EVOLUTION AND DEVELOPMENT OF TIDAL MARSHES

R. Scott Warren, *Professor of Botany, Connecticut College*

The previous chapter on the geologic history of Long Island Sound (LIS) discussed a steady rise in sea-level of about 3 to 4 millimeters per year, or an average of a foot or more per century, which began about 9,000 years ago. As the waters of Long Island Sound flooded the coastal uplands they moved the shoreline inland, a process termed "marine transgression." The drowned coastal stream and river valleys are now our present day coves, embayments, and tidal marshes.

Tidal marshes formed in quiet, "low energy" environments, protected from the direct wave energy of the open shoreline. In these areas fine grained suspended sediments settled out, filling the coastal basins with marine silts and clays. About 5,000 to 3,000 years ago sea level rise began to slow, and by 2000 years ago the rate reached about one millimeter per year or less, roughly 10 centimeters (four inches) per century. Under this new regime of slower marine transgression a single species of tidal marsh grass established the first permanent footholds in the low energy, sedimentary environments of the drowned valleys and developing embayments. Grass shoots slowed water movement, trapping and accumulating even more sediments. This enhanced sedimentation, coupled with the increasing volume of below-ground roots and rhizomes, allowed the elevation of these newly developing marshes to keep up with rising sea level.

The initial invader, Smooth Cord-grass (*Spartina alterniflora*), thrives at elevations between mean high tide and a bit below mean sea level, roughly the upper two-thirds of the mean tide range, where it is flooded by tidal waters twice a day. These new Cord-grass stands created habitat for Ribbed Mussels (*Guekensia demissa*) and fiddler crabs (*Uca* spp.), both of which, in turn, enhanced the growth of the Cord-grass. Denser stands of grass stems slowed tidal water even more, further increasing sediment deposition. With the right conditions Cord-grass could expand seaward, encroaching over mudflats, and

also landward, over flooding uplands. Continued sedimentation and rhizome growth raised elevation on the landward side of these new marshes above the mean high tide level, creating the less frequently flooded high marsh habitat. Salt Meadow Cord-grass (*Spartina patens*), Black Grass (*Juncus gerardii*) and Spike Grass (*Distichlis spicata*) became the high marsh dominants. These plants are shorter in height than their low marsh counterpart, with finer stems and leaves and, unlike Smooth Cord-grass, their roots and rhizomes tend to form a dense turf. These two communities, low and high marsh, will be described in detail in the following chapter.

As sea-level continued to rise, Smooth Cord-grass could continue its spread from the seaward or bayfront edge of these new marshes out over aggrading tidal flats. At the same time the marine transgression, driven by sea-level rise, continued to flood more and more surrounding uplands, moving the high marsh community landward. This movement of marsh out over mud flats and adjacent upland, as sea level slowly rose, is illustrated in Figure 1.

At the highest elevations, the marine-upland transition, where flooding occurs only during extreme spring high tides, other marsh plants formed a distinctive upper marsh border. Characteristic upper border species include the shrub Marsh Elder (*Iva frutescens*), often mixed with or even replaced by Switch Grass (*Panicum virgatum*) or Phragmites (also called Common Reed, *Phragmites australis*).

With continued sea-level rise roots and rhizomes of the oldest plants, the ones that really started the marsh building process, were buried, submerged under new sediments, roots and rhizomes, and the slowly deepening waters of Long Island Sound. This anaerobic, salty, soil environment inhibited the normal decomposition of these underground plant remains. They are preserved as peat and today provide an historic record of marsh development and vegetation change over the past 3000 - 4000 years. The oldest salt marshes, which are more common toward the western end of the State, have about three meters (10 feet) of peat, which overlie either mud flats of marine clays and silts, or, less frequently, upland soils. More recently formed marshes have shallower depths, with high marsh peat found over upland soils and low marsh Smooth Cord-grass peat over marine sediments (Fig.1). Except for Phragmites, the roots and rhizomes of the upper border plants decompose fairly quickly, and their remains are usually harder to find.

Ecologists and geologists have pieced together the story of marsh development by analyzing peat and sediment cores removed from marshes and embayments. Peat sampling tools have been developed which can be forced down through the marsh, cutting out a plug or long tube of peat which is continuous from the current surface to the bottom layers. These cores can be

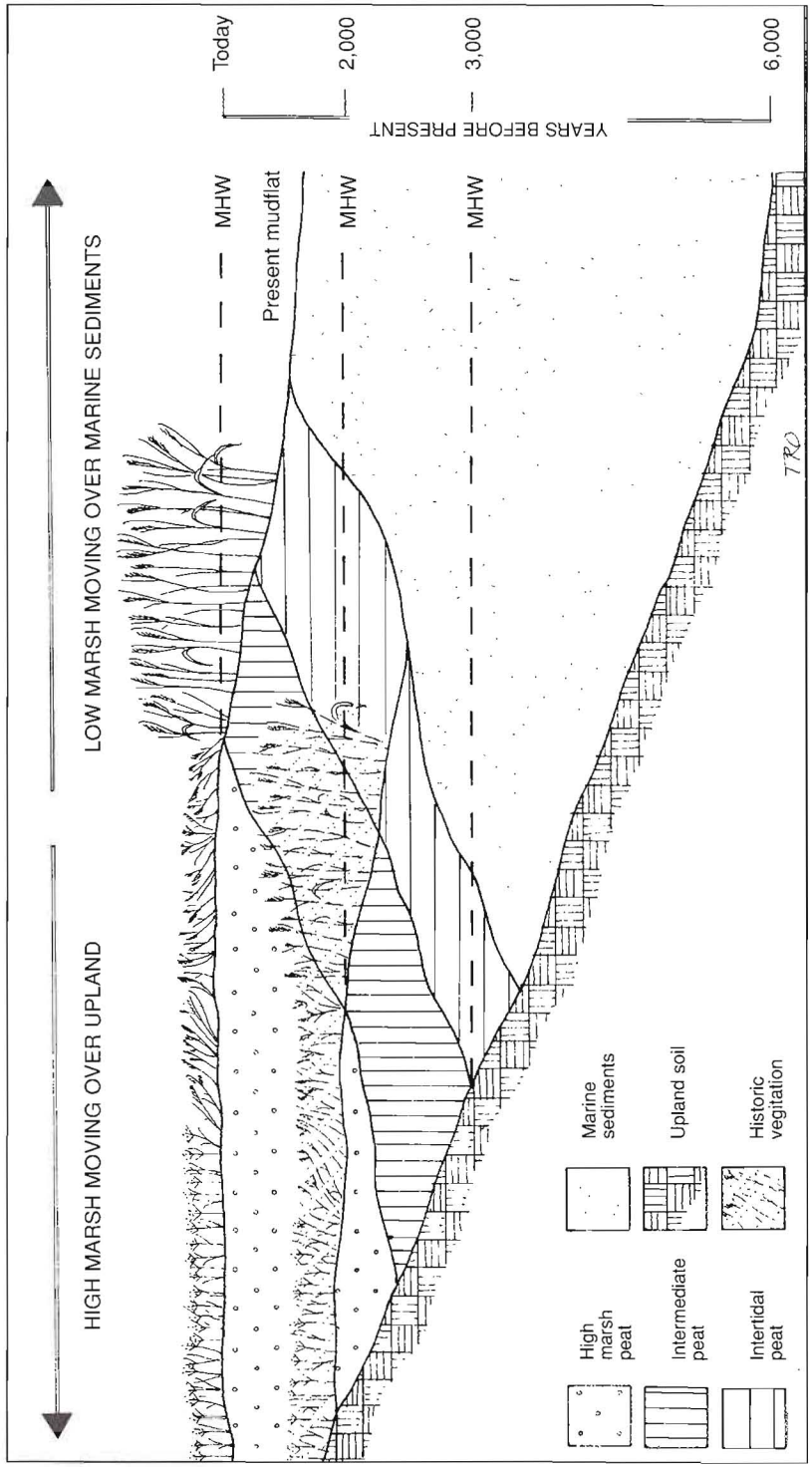

Fig.1 Hypothetical cross-section of a salt marsh showing its development over time. As sea level rises, sediments, roots and rhizomes build up at the same rate to form peat. As the marsh rises, it expands out over mud flats toward the water, and also landward. The illustration shows a marsh surface, with its vegetation, at 2,000 years before the present (yrs bp). Past levels of mean high water (mhw) are also shown for 3,000 and 2,000 years ago and for the present.

removed intact, and plant roots and rhizomes, as well as the preserved shells of microscopic animals called Foraminifera, can be identified to species. Since the different marsh plants and Foraminifera characterize different habitats within tidal marshes (high marsh, low marsh, etc.), their preserved remains can be used to reconstruct the historic marsh environment as one moves down through a core, and simultaneously back through time. A time line for plant, animal and environmental changes recorded within the peat can be dated using the naturally occurring isotopes of carbon 14 and lead 210. In addition, horizons, distinct horizontal bands which act as markers in the core, can be associated with specific known historic events. One example of such markers in a peat core are lines of sand deposited on the marsh by hurricanes (Fig. 2).

Peat cores have been analyzed from a number of Long Island Sound tidal marshes, and the developmental history of a few marsh systems has been studied in detail. Some of the pioneering work on the history of tidal marsh development was done during the early 1960s on the Hammock River Marshes in Clinton. This system still serves as a site for increasingly sophisticated research in this field, and has also been the subject of marsh restoration projects. A very detailed investigation has also been made on the formation and development of the Pataguanset River marshes in East Lyme (Fig. 3), and the Barn Island marshes in Stonington have also been sites of research into tidal wetland community change over time.

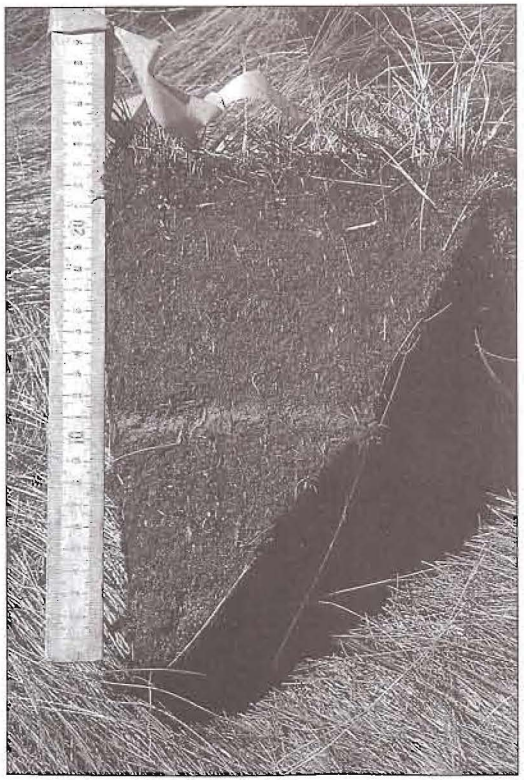

Fig. 2 A slice of peat from the Barn Island salt marsh which clearly shows a sand line 12-15 centimeters below the surface, produced by the 1938 hurricane. All the peat above the line has accumulated on the marsh since that date. (R.S. Warren)

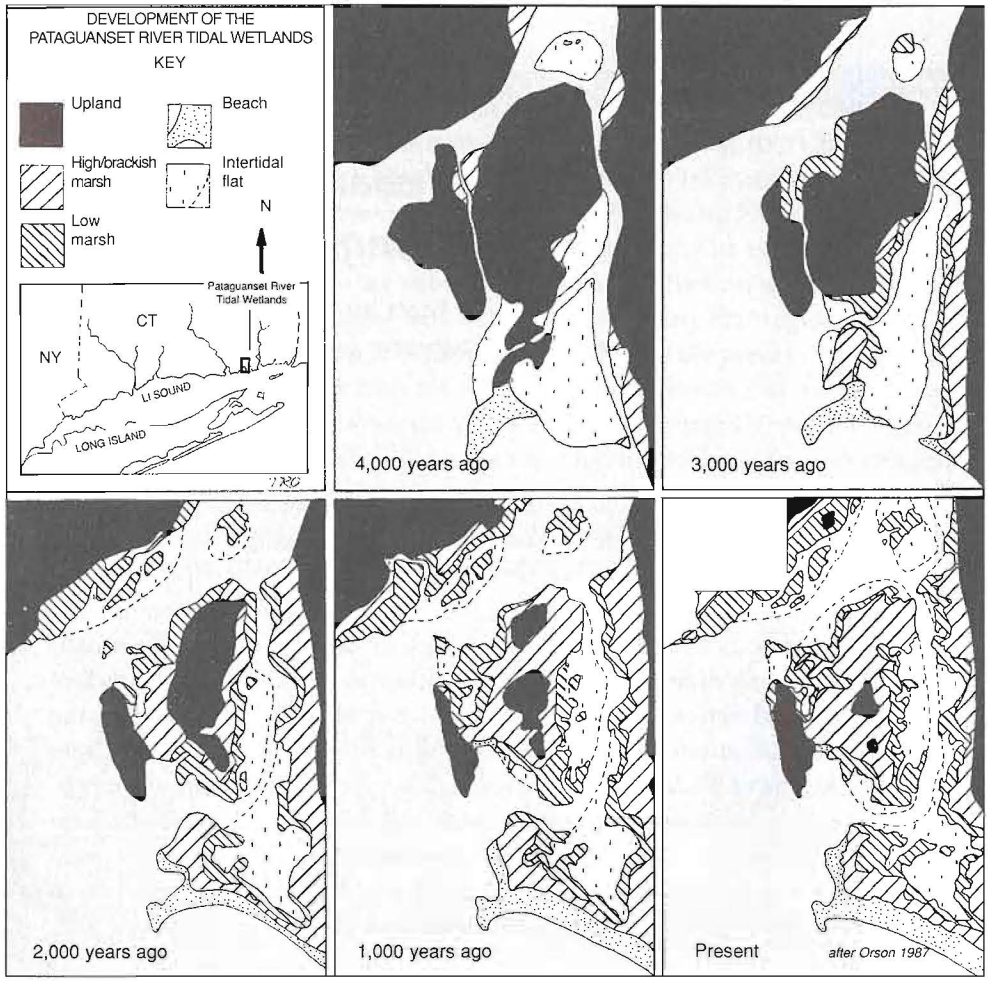

Fig. 3 Proposed historic development of tidal marshes in the lower Pataguanset River estuary. Sediments accumulated at an average rate of about one meter per thousand years. Thus the 4,000 year old marsh surface is about four meters below the current surface.

SUGGESTED READING

Niering, W.A., R.S. Warren and C.G. Weymouth. 1977. Our Dynamic Tidal Marshes. Vegetation Changes as Revealed by Peat Analysis. Connecticut Arboretum Bulletin No. 22. The Connecticut Arboretum. New London, CT. 12 pp.

Orson, R.A., R.S. Warren and W.A. Niering. 1987. Development of a Tidal Marsh in a New England River Valley. Estuaries 10(1): 20-27.

Redfield, A.C. 1972. Development of a New England Salt Marsh. Ecological Monographs 42: 201-237.