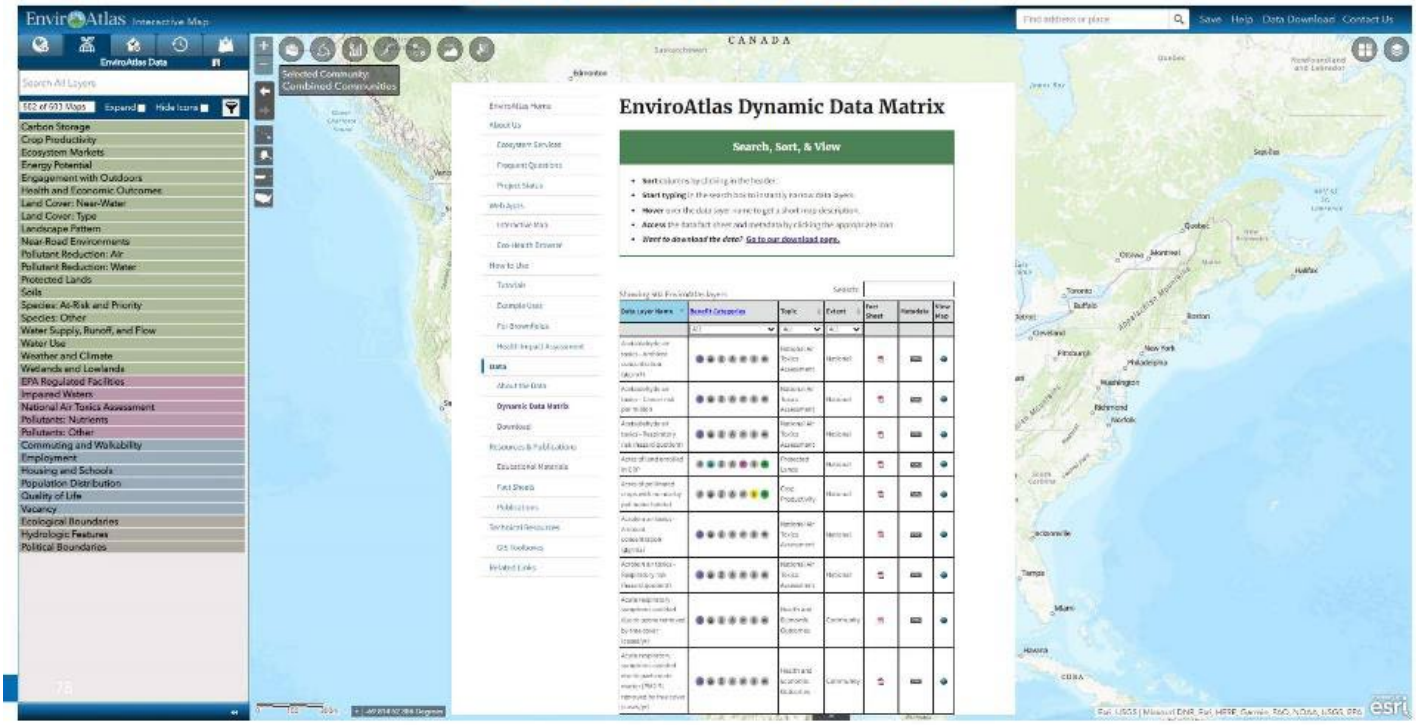
75

How does it work?

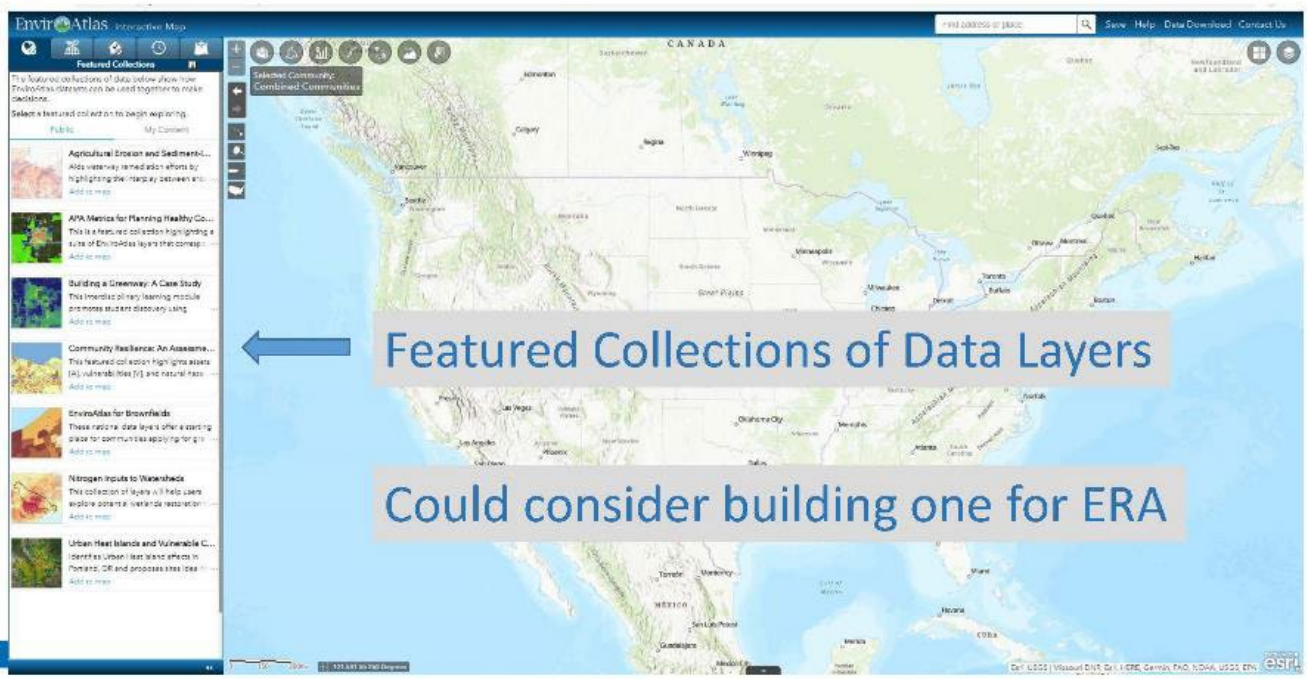


https://epa.gov/enviroatlas

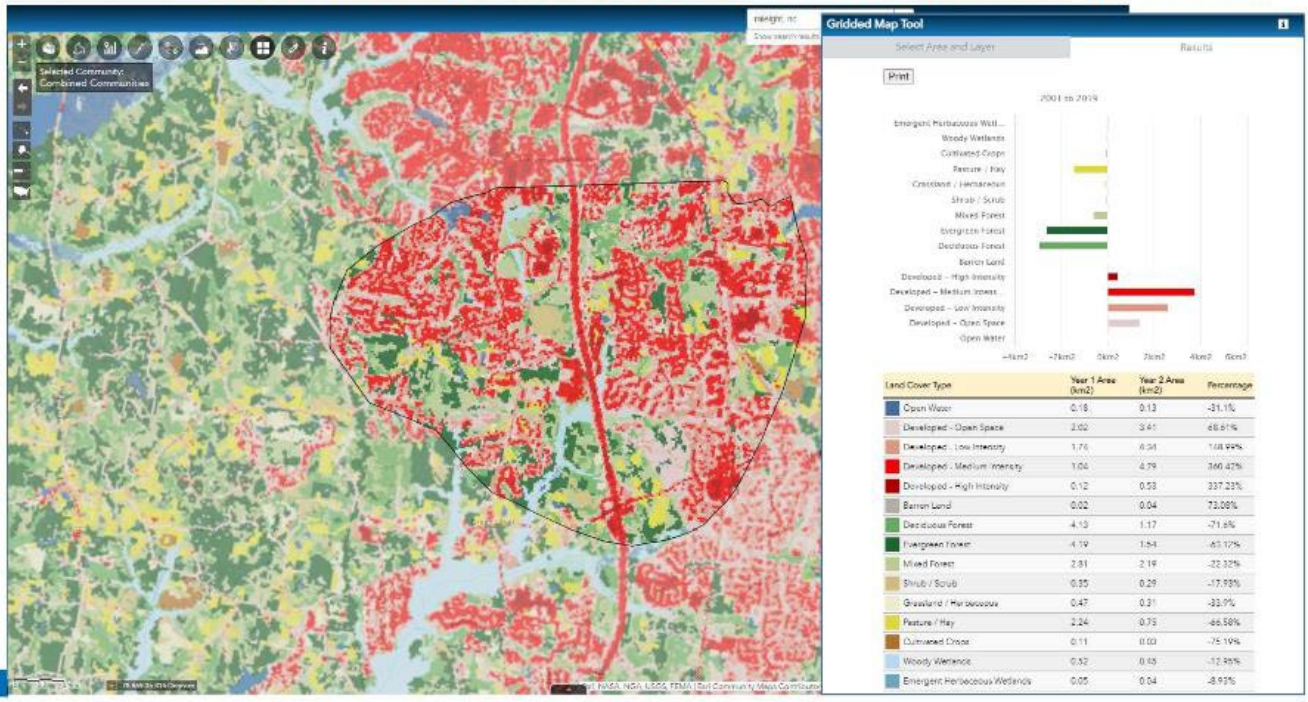
How does it work?



How does it work?



How does it work? Sneak peak at new functionality coming soon

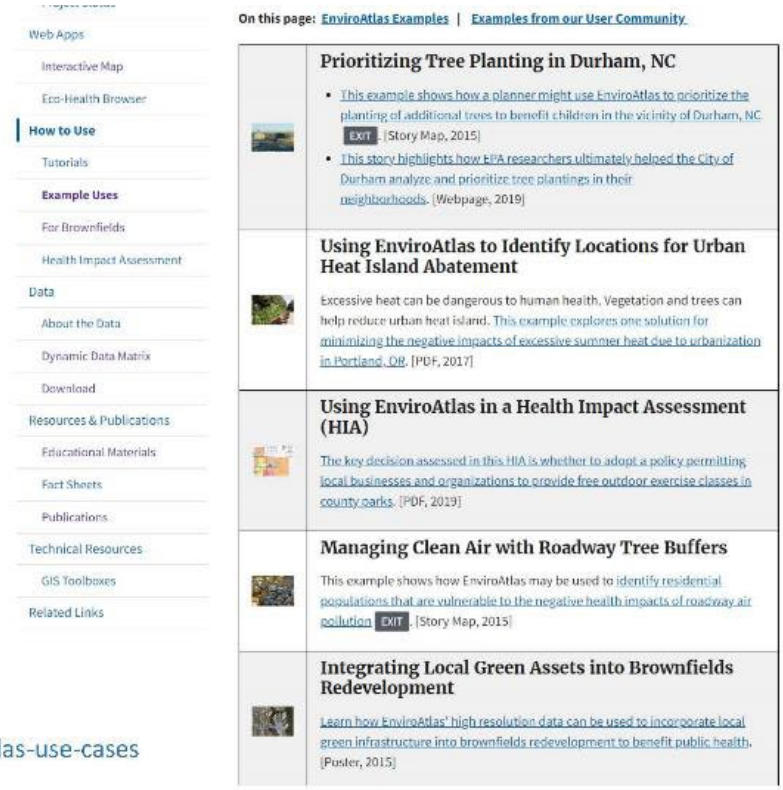


Examples of how it could be used

Visualizing and understanding the ecological and socio-economic conditions of a site and of the surrounding area

- Land cover and land cover change
- Proximity of sites reporting to EPA (e.g., Superfund, RCRA, Brownfields, water dischargers, etc)
- Riparian area land cover
- Proximity to water bodies and flowing water
- Hydrological connectivity
- Habitat connectivity
- Access to green space
- Habitat suitability for suites of species (e.g., T & E, climate vulnerable birds, etc)
- Soil retained on landscape by existing land cover
- Presence of floodplains
- Proximity of wetlands
- People and demographics

Examples of how it could be used



https://www.epa.gov/enviroatlas/enviroatlas-use-cases

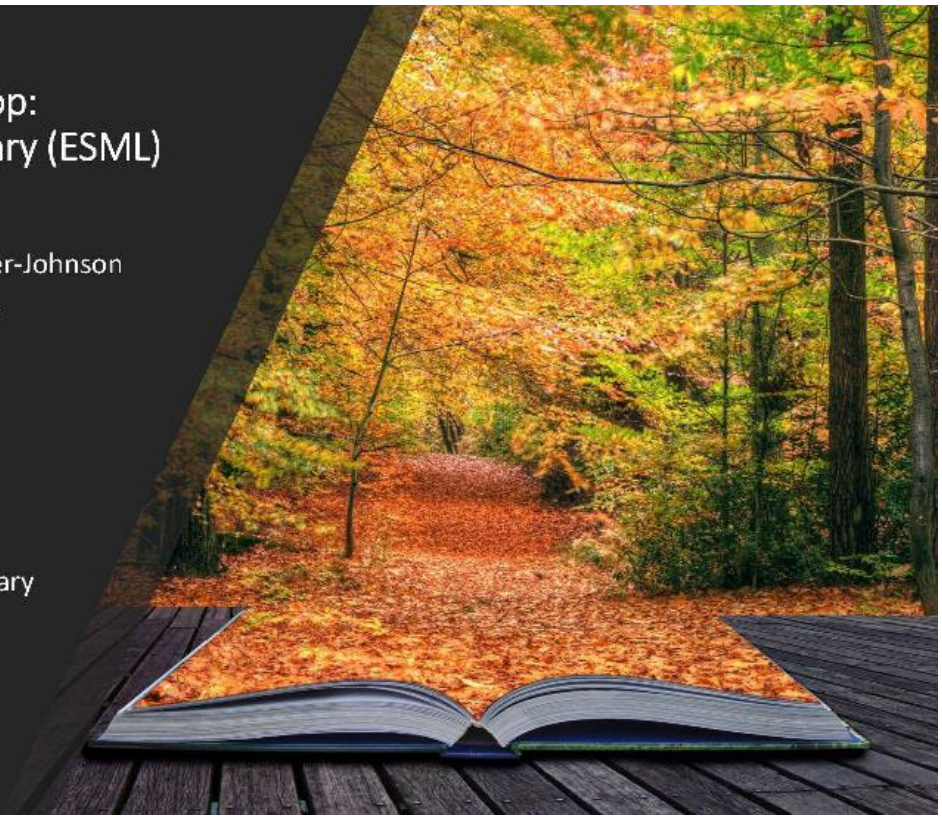
82

Thank you!
Questions will be discussed in breakout session

- Annie: Neale.anne@epa.gov
- EnviroAtlas: enviroatlas@epa.gov
- Website: epa.gov/enviroatlas

83

ERAF EGS STLR Workshop: EcoService Models Library (ESML)



- Tool Leader: Tammy Newcomer-Johnson
- Facilitator: Brandon Chambers
- Recorder: Kaitlyn Hines

- February 28, 2022

https://www.epa.gov/eco-research/ecoservice-models-library

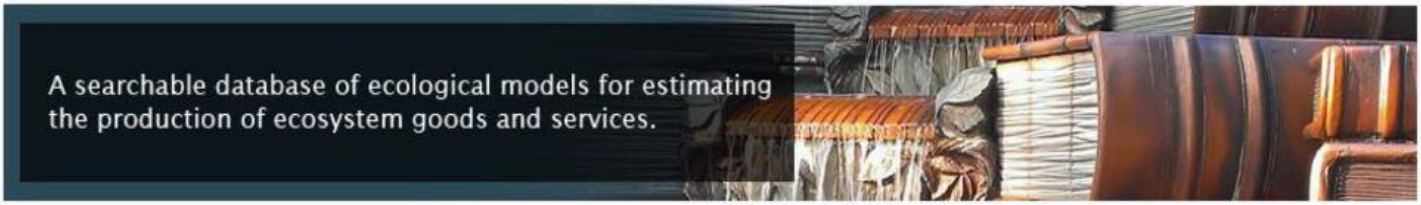
EPA United States Environmental Protection Agency

Outline

- What is the EcoService Models Library (ESML)?
- Why bother with it?
- How does it work?
- Examples of how it could be used

https://www.epa.gov/eco-research/ecoservice-models-library

What is the EcoService Models Library (ESML)? https://ESML.epa.gov/



- Detailed descriptions of **>255 ecological models (>50 individual descriptors** – covering purpose, approach, and environmental use such as ecosystem services using NESCS Plus and CICES)
- Detailed descriptions of **ecological model variables (40 additional descriptors)**
- **Variable Relationship Diagrams**, conceptual diagrams for each model

3

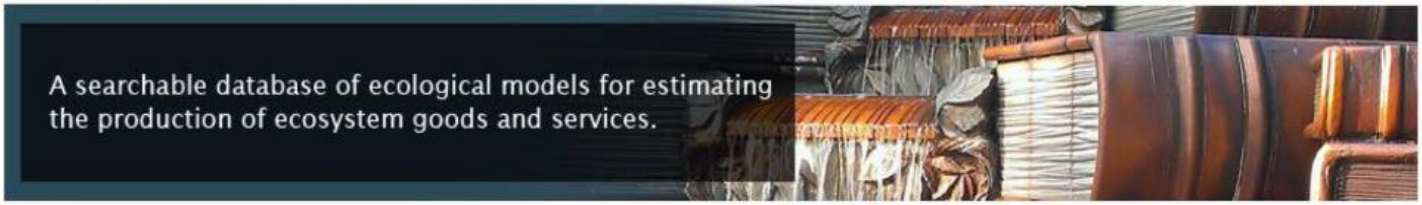
86

What is the EcoService Models Library (ESML)?
Some things ESML is not:

- not a modeling system
- not an ecological valuation database
- not a decision support system
- not a compendium of model software
- not a substitute for original documentation
- not an endorsement

87 https://www.epa.gov/eco-research/ecoservice-models-library

Why bother with the EcoService Models Library (ESML)?



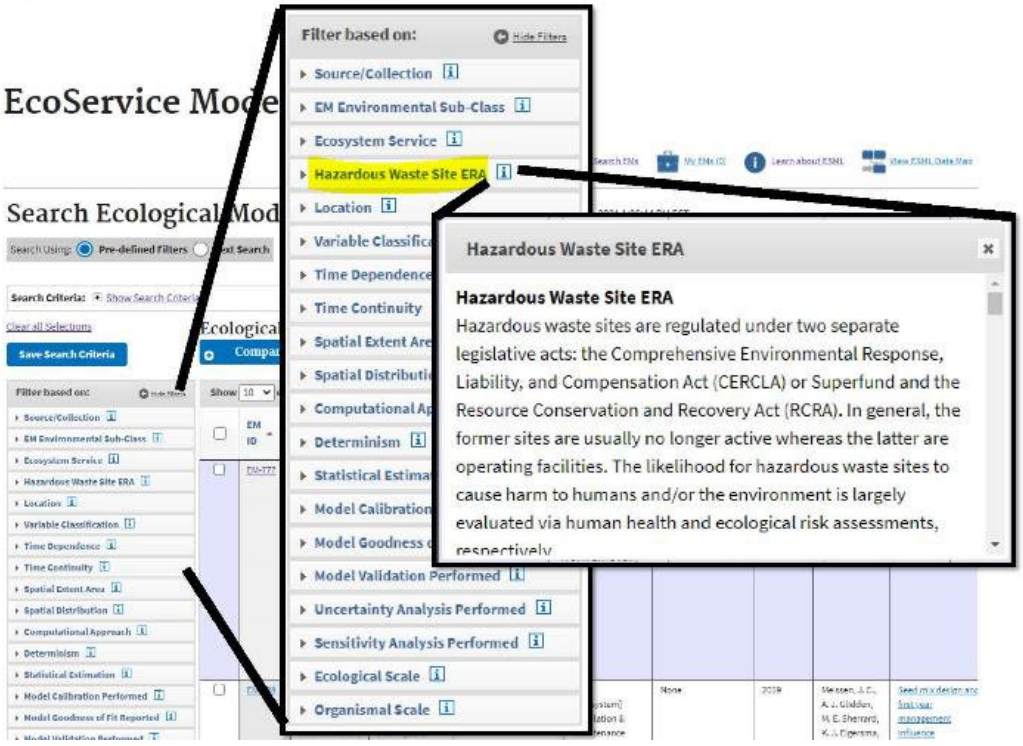
- Help planners, analysts, risk assessors, and scientists to understand and select useful ecological models
- Help researchers interested in improving ecological modeling methods

https://www.epa.gov/eco-research/ecoservice-models-library

88

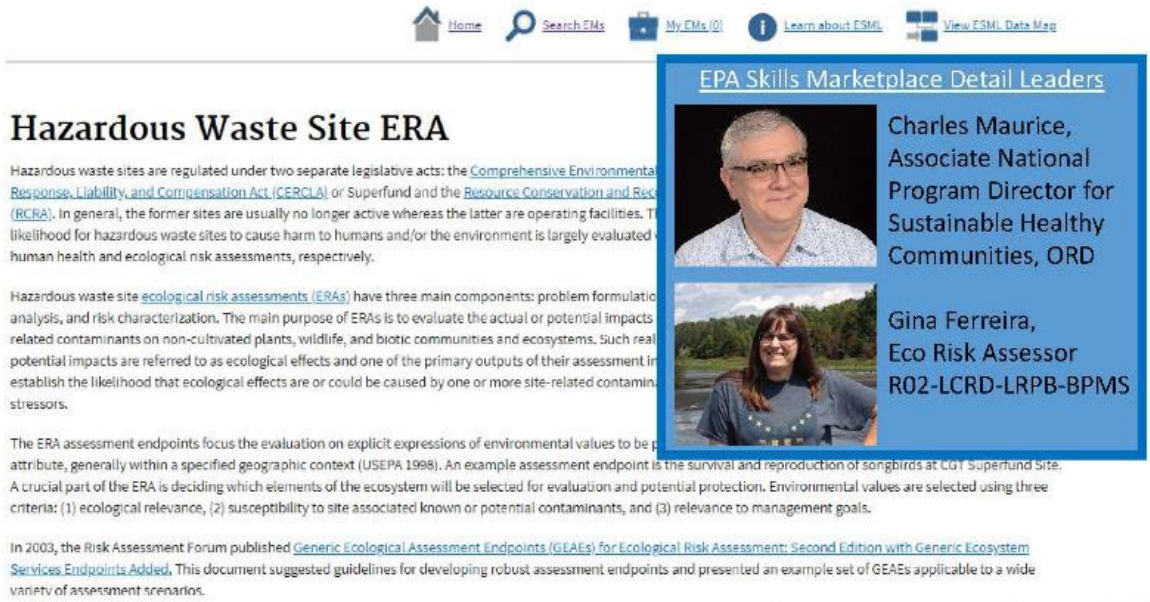
How does it work?

Search for Ecological Models (EMs)



How does it work?

EcoService Models Library (ESML)



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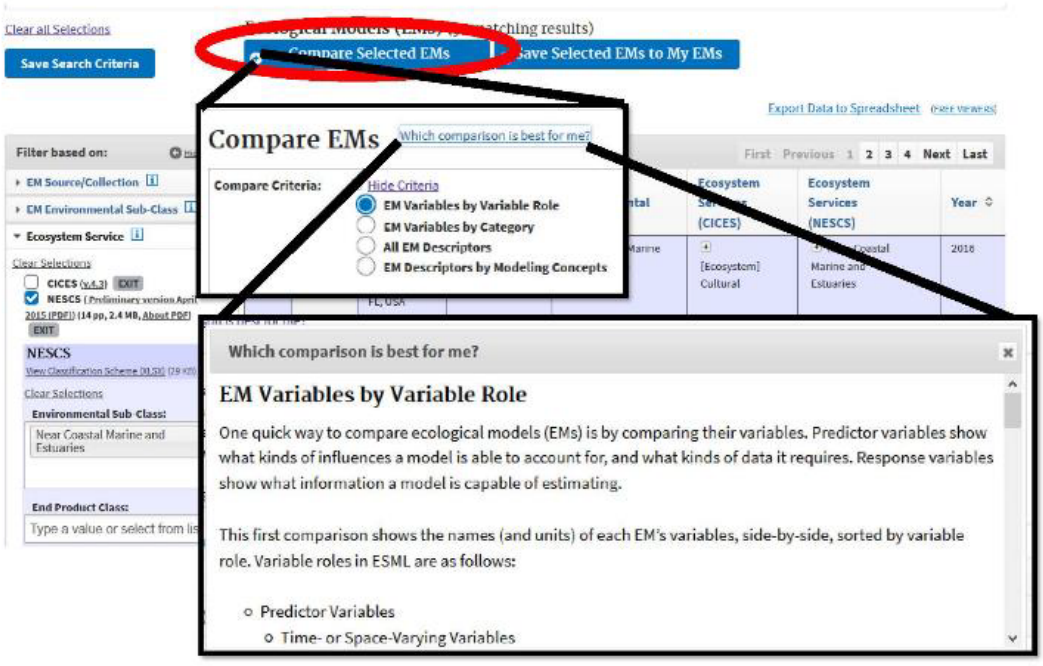
https://esml.epa.gov/secondary/readPGESAE

How does it work?

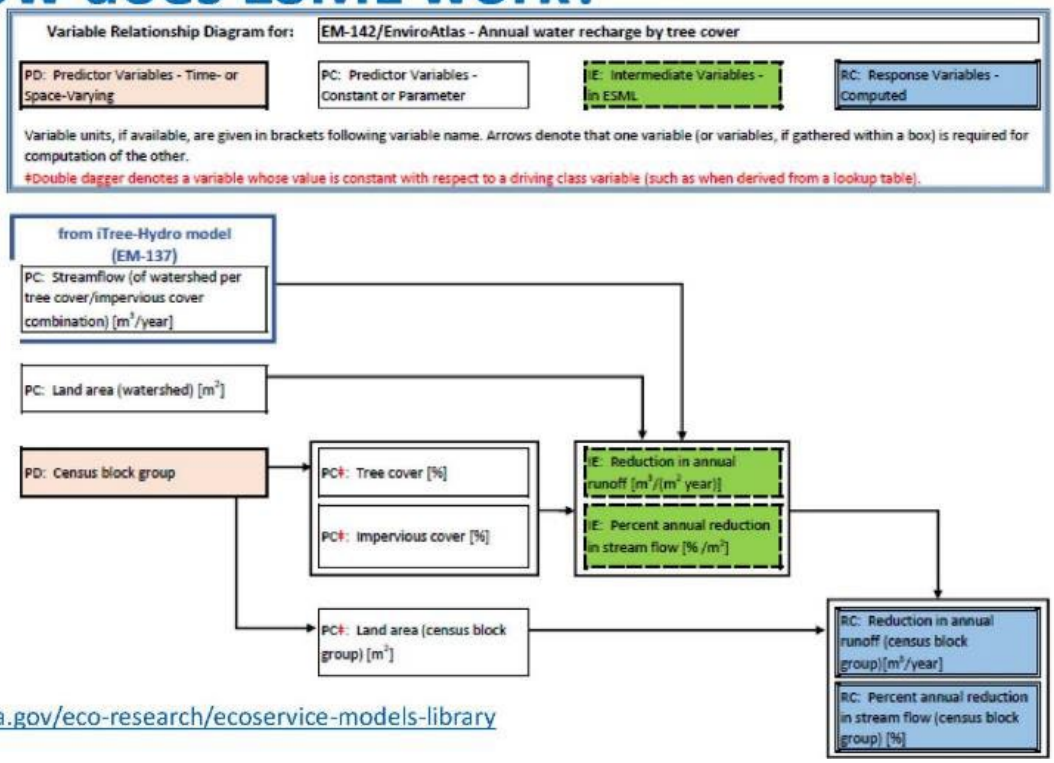
Compare Selected Ecological Models (EMs)



8

How does ESML work?

Variable Relationship Diagrams show model logic



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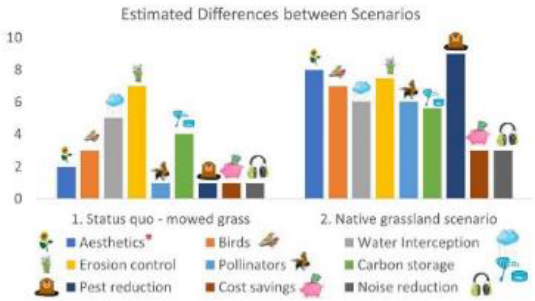
Example of how ESML could be used
East Mount Zion Landfill Revegetation

Scenarios

1. Status quo – mowed grass
2. Native grassland scenario



Models

- ESII (Ecosystem Services Identification and Inventory) Tool
- Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Carbon
- InVEST Pollination
- Grassland Bird Models

94

https://www.epa.gov/eco-research/ecoservice-models-library

Thank you!
Questions will be discussed in breakout session

- Tool Lead: Tammy Newcomer-Johnson Newcomer-Johnson.Tammy@epa.gov
- Facilitator: Brandon Chambers bchambers@cbi.org
- Recorder: Kaitlyn Hines Hines.Kaitlyn@epa.gov

URL: https://www.epa.gov/eco-research/ecoservice-models-library

95

Appendix 2 – Theoretical Case Study Presentation

Operationalizing Ecosystem Services Endpoints and Assessment Tools for Supporting Risk Assessments and Contaminated Site Cleanups

Facilitated Case Study Discussion

Superfund Technology Liaison Research (STLR) – Funded Workshop

by Ecological Risk Assessment Forum (ERAF) Ecosystem Goods and Services (EGS) Workgroup

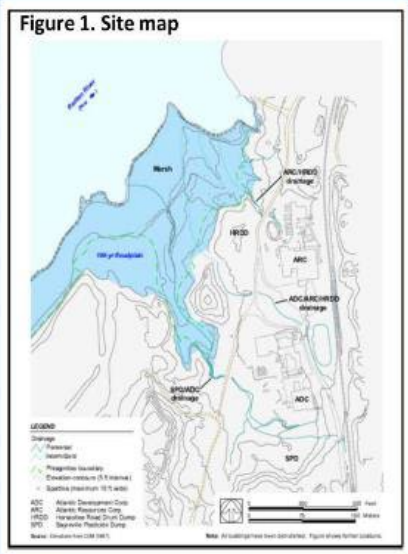
Co-chairs: Gina Ferreira and Steph Kim

CBI Facilitators: Pat Field and Brandon Chambers

2/28/2022

Disclaimer: The views expressed are those of the author(s) and do not necessarily represent the views or policies of the U.S. EPA.

Site Map & Background



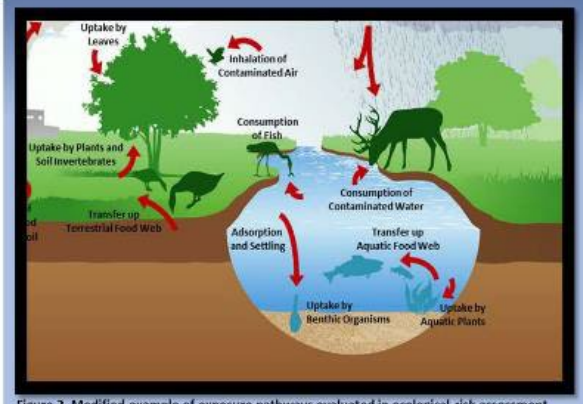


Figure 2. Modified example of exposure pathways evaluated in ecological risk assessment

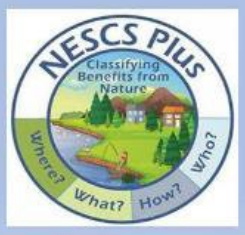
Examples of ecological receptors for measures of effects at this site:

- Aquatic macroinvertebrate (Lumbriculus variegatus, blackworm)
- Terrestrial invertebrate community (Eisenia fetida, earthworm)
- Estuarine fish population in the Raritan River
- Bird and mammal population abundance in the marsh and the river

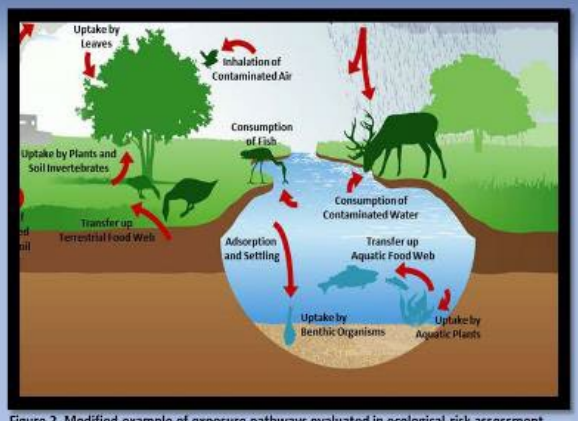
Overview of Site

- This site is an abandoned hazardous waste site located in central New Jersey along the Raritan River.
- Polychlorinated biphenyls (PCBs) and metals (arsenic and mercury) are found at elevated concentrations in shallow surface sediments of the stream channel and at lower concentrations within the marsh itself and at depth.

From the four EGS tools discussed today, which ones do you think can be applied and utilized during the planning and scoping phase of the site?



Screening Level Ecological Risk Assessment (SLERA)



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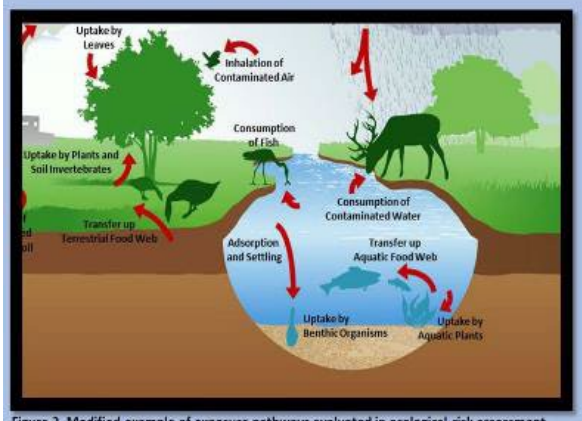
Sources: Figure 1 (https://nepis.epa.gov/Exe/ZyPDF.cgi/P100IS1S.PDF?Dockey=P100IS1S.PDF); Figure 2 (https://www.epa.gov/ecotox/ecotox-modules-exposure-pathways-exposure-pathways-eco)

A SLERA was conducted for the site to determine which contaminants and exposure pathways presented ecological risks based on conservative assumptions. Three primary contaminants of potential concern (COPCs) identified in the marsh and associated drainage ways were PCBs, arsenic, and mercury.

SLERA Assessment Endpoints



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PROTECTION OF THE SURVIVAL, GROWTH, AND REPRODUCTION OF:

- **Aquatic invertebrates**
- **Forage Fish**
- **Mammals (short-tailed shrew)**
- **Birds (marsh wren, red-tailed hawk, spotted sandpiper)**
- **Amphibians (green frog) and fiddler crab**

Screening Level Ecological Risk Assessment (SLERA)

***Ecological receptors*: aquatic invertebrates, forage fish, short-tailed shrew, marsh wren, red-tailed hawk, spotted sandpiper, green frog, and fiddler crab**
***Habitats*: river, march, and stream**

What generic ecosystem service endpoints can be created for the SLERA?

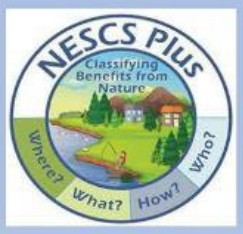
Generic Ecosystem Service	Conventional Assessment Endpoint	Measurement Endpoint	Benefit
Food production	Fish population vitality	Fish abundance Size structure Species number	Nutrition Recreation Income Enjoyment
Recreational opportunity	Bird species diversity	Bird abundance Species number	Recreation Enjoyment Nutrition Income

Screening Level Ecological Risk Assessment (SLERA)

***Ecological receptors*: aquatic invertebrates, forage fish, red-tailed hawk, short-tailed shrew, marsh wren, spotted sandpiper, green frog, and fiddler crab**

***Habitats*: river, march, and stream**

How can the EGS tools discussed today be applied and utilized for the SLERA?



Baseline Ecological Risk Assessment (BERA)

- Further develop the conceptual site model
- Consider contaminant fate and transport
- Identify ecosystems potentially at risk
- Identify complete exposure pathways
- Select assessment endpoints, candidate measurement endpoints

BERA Assessment Endpoints in the Marsh and River Ecosystems

- **Aquatic and terrestrial macroinvertebrate community** abundance and population production in **marsh** sediment/soil
- **Estuarine fish population** abundance and community structure in the **Raritan River**
- Wildlife population abundance in the **marsh and the river** (representative species for the marsh were the **short-tailed shrew, muskrat, marsh wren and red-tailed hawk**, and the species selected for the river were the **osprey and the herring gull**)

Questions Related to BERA Assessment Endpoints

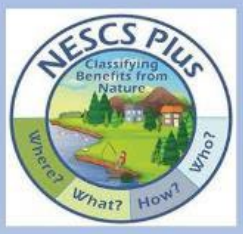
What site-specific ecosystem service assessment endpoints can you think of that

- **correspond to the conventional ones presented here?**
- **can assist with risk management decisions and remedy selection?**
- **can facilitate risk communication with the public and partners?**

Baseline Ecological Risk Assessment (BERA) Summary

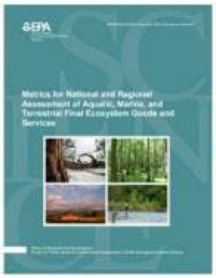
- Benthic organisms in river sediment => showed **RISK**
- Terrestrial invertebrates in marsh sediment => showed **RISK**
- Estuarine fish => showed **NO RISK**
- Birds (marsh wren, osprey, herring gull) exposed to marsh sediment => showed **RISK**
- Mammals (muskrat, short-tailed shrew) exposed to marsh sediment=> showed **RISK**

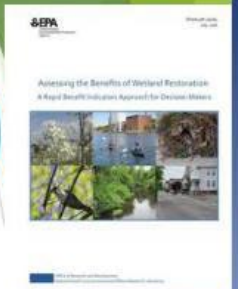
How can the EGS tools discussed today be applied and utilized for the BERA?

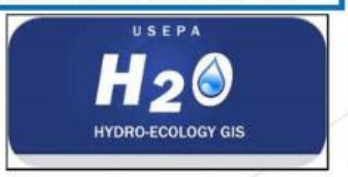


U.S. Environmental Protection Agency

EPA ES Tools







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Appendix 3 – EGS Tool Outputs Based on Workshop's Hazardous Site Case Study

NESCS Plus

During the Workshop's Case Study session, the NESCS Plus was run real-time to identing potential FEGS that might be relevant to the ERA (Figure A3-1).

NESCS Plus ID (WWW.X.YYYY.ZZZZ)	Environment Class (W)	Environment Subclass I (WW)	Environment Subclass II (WWW)	Ecological End-Product Class (X)	Direct Use/Non-Use Class (Y)	Direct Use/Non-Use Subclass I (YY)	Direct Use/Non-Use Subclass II (YYYY)	Direct User Class (Z)	Direct User Subclass I (ZZ)	Dir Use Sul II (Z
111.3.110Y.1531	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Protection of human property	All Direct Use Subclass IIs	Industry	Real Estate Rental and Leasing	Real
111.3.110Y.1532	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Protection of human property	All Direct Use Subclass IIs	Industry	Real Estate Rental and Leasing	Rent Leas Servi
111.3.110Y.2111	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Protection of human property	All Direct Use Subclass IIs	Households	Households	Hous
111.3.111Y.2111	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Recreation/tourism	All Direct Use Subclass IIs	Households	Households	Hous
111.3.111Y.2111	Aquatic	Open Water	Rivers and Streams	Water	Direct Use	Recreation/tourism	All Direct Use Subclass IIs	Households	Households	Hous
111.4.109Y.2111	Aquatic	Open Water	Rivers and	Fauna	Direct Use	Support of human health and life or	All Direct Use	Households	Households	Hous

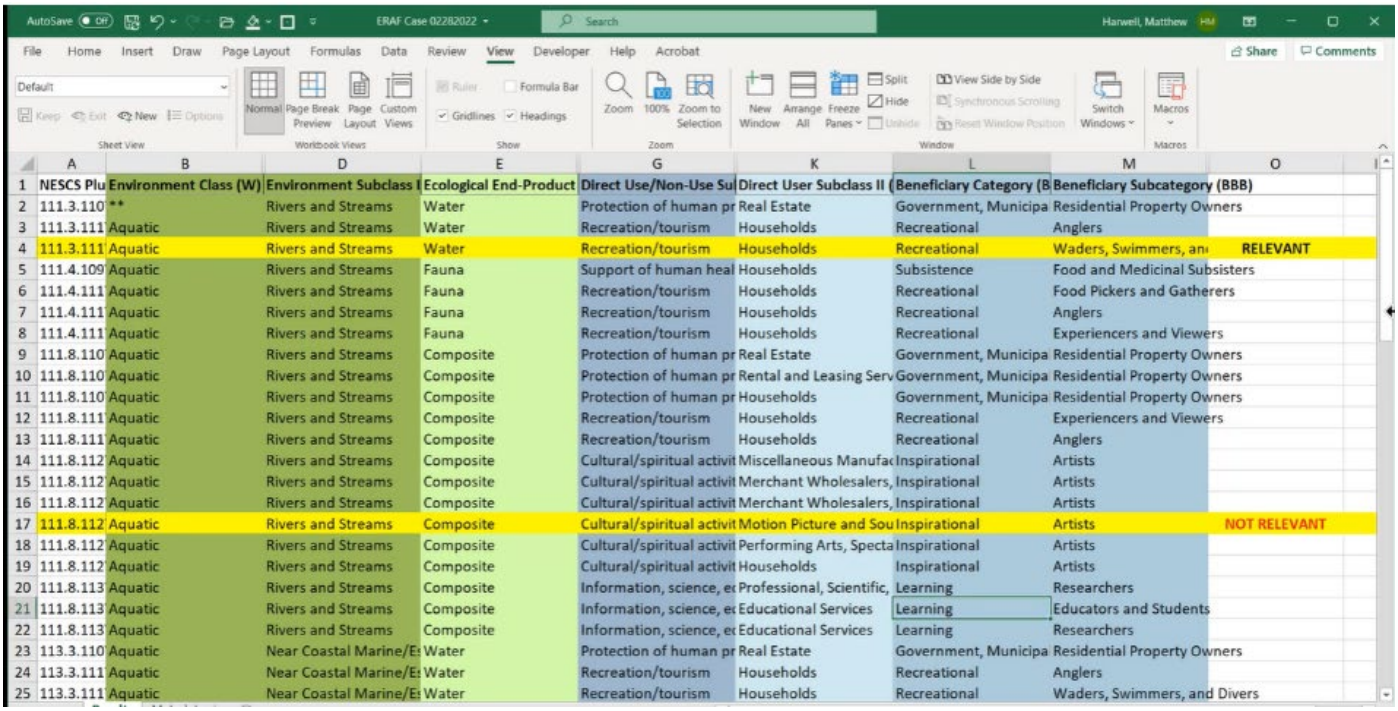
Figure A3-1. *Screenshot of some of the NESCS Plus results for the workshop's Case Study exercise.*

The NESCS Plus allows for export of results into an .XLS format, allowing the user to examine results separately.

As an example, Figure A3-2 shows two rows in yellow highlight that the workshop participants discussed further. Row 4 shows: (1) Environment: Aquatic -> Rivers and Streams; (2) Ecological End-Product: Water; (3) Use: Recreation/Tourism; (4) User: Households; (5) Beneficiary: Recreational -> Waders, Swimmers, and Divers. Workshop participants discussed this row and concluded that this FEGS was likely relevant to the case study.

In contrast, Row 17 shows: (1) Environment: Aquatic -> Rivers and Streams; (2) Ecological End-Product: Composite; (3) Use: Cultural/spiritual activities; (4) User: Motion Picture and Sound Recording

Industries; (5) Beneficiary: Inspirational -> Artists. Workshop participants discussed this row and concluded that this type of user was not likely relevant to the case study for the purpose of an ERA.



	A	B	D	E	G	K	L	M	O
1	NESCS Plu	Environment Class (W)	Environment Subclass I	Ecological End-Product	Direct Use/Non-Use Sul	Direct User Subclass II (	Beneficiary Category (B	Beneficiary Subcategory (BBB)	
2	111.3.110	**	Rivers and Streams	Water	Protection of human pr	Real Estate	Government, Municipa	Residential Property Owners	
3	111.3.111	Aquatic	Rivers and Streams	Water	Recreation/tourism	Households	Recreational	Anglers	
4	111.3.111	Aquatic	Rivers and Streams	Water	Recreation/tourism	Households	Recreational	Waders, Swimmers, an	RELEVANT
5	111.4.109	Aquatic	Rivers and Streams	Fauna	Support of human heal	Households	Subsistence	Food and Medicinal Subsisters	
6	111.4.111	Aquatic	Rivers and Streams	Fauna	Recreation/tourism	Households	Recreational	Food Pickers and Gatherers	
7	111.4.111	Aquatic	Rivers and Streams	Fauna	Recreation/tourism	Households	Recreational	Anglers	
8	111.4.111	Aquatic	Rivers and Streams	Fauna	Recreation/tourism	Households	Recreational	Experiencers and Viewers	
9	111.8.110	Aquatic	Rivers and Streams	Composite	Protection of human pr	Real Estate	Government, Municipa	Residential Property Owners	
10	111.8.110	Aquatic	Rivers and Streams	Composite	Protection of human pr	Rental and Leasing Serv	Government, Municipa	Residential Property Owners	
11	111.8.110	Aquatic	Rivers and Streams	Composite	Protection of human pr	Households	Government, Municipa	Residential Property Owners	
12	111.8.111	Aquatic	Rivers and Streams	Composite	Recreation/tourism	Households	Recreational	Experiencers and Viewers	
13	111.8.111	Aquatic	Rivers and Streams	Composite	Recreation/tourism	Households	Recreational	Anglers	
14	111.8.112	Aquatic	Rivers and Streams	Composite	Cultural/spiritual activit	Miscellaneous Manufac	Inspirational	Artists	
15	111.8.112	Aquatic	Rivers and Streams	Composite	Cultural/spiritual activit	Merchant Wholesalers,	Inspirational	Artists	
16	111.8.112	Aquatic	Rivers and Streams	Composite	Cultural/spiritual activit	Merchant Wholesalers,	Inspirational	Artists	
17	111.8.112	Aquatic	Rivers and Streams	Composite	Cultural/spiritual activit	Motion Picture and Sou	Inspirational	Artists	NOT RELEVANT
18	111.8.112	Aquatic	Rivers and Streams	Composite	Cultural/spiritual activit	Performing Arts, Specta	Inspirational	Artists	
19	111.8.112	Aquatic	Rivers and Streams	Composite	Cultural/spiritual activit	Households	Inspirational	Artists	
20	111.8.113	Aquatic	Rivers and Streams	Composite	Information, science, e	Professional, Scientific,	Learning	Researchers	
21	111.8.113	Aquatic	Rivers and Streams	Composite	Information, science, e	Educational Services	Learning	Educators and Students	
22	111.8.113	Aquatic	Rivers and Streams	Composite	Information, science, e	Educational Services	Learning	Researchers	
23	113.3.110	Aquatic	Near Coastal Marine/E	Water	Protection of human pr	Real Estate	Government, Municipa	Residential Property Owners	
24	113.3.111	Aquatic	Near Coastal Marine/E	Water	Recreation/tourism	Households	Recreational	Anglers	
25	113.3.111	Aquatic	Near Coastal Marine/E	Water	Recreation/tourism	Households	Recreational	Waders, Swimmers, and Divers	

Figure A3-2. *Example of NESCS Plus export. Two example FEGS rows (#4 and #17) were highlighted in yellow and discussed for their potential relevance to the workshop's Case Study Exercise.*

FST

As mentioned above, a quick NESCS Plus run led to the identification of 69 potential services. The FST can be used to bring specificity to that list and to identify the most relevant services. This example case study is a particularly interesting one for considering EGS because the site is not accessible by the general public. With many of the beneficial uses requiring direct access off the table, it could be easy to overlook the services that are provided by the site.

The case study example does not specify any stakeholder, but since the FST begins with stakeholder groups, a situation was hypothesized in which key stakeholder groups include downstream homeowners, the municipal government in the area, a local environmental non-profit, a fishing club, an outdoor activities club, and the general public. For this example, the criteria of "Magnitude and Probability of Impact," "Proximity," "Economic Interest," and "Underrepresented and Underserved Groups" were used. Those four criteria were given equal weights and no other criteria were used (Figure A3-3). Each of these groups were then scored using generalizations of how each group might function (Figure A3-4). The result is a relative prioritization of the stakeholder groups (Figure A3-5).

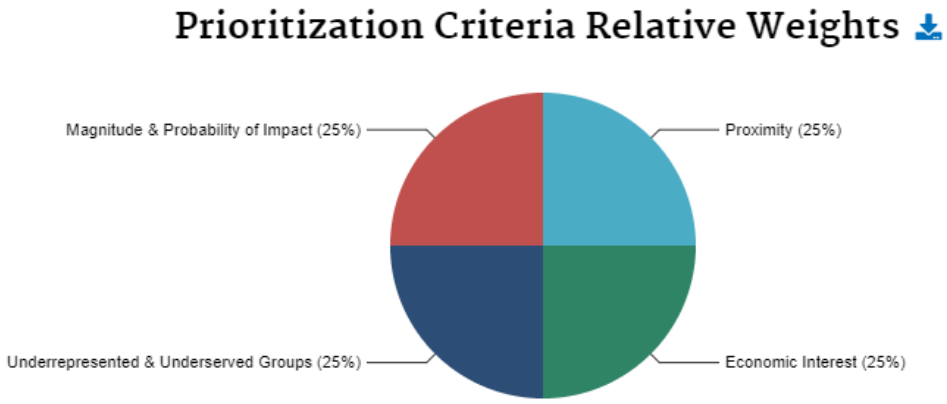


Figure A3-3. *Screenshot of the FST criteria weights for workshop's Case Study Exercise.*

	Stakeholder Group	Magnitude & Probability of Impact	Level of influence	Level of interest	Urgency & Temporal immediacy	Proximity	Economic interest	Rights	Fairness	Underrepresented & Underserved Groups
	Downstream Homeowners	70				100	100			100
	Municipal Government	50				10	100			50
	Environmental Non-Profit	30				50	0			50
	Fishing Club	60				50	0			0
	General Public	20				50	0			100

Figure A3-4. *Screenshot of the FST criteria scores for workshop's Case Study Exercise (unweighted criteria were not scored).*

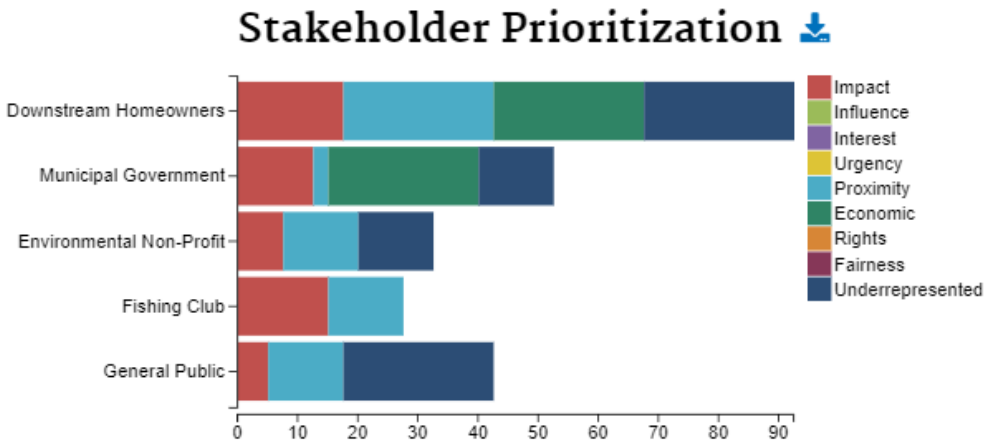


Figure A3-5. *Screenshot of FST stakeholder prioritization for workshop's Case Study Exercise.*

Continuing with a hypothetical generalization of how each of these groups might be interacting with the river, the beneficiary groups making up each stakeholder group were identified (Figure A3-6) and the environmental attributes of interest for each beneficial use (Figure A3-7).

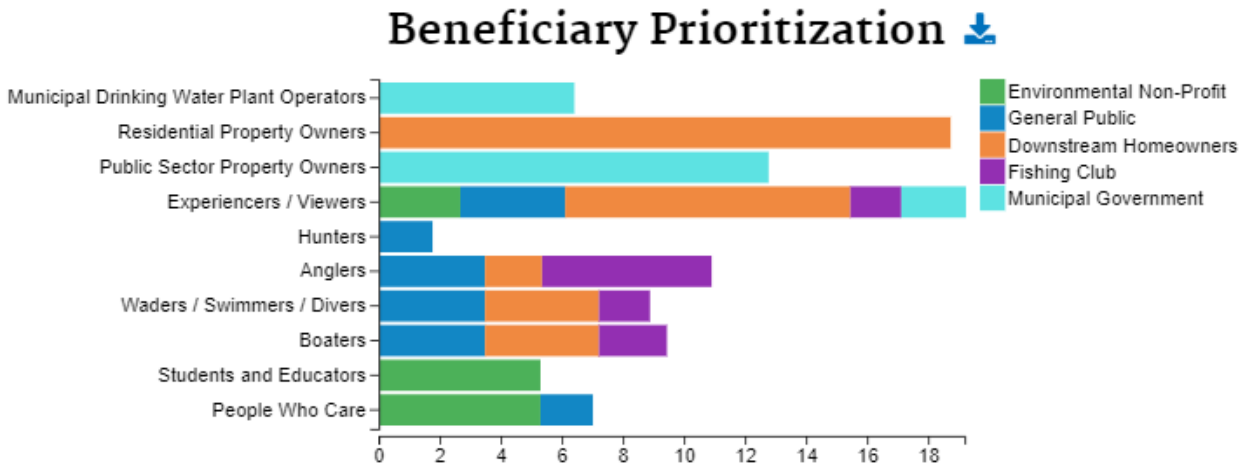


Figure A3-6. *Screenshot FST beneficiary prioritization for workshop's Case Study Exercise.*

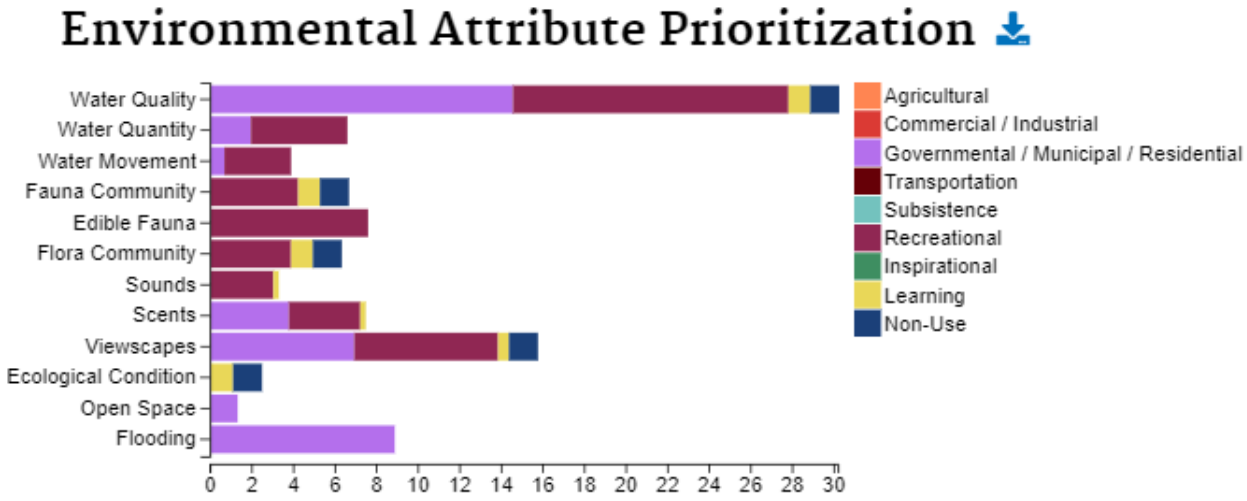


Figure A3-7. *Screenshot of FST attribute prioritization for workshop's Case Study Exercise.*

The results of the FST provide a far smaller set of ecosystem services of concern and clear guidance on the attributes and uses that will be of greatest concern to the community.

EnviroAtlas

After the workshop, a few data layers and tools in the EnviroAtlas Interactive Map were examined to see if they could be useful to the case study. The following maps provide an example of some of the maps available through the EnviroAtlas. A hydrological unit code (HUC) is a way of identifying a watershed or part of a watershed as part of a hierarchical classification system of drainage basins within the US. The HUC-2s, for example, define major river basins, each HUC-2 contains thousands of HUC-12s. The hierarchical system also includes HUC-4s, HUC-6s, HUC-8s, HUC-10s, and HUC-14s with the number after the acronym 'HUC' indicating the number of digits in the identifying code. Many of the maps have values summarized by 12-digit HUCs, which are a medium sized watershed. Other maps have values available for every 30 by 30-meter pixel. The legends in the maps indicate what the colors mean.

First, the case study area was located and displayed the Superfund Site and its boundary in the Interactive Map (Figure A3-8). Other NPL Superfund sites, permitted water dischargers, and active RCRA sites were also included to get an idea of what else was in the vicinity.

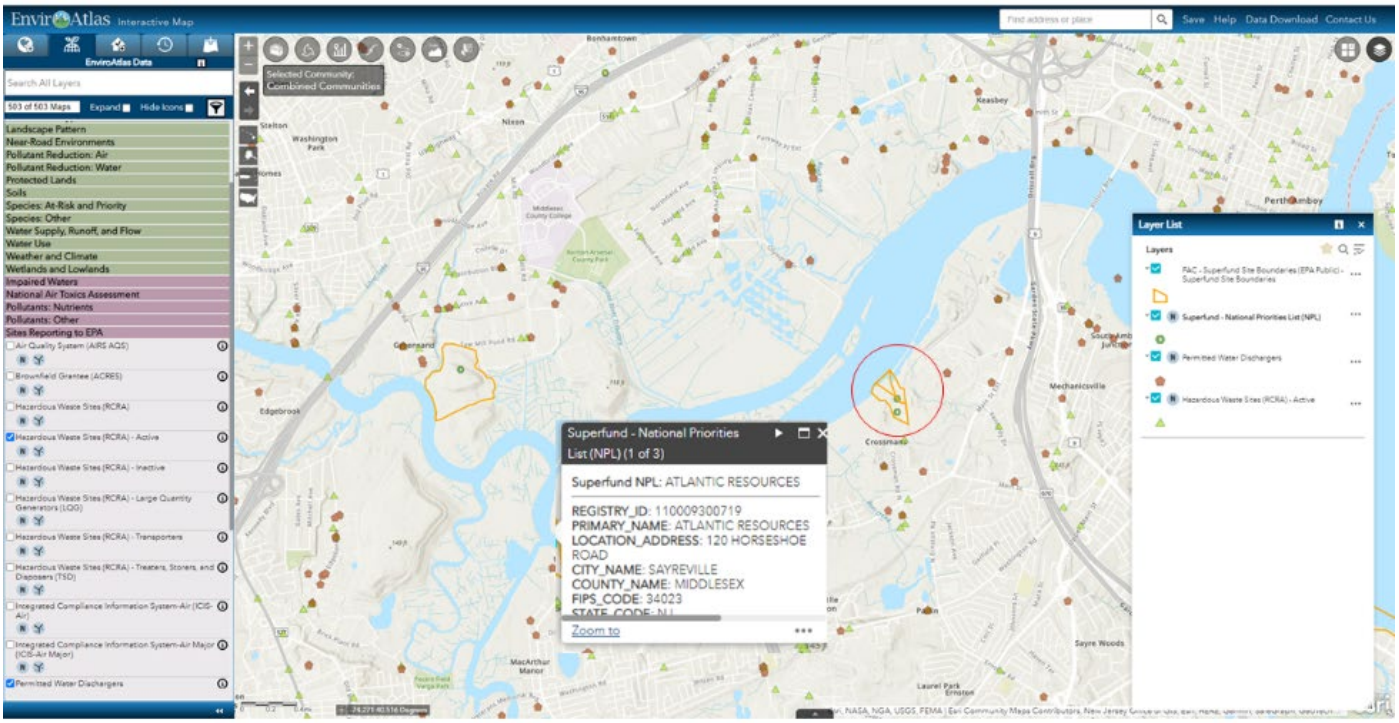


Figure A3-8. *EnviroAtlas Interactive Map showing Case Study Superfund Site, other NPL Superfund sites, water dischargers, and RCRA sites.*

The land cover in the Case Study area was then examined as many EGS flow from, or are impacted by, land cover and land use. The National Land Cover Dataset was added to the map which indicates a land cover class for every 30 by 30-meter pixel (Figure A3-9).

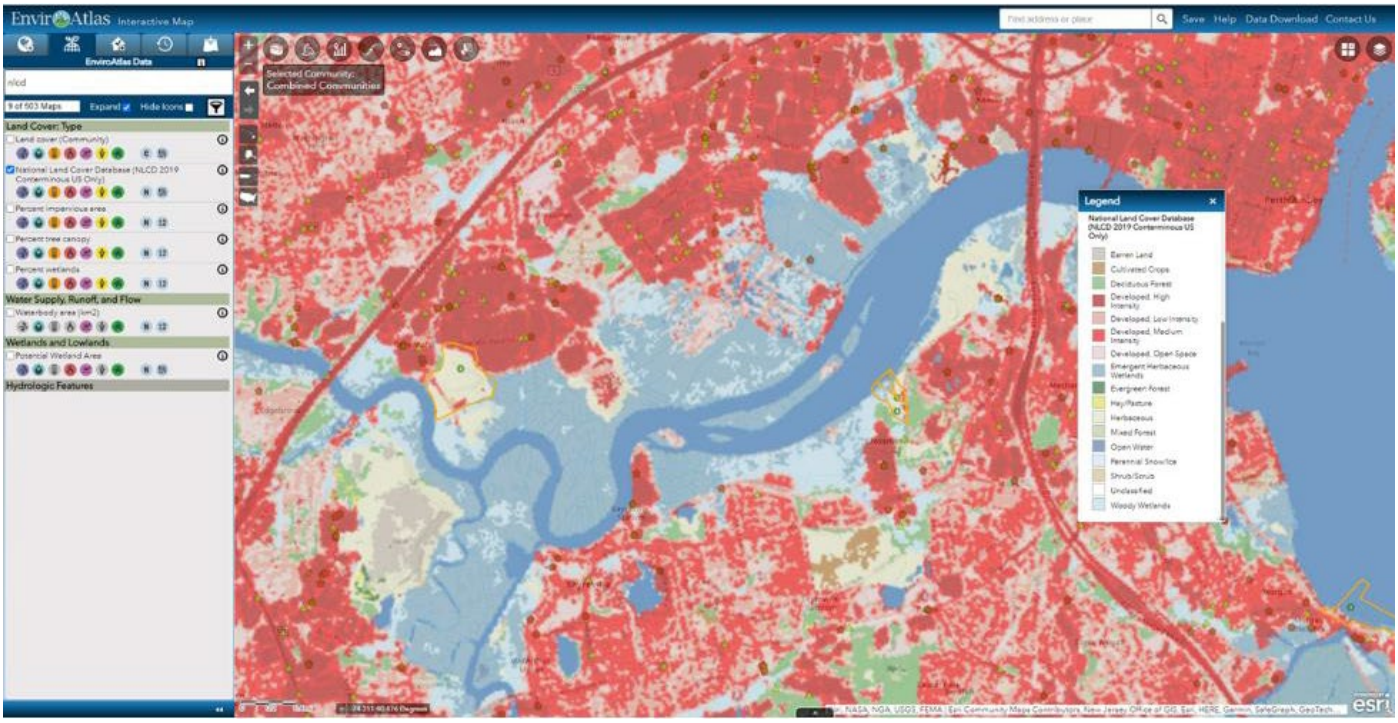


Figure A3-9. *Land Cover in vicinity of Horseshoe Road Superfund facility.*

Because of potential impacts to species and to fisherpersons who may eat locally caught fish, it is important to understand impaired waterways in the area and how many streams were impaired for metals other than mercury (Figure A3-10).

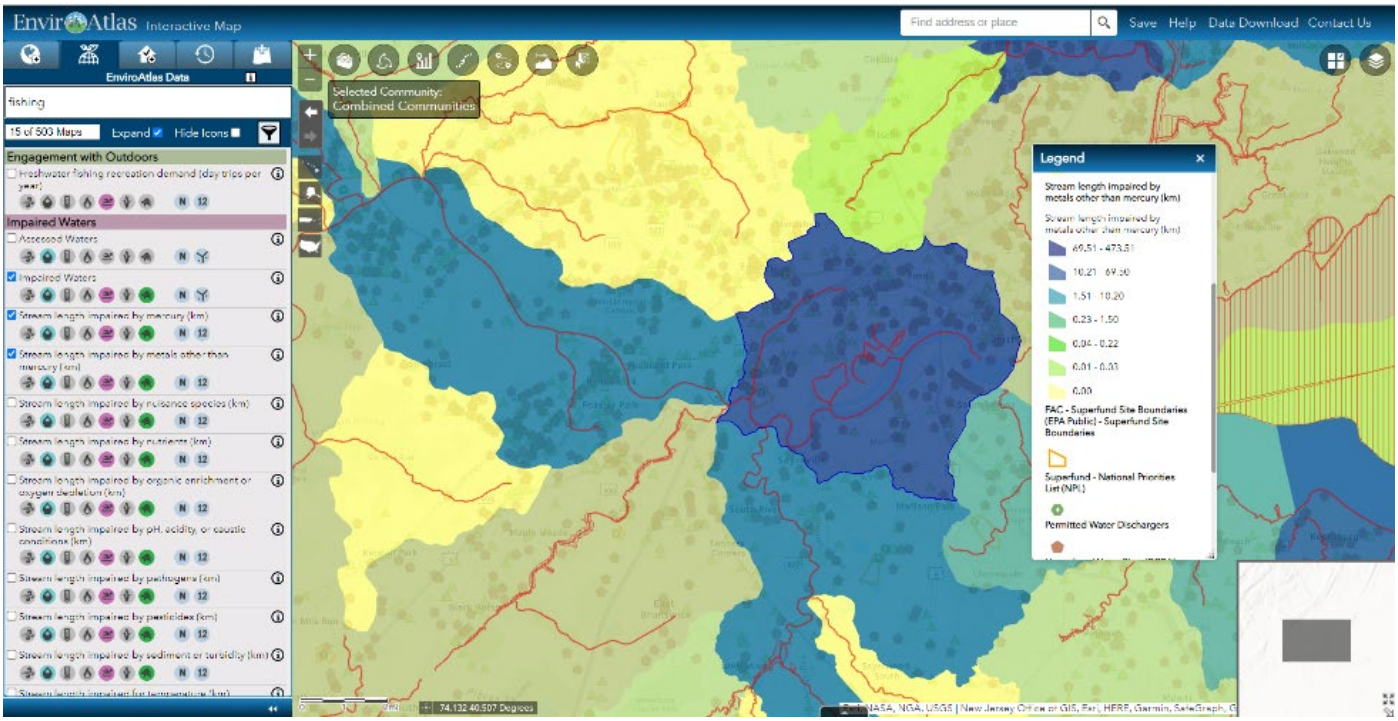


Figure A3-10. *Impaired waters in the vicinity, red lines and areas indicate impaired waters reported by states. Colored polygons indicate kilometers of stream in the watershed impaired for metals other than mercury.*

Although the watershed did not have any observed endangered species according to natural heritage data in the EnviroAtlas, modeled USGS GAP analysis data indicated that the area was suitable habitat for endangered and rare birds (Figure A3-11). The natural heritage data indicate when a species has been observed but that does not mean a species is not there, only that no-one has reported seeing it there.

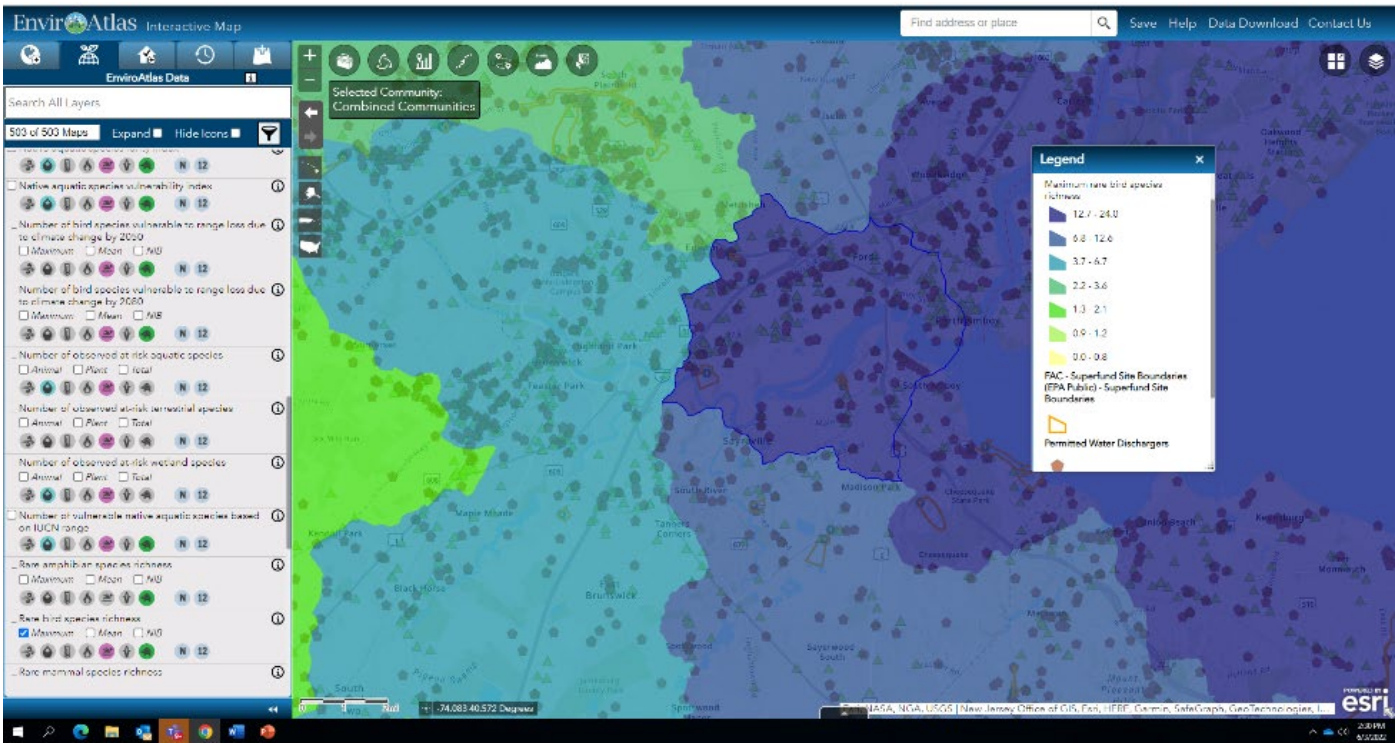


Figure A3-11. *Modeled habitat suitability for rare birds.*

Wetlands provide many EGS; to visualize wetlands in the Case Study vicinity, the National Wetland Inventory was added to the map (Figure A3-12).

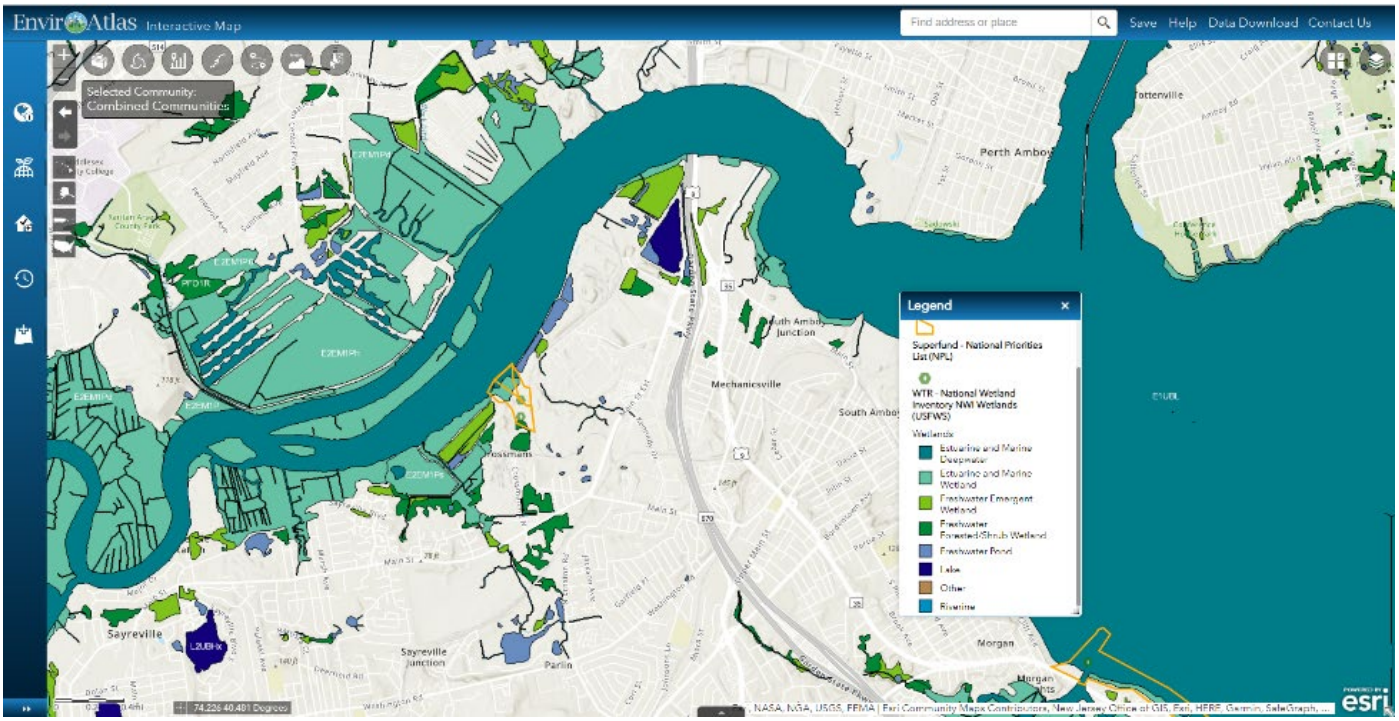


Figure A3-12. *National Wetland Inventory maps showing wetland type in the area.*

With so many wetlands in the area, there may be a local demand for bird hunting, so the map showing migratory bird hunting demand in the local area was investigated. This map (Figure A3-13) indicated there may be significant demand for bird hunting in the local area.

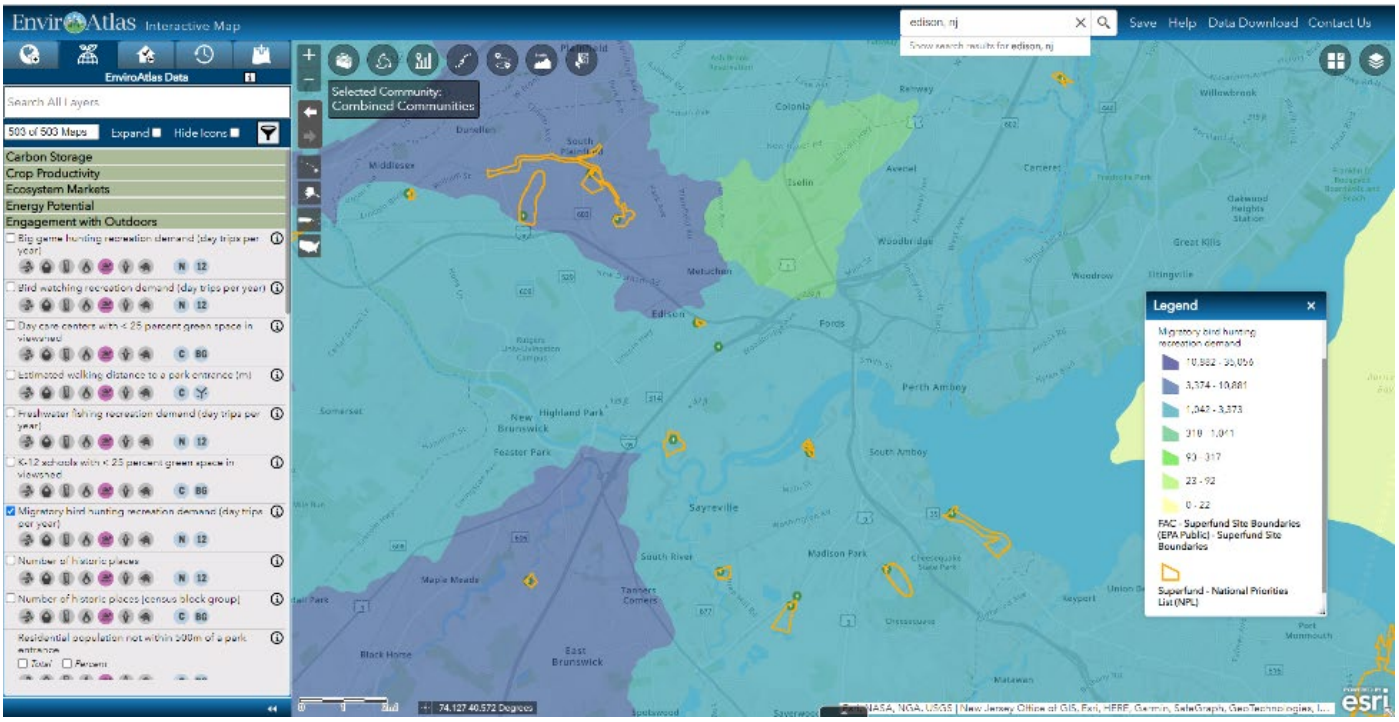


Figure A3-13. *Migratory bird hunting recreation demand.*

Humans are the beneficiaries of EGS and as such, to see where people lived in proximity to the Superfund site with a finer granularity than that of the U.S. Census data, a map of the allocation of people to 30 by 30-meter grid cells was examined (Figure A3-14).

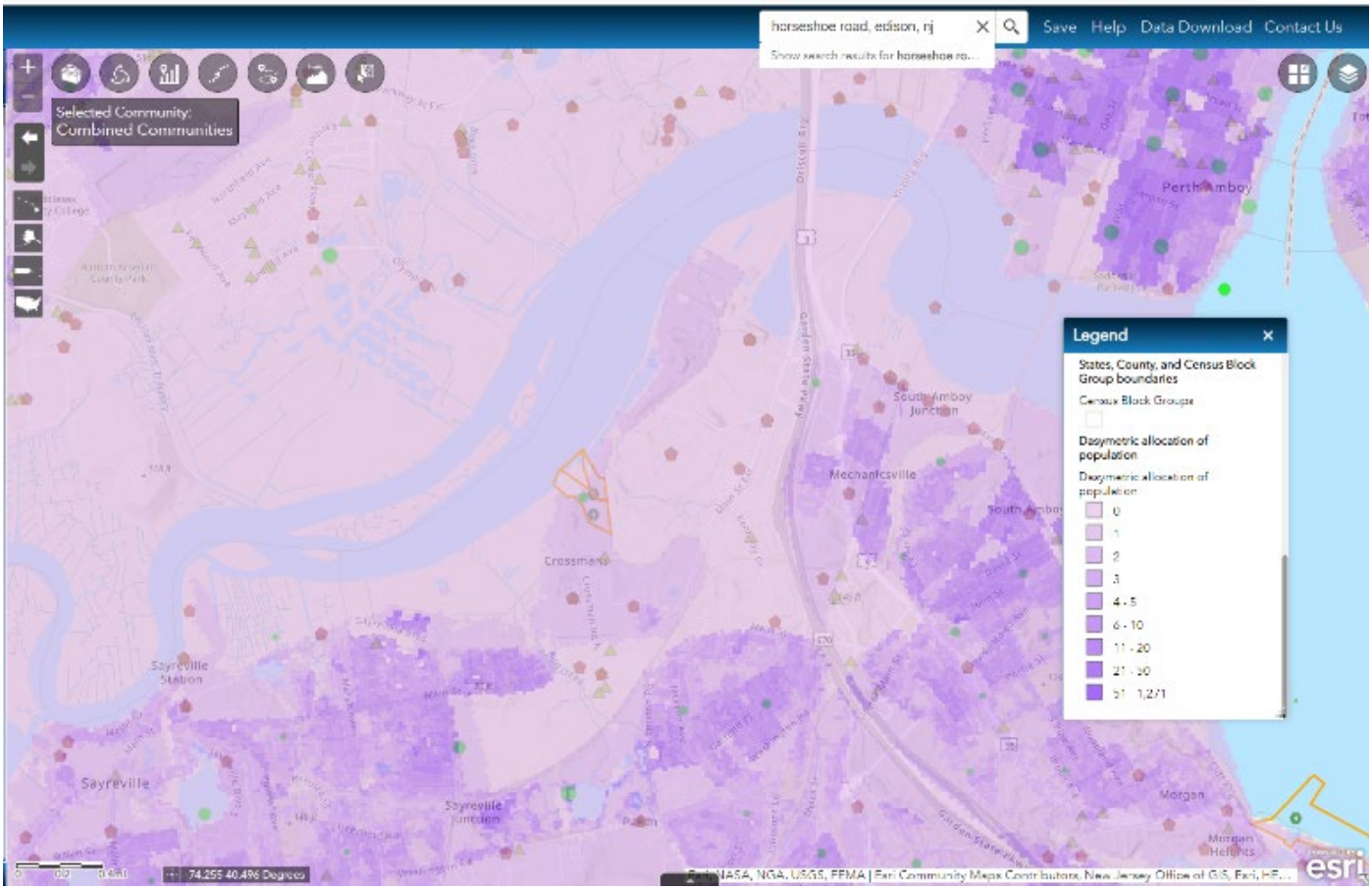


Figure A3-14. *Estimated population living in every 30 by 30-meter pixel.*

Once the full suite of maps has been added to the Interactive Map for the Case Study, the EnviroAtlas session can be easily saved and shared with colleagues. This allows those colleagues to open the EnviroAtlas Interactive Map, load the file and immediately see the same suite of Case Study Maps.

ESML

Using the case study, the ESML was searched using the "Hazardous Waste Site ERA" filter. Three filtering criteria were chosen to be most relevant to the case study: (1) water purification for drinking, domestic, industrial, and agricultural use; (2) food production (e.g., catchable, edible fish for recreational, commercial, and subsistence uses); and (3) air purification (for breathing and visibility). A total of 91 potential models (Figure A3-15).

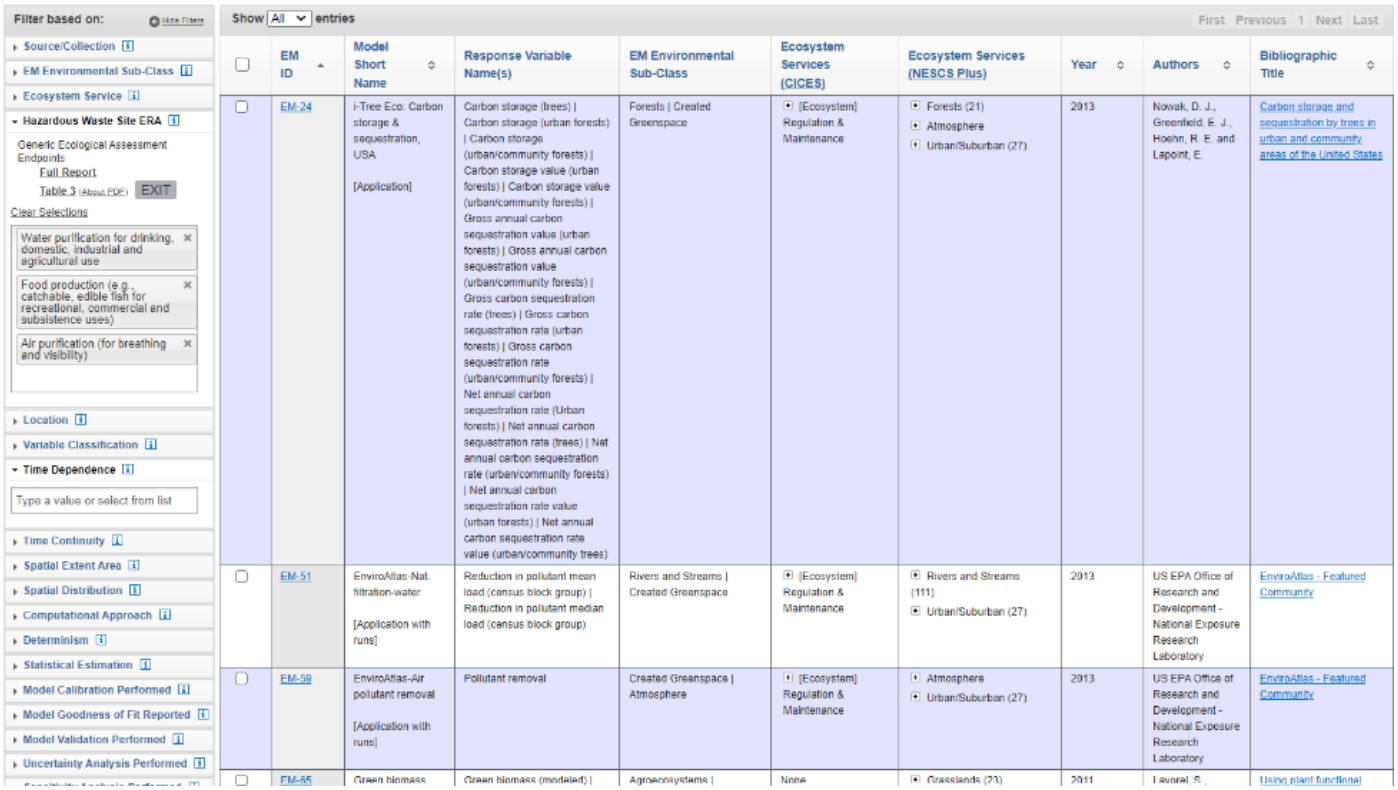


Figure A3-15. *Screenshot of some of the ESML results for the workshop's Case Study. Three criteria from the "Hazardous Waste Site ERA" filter were chosen to be most relevant to the case study.*

The ESML allows for export of results into an .XLS format allowing the user to examine results separately. For this case study, looking at the predictor and response variable data fields, there were three potential models that might have relevance to a risk assessment: one on reduction in pollutant load; one on metal removal (albeit different metals); and one on biotic integrity indices (Figure A3-16).

A	B	I	J	M
EM ID	**Model Short Name**	**Predictor Variable [Predictor Variable Position]**	**Response Variable [Response Variable Position]**	**Bibliographic Title**
EM-51	EnviroAtlas-Nat. filtration-water	Census block group | Pollutant | Pollutant pooled mean event-mean concentration | Pollutant pooled median event-mean concentration | Reduction in annual runoff (census block group)	Reduction in pollutant mean load (census block group) | Reduction in pollutant median load (census block group)	EnviroAtlas - Featured Community
EM-656	P8 UCM	Accumulation rate (impervious surface) | Area | Copper | Daily air temperature | Decay rate - second order (particle) | Decay rate - first order (particle) | Device class | Direct impervious fraction | Directly connected impervious coefficient (0-1) | Directly connected impervious fraction | Elevation | Filtration efficiency (particle	Copper removal | Copper removal efficiency | Lead removal | Lead removal efficiency | Total kjeldahl nitrogen removal efficiency | Total kjelhahl nitrogen removal | Total phosphorus removal | Zinc removal | Zinc removal efficiency	P8 Urban Catchment Model Version 3.5
EM-821	Aquatic vertebrate IBI for Western streams, USA	Anthropogenic reference criteria (disturbance) | Composition | Conductivity | Ecoregions | Environmental variables | Evenness/diversity | Functional feeding group | Habitat | Richness | Riparian disturbance | Riparian vegetation complexity | Tolerance to pollution | Total nitrogen | Total phosphorus | Vertebrate assemblage (fish & amphibian) metrics	Assemblage tolerance index | Index of biotic integrity (IBI) Mountain region | Index of biotic integrity (IBI) Mountain region (least disturbed) | Index of biotic integrity (IBI) Mountain region (most disturbed) | Index of biotic integrity (IBI) Plains region | Index of biotic integrity (IBI) Plains region (least disturbed) | Index of biotic integrity (IBI) Plains region (most disturbed) | Index of biotic integrity (IBI) Xeric region | Index of biotic integrity (IBI) Xeric region (least disturbed) | Index of biotic integrity (IBI) Xeric region (most disturbed) | Native benthic species richness | Proportion of invertivore-piscivore species | Proportion of lithophilic reproducing species | Vertebrate species richness	A Predictive Index of Biotic Integrity Model for A predictive index of biotic integrity model foraquatic-vertebrate assemblages of Western U.S. Streams

Figure A3-16. *Example of ESML export (showing only a few data fields). Three potentially relevant EGS models were identified for this case study based on predictor and response variables captured by ESML.*

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