SALT MARSH RESTORATION TECHNIQUES AND RESEARCH AT PARKER RIVER NWR

INTRODUCTION

Multiple studies, models, and expert opinions predict that salt marshes in Plum Island Sound, which are currently dominated by high marsh, will increasingly shift toward low marsh and open water (Langston et al. 2020). In 2012, refuge staff began noticing various changes suggestive of such a trend. Changes include (1) shift of high marsh habitat (*Spartina patens*) to low marsh habitat (*S. alterniflora*); (2) increased inundation of significant portions of marsh driven by wind and tides; (3) enlarging salt pools; (4) more algal mat growth in pools and mudflats; (5) draining of some pools; and (6) ponding of marsh surface in between ditches. While change is inevitable, and healthy habitats and wildlife are resilient, the rate of sea level rise and other anthropogenic alterations are compromising the natural resilience of this system. Parker River NWR and partners are piloting multiple strategies to address these stressors in hopes of improving the salt marsh's ability to adapt to climate change.

Below is a summary of each technique and findings from the pilot studies thus far. We also describe some of the natural adaptive processes we have observed in the salt marsh, which inform restoration efforts.

RESTORATION TECHNIQUES

Runneling

Rationale: Due to sea level rise combined with historic marsh alterations, pools are enlarging, and excessive water is remaining on the marsh surface. In some areas of particular concern, algal mats have also killed adjacent high marsh vegetation (*S. patens*). Unaddressed, excessive water and vegetation dieback can lead to peat decomposition and loss of large marsh units, as seen in Rhode Island. Runneling allows these highly saturated areas to drain adequately and regrow vegetation.

Methods**:** Using a hand spade or low pressure equipment, we created shallow runnels to connect areas of standing water with an adjacent ditch or creek to encourage drainage. In 2015, we also experimented with hand transplant of *S. alterniflora* to facilitate vegetation growth along the edges of drained pools.

Results to Date**:** Runneling was effective in partially draining pools and exposing pool edges (particularly during neap tides). Following runneling, both *S. alterniflora* and *S. patens* began to recolonize exposed pool edges within a few months. Single-season survival of transplanted *S. alterniflora* ranged between 45 and 85 percent at two experimental sites (Burdick et al. 2017). However, recolonization also occurred quickly in the absence of transplants, indicating the additional effort and disturbance is unnecessary. Vegetative cover also increased substantially the year after runneling.

In the example below, about 60 percent of the large pool is drained through the runnel, creating multiple smaller pools.

Figure 1. Aerial photo of a megapool prior to runneling (left, 2013O and after runneling in 2015 (right, 2019)

Ditch Plug Removal and OMWM Modification

Rationale: Ditch plug removal is a type of runneling specifically used to address Open Marsh Water Management (OMWM) infrastructure. Mosquito control legacy infrastructure includes both ditches (initially intended to drain water off the marsh surface) and ditch plugs (designed to keep water on the marsh surface) for the purpose of mosquito control and/or to benefit fish and waterfowl. With sea level rise and increased inundation, OMWM infrastructures are now accelerating marsh conversion (high marsh to low marsh) and degradation by holding excessive water on the marsh surface. Ditch plug removal and OMWM modification eliminate the man-made structures that impound water, allowing appropriate drainage and regrowth of vegetation.

Methods: Initially, we used a radial ditcher to breach ditch plugs and spread removed sediment evenly across the adjacent marsh surface. We later used hand spades or low-pressure excavation equipment to remove or modify ditch plugs. OMWM modification involves the same set of equipment, but rather than removing the plug entirely, we remove the top 25-30 cm to preserve biological control of mosquitos. In some cases, we spread out the sediment removed from ditch plugs; in other cases, we created small microtopography islands (discussed below).

Results to Date: Ditch plug removal quickly drained flooded areas, as indicated by water loggers. Immediately after removal, water drained from the marsh almost 20 cm more than during pre-restoration. Vegetation also recolonized mudflats quickly. In vegetation plots near ditch plug removal sites, bare mud slightly decreased while *S. alterniflora* slightly increased during the first two years following restoration. However, the scale of marsh response and revegetation was best captured through aerial imagery and photo stations. (See example projects below.)

Example: In May 2017, we removed two ditch plugs near the north end of the Salt Pannes Observation Area, a high visitor use area along the Refuge Road. The plugs were impounding water on the marsh surface, creating new pools and killing vegetation. After removing ditch plugs, the pools drained almost immediately. Within two years, the pools and surrounding areas were densely vegetated with a combination low marsh and high marsh species.

Figure 2. Arial and on-the-ground imagery of the ditch plug removal site north of the Salt Pannes before and after restoration in May 2017. Aerial images are from Google Earth.

Runnel Results on Salt Panne Hydrology

In May and June 2019, we also removed several ditch plugs to connect the main Salt Pannes directly to tidal creeks. The Salt Pannes historically supported shorebirds, but recent pool expansion and extensive algal mats limited foraging opportunities and caused vegetation dieback. By the summer of 2020, the Salt Pannes had a predictable tidal hydrology, flooding during spring tides and draining during neap tides to expose mudflats. We frequently observed flocks of shorebirds roosting and foraging in the Salt Pannes around neap tides.

Microtopography Islands

Rationale: Microtopography islands increase marsh elevation in small patches using spoil from ditch plug removal. Marshes will need to increase in elevation in order to keep pace with sea level rise and to support salt marsh sparrows, which nest on the marsh surface and are therefore vulnerable to tidal flooding. Microtopography islands are small, but they may inform future restoration efforts on a larger scale. For example, sparrow activity and vegetation changes on and around microtopography islands may predict responses to broader thin layer deposition projects.

Methods: After removing or modifying ditch plugs using a low pressure excavator and hand tools, we mounded the excess sediment into small “islands” of higher elevation on the marsh surface. Islands were round, donut-shaped, or c-shaped. Dimensions were variable, but each island had a footprint of approximately one meter square. We located the islands in areas of low marsh adjacent to restoration areas, limiting the need to transport the sediment over long distances. We used laser levels to ensure that the island elevation never exceeded the maximum elevation of the surrounding marsh, increasing the likelihood that the islands would be colonized by marsh vegetation rather than upland vegetation or invasive species.

Results to Date: We constructed microtopography islands in 2019, and each island was mostly or completely vegetated by the summer of 2020. We did not need to directly seed any of the islands. They were primarily colonized by desirable high marsh species (*S. patens*) and appeared potentially suitable for saltmarsh sparrow nesting. Although we observed saltmarsh sparrow activity around the islands, we did not detect any nests, and we are unsure whether these higher elevation patches could increase predation risk.

Example: In this example below, the microtopraphy island was vegetated with 60% S. alterniflora and 40% S. patens 3 months after creation. The following year, the vegetation was 80% S. patens and 20% S. alterniflora, with 60% thatch. It supports the vegetation structure and elevation to support nesting sparrows.

Figure 3. Microtopography island in the sub-HQ marsh, showing quick revegtation and development of vegetation structure capable of supporting nesting salt marsh sparrow.

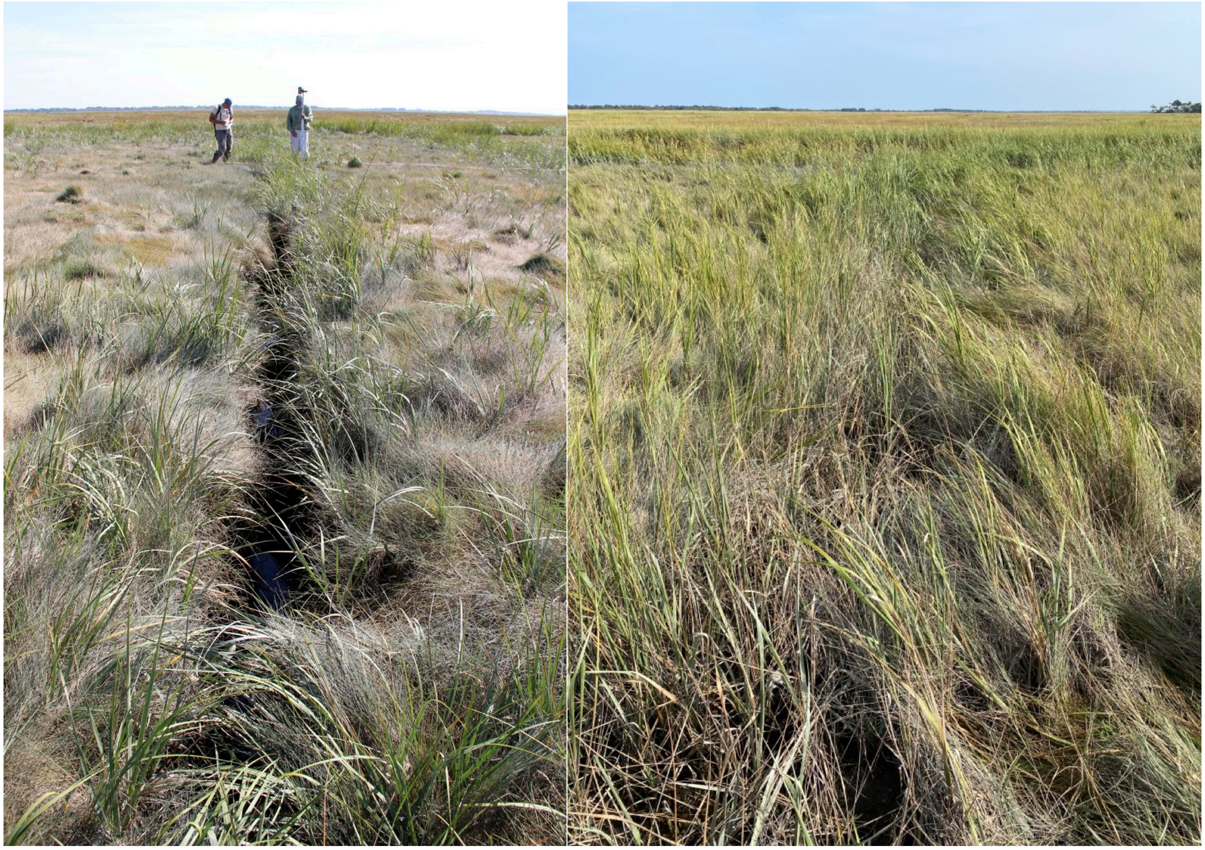
Ditch Remediation

Rationale**:** In northeastern salt marshes, natural tidal creek hydrology was largely replaced by extensive drainage ditches, particularly for mosquito control in the 1900s. However, some historic ditches have collapsed or clogged, preventing drainage and impounding water. With increased flooding and inundation, pools of standing water are also forming between ditches and killing vegetation. Additionally, ditches are associated with significant marsh subsidence caused by peat decomposition and lack of accretion (Burdick et al. 2020). Ditch remediation "heals" select ditches through the addition of hay, facilitating vegetation growth and peat development within each channel. By directing tidal flow into a smaller number of primary channels, we can create a more natural pattern of tidal flow. Lower ditch density should also reduce sedimentation and clogging in ditches that remain open.

Methods: Near the end of the growing season, we mowed salt marsh vegetation adjacent to each target ditch using a brush mower. We then air dried the cut "hay" overnight and loosely braided it. We added a 15-20 cm thick layer of braided hay to the bottom of each ditch, compacted it manually, and secured it with twine and wooden stakes. Use of on-site hay avoids the introduction of invasive species and limits impacts from transporting material across the marsh. In the future, we plan to implement a second phase of ditch remediation at the pilot sites (remediated between 2014 and 2016) to fine tune new hydrologic dynamics, address inundation in the adjacent marsh platform, and accelerate redirection of water to selected open ditches. See Burdick et al. (2020) for additional details on methods, monitoring, and results.

Results to Date**:** Over the first three years following ditch remediation, treated ditches became shallower and more vegetated. The only species that colonized remediated channels was *S. alterniflora*, which increased in percent cover and stem density. Some small, shallow ditches have completed healed and is colonized by S. patens. Most ditches are colonized by S. alterniflora and are 20-30 cm below marsh surface. In our earliest pilot sites, there is marsh platform inundation in between the healed ditches. These areas will be advanced, using runnels to create the single-channel hydrology. Ditch Remediation technique has been adapted in the later treatments to avoid inundation of adjacent marsh platform.

Example:



NATURAL ADAPTIVE PROCESSES

Sediment Deposition

Description: Large volumes of sediment sometimes settle on the salt marsh surface during storms. A particularly large sediment deposition event occurred in the winter of 2018, when ice rafts froze to the mudflats in Plum Island Sound and then drifted onto the adjacent marsh (Figure XX). The ice rafts deposited more than 24 ha of sediment at an average depth of approximately 26 mm, nearly ten times more than the background accretion rate (Moore et al. 2019). This event provided a unique opportunity to assess the impacts of large-scale sediment deposition on the salt marsh and inform potential restoration efforts. Specifically, natural sediment deposition events are similar to “thin layer deposition,” a marsh restoration technique utilized mostly in the Mid-Atlantic but not in New England. Thin layer deposition applies dredged material directly to degraded marsh surfaces to increase elevation and resilience.

Figure 5. Photos of the sediment deposition site taken from a similar vantage point in May 2018 (left)and September 2018 (right).

Sediment core taken in November 2021 show vegetation growing through thick sediment deposit. Core taken from area that was deposited with 20+cm of mineral soil from mudflats, that is now covered with thick S. patens.

Results to Date: Following the 2018 growing season, the percent cover of vegetation was significantly lower in sediment deposit areas compared to control areas (Moore et al. 2019). However, percent cover still exceeded 70%, and species composition did not change, suggesting negative impacts to marsh vegetation are short-lived (Moore et al. 2019). Soil conditions were also similar in sediment deposit and control areas (Moore et al. 2019). Site visits with David Burdick in 2021 found that the vegetation community has transitioned from one dominated by Distchilis (early successional species) to a mixed high marsh composition, including thick S. patens patches. Soil samples showed nice root zone formation, and no signs of biogeochemical concerns. Additional monitoring of this event will help with future sediment deposition actions, if needed.

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