Meta-analysis of marsh recovery in the northern Gulf of Mexico

Allison Ebbets, Diana Lane, Terill Hollweg, Mary Huisenga, Abt Associates

Philip Dixon, Iowa State University

Jessica Gurevitch, Stony Brook University

December 13, 2016
Introduction

- Key questions:
  - To what extent do restored wetlands function similarly to reference wetlands?
  - What is the length of time required for restored wetlands to achieve structural and functional similarity with reference wetlands?

- Effective planning, implementation, and monitoring require understanding the expected benefits of coastal marsh restoration projects

- Need for meta-analysis to go beyond studies of individual restored sites
Methods

- Conducted a systematic literature search, data compilation, and meta-analysis to evaluate vegetation and soil recovery at restored and reference marsh habitats in the GOM

- Key criteria for inclusion:
  - Vegetation and/or soil data
    - Paired data collection at a restored marsh and a reference marsh
  - Marsh creation or thin-layer sediment addition
  - Located in the northern or central GOM

Sabine NWR Source: USFWS

Aransas NWR Source: USFWS
Methods

**Literature Search**
- Keyword search
- Author-based search
- Additional searches

**Publication Screening: 631 records screened**
Reviewed publications against screening criteria

**Data Compilation: > 400 data points from 25 studies**
- Extracted, compiled, and QC’d marsh data
- Compiled additional qualitative information

**Meta-analysis**
- Meta-regression – mean response ratio
- Unweighted quantile regression – 20th percentile response ratios
Methods

- 25 studies reported useable data
- 37 studies geographically and methodologically relevant but lacked quantifiable data
Methods

- Grouped data into six “Response Groups” for statistical analyses
  - Belowground biomass or productivity
  - Vegetation cover
  - Aboveground biomass, productivity, or stem density
  - Soil organic content (soil OC) or soil carbon
  - Inorganic soil nutrients (nitrogen or phosphorus)
  - Soil total N
Methods: Paired Analysis

- Calculated a paired response ratio (RR) for each data point collected at a restored site and a paired reference site

\[ \ln RR = \ln \left( \frac{\bar{Y}_{\text{restored}}}{\bar{Y}_{\text{reference}}} \right) \]

Values > 0 indicate metrics at restored site are greater than at reference site

- Estimated rate of recovery by calculating regressions of RR versus age
  - Mean response ratio: used meta-regression
  - 20th percentile response ratio: used unweighted quantile regression
Results – Overall Response Ratio

- Recovery defined by convergence of RR to zero
  - “More isn’t better”
- Vegetation shows greater recovery than soil
  - Early: 0–5 years for aboveground metrics; 0–15 years for belowground metrics
Results – Belowground Biomass

- Restored 56% below reference at time 0
- Recovery ~ 17 years after restoration
- Steeper recovery curve than mean
- Recovery ~ 22 years after restoration
Results – Vegetation Cover

- Restored 68% below reference at time 0
- Recovery ~ 5 years after restoration
- Much steeper recovery curve than mean
- Curve approaches zero at ~ 5 years but never crosses zero line
Results – Aboveground Biomass

- Restored 33% greater than reference at time 0
- Recovery ~ 17 years after restoration
- High variability during first 10 years

- Restored 18% less than reference at time 0
- Recovery flat or negative – Diverging from equality
Results – Soil

- Marsh type significant co-variates for soil variables
- Very few data points at restored marshes older than 15 years – difficult to detect trends
- Total N in saline marshes shows the least recovery
Conclusions: Biomass versus Cover

- Recovery trajectory for aboveground biomass and vegetation cover were distinct
  - Explanations given for higher aboveground biomass at young restored sites:
    - Edwards and Mills (2005): Higher levels of dead biomass, minor elevation differences
    - Graham and Mendelssohn (2013): Reference sites may be stressed and eroding, and less productive
Conclusions: Conceptual Model

- Rapid recovery of vegetation cover in first 5 years
- Slower recovery for belowground vegetation components
- Slowest recovery for soil organic content and soil N

Tampa Bay Restoration: NOAA Photo Library
Conclusions: Looking Forward

- Need for long-term monitoring that includes belowground variables
- Select appropriate metrics to assess marsh recovery at different stages
  - Aboveground vegetation provides short-term information
  - Belowground vegetation and soil metrics provide more integrated long-term information
- Conclusions about recovery will depend on biological and statistical measures selected
  - 20th percentile of site data tells different story from mean values
Acknowledgments

- This work was supported by DWH NRDA funding, through contracts with NOAA and the State of Louisiana

- The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of NOAA, Louisiana, or of any other natural resource Trustee for the DWH NRDA