Context Document: Salt Marsh Ecosystem Service Logic Model

Project: GEMS
http://bit.ly/NI-GEMS

Ecosystem Service Logic Models (ESLMs) are conceptual models that summarize the effects of an intervention, such as a habitat restoration project, on the ecological and social systems. Each model links changes in biophysical systems caused by an intervention to measurable socioeconomic, human well-being, and ecological outcomes. ESLMs assume that the restoration is successful and include all potentially significant outcomes for the intervention; not all outcomes will be relevant to each individual project, depending on location and environmental conditions.

The direction of an outcome (whether the restoration will have a positive or negative influence) often depends on the specific situation or is unclear due to multiple links (arrows) leading into an outcome that may have opposite effects. Thus, language like "increased" or "decreased" is not included in the models. These models are often used to consider management with or without an intervention or to compare different interventions.

This context document includes additional information about the restoration approach and details about some of the relationships in the salt marsh restoration ESLM created for the Gulf of Mexico. This document also includes a list of the references used to develop the ESLM and names of experts with whom we spoke to refine the model.

Salt Marsh Restoration Description and Use in the Gulf of Mexico

Salt marsh restoration techniques in the Gulf of Mexico consist of constructing dikes to isolate an area and pumping in sediment, planting new native vegetation, or creating river diversions. River diversions, where water from rivers is diverted to flow through marsh areas, are most often used in Louisiana but have also been used in Texas and are normally considered a long-term restoration. These interventions typically create conditions for native salt marsh vegetation to reestablish. Planting new vegetation kick-starts this process and provides a layer of redundancy when paired with one of the other restoration actions. There is varied support among the methods for salt marsh restoration, with fishermen in the Gulf of Mexico advocating for the dike system over river diversions, which they view as harming fishery resources. Dike/sediment systems and river diversions considerably alter salinity and sediment in the marsh, yielding varied effects on economically significant species for fishermen.

External Factors That Influence Success

Sea level rise can cause marsh loss through drowning if marshes are not able to accrete vertically to keep up with rising sea level; this threatens the long-term sustainability of restored marshes. Wetlands in certain areas of the Gulf of Mexico, such as the Chenier Plain in Louisiana, are more vulnerable to sea level rise due to high subsidence rates (Jankowski et al. 2017). Mangrove encroachment into existing marsh areas is also likely to increase due to climate change and can further threaten restored marshes (Armitage et al. 2015)

Model Notes and Clarifications

Salinity Changes: Dike/sediment systems and river diversions considerably alter salinity and sediment in the marsh (Moreno-Mateos et al. 2012). This can cause population changes for economically valuable species like oysters and fish, which require certain salinity ranges to survive. Salinity alterations can also cause algal blooms, which has been exhibited in the Mississippi River (Das et al. 2012).

Habitat Persistence: Habitat persistence could come before or after habitat quality or quantity, though in the current version of the model, it is after.

Time Considerations: Structural and functional measures for salt marsh recovery will probably occur on different timescales. Structural measures like vegetation cover may recover in a short term (years to decades). Functional measures like nutrient cycling may take much longer to fully recover (on the order of centuries).

Vegetation: Planting vegetation is a restoration technique, but vegetation biomass itself is an ecological outcome that refers to the reliance on marsh vegetation by primary consumers to perpetuate trophic dynamics in the ecosystem.

Nutrition for Communities: This as an expected socioeconomic outcome of restoration projects can come from two sources: changes in fish and shellfish harvesting, and changes in land-based hunting on restoration areas. For this model, the source of nutrition is mainly from changes in fish and shellfish harvesting.

Experts Consulted

Dr. R. Eugene Turner, Louisiana State University

Dr. Melissa Carle, NOAA Restoration Center

Dr. Matthew Baumann, S.C. Department of Health & Environmental Control (formerly Industrial Economics, Inc.)

References

Armitage, A.R., W.E. Highfield, S.D. Brody, and P. Louchouam. 2015. "The Contribution of Mangrove Expansion to Salt Marsh Loss on the Texas Gulf Coast." *PLoS ONE* 10(5): e0125404. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4422646/pdf/pone.0125404.pdf.

Craft, C., J. Reader, J.N. Sacco, and S.W. Broome. 1999. "Twenty-Five Years of Ecosystem Development of Constructed Spartina Alterniflora (Loisel) Marshes." *Ecological Applications* 9(4): 1405–1419.

Craft et al. 2003. "The Pace of Ecosystem Development of Constructed Spartina Alterniflora Marshes." *Ecological Applications* 13(5): 1417–1482.

Das, A., et al. 2012. "Impacts of Mississippi River Diversions on Salinity Gradients in a Deltaic Louisiana Estuary: Ecological and Management Implications." *Estuarine, Coastal and Shelf Science* 111: 17–26.

Jankowski, K.L., T. Tornqvist, and A.M. Fernandex. 2017. "Vulnerability of Lousiana's Coastal Wetlands to Present-Day Rates of Relative Sea-Level Rise." *Nature Communications* 8: 14792. https://www.nature.com/articles/ncomms14792/.

Moreno-Mateos, D., M.E. Power, F.A. Comin, and R. Yockteng. 2012. "Structural and Functional Loss in Restored Wetland Ecosystems." *PLOS Biology* 10(1): e1001247.

Strange et al. 2002. "Determining Ecological Equivalence in Service-To-Service Scaling of Salt Marsh Restoration." *Journal of Environmental Management* 29(2): 290–300.