Habitat Evaluation Scoring Method to Estimate Ecosystem Service Improvements from Restoration

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The Challenge – Valuation of Ecosystem Services from Restoration

Natural resource damage assessments attempt to make the public whole through restoration or replacement of the injured natural resource, or for acquisition of an equivalent resource [CERCLA §107(f)(1)].

How can you value the flow of ecosystem services in a scientifically sound manner?

The Natural Resource Damage Assessment Process

- Evaluate injury to natural resource services
- Determine whether injury has occurred
- Quantify the extent and severity of injury
- Injury estimates are used to scale restoration actions

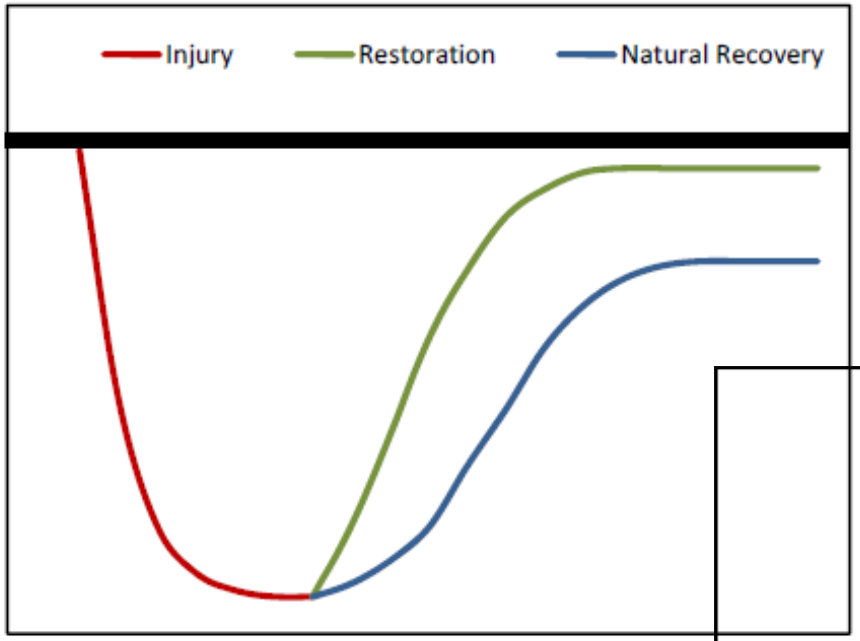
Valuation of Injury/Restoration Credit

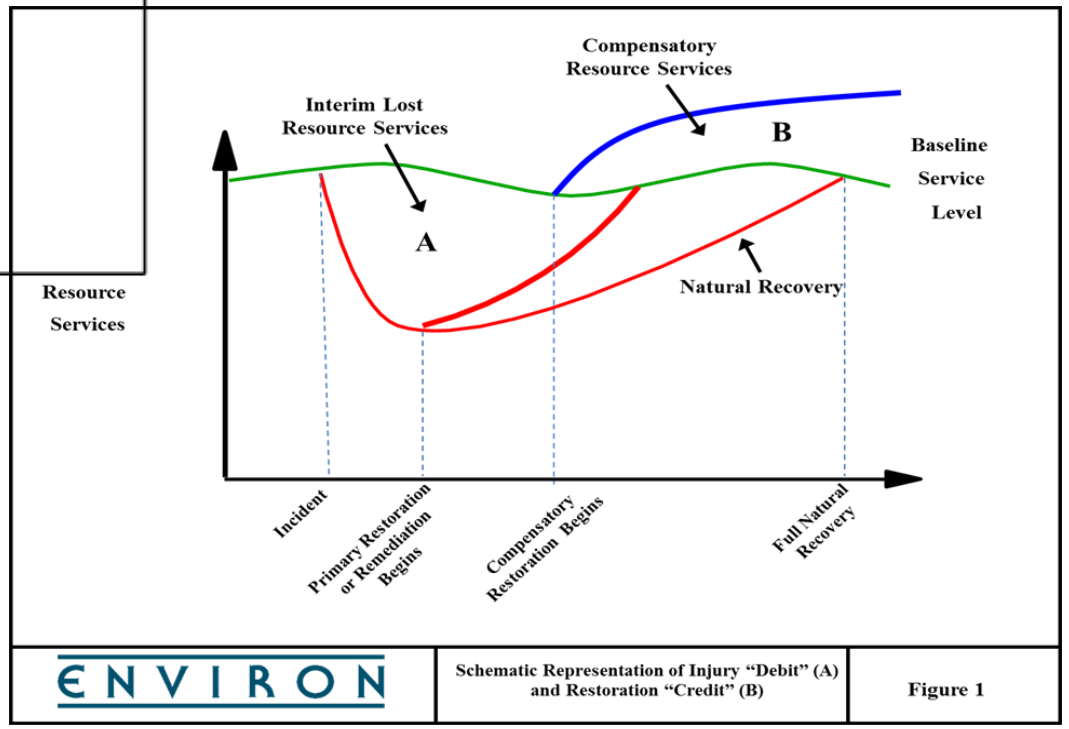
- Best professional judgment
- Literature reviews
- Case precedents
- *Functional assessment methods*

Habitat Equivalency Analysis (HEA)

- Service to service valuation method
- Uses resource-specific units
- Represents "services" provided but for the injury
- Two Components
  - Injury (debit) calculation
  - Restoration (credit) calculation

Restoration-Based Valuation





Habitat Equivalency Analysis

- Parameters
  - Present Year
  - Project Start Year
  - *Relative Benefits/Service Improvement*
  - Maturation Curve
  - Project Lifespan
  - Discount Rate

Habitat Equivalency Analysis

- Maturity Curve
  - Time to full maturity/recovery of project
  - Shape of recovery trajectory
    - Linear
    - Sigmoidal
- Lifespan
  - Life expectancy of project
  - Can incorporate multiple factors
    - Erosion rates
    - Sea level rise
    - Storm damage

Habitat Equivalency Analysis

- Relative Benefit/Service Improvement
  - Improvement in ecosystem function relative to baseline conditions
    - Historical or pre-incident conditions
    - Adjacent natural marsh condition (reference site)
    - Condition after injury (pre-restoration condition)
  - No standard method of determining service improvement
  - Often arbitrarily determined

Assessing Ecosystem Function

"Ecosystem functions are the physical, chemical, and biological processes or attributes that contribute to the self-maintenance of an ecosystem" – *King & Mazzotta 2000*

- Biomass production
- Decomposition
- Water retention, storage, processing
- Nutrient cycling
- Soil formation and retention
- Provision of habitat

Functional Assessments

- Used to evaluate ecosystem functions and/or services
- Range from quick, semi-quantitative to detailed, quantitative models
- Examples: WVA, HSI, HGM
  - Mostly for wetland habitats
  - A few for other habitat types
    - Barrier islands, forests, lakes & streams
  - Habitat-specific and often regional
- Input parameters vary by approach

Functional Assessments

Protocol		Components	Habitat Types	Geographic Location
FQI / FQAI	Floristic Quality Assessment Indices	Vegetation by ecological conservatism	Wetland, forest, prairie, savannah (separately by community types)	Regional - US
HEP / HSI	Habitat Evaluation Procedure / Habitat Suitability Indices	Quality and quantity of habitat for wildlife, fish, invertebrates	Most terrestrial, wetland & aquatic habitats	Regional - US
HGM	Hydrogeomorphic Approach	Assessment of wetland functions (hydrology, biogeochemistry, habitat)	Wetlands (separately for each subclass)	Regional - US
IBI	Index of Biotic Integrity	Biological condition (fish, plants, invertebrates)	Lakes, streams, wetlands	Regional - US
RAP	Rapid assessment protocols	8 Wetland function (hydrology, detritus, vegetation, fauna)	Wetlands (separately by subclass)	Regional – NE and Midwest US
WET	Wetland Evaluation Technique	11 wetland functions (hydrology, recreation, biogeochemistry, habitat)	Wetlands (can compare different types)	US
WVA	Wetland Value Assessment	Quantity and quality of habitat	Wetlands, Barrier Island/Headland, Coastal Chenier/Ridge	Coastal Louisiana

New Hybrid Functional Assessment

- Compare baseline site to post-restoration expected improvements
  - Score pre- and post- restoration conditions
  - Score references sites to establish baseline
- Flexible list of parameters
  - Representing biological, physical, chemical, and human use functions
  - Generalizable across habitats & regions
  - Optional weighting factors for parameters

Hybrid Model Parameters

- Biological Functions
  - Vegetation quality
  - Wildlife Utilization
  - Biodiversity
  - Habitat Quality
- Chemical Functions
  - Water Quality
  - Carbon Export
  - Nutrient cycling
- Physical Functions
  - Adjacent upland support
  - Substrate quality
  - Hydrologic Modification
  - Hydrologic Connectivity
  - Erosion Control
  - Shoreline Protection
- Human Use Potential

Hybrid Assessment Model

- Scores individual ecosystem functions on scale of 0-4
  - 0 represents little to no functional capacity
  - 4 represents the highest level of function
- Weighting factors can be used to adjust which functional parameters are most important or applicable to a restoration project

Hybrid Scoring Sheet

Project Site: _____ Date: _____

Habitat Type: _____ Name: _____

Metric	Weighting Factor	Pre-Restoration Score						Post-Restoration Score					
		0	1	2	3	4	TOTAL	0	1	2	3	4	TOTAL
BIOLOGICAL FUNCTION													
Vegetation Quality													
% Ground Cover													
% Canopy Cover													
% Invasive Species													
% Open Water													
Wildlife Utilization													
Fish and invertebrates													
Mammals													
Birds													
Turtles													
Habitat Quality													
Refugia/Shelter													
Nursery Habitat													
Foraging Habitat													
PHYSICAL FUNCTION													
Adjacent Upland Support													
Substrate Quality													
Hydrologic Modification													
Hydrologic Connectivity													
Erosion Control/Sediment Retention													
Shoreline Protection													
CHEMICAL FUNCTION													
Water Quality													
Productivity													
Nutrient Cycling													
HUMAN USE FUNCTION													
Human Use Potential													
	SITE TOTAL					Pre						Post	

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Hybrid Scoring Sheet Criteria

SCORE	0	1	2	3	4
BIOLOGICAL FUNCTION					
Vegetation Quality					
% Ground Cover	0%	25%	50%	75%	100%
% Canopy Cover	0%	25%	50%	75%	100%
% Invasive	76-100%	41-75%	21-40%	11-20%	0-10%
% Open Water	76-100%	41-75%	21-40%	11-20%	0-10%
Wildlife Utilization / Diversity					
Fish & invertebrates	Low / no diversity	Moderate-low diversity	Moderate diversity	Moderate-high diversity	High diversity
Mammals	Low / no diversity	Moderate-low diversity	Moderate diversity	Moderate-high diversity	High diversity
Birds	Low / no diversity	Moderate-low diversity	Moderate diversity	Moderate-high diversity	High diversity
Turtles	Low / no diversity	Moderate-low diversity	Moderate diversity	Moderate-high diversity	High diversity
Habitat Quality For Typical Species in this Habitat Type					
Refugia/Shelter	Little / no function	Heavily impaired	Moderately impaired	Slightly impaired	Not impaired
Nursery Habitat	Little function	Heavily impaired	Moderately impaired	Slightly impaired	Not impaired
Foraging Habitat	Little function	Heavily impaired	Moderately impaired	Slightly impaired	Not impaired

Hybrid Scoring Sheet Criteria

SCORE	0	1	2	3	4
PHYSICAL FUNCTION					
Adjacent Upland Support	Subwatershed is > 90% developed	Subwatershed is 70-90% developed	Subwatershed is 40-70% developed	Subwatershed is 20-40% developed	Subwatershed is < 20% developed
Substrate Quality	Severely altered; function heavily impaired	Highly impacted; function impaired	Moderately impacted; function moderately impaired	Slightly impacted; function slightly impaired	High quality; no functional impairment
Hydrologic Modification	Severe; heavily controlled	High; function impaired	Moderate; some impairement	Slight; some impairement	None; mostly natural function
Hydrologic Connectivity	Hydrologic connections severed	Hydrologic connections severely impaired	Hydrologic connections moderately impaired	Hydrologic connections slightly impaired	Hydrologic connections primarily intact
Erosion Control / Sediment Retention	High erosion, no retention	Moderate-high erosion, little retention	Moderate levels of erosion and retention	Moderate-low erosion, moderate-high retention	Low erosion, high retention
Shoreline Protection	No protection	Little protection	Moderate protection	Moderate-high protection	High protection
CHEMICAL FUNCTION					
Water Quality	Very poor	Severely impaired	Moderately impaired	Slightly impaired	Little impairement
Productivity	No productivity	Low productivity	Low to moderate productivity	Moderate productivity	Typical of habitat type
Nutrient Cycling	Slow cycling and little nutrient removal	Moderate-slow cycling and removal	Moderate cycling and removal	Moderate-fast cycling and removal	Rapid cycling and high nutrient removal
HUMAN USE FUNCTION					
Human Use Potential	Low	Moderate-Low	Moderate	Moderate-High	High

Open Water and Marsh Edge

Source: Environmental Working Group 2007

Vegetative Cover

High vegetative cover

Low vegetative cover

Photo Credit: Mary Sorensen

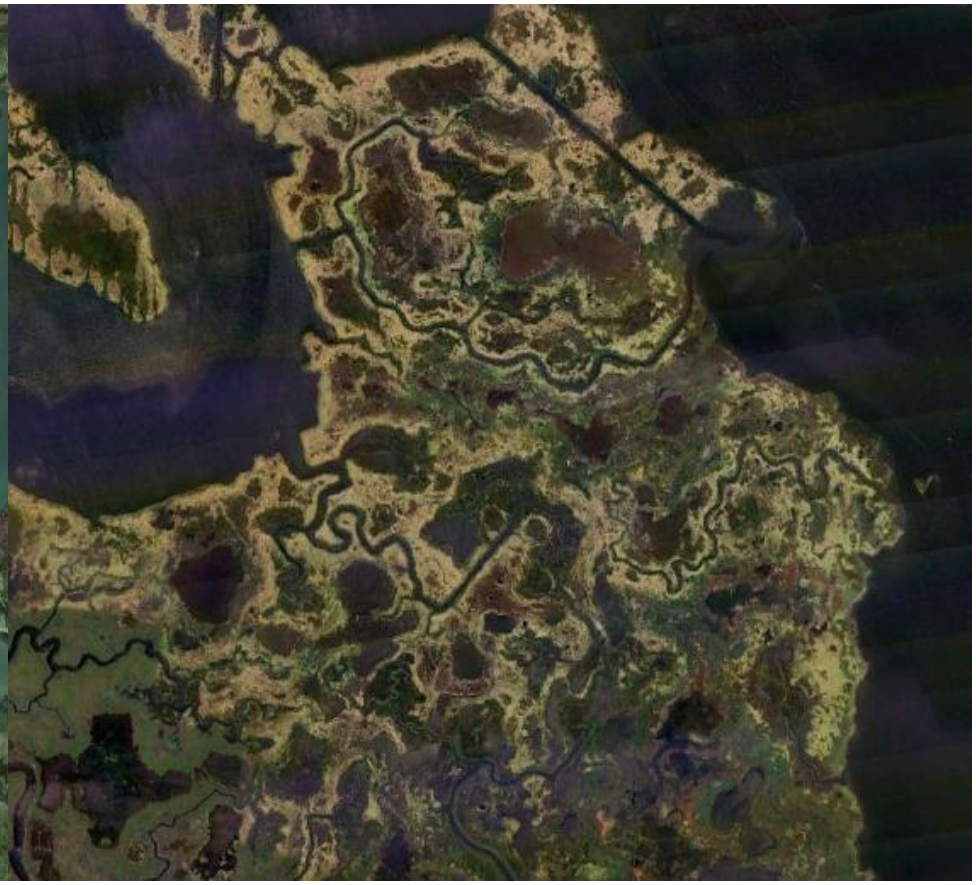
Landscape Setting: Upland Support

Urban setting –
Low upland support

Rural setting –
High upland support

Image source: Google

Hydrologic Modification



Severe hydrologic modification

Low hydrologic modification

Image source: Google

Invasive Species

Example Sites

Garbage dump

Reference Marsh

Marsh Dieback

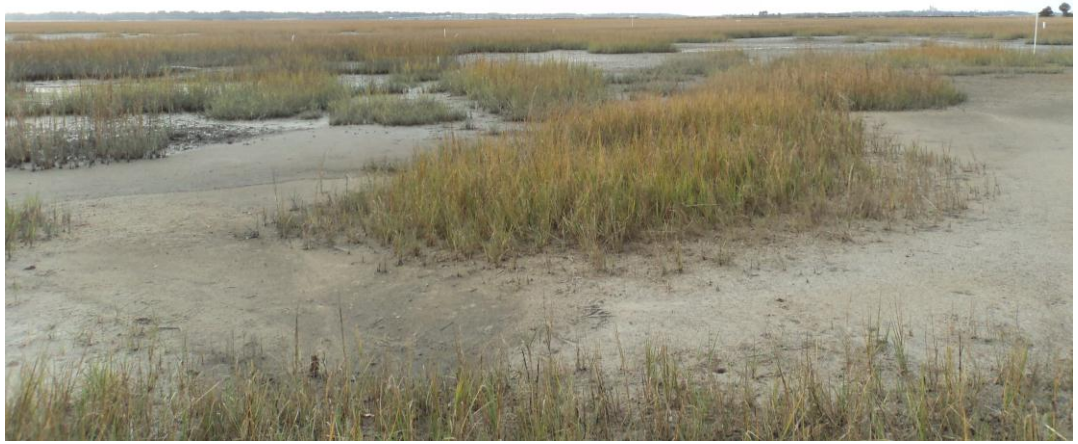


Photo Credit: Mary Sorensen

Hybrid Scoring Example

- Pre-Restoration Condition
  - Current condition of the restoration site
- Post-Restoration Condition
  - Expected conditions after restoration is completed
  - At full maturity
- Baseline Condition
  - Identical habitat type
  - Close proximity to restoration site
  - Not affected by the "disturbance event"
  - Functions as a reference standard for comparison

Hybrid Scoring Example

Project Site: Example One
Habitat Type: Salt Marsh
Date: 2012
Name: TB

Metric	Weighting Factor	Pre-Restoration Score						Post-Restoration Score						Baseline Conditions					
		0	1	2	3	4	TOTAL	0	1	2	3	4	TOTAL	0	1	2	3	4	TOTAL
BIOLOGICAL FUNCTION																			
Vegetation Quality																			
% Ground Cover					X		3					X	4					X	4
% Canopy Cover		X					0			X			2				X		3
% Invasive Species		X					0					X	4					X	4
% Open Water			X				1				X		3				X		3
Wildlife Utilization																			
Fish and invertebrates			X				1				X		3					X	4
Mammals			X				1				X		3					X	4
Birds				X			2				X		3					X	4
Turtles			X				1				X		3					X	4
Habitat Quality																			
Refugia/Shelter			X				1				X		3					X	4
Nursery Habitat			X				1				X		3					X	4
Foraging Habitat				X			2				X		3					X	4
PHYSICAL FUNCTION																			
Adjacent Upland Support			X				1		X				1		X				1
Substrate Quality			X				1			X			2				X		3
Hydrologic Modification			X				1			X			2				X		3
Hydrologic Connectivity			X				1				X		3				X		3
Erosion Control/Sediment Retention		X					0				X		3				X		3
Shoreline Protection		X					0				X		3				X		3
CHEMICAL FUNCTION																			
Water Quality			X				1				X		3				X		3
Productivity			X				1				X		3				X		3
Nutrient Cycling				X			2				X		3				X		3
HUMAN USE FUNCTION																			
Human Use Potential					X		3					X	4					X	4
	SITE TOTAL					Pre	24					Post	61				Baseline		71

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Hybrid Scoring Example

- Pre- vs. Post-Comparison
  - Improvement of 254%
  - Some conditions improved greatly (water quality, shoreline protection)
  - Other conditions did not improve (upland support)
- Baseline Comparison
  - 27% improvement from pre-restoration conditions to post-restoration conditions, relative to baseline
  - Now serves 86% of the function of the reference marsh

Restoration Credit Analysis

- Compared to reference site
  - Relative benefits = 27%
  - Start date = 2013
  - 5 years to full maturity
  - Linear maturity curve
  - 30 year lifespan
  - 3% discount rate
  - 5 DSAYs per acre

Advantages of Using Functional Assessments in HEA

- Provides common framework to estimate service improvements
- Clearly communicates expectations of the restoration project to the public
- Improves linkage between design, valuation, and short- and long-term performance measures

Potential Disadvantages of Using Functional Assessments in HEA

- HEA is a simple tool, allowing maximum flexibility – incorporating functional assessments into process adds complexity
- Very difficult to predict performance of a restored biological system
- Functional assessment metrics do not necessarily translate into ecosystem services

Take Home Messages

- Although very challenging, current regulations require the valuation of services provided from restored habitats
- Incorporating functional assessments into the HEA model provides a more transparent method to predict restoration benefits
- Without a clear basis for the valuation, there is no defensible way to document success or failure of a specific action