Comparing Salt Marsh Ecosystem Responses to Different Restoration Techniques.

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Galveston Bay Estuary Features

- 660 square miles of water; 232 miles of shoreline
- 2 major tributary systems (Trinity & San Jacinto Rivers) with multiple sub-watersheds
- 33,000 square mile watershed extends to Dallas/Ft.Worth
- Wind-driven circulation
- Sub-bays

Map taken from Natural Outlook – Fall 2002. TCEQ
Benefits provided by Galveston Bay

- Ecological benefits
- Recreational opportunities
- Economic benefits of trade and industry
- Ecotourism

These benefits require responsible stewardship
Threats to Galveston Bay ecosystems

• Dense development along shorelines
• Declining water and sediment quality
• Loss of species diversity and biological productivity
• Subsidence and erosion
  – ±45,000 acres of marsh were lost between 1950 and 1995
  – Approximately 2,160 additional acres of marsh were lost between 1995-2002 (1,238 acres were emergent marsh)
Pierce Marsh

- 2300+ acre embayment
- Formerly upland/high marsh/low marsh complex converted to open water due to subsidence
- 70% open water, 20% low marsh, 10% high marsh
- Extensive low marsh restoration efforts since 1999
Evidence of subsidence: fence remaining from when the land was previously grazed

Photo courtesy of the Galveston Bay Foundation
GBF Habitat Restoration

- Actively restoring habitat in partnership with diverse team of local partners, including GBEP, NOAA, USFWS, TPWD, many others
- Diverse habitat types: wetland, sea grass, & reef
- Working directly with local citizens for “community based” habitat restoration
- Volunteer-based: Marsh Mania planting events
Model of terrace construction for marsh restoration

Figure 1. Cross sectional view of typical terraces constructed at Pierce Marsh. Water level elevations are determined from via bathymetric survey. Typical terrace elevations and water levels are given in National Geodetic Vertical Datum (NGVD). Terraces were constructed with a 3:1 side slope using material taken from the adjacent borrow area.
Marsh Restoration: Evolving Techniques

- Islands
- Confined uniform fill
- Unconfined fill
- Mounds
- Terracing

Vegetated area (acre:acre)

Cost

Marsh Fringe LF/acre

~ 850

~ 580

0.3:1

0.9:1

~ 850

~ 580

0.3:1

0.9:1
Concerns

• Habitat-use modeling demonstrates the importance of SAV and vegetated tidal fringe (Minello 2004)

• Research in GB indicates that created marsh function is often reduced when compared to natural marsh (Minello & Webb 1997, Minello & Rozas 2000)

• Additional research, new tools, & continued adaptive management techniques needed for improved results
Data & Research Needs

Some data and research needs as identified by the Galveston Bay Estuary Program and the NOAA Restoration Center Southeast region:

- Additional long-term monitoring data on restoration sites
- Impact data regarding net gain/loss when open water is converted to marsh
- Continued integration and use of collaborative database programs such as the National Biological Information Infrastructure (NBII) and others
Our Project

Evaluate the ecological function of five restoration sites / strategies and a natural reference marsh within the Pierce Marsh complex by comparing:

1. Plant community richness and diversity
2. Characteristics of *Spartina alterniflora* (*marsh cordgrass*)
   - morphology (shoot and leaf blade characteristics)
   - above-ground and below-ground biomass
   - chlorophyll and productivity
3. Stress enzyme production in *S. alterniflora*
Our Project

Evaluate the ecological function of four restoration sites / strategies and a natural reference marsh within the Pierce Marsh complex by comparing:

4. Benthic macroinvertebrate community diversity
5. Substrate utilization by benthic microbial communities
6. Sediment macronutrients and heavy metals
7. Provide great training opportunities for our students
Results
Are there differences in the physical nature of the sediment comprising the different restoration designs?  No
Do the sediment macronutrients vary between the sites or among the restoration designs? Yes- potassium and phosphorus were higher at the reference site than any of the restored sites.
Are there differences in total plant cover or cover by *Spartina alterniflora* among the sites? Yes- total plant coverage was highest at the reference site. Of greatest concern is the nearly complete loss of *S. alterniflora* cover at GRD and SIN (<2% at each site). The decrease in terrace berm integrity at both sites has resulted in a loss of suitable substrate and tidal regime for *S. alterniflora*; these sites were instead dominated by *B. maritima* and *Borrichia frutescens* in 2013.
Do the sites differ in production (measured as biomass and shoot: root ratios of Spartina alterniflora)? Yes- root biomass from the reference marsh was 3 to 15 times higher than the restored sites. The age and undisturbed nature of the REF marsh surely factored into the tremendous root biomass; however, there was no relationship between site age and root biomass at the restored sites. High root biomass is essential to the overall productivity and ecological services provided by salt marshes, e.g., stabilizing sediments and exporting nutrients.
Are the species distributions and importance values comparable between the reference and restored sites? No
Do the sites differ in benthic macroinvertebrate community taxa and abundance? Yes.
Do the sites differ in benthic microbial species richness and abundance? Yes.
Conclusions

- **Objective:** determine if there are differences in marsh function that can be attributed to restoration technique.

- **Confoundering variables**
  - restoration design (GRD, SIN, ZIG, BUM)
  - hydrology (open to fetch versus protected)

- We were still able to see real differences in functional measures among the restored sites and between the restored sites and the reference marsh.
Conclusions

None of the restored marshes are functioning at the same level as the reference marsh
- significantly higher total percent plant cover
- significantly higher root biomass
- significantly higher station productivity (due to increased stand density)

Only the BUM (beneficial uses material) design comes close; even though BUM is the most recent construction, this design type has a marsh edge most similar to a natural marsh (e.g., REF) and is most similar to the reference in *Spartina* shoot density and station productivity
Conclusions

- We are currently analyzing our 2013 samples to examine changes associated with maturation of communities in each restoration design marsh, as well as other changes (e.g., post-Hurricane Ike)
- Link to our study’s maps on NBII: http://maps.harc.edu/Marshes/
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Questions?