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Phase II of tidal Marsh Restoration at Steedman Woods Reserve at York, Maine

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INTRODUCTION

One of the earliest settlements of our nation was located in York, Maine. It was the site of early homesteads and a tidal mill driven by the controlled flow of tidal waters into and out of Barrell Millpond. It has been a focus of historic reuse and preservation, with the rebuilding of the causeway and the construction of the Wiggley Bridge, set up to allow passage over and preserve the old mill sluice. Most recently, the peninsula was purchased by a benefactor, Mr. Steedman, to avoid further development and preserve 18 acres directly northwest of the Bridge; an area now called Steedman Woods. Management of the point and access routes, including the causeway, is in the hands of The Museums of Old York, a regionally important historical institution that owns and manages many of the oldest existing homesteads in York as well as some conservation lands. The Museums of Old York owns and manages Steedman Woods Reserve as a historical site and passive recreational area. This report summarizes our work over the past two years (2012 and 2013) to restore salt marsh to the shorelines around Steedman Point.

PROBLEM

North of the Bridge, on the Barrell Millpond side, a granite stairway leads people down to the intertidal shoreline, where some walk their dogs and others use the area as a casual bathing beach. The shore is not particularly inviting and signs request people do not use the shore, but there is great attraction of bathers and boaters to the rapids that form with the incoming and outgoing tides through the old sluiceway. The Museums of Old York is concerned by recent signs of erosion and overuse by the public of the unprotected shoreline just north of the Wiggley Bridge. South of the bridge (York River side) large granite blocks have fallen off the abutment, creating a stairway for people to access the eroding shore. Conditions on the river side are similar to the pond side, with increased foot traffic interacting with erosive forces that has led to salt marsh loss. Entire sections of the salt marsh have been lost to erosion, and feedback exacerbates the problems: with more shore area for people to use and more erosion, since the protective peat of the marsh is gone. Erosion was observed along the edge of the shoreline into the upland on both sides of the point adjacent to the Bridge.

RESTORATION PLAN

To begin solving the problems of unregulated use, salt marsh loss and erosion, a partnership between The Museums of Old York, the Town of York, and the University of New Hampshire was formed. A variety of actions were suggested in an analysis of the problem, including measures to keep the public from using the shoreline, reestablishing the marsh through plantings, and reducing erosion. The Steedman Woods Committee worked to develop and install educational signs identifying the problem and need for the public to help stay off the shoreline. They decided to create trail barriers and cover the stair access points using small rip-rap stones.

Planting and erosion control were split into two phases, with the focus of restoration activities on the Barrell Pond shoreline in 2012 and restoration of the York River shoreline in 2013. The effort to recreate salt marsh habitat at the site included planting a variety of native salt marsh plants. Other restoration actions included placing short stakes to protect each plant and installation of boulders at the seaward edge of the plantings to reduce erosion. Removal of some terrestrial vegetation (overhanging tree branches) was also suggested to reduce shade to the planted areas, but was not included in permitted activities by the Town of York. While the scientific basis for developing an approach to solving erosion problems are well-grounded, specific solutions for developing salt marsh at this site are likely to be somewhat experimental due to high levels of human disturbance (e.g., foot and boat traffic, causeway) and such interactive factors as shading from trees and grazing by snails.

METHODS

Site Description

South of the Wiggley Bridge (York River side) is a small tidally influenced area of shoreline, which is mostly devoid of marsh peat and contains no living vascular plants (Figure 1). Erosion from the York River is clearly evident, likely from daily boat traffic and storms. What little peat is found here is the remnant of marsh that has been eroded away. The sediments consist mainly of inorganic, sandy to gravely areas that are wetter at lower elevations and steadily dry out up gradient. The salinity of the floodwaters is near seawater concentration, around 30 ppt.

Figure 1. Eroded areas on the southern side of the Wiggley Bridge (top) and the northern side (bottom), before restoration.

North of the Bridge (Barrell Pond side), the area is comprised mostly of barren inorganic sediments with small islands of marsh and unvegetated pools (Figure 1). The sediments of the barren areas vary from silt to cobble (Figure 2). The sediment surface is also littered with common periwinkles and their shells. Very little organic matter is found here except in the marsh areas and at the higher elevations where terrestrial soil has been eroded down slope. Islands of existing marsh growing on thin peat deposits are mostly populated by stunted smooth cordgrass (*Spartina alterniflora*), with macroalgae mixed in. Although no motorboat traffic occurs on the Pond side, a strong current flowing under the bridge appears to contribute to erosion. Similar to the river side, the salinity of the floodwaters is also around 30 ppt.

Figure 2. Silt to cobble substrate found in the northern area (Barrell Pond).

York River Restoration

In 2013, UNH scientists installed erosion control structures and transplanted halophytic species. Several rows of wooden stakes (1 by 1 inch) were pounded into the sediment across the entire area where marsh is desired. These 18-inch stakes were left protruding 2-4 inches above the soil surface (Figure 3). Stakes protect plants by reducing foot traffic, wave energy and erosion as well as preventing damage from sheet ice in the winter. In addition to stakes, wave baffles were constructed and deployed (Figure 4). The baffles were constructed of sheets of biodegradable fabric (jute), 4 feet wide, wrapped around wrack that washed up on the Barrell Pond shoreline. These baffles were then staked to the shore in rows. A total of 43 baffles were installed in 4 rows parallel to the shoreline. Lastly, a variety of boulders were moved from the lower intertidal zone and dug into the outer edge and within the planting area. The boulders protect the shoreline from waves caused from boating traffic and storms as well as ice floes in winter (Figure 5).

Figure 3. Wooden stakes used at restoration areas to protect plants.

Several species of salt marsh halophytes were collected and planted on 1-foot centers behind every stake and wave dampening structure (baffles and boulders; Figures 4 and 5). A total of 905 plants were transplanted in the late spring/early summer, including alkali grass (*Puccinellia maritima*), salt hay *(Spartina patens*) and smooth cordgrass (*Spartina alterniflora*). Transplants of salt hay and smooth cordgrass consisted of plugs (approximately 1 by 1 inch), whereas alkali grass was 3" diameter peat pots, each containing several shoots in one planting unit. Each species was planted according to flooding tolerance; smooth cordgrass in the low elevations, salt hay in the mid to high elevations and alkali grass at the high marsh-upland edge. This specific marsh zonation is common and occurs in the existing adjacent marsh to the west, therefore similar elevations were used for the plant zones in the restoration area.

Figure 4. Wave baffle installed to reduce wave energy and erosion. Sand shoreward (left side) and lag deposit of pebbles (right side) of wave baffles.

Figure 5. River planting site with biodegradable wave baffles and boulders.

Barrell Pond Restoration

In 2012, the Barrell Pond side of the point was marked with signs landward and seaward, requesting people keep out of the restoration area. A substantial rope fence was erected along the trail from uplands to the Wiggley Bridge, further directing the public to stay on the trail and not use the shoreline. In addition to reducing human disturbance, over 1200 stakes and 790 salt marsh plants were installed over an area of 10,000 square feet, from the mean tide line up to and slightly over the mean high tide line (Figure 6). Due to the limited area above mean high tide, which was substantially shaded from overhanging trees, over 95% of the transplants utilized were smooth cordgrass. These were planted as bare root plugs landward (behind) wooden stakes. In the fall, 28 alkali grass plants growing in 3-inch diameter peat pots were planted behind wooden stakes at the upper edge of the site, but where shading was less prevalent.

Figure 6. *Barrell Pond planting site with over 1200 stakes and 1100 plants.*

In 2013, The Museums of Old York worked with the Town to add rip-rap to cover the granite stair that further inhibits access to the shore on both sides of the trail (Barrell Pond and York River). Since the survival of the smooth cordgrass planted last year was of concern, a variety of planting approaches were employed at the Barrell Pond shoreline in the spring of 2013 that added over 500 planting units to the site (1298 for 2012-13 combined). Specifically, plant species and planting units were altered as an attempt to increase survivorship. These measures included:

1) A larger proportion of transplants were alkali grass (46% vs. 5% from 2012).
2) Bare root seedlings of smooth cordgrass were replaced by plugs, containing several shoots that limit root disturbance and desiccation. Additionally, larger intact peat blocks were installed at different elevations as an experiment (discussed below).
3) In response to potential grazing by snails, several thousand common periwinkles were removed from the site between late May and early June. Volunteers removed more snails later in June and July. In late June, experimental exclosures (discussed below) were built and snails were periodically removed.

Planting Experiments

In April 2013, addition of smooth cordgrass plants growing in intact peat blocks (4 by 4 inches in area, 6 inches deep) were dug into the sediment on the Barrell Pond side to determine whether existing soil conditions (sandy, rocky, and dry) were too inhospitable for the plants. Using small blocks of peat that had been dislodged from a natural marsh by winter ice, six replicates were planted together at three different locations to determine if adding a thick peat layer along with a mostly intact root system would increase their survival and success. Transplanted peat blocks were placed at a low, mid and high elevation; all within elevations where existing plants were established. These plants were regularly monitored throughout the growing season.

On the Barrell Pond side of the bridge, smooth cordgrass plugs were planted within exclosures to determine if periwinkles were affecting the survival of grass transplants through grazing. Three exclosures, approximately 2 feet in height, were built with water permeable silt fencing to cover a 1 m^2 area in late June 2013. The design of the exclosures also protected the plants from wave and current exposure, so the impacts of snails could only be distinguished from exposure impacts through direct observation. Six smooth cordgrass plugs were transplanted in each exclosure and also adjacent to them as a control (Figure 7). Since there were 3 exclosures and paired controls, 36 total plugs were utilized for this experiment. Plants were evenly spaced (~12 inches) so that they were not touching each other or the exclosure hardware. Plants and fauna (e.g., snails and crabs) were monitored periodically through the growing season to mid October. All invading fauna were quantified and removed from the exclosures during regular monitoring. These two experiments added another 50 planting units (18 peat blocks and 32 plugs) of smooth cordgrass to the site.

Figure 7. Periwinkle exclosure experiment showing 6 plugs of cordgrass planted inside and outside the sediment fencing. Snails were periodically monitored and removed from the exclosures.

RESULTS AND DISCUSSION

The difficult problem of convincing the public that their use has been slowly destroying the site and that they need to keep off the shoreline and stay on the paths seems to have been solved. Through the use of signage, rope fencing along both sides of the path and riprap cover of welcoming access points, trampling of the site by the public has been reduced dramatically. Although we occasionally observed dogs running through the site, we found most of the people that visited the public trails were respectful of the signs and our effort to restore marsh to the eroding shoreline.

York River Restoration

The focus of Phase II was the south side of the point at Steedman Woods along the York River. In 2013, 905 planting units were installed behind approximately 700 stakes and 43 wave baffles. The wave baffles reduce wave energy and also help stabilize the site by catching sediment being eroded into the River. Observations of sediment erosion and movement toward the River seemed greatest following rainstorms that produced small eroding gullies (Figure 8). Significant amounts of sediment collected on the landward side of the wave baffles through the summer (Figure 4). To add another layer of protection from erosive forces, 14 boulders were moved up to the planted area of the shoreline where they help break up waves and currents (Figure 5).

Figure 8. River planting site with erosion gully (center).

Of the 905 plants added to the site, 192 were alkali grass, 103 were salt hay and 610 were cordgrass. Casual observations showed few snails and very good survival through July (Figure 9).

Figure 9. Plantings of smooth cordgrass on York River shoreline in July, 2013.

Survival at the York River shoreline was assessed on September 1 2013. We found 63 alkali grass and 32 salt hay plants alive at the upper planting zones (Table 1). These represented about one third of those planted. The cordgrass had a slightly higher survival rate of approximately 46%. Survival by row for cordgrass was low at upper elevations (33%), but increased gradually to 60 to 70% for the four middle rows before decreasing to 23% for the lowest elevation. Overall, the survival rate was just over 40% for the York River site (Table 1).

Table 1. Plants installed and survival by site, year and species.

Restoration site	Year	Plant Species	Number Planted	Assessed May '13	Survival Rate	Assessed Sept. '13	Survival Rate
York River Shoreline	2013	Alkali grass	192			63	33%
		Salt hay	103			32	31%
		Cordgrass	610			279	46%
		Total	**905**			**374**	**41%**
Barrell Pond Shoreline	2012	Alkali grass	28	22	79%		
		Cordgrass	762	na	1-2%		
Barrell Pond Shoreline	2013	Alkali grass	233			7	5%
		Cordgrass	225			25	14%
		Total	**1248**				

Over 500 snails were removed from the site when it was assessed in September; perhaps snail activity increased in late August and depressed plant survival rates. Figure 10 shows snails at the site and the inset shows the snails surrounding a grazed plant (classified as non-living). While we remain cautiously optimistic for the success of this site, common periwinkles seem to be a real threat (see discussion below) and snail populations will need to be controlled. Snails should be collected and removed from this site beginning in mid April until the threat from snail grazing is passed (early June), and then again in late August through September when snail populations rebound.

Figure 10. Snails return to planting sites in September and damage cordgrass shoots.

Barrell Pond Restoration

Almost 800 plants, the majority being cordgrass, were planted at this site in 2012 (Table 1). Very few of the cordgrass planted in 2012 survived. However, some green shoots did emerge from the 2012 plants, but most appeared to be grazed soon after emergence and did not last long into 2013 (Figure 11). Despite the presence of snails, some plants from 2012 did survive and grow along the upper elevations and adjacent to one of the intertidal pools (Figure 12).

In May of 2013, over 200 alkali grass plants were added to upper elevations since many of the alkali grass planted in the fall survived the winter (79%; Figure 13). In addition, 225 smooth cordgrass plugs were planted in May 2013, generally at upper elevations of the planting site (Table 1). In all, a total of 1248 units were planted at this site (not counting the two experiments, which sum to an additional 50 planting units).

Figure 11. Cordgrass emerging from 2012 planting unit in May, 2013. Note top of new shoot is already grazed.

Figure 12. Cordgrass growing in summer 2013 among stakes established in 2012.

Figure 13. Alkali grass greening up in early spring. Photo taken April 24, 2013.

Planting Experiments

The poor plant survival in 2012 may have been due to dry, rocky conditions found at the Barrell Pond site, so a small experiment was set up in April. Six peat blocks (4 by 4 inch planting units) were placed together at three different locations (18 units in all) to determine if adding a thick peat layer would increase their survival and success. These plants never seemed to have good success. Even though plants put up new shoots through June, high snail densities may have resulted in plant death from grazing as the new shoots emerged from the peat. In May, newly planted cordgrass shoots were seen damaged by grazing snails (Figure 14) and we observed that some plant leaves were also shredded, perhaps by green crabs. New shoots that had been observed expanding from the existing marsh edges last fall (reported in Phase I, 2012) were grazed in 2013, and newly denuded edges of existing marsh indicated the existing marsh is shrinking (Figure 15).

Figure 14. Visible signs of grazing are marked with circles and include lesions, dead leaf tips and cracked leaves.

In response to the snail threat, over 14,000 of the common periwinkles were removed from the site between late May and early June. However, the snails appear to be replaced in a matter of days by an endless source of more snails. Volunteers removed more snails later in June and July, and at this point in the season the snail populations subsided, perhaps due to desiccation stress during hot summer days. Snails returned at high densities in September, as the weather cooled (Figure 16).

Figure 15. Edge of existing marsh at Barrell Pond in 2012 (thin black line) derived from position of stakes that were placed approximately 12 inches from marsh edge in 2012. Compare with marsh edge in 2013 (thick gray line). Vegetated marsh is retreating to right.

Figure 16. Snails have returned to planting site in Barrell Pond in fall, 2013.

In June, an exclosure experiment was set up to test whether protecting plants by sediment fencing might help protect the plants from snails and physical exposure to waves and currents. Cordgrass plugs were planted within three exclosures and directly outside each exclosure for comparison (36 plants total). Exclosures kept out most snails through July, with about 10 snails distributed within the three exclosures on each of three return visits. In late July, we observed that all 18 plants were alive (15 were growing vigorously) within exclosures, but the outside control plots had three dead plants (Figure 17), with few appearing to be healthy. On our next visit on September 1st, snail densities had increased dramatically, and about 100 snails were found within each of the two lower elevation exclosures. By September, it was clear that plants at the highest elevation plot experienced less snail pressure. There were no snails found and all plants were alive in the exclosure, while five plants were still alive in the control. In comparison, 11 of the 12 plants were alive in the two lower exclosures, but only 2 of 12 plants survived outside the exclosures (Figure 17).

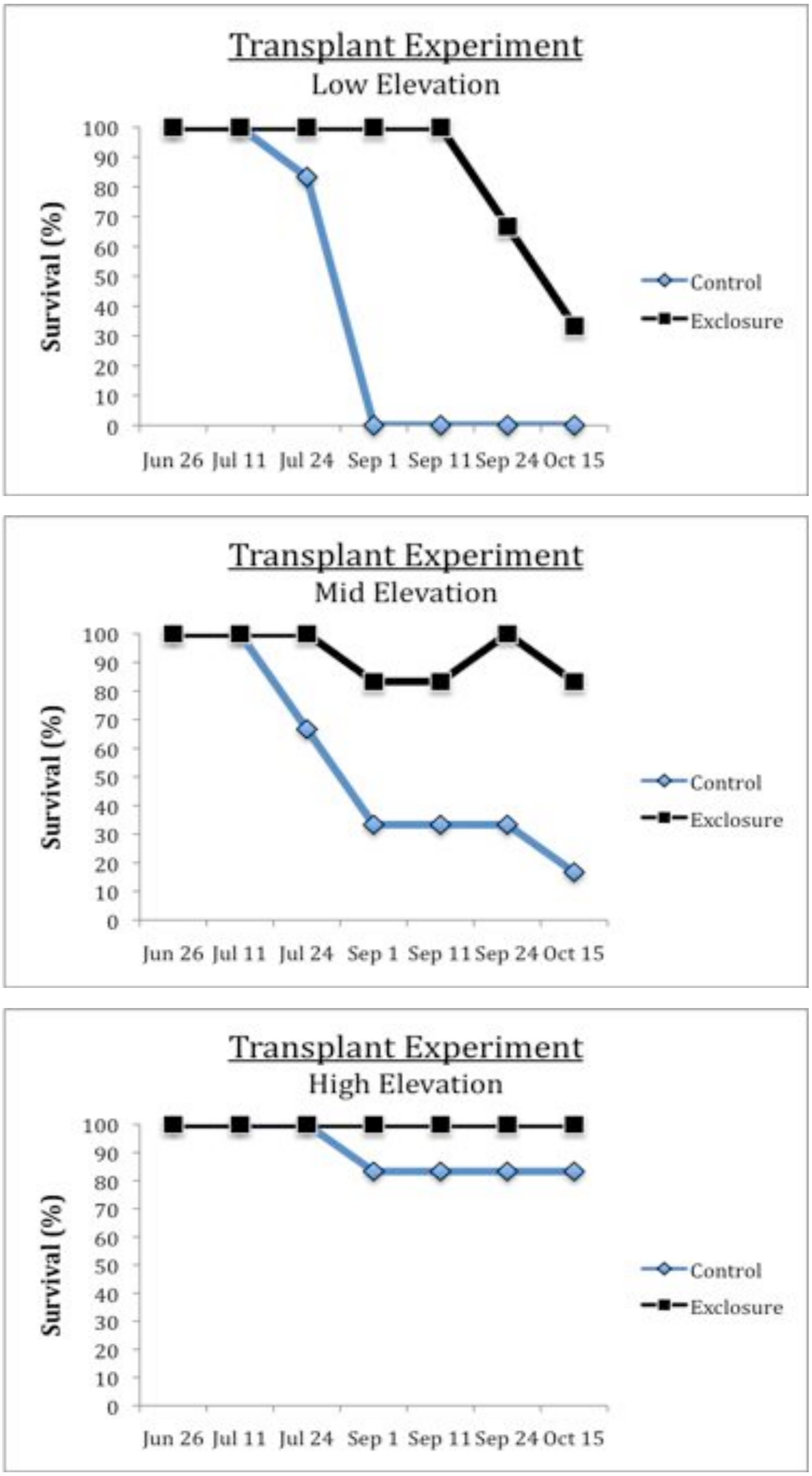

Figure 17. Survival of corgrass planted June 26th within snail exclosures and adjacent to them (controls) at three elevations. Each plot was planted with six plugs of cordgrass.

We began to count snails outside as well as inside the exclosures in September, and we found about half the snail numbers within exclosures (Table 2). Even though the snails returned and got into the exclosures, the reduced snail numbers were associated with better plant survival and health, and this trend continued until sampling ended October 15th (Figure 18).

Table 2. Survival of cordgrass plants along with snail and crab numbers assessed 24 September 2013 in the snail exclosure experiment. In parentheses is the total number of snails or crabs found in each plot from September 1 to October 15, 2013.

Treatment	Elevation	Survival	Snails	Crabs
Control	Low	0.0%	63 (222)	0 (0)
	Mid	33.3%	76 (334)	0 (0)
	High	83.3%	3 (150)	0 (0)
	Total		**142** (706)	**0** (0)
	Average	**38.9%**		
Exclosure	Low	66.7%	37 (205)	0 (2)
	Mid	100.0%	32 (214)	0 (1)
	High	100.0%	3 (19)	0 (3)
	Total		**72** (438)	**0** (6)
	Average	**88.9%**		

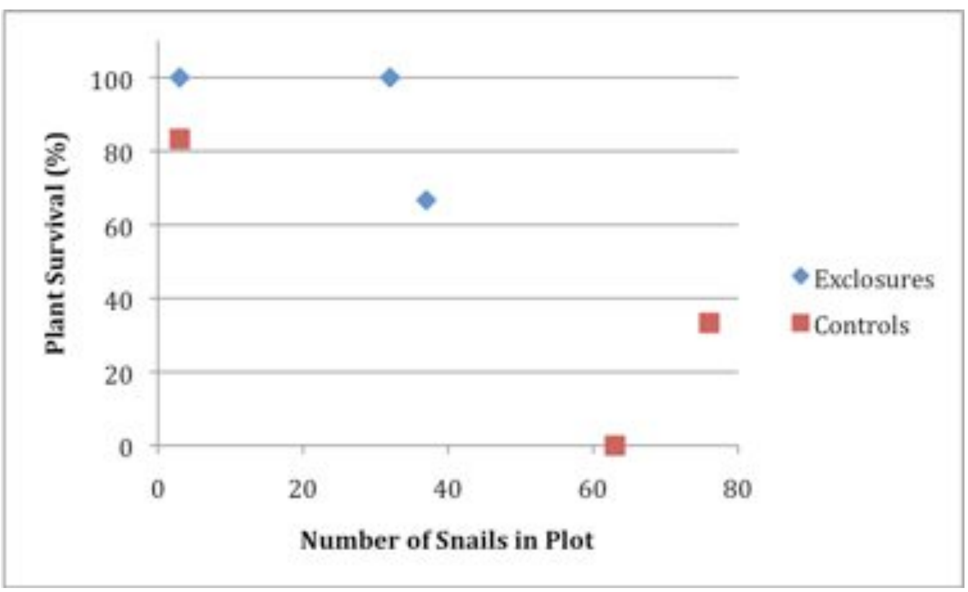

Figure 18. Relationship between snails and cordgrass survival in exclosure experiment.

It is well established that the marsh periwinkle, *Littoraria irrorata*, is an important grazer of cordgrass in the salt marshes of the southeastern US (Silliman and Zieman 2001, Silliman and Bertness 2002). These snails are fungal farmers, scraping the cordgrass leaves with their radula to allow fungus to attack the plant, then returning to consume the fungus (Silliman and Newell 2003). Scientists working in South Carolina, found extensive grazing by marsh periwinkles did not reduce plant production (Kiehn and Morris 2009). So it seems while grazing may be important in some marshes, it does not seem to control cordgrass production in all marsh systems.

An examination of the common periwinkle, *Littorina litorea*, along a rocky New England shoreline containing small sections of cordgrass-dominated salt marsh was carried out 30 years ago. The snail, considered exotic, grazed plant stems and rhizomes (new shoots), thereby limiting marsh expansion where snails were not removed (Bertness 1984). More recently, a team of researchers in Wells, Maine reexamined the role of the introduced snail (Tyrrell et al. 2008). They found *L littorea* reduced biomass of cordgrass growing in stressful conditions but not in a marsh where physical conditions were benign. The difference was similar to the differences between the work of Silliman and Zieman (2001) and Kiehn and Morris (2009) and was in accord with our results on Barrell Pond: low-density marshes were more susceptible to damage from snails, especially at lower elevations (Figures 17 and 18).

We had thought that the severity of dry, rocky soil conditions with low organic matter might result in dessication stress to cordgrass as found by others (Stagg and Mendelssohn 2001). However our planting experiment using peat blocks did not improve survival, suggesting drier soil conditions did not negatively affect the planted cordgrass. In contrast, our exclosure experiment showed the lower elevation sites that were wetter were associated with greater plant mortality.

The mechanism of grazing to enhance fungal infection was inferred by the Wells research team, both from grazing experiments (Tyrrell et al. 2008) and the previous work in the southeast done with the marsh periwinkle (Silliman and Newell 2003). Tyrrell and colleagues concluded that grazing by the snail could significantly reduce the biomass of a pioneer marsh plant, such as those of our planting effort. Unfortunately a critical component of our marsh restoration effort depended upon the survival and proliferation of low-density cordgrass plantings. Our observation of the almost total loss of plants at the Barrell Pond planting site in 2012 and 2013 was unexpected and greatly disappointing. However, given the number of common periwinkles found at this site, the result is not surprising in retrospect.

It is not uncommon to find ecological barriers to restoration of a previous condition (Scheffer and Carpenter 2003) including salt marshes (Jefferies et al. 2006). Here at Steedman Point, erosive forces and human use of the beach were controlled by restoration actions, but snails and shade were not uncontrolled and presented formidable barriers to reestablishing a feedback system where marsh could establish and prosper into the future. At Barrell Pond shoreline, the sediment surface appears to be stabilized and direct human impacts have been substantially reduced. Future efforts should focus on snail control to preserve and encourage expansion of existing marsh fragments as well as protection of future plantings. Future planting should focus on high-density plantings of species less susceptible to grazing coupled with barriers to exclude snails from planted areas. A common material of galvanized steel mesh, called hardware cloth, has been recommended (Bertness 1984). In addition, overhanging trees shade the upper marsh from mid-day to evening and reduction in shade should be reconsidered for future restoration efforts.

Along the York River shoreline, efforts to discourage human use and control erosion have been effective. Some erosion is still evident, but it has been reduced by the wave baffles, stakes and boulders. The threat from snails is much lower on this side of the Point, but it is still significant. Plant survival was good, but not great, and further efforts to encourage the development of the marsh will need to include snail removal in spring and late summer for several years. The site may also need more erosion protection or maintenance of structures already in place, depending on the condition of the site in spring 2014. For example, the wave baffles should be assessed and replaced if needed following the winter. The restoration activities in 2013 were successful in establishing and protecting plants and we are cautiously optimistic for the future development of the marsh.

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