Functional Marsh Metrics for HEA

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Restoration of Natural Resource Injuries (eg, U.S. OPA 90)

- First, assess if injury has occurred to any environmental resource or service (to humans)
- Second, quantify the magnitude of injury
- Third, develop restoration options
- Fourth, scale preferred restoration option to compensate for loss through mitigation

Components of the HEA Presentation

- List of marsh ecosystem services
- Potential marsh metrics
- Unresolved issues to contemplate

Ecosystem services provided by tidal marshes that may be appropriate for quantitative injury assessment.

1) Habitat and food web support

- High production at base of food chain
  - Vascular plants
  - Microphytobenthos
  - Microbial decomposers
  - Benthic and phytal invertebrates (herbivores & detritivores)
- Refuge and foraging grounds for small fishes and crustaceans
- Feeding grounds for larger crabs and fishes during high water
- Habitat for wildlife (birds, mammals, reptiles)

Ecosystem services provided by tidal marshes that may be appropriate for quantitative injury assessment (continued).

2) Buffer against storm wave damage
3) Shoreline stabilization
4) Hydrologic processing
    - Flood water storage
5) Water quality
    - Sediment trapping
    - Nutrient cycling
    - Chemical and metal retention
    - Pathogen removal

Ecosystem services provided by tidal marshes that may be appropriate for quantitative injury assessment (continued).

6) Biodiversity preservation
7) Carbon storage
8) Socio-economic services to humans
    - Aesthetics
    - Natural heritage
    - Ecotourism
    - Education
    - Psychological health
    - Duck and goose hunting
    - Grazing livestock

Potential marsh metrics

1) Microphytobenthos production assay

2) Cotton strip bioassay and other biogeochemical measures like sulfide concentrations

3) Summing production across multiple consumer trophic levels

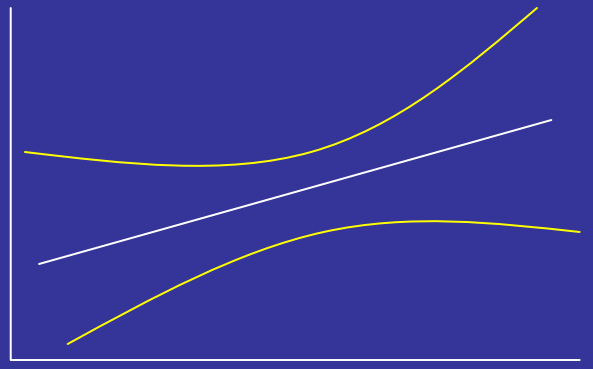
4) Below-ground biomass of vascular plants

5) Stem densities and heights of plants (as an index of vascular plant biomass) by species and marsh zone (*Spartina* vs *Juncus*)

Metrics for Quantifying Injury and Scaling Restoration

- Production (but at what trophic level?) the norm
- Food web structure vaguely known, especially for microbial elements
- Unresolved paradox of refuge functioning implies that scaling differs by trophic level
- Index of ecosystem health (e.g.,IBI in Chesapeake as suggested by Buchman (2003) (but linear with ecosystem services?)
- Explicit ecosystem services (complex and unknown)

Uncertainty



- Capability of discipline of ecology to make quantitative predictions is limited – need formal uncertainty analyses of restoration options
- Mitigation ratios (3:1, etc) often used to handle uncertainty - fixed costs to restorer
- Monitoring coupled with adaptive management of restoration - variable costs but benefits of learning
- Multiple restoration actions – bet hedging

Production metrics for injury

- Does production have the same value independent of age (size) class?
- Does production scale with both ecological services and human services?
- Should ecosystem services not be identified and then explicitly restored (e.g., 1) vascular plant production, 2) structural habitat provision, 3) filtering of nutrients, sediments, and pathogens; for marshes)?

Habitat connections