Effects of disturbance and fertility upon the vegetation of a Louisiana coastal marsh: an evaluation of Huston's general model of diversity (EPA Science and Technology Grant)

McFalls/Keddy/Shaffer/ Campbell

Fire, herbivory, nutrients, and sedimentation are major factors controlling marsh structure and composition. These factors are not routinely manipulated in robust replicated factorial design experiments. A large experimental facility, Turtle Cove Experimental Marsh, was constructed in the wetlands behind the Turtle Cove Environmental Research Station through a collaborative effort between the research laboratories of Dr. Paul Keddy (Edward G. Schlieder Endowed Chair for Environmental Studies) and Dr. Gary Shaffer (Southeastern Wetlands Restoration Laboratory).

The study site is a marsh on the Manchac landbridge, a narrow strip of land that separates Lakes Pontchartrain and Maurepas. This landmass is very important in maintaining salinity gradients within the basin, and the landbridge's long-term stability is imperative to the health of the entire eastern portion of the basin. The future of these marshes is threatened by a multitude of factors including: relative sea level rise (eustatic sea level rise + steric sea level rise + subsidence), saltwater intrusion, altered hydrology (e.g. canal construction for petrochemical exploration & logging), exotic species, wave erosion, and the elimination of riverine inputs by artificial levees built along the Mississippi River. All of these factors combined result, regionally, in some of the highest land loss rates in the world (Boesch et al. 1994). The study site is part of one of the nation's largest coastal oligohaline systems (Moore 1992) – one of the most complex and least understood types of wetland according to Odum (1988).

There are two main objectives for the project:

1. to explore the effects of multiple disturbance and fertility regimes upon plant community structure

2. to set targets and provide guidelines for restoration.

The main theoretical framework for this experiment is provided by Huston's general model of diversity (Huston 1979). All of the treatments can be arranged along Huston's two orthogonal axes, the rate of disturbance and the rate of recovery from disturbance (i.e. fertility). Disturbance treatments are ranked in a hypothesized order of intensity by the proportion of aboveground biomass killed and how long the vegetation takes to recover. Fertility treatments are ranked by the rate at which they are hypothesized to accelerate recovery from disturbance.

The overall experimental design is a repeated measures split-block 2 x 4 x 4 factorial with 3 replicates. Three main plots exclude mammalian herbivores such as nutria with 6-foot high vinyl coated weld-wire fence buried 18 inches into the marsh substrate. Three main plots paired with the herbivore exclosures are open to grazing. Within both types of these main plots, 3 x 3 m plots have been receiving factorial combinations of fertility and disturbance treatments since early 2002. Overall, there are 32 different plots replicated 3 times. More than a half mile of boardwalk and catwalks provide access to the Turtle Cove Experimental Marsh.

The ranked disturbance treatments are: control, prescribed fire, single herbicide, and double herbicide. Prescribed fire is a management tool in many marsh areas of Louisiana, but it has not been studied in the Manchac area. Studies are also lacking in wetland systems on fire and multiple interactions. The herbicide treatments are designed to act as generic disturbances. The single herbicide treatment, applied once a year, examines the role of the seed bank in marsh recovery. The double herbicide treatment, applied twice a year, increases the intensity of the disturbance and shows the role of dispersed propagules in marsh recovery from disturbance.

A freshwater diversion into the general area has been proposed to help slow land loss rates in this rapidly submerging coastal area. The nutrients and sediment deposition that would accompany the riverine inputs

provided ideal fertility treatments for the experiment. The ranked fertility treatments include: control, fertilizer addition, sediment addition, sediment + fertilizer addition. The fertilizer addition acts as the nutrients that a marsh would receive from overland sheet flow from a diversion project. The sediment addition (1 cm) attempts to mimic the sediment deposition that would occur if a diversion were in place. The sediment +fertilizer addition most accurately emulates the proposed freshwater diversion since it combines the increased nutrient levels with increased elevation (decreased inundation times). The factorial nature of the experiment allows the research team to examine the interaction between herbivory, disturbance treatments, and fertility treatments.

Initial results show that nutria, the principal vertebrate herbivore of the marsh, may limit biomass production and increase species richness. Prescribed fire does not appear to have a place in management of the area - it seems to promote heavy, localized herbivory in burned areas thereby, reducing the amount of organic matter incorporated in the soil. The sediment + fertilizer treatment, which simulated a proposed freshwater diversion, significantly increased biomass production with no reduction in species diversity. Huston's general model of diversity appeared to be applicable to the Manchac marsh.

Preliminary results have been presented during oral sessions at the 24th annual Society of Wetland Scientists' meeting on June 13, 2003 and the Louisiana Association of Professional Biologists' symposium on August 21, 2003. During 2004, the long-term work on fire, sediment, fertilizer, grazing, and disturbance in the Turtle Cove Experimental Marsh will be continued. In addition, we will be increasing the emphasis upon biological diversity, including seeds buried in the soil of the experimental marsh.

Boesch, D.F., M.N. Josselyn, A.J. Mehta, J.T. Morris, W.K. Nuttle, C.A. Simenstad, and D.J.P. Swift. 1994. Scientific assessment of coastal wetland loss, restoration, and management in Louisiana. Journal of Coastal Research (Special Issue) **20**: 1-84.

Huston, M.A. 1979. A general hypothesis of species diversity. The American Naturalist **113**:81-101.

Moore, R.H. 1992. Low-salinity back bays and lagoons. P. 541-614 in Hackney, C.T., S.M. Adams, and W.H. Martin (eds.) *Biodiversity of the Southeastern United States*. Wiley, NY, USA.

Odum, W.E. 1988. Comparative ecology of tidal freshwater and salt marshes. Annual Review of Ecology and Systematics **19**:147-176.