

## Introduction

Linking the benefits of the natural environment to the health and wellbeing of people has become increasingly important. One way to better understand this human/environment linkage is to identify, evaluate and characterize benefits from nature, which we call “ecosystem goods and services” (EGS). When these goods and services directly benefit humans, we call them Final EGS (FEGS).

Within the U.S. EPA Superfund and RCRA hazardous waste site cleanup processes, ecological risk assessment (ERA) is the mechanism by which threats to non-human ecological receptors are evaluated. Various efforts have considered incorporating EGS into hazardous waste site decisions (e.g., U.S. EPA 2017 which includes a broader survey of EPA EGS efforts and references) and ecological risk assessment (e.g., U.S. EPA 2016 which describes the linkage between assessment endpoints and EGS). However, it can be difficult to identify and quantify the benefits and communicate about them to decision makers and stakeholders. We believe incorporating EGS methodologies and tools into ecological risk assessment can help address this challenge.

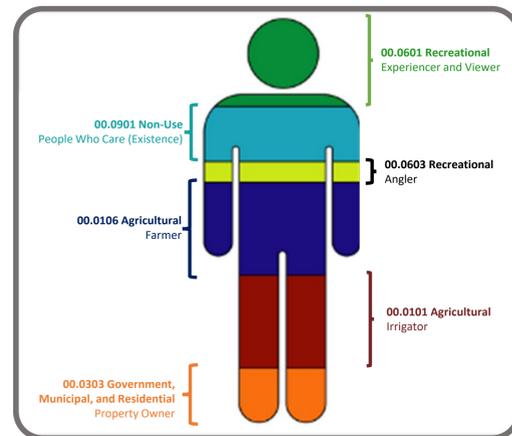
Depending on the circumstances, EGS can be incorporated into specific steps of the ecological risk assessment or throughout the process as a whole. We aim to conceptually highlight potential ways that EGS can be incorporated into ecological risk assessment.

## Objectives

- Suggest steps in the ERA process where EGS concepts could be incorporated
- Increase familiarity of EGS concepts and tools among ecorisk assessors
- Promote development of a strategic and consistent approach to incorporating EGS into ERA
- Highlight the utility and value of incorporating EGS into ERA

## EGS Environmental Classes and Beneficiary Categories

EGS can be depicted by a standardized hierarchy of environmental classes and beneficiary categories, represented by a 6-digit code (i.e., XX.YYYY) developed by Landers and Nahlik (2013). The 2 digits identify the environmental class/subclass and the 4 digits identify the human beneficiary category/subcategory. This allows multiple benefits to be identified for individuals or groups of people.



2-Digit Codes	Environmental Classes & Subclasses
1	<b>Aquatic</b>
11	Rivers/Streams
12	Wetlands
13	Lakes/Ponds
14	Estuaries/Near Coastal/Marine
15	Groundwater
2	<b>Terrestrial</b>
21	Forests
22	Agroecosystems
23	Created Greenspace
24	Grasslands
25	Scrubland/Shrubland
26	Barren/Rock/Sand
27	Tundra
28	Ice/Snow
29	Caves
3	<b>Atmospheric</b>
31	Atmosphere

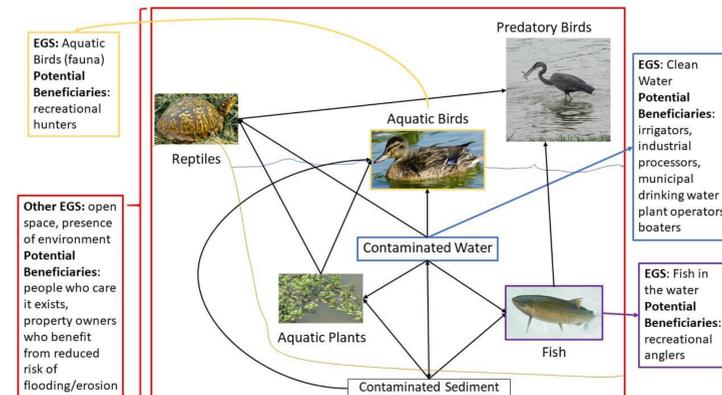
Adapted from Landers and Nahlik 2013

## Crosswalk of Example EGS Activities with Generic ERA Phases

ERA Phases <sup>a</sup>	Example EGS Topics and Activities	Some Potential EPA EGS Tools <sup>b</sup>	Decision Questions
Planning and Scoping	<ul style="list-style-type: none"> <li>• Identify EGS in site landscape</li> </ul>	<ul style="list-style-type: none"> <li>• FEGS Scoping Tool<sup>c</sup></li> <li>• FEGS Classification System</li> <li>• National Ecosystem Services Classification System (NESCS)</li> </ul>	<ul style="list-style-type: none"> <li>• Who are the stakeholders and what are their relative standings and levels of impact?</li> <li>• Do EGS classification systems help with selection, completeness, and comparability across assessment endpoints?</li> <li>• Would inclusion of EGS facilitate broader conversation with stakeholders and include ecosystem structure, function and benefits they had not considered?</li> </ul>
Problem Formulation	<ul style="list-style-type: none"> <li>• Describe EGS benefits</li> <li>• Estimate magnitudes of EGS benefits</li> <li>• Incorporate EGS into conceptual site model (CSM)</li> </ul>	<ul style="list-style-type: none"> <li>• FEGS Scoping Tool<sup>c</sup></li> <li>• EcoService Models Library (ESML)</li> <li>• Eco-Health Relationship Browser</li> <li>• EnviroAtlas</li> <li>• Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)<sup>c</sup></li> </ul>	<ul style="list-style-type: none"> <li>• What resources have stakeholders indicated are important for protection?</li> <li>• What health concerns do they have?</li> <li>• Has there been prioritization by stakeholders?</li> <li>• What do spatial data-layers tell us about the site and it's surrounding area?</li> </ul>
Analysis	<ul style="list-style-type: none"> <li>• Evaluate potential EGS/site contaminants connectivity</li> <li>• Evaluate potential effects of site contaminants on EGS</li> <li>• Evaluate EGS condition (functionality, impairment level)</li> <li>• Evaluate EGS resilience/vulnerability to site contaminants</li> <li>• Calculate EGS cost savings and other benefits</li> <li>• Assess EGS capacity (type, temporal, seasonal)</li> <li>• Assess EGS importance to stakeholders</li> <li>• Assess EGS maintenance effort and cost</li> <li>• Identify key features or parameters to protect EGS benefits</li> </ul>	<ul style="list-style-type: none"> <li>• EcoService Models Library (ESML)</li> <li>• EnviroAtlas</li> <li>• EPA H2O Tool</li> <li>• Rapid Benefit Indicators (RBI) Approach</li> <li>• Visualizing Ecosystem Land Management Assessments (VELMA) Model</li> <li>• Causal Analysis/Diagnosis Decision Information System (CADDIS)</li> </ul>	<ul style="list-style-type: none"> <li>• Are EGS attributes quantifiable (i.e., can they be measured or modeled)?</li> <li>• Which indicators might serve as proxy for assessing classes of EGS?</li> <li>• What spatial and temporal factors need to be considered?</li> <li>• Can EGS-related ecological receptors be aggregated in space or across contaminants?</li> <li>• What are the estimated differences in benefits between multiple future scenarios?</li> <li>• How do upstream and downstream areas affect or are affected by the site?</li> <li>• How might benefits be valued?</li> </ul>
Risk Characterization	<ul style="list-style-type: none"> <li>• Compare costs and benefits of EGS</li> <li>• Characterize site contaminant threats to EGS</li> <li>• Characterize EGS impairment level by site contaminants</li> </ul>	<ul style="list-style-type: none"> <li>• EcoService Models Library (ESML)</li> <li>• EnviroAtlas</li> <li>• EPA H2O Tool</li> <li>• Rapid Benefit Indicators (RBI) Approach</li> </ul>	<ul style="list-style-type: none"> <li>• Would EGS help with risk characterization of aggregate and cumulative risk?</li> <li>• Can costs and benefits be compared using similar units of measure?</li> <li>• Where are the beneficiaries?</li> <li>• Which beneficial uses might be impacted or restored?</li> </ul>
Risk Communication <sup>d</sup>	<ul style="list-style-type: none"> <li>• Articulate EGS benefits and costs</li> </ul>	<ul style="list-style-type: none"> <li>• All of the above</li> </ul>	<ul style="list-style-type: none"> <li>• What EGS do decision makers and stakeholders care about?</li> <li>• How do EGS contribute to human health and wellbeing?</li> </ul>

<sup>a</sup> From U.S. EPA 1998 <sup>b</sup> Descriptions and links available at: <https://www.epa.gov/eco-research/ecosystem-services> <sup>c</sup> Beta version - not yet publicly available <sup>d</sup> Risk Communication is not an ERA Phase, but instead occurs throughout the ERA process.

## Example Conceptual Site Model



## Conclusions and Future Directions

Through the development of new EGS tools and resources, EPA has taken some important first steps towards incorporating EGS into ecological risk assessment. These new tools and resources have revealed new opportunities for further incorporating EGS into ecological risk assessment, however, more work is still needed to fully explore these opportunities.

Potential next steps are:

- Developing and publishing an EcoUpdate and other guidelines on the topic.
- Developing more methods, tools, and case studies to help identify, quantify, and prioritize EGS and EGS features, as well as evaluate and communicate societal values of EGS.

## References

- Landers, D. and A. Nahlik. 2013. Final Ecosystem Goods and Services Classification System (FEGS-CS). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-13/ORD-004914.
- U.S. EPA. 1998. Guidelines for Ecological Risk Assessment. EPA 630-R-95-002F.
- U.S. EPA. 2016. Generic Ecological Assessment Endpoints (GAEs) For Ecological Risk Assessment: Second Edition with Generic Ecosystem Services Endpoints Added. EPA 100-F-15-005.
- U.S. EPA. 2017. Engineering Forum Issue Paper: Ecosystem Services at Contaminated Site Cleanups. EPA 542-R-17-004. Available: <https://semspub.epa.gov/work/HQ/100000459.pdf>

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