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The Ongoing Salt Marsh Restoration at Stonington, Connecticut

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INTRODUCTION

The Atlantic coast of the northeastern United States is dotted with innumerable salt marshes, all of which are quite similar in structure and species composition. Salinity, frequency of tidal inundation and nutrient availability vary significantly across these salt marshes, leading to complex patchworks of distinct vegetation zones. Each zone can be characterized by one or two dominant species which have adapted to tolerate the localized conditions (Niering and Warren 1980). Where a salt marsh meets open water, unbroken stands of tall salt marsh cordgrass, *Spartina alterniflora*, dominate the area between the mean daily low and high tide lines. Above mean daily high tide line but below the mean monthly high tide line, *Spartina patens*, salt meadow hay, intersperses with stands of spikegrass, *Distichlis spicata*. Tidewater from the monthly high tides collects in shallow depressions in this area, providing areas of open water above the mean daily high tide line. Evaporation of this water creates extraordinarily saline conditions, often twice as high as that of the open salt water. A stunted form of *Spartina alterniflora* is one of the few plants that will grow in these hyper-saline pannes.*Juncus gerardi*, black rush, dominates the areas that are only flooded by extremely high tides. At the brackish edges of the marsh, *Typha angustifolia*and *Phragmites australis*, narrow-leafed cattail and reedgrass, respectively, are the dominant species.

From the brief description of typical northeastern United States salt marsh vegetation given above, it is evident that the spatial distribution of salt marsh plants within a marsh depends heavily on the localized physical conditions. Any disturbance or human intervention which alters these physical conditions can significantly alter the spatial distribution of the vegetation. Most salt marshes in this area have been subjected to a variety of human caused disturbances (Broome et al. 1988). Nearly all of the salt marshes in this area have been ditched for mosquito control, simplifying the structure of the marsh and altering the ratio of open water to emergent plants. The topography of some marshes has been altered by the deposition of material dredged from nearby channels. Many others have had tidal flushing interrupted by diking for agriculture or road building, shifting the balance between fresh water input from the uplands and salt water carried by the tides.

BARN ISLAND MARSH #1:

Site History The five salt marshes at Barn Island Wildlife management area in southeastern Connecticut are no exceptions to the general rule of human disturbance in marshes. For over 300 years, salt hay farmers have been removing *Spartina patens* from these marshes every 3 or 4 years by mowing (Peck et al 1994). Although never dredged for navigation, the topography of these marshes was altered by the mosquito control ditching that occured in the 1930's. The peat removed during ditching was usually deposited next to the ditch, creating a levee with a surface higher than the interior marsh. This impedes water flow to the interior marsh and can create hypersaline pannes. Although this phenomenon is not explictly mentioned in the literature, it was a common ditching practice and likely to have been a factor in the degradation of the marshes. Mosquito control ditching also reduced available wildlife habitat by removing open water. In response, 4 of the 5 marshes were impounded in the late 1940's in an attempt to increase open water (Barret and Niering 1993). Although this impoundment was successful in increasing open water, it also deprived the marshes of tidal flooding, greatly altering salinity throughout the marsh and changing the composition of the plant community as well. Use of the impoundments by waterfowl peaked in 1960 and then declined rapidly as the composition of the plant community continued to change. Barn Island Marsh #1 is the largest (20 ha) and easternmost impounded marsh at the refuge. Like all of the other marshes at Barn Island, it lies in a north-south valley that constrains the possibility of marsh expansion. The watershed above this valley is the source of freshwater input. The marsh is bordered on the north by an elevated dirt track that completely eliminates tidal flushing on its north side. The impoundment, built in 1946, lies 1 km south of the dirt track. A relatively intact salt marsh exists south of the impoundment, buffering the it against the direct influence of Little Narragansett Bay and Long Island Sound (Sinicrope et al. 1990). The vegetation studies and restoration efforts involve the area between the impoundment and the dirt track. Several studies have chronicled the vegetation present at various times before and after impoundment. Taken together, they provide a reasonable picture of the vegetation changes wrought by the cessation of tidal flushing. Miller and Egler (1950) compiled a map of the pre-impoundment vegetation and found it to have the typical salt marsh vegetation composition and patterns outlined above. They also found that 1 year after impoundment *Spartina spp*. still dominated the marsh, but salinities had already begun to drop. In 1970, the Connecticut Department of Environmental Protection evidenced concern about the prevalence of Phragmites australis in the impoundment area (Sinicrope et al. 1990). In the mid-1970's, when the marsh was at its freshest state, Hebard's (1976) vegetation map showed the site to be a Typha angustifolia wetland, with significant amounts of Phragmites australis in the more brackish areas.

RESTORATION EFFORTS

Since it became a state wildlife refuge in the 1940's, the entire Barn Island area has been managed to maximize waterfowl hunting and other recreational opportunities.

When use of the impoundments by waterfowl declined seriously after 1960, it became obvious that a change in management schemes was necessary in order for the refuge to meet its management goals. The first attempts at what might now be termed restoration were narrowly focused on reducing or eliminating Phragmites australis. From 1965 to 1971, various herbicides were used to control the plant, but none achieved much lasting success (Barrett and Neiring 1993). In 1970, an old culvert in the center of impoundment, located at the old tidal stream channel, was retrofitted with a flapper gate to allow tidal inflow (Sinicrope et al. 1990). The DEP hoped that this would increase the salinity enough to control *Phragmites australis*. Unfortunately, the gate did not allow in enough salt water to change the salinity appreciably; consequently, the marsh remained dominated by *Typha angustifolia* and *Phragmites australis*. By the late 1970's it became obvious that such small efforts concentrated on the control of a single species would not be effective in reestablishing conditions favorable to waterfowl. The DEP decided to restore the functional integrity between the marsh and Little Narragansett Bay (Sinicrope et al. 1990). This, of course, meant the restoration of significant tidal flushing. In order to reach this goal, a 1.5 m diameter culvert was installed in the impoundment in 1978. The flapper gate installed on the original 0.6 m diameter culvert in 1970 was removed in 1979, slightly increasing tidal exchange volume. In response to an act by the Connecticut State Legislature mandating restoration of the impounded marshes at Barn Island, a 2.1 m diameter culvert was installed in 1982. This addition brought the combined cross-sectional area of the culverts to 20% of the tidal creek's original cross section.

EVALUATION

Despite the discrepancy between the current and original cross-sectional area of inflow, several studies indicate that the restoration attempts have been at least partially successful in restoring salt marsh vegetation to the site. Two major studies focusing on changes in vegetation since the restoration of tidal influx have been undertaken. Sinicrope et al. (1990) compared the distribution of vegetation present in the marsh in 1988 to the vegetation distribution in 1976 as mapped by Hebard (1976). After surveying the vegetation by following Hebard's methods as closely as possible, they found dramatic changes in the composition and distribution of species throughout the area of the marsh where tidal flushing had been restored. The area covered by Typha angustifolia declined from 74% to 16% of the marsh, and the remaining stands were mostly stunted. *Spartina alterniflora* increased its coverage from <1% to 45% of the marsh. Coverage of the marsh by high marsh plants approached 20%. Ironically, the one species that the DEP set out to control, *Phragmites australis*, increased in coverage from 6% to 17%. However, most the stands of *Phragmites australis* evidenced stunted growth, and the authors believed that the plant would not continue to increase in coverage. Other freshwater and brackish plants declined significantly. These findings led the authors to conclude that the marsh had been restored to a significant degree. A perhaps more useful evaluation of the success of the project was undertaken by Barrett and Niering (1993). Using a geographical information system, they compared preimpounded, impounded and postrestoration vegetation maps to determine the number and direction of trends that vegetation changes have taken. The use of preimpoundment vegetation maps allowed them to evaluate the success of the restoration in the strictest sense. They determined that only 28% of the marsh had been restored to its preimpoundment vegetation. However, if the definition of restoration was broadened to accommodate the establishment of salt marsh vegetation regardless of pre-impoundment spatial position, then 63% of the marsh can be considered restored. *Typha angustifolia* and*Phragmites australis* accounted for 37% of the marsh. Of course, plants are not the only components of the salt marsh ecosystem. In fact, the genesis of this restoration project lay in regaining habitat for important waterfowl. Aside from casual observations (Sinicrope et al. 1990), no determination of waterfowl usage at the restored site has been performed. Peck et al. (1994) have examined the marsh for evidence of macroinvertebrates, however. They compared the populations of two macroinvertebrates, the high marsh snail (*Melampus bidentatus*) and the ribbed mussel (*Guekensia demissa*), in the restored marsh with the one unimpounded marsh at Barn Island. Although there were differences in the density and biomass of these invertebrates between the two marshes, they were small enough to allow the authors to conclude that the marsh was in an advanced stage of restoration.

CRITIQUE

Judging by the evidence provided by the three evaluations of the Barn Island salt marsh restoration, the efforts seemed to have achieved a signficant amount of success in a relatively short period of time. Although by no means complete, the restoration has proceeded significantly towards establishing the original salt marsh community. Several factors account for this rapid restoration. Tidal flushing is obviously the single-most important factor in the establishment of a salt marsh. By restoring tidal flushing to the marsh, salinities were increased to the point at which Typha angustifolia and Phragmites australis began to suffer. This allowed establishment of Spartina alterniflora and other salt marsh plants. The relatively intact salt marsh on the south side of the impoundment proved to be a handy propagule source. Finally, although eliminating the tidal flushing had a dramatic impact on the plant community, it apparently did not impact the system in such a way as to seriously decrease the ability of the salt marsh plants to recolonize. Had the original community been lost through a more serious disturbance, the restoration probably would not have proceeded as easily or as successfully. Conversely, had the original DEP plan for Phragmites australis control been executed in a more effective manner that allowed for greater tidal inflow, it could have had consequences reaching far beyond the control of one problem plant by giving later restoration efforts the benefit of a head start on natural recolonization.

Restoration can encompass a variety of outcomes, and which of those outcomes are the actual goals of a project are not always made clear. In the case of the Barn Island marsh, restoration began as an attempt to control *Phragmites australis* and gradually evolved into a full scale marsh restoration. Even then the exact goals of the restoration were not quite explicit. Given the variety of goals possible in restoration, it seems to make sense to adopt a evaluation procedure that measures success in several different ways, as did Barrett and Niering (1993). Of course, scientifically gathered predisturbance data is not always available, in which case the method chosen by Sinicrope et al. (1990), comparing pre- and postrestoration conditions, must be adequate. Peck et al. (1994) show that evaluators still have options when even prerestoration data is unavailable. They resolve this problem by comparing the restored system with an appropriately similar system. Although the Barn Island marsh restoration effort seems to have engendered considerable success, the impulse to put another notch on the restoration success belt and move on should be held in check. The restoration was by no means a complete success; 37% of the marsh was still covered by *Typha angustifolia* and *Phragmites australis* as of 1988. Sinicrope et al (1990) expressed optimism that re-establishment of the salt marsh species would continue unimpeded. Barrett and Niering (1993), on the other hand, were concerned that low rates of peat accumulation during the freshwater years will hamper the ability of the system to match peat accumulation rates with relative sea level rise, something natural marshes appear to be doing. The eastern United States has been experiencing relative sea level rise for several thousand years, with little apparent loss of salt marshes. Global warming has the potential to greatly accelerate this trend. If the surface of the restored marsh falls relative to the water level, many of the restoration gains of the past decade and a half could be lost. This reason alone is enough to suggest judgment be reserved on the absolute success of the project. If the restored marsh can compensate for relative sea level rise as well as relatively intact marshes, then perhaps pronouncements of success can be less qualified.

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