Measuring Functional Equivalency in Restored Tidal Wetlands: Are We There Yet?

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How do we promote development from this …

... to this?
Past and Present Distribution of SF Bay Wetlands

(from San Francisco Estuary Institute)
Overview

• Functional assessment
• Ecosystem services & human benefits
• Landscape scale issues
• Rapid assessments
• Trajectories
Functions of Interest: Tidal Wetlands

- Primary productivity
- Food webs
- Biodiversity support
- Physical development
- Soil biogeochemistry
  - nutrient dynamics
  - carbon sequestration
Assessing Ecosystem Functions

• Continuing focus on primary productivity (although usually just plant cover)

• Lots of recent research with food webs and secondary productivity, especially focusing on isotopic analyses

• Some interest in other functions (but no time to review them here)
Plant Response Over Time

(from Nordström et al. 2014)
Taxonomic Composition of Benthos

(from Nordström et al. 2014)
Isotopic Signatures of Benthos

(from Nordström et al. 2014)
Organic Matter Sources to Mussels

(from Howe & Simenstad 2014)
Fish Species along Salinity Gradient

(from Weinstein et al. 2014)
Linking Functions to Human Benefits

• Less progress here
• Some obvious links
  • food webs and fisheries
  • storm protection & flooding
  • carbon sequestration
• Indirect links
  • water quality improvements
  • biodiversity
  • broader food web issues
Coastal Flooding: Venice Lagoon
Acqua Alta: High Water
Venice Lagoon:
Acqua Alta Events per Decade
Restoration Challenges for Assessing Storm Impacts

- Difficult to quantify benefits of reduced storm impacts
- Unpredictable, infrequent events
- Impacts are likely to get worse into the future
Carbon Sequestration Estimates

- dated sediment cores using radio-isotopes

- combined with vertical profiles of soil characteristics (soil density & carbon content)
Soil Carbon Sequestration across Global Ecosystems

(from McLeod et al. 2011)
Average Carbon Sequestration Rates: $^{210}$Pb

100 g C/m² is ~3.7 tons CO₂/ha

(from Callaway et al. 2012)
Restoration Issues for Carbon Sequestration

• Need to focus on long-term carbon removal

• Substantial amount of short-term carbon accumulation will be lost to decomposition

• Temporal disconnect between restoration data and sequestration needs
Landscape-Scale Issues?

- Recent development of “seascape” concept
- Opportunities for:
  - spatial model development
  - remote sensing
Seascape Examples

(from Boström et al. 2011: Special issues of Marine Ecology Progress Series)
Increase in Seascape Publications

(from Boström et al. 2011)
Seascape Topics

Landscape/patch metrics

- Area
- Cover (%)
- Other
- Geomorphology
- Patch size
- Elevation
- Configuration
- Edge effect

Proportion (%)

Salt marsh

Target taxa

- Other
- Birds
- Molluscs
- Macrofauna
- Decapods
- Fish

(from Boström et al. 2011)
SF Bay Spatial Model: Existing Conditions

Model varies:
- sea-level rise (SLR)
  - low = 52 cm/century
  - high = 165 m/century
- suspended sediment concentrations
  - also low and high but depends on region

(from Stralberg et al. 2011)
Predictions: Low SLR and High Sediment

• 55% increase in wetland habitat (mostly mid marsh)

• but this probably is not very realistic

(from Stralberg et al. 2011)
Predictions: High SLR and Low Sediment

- 61% wetland loss over 100-year period
- only low marsh habitats remain

(from Stralberg et al. 2011)
Rapid Assessments

• Lots of interest in developing rapid assessment methods: ORAM, CRAM, & many more

• Focus is on indicators of ecosystem structure and function

• Many benefits (multi-site comparisons, regional data, multiple indicators, etc.)

• But, rapid assessments are unlikely to give deep insight into function
Need for Long-Term Evaluations

• On-going work on “trajectories” of ecosystem development

• Can give lots of insight into site development

• But, not all trajectories are equal or predictable
Hypothetical Trajectories of Ecosystem Development

(Hobbs & Mooney 1993) (Dobson et al. 1997)

(from Langman et al. 2012)
(from Osland et al. 2012)
(from Staszak & Armitage 2013)
Conclusions

• Are we there yet? NO

• Many improvements, but ...

• Still lots of opportunity to improve functional assessment of tidal wetlands

• Need to further develop indicators for rapid assessment

• And continue to develop trajectory evaluation
Citations


Contact me for more citations: callaway@usfca.edu