Salt Marsh Conservation and Adaptation in Allens Pond: A Case Study in Buzzards Bay

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SUMMARY: The salt marshes around Allens Pond demonstrate how historic alterations and current stressors are degrading salt marsh habitat throughout the Northeast U.S. They are also illustrative of the multiple strategies at different scales that can be used to facilitate adaptation in order to retain valuable salt marsh habitat. This report describes the existing conditions and stressors facing this marsh and the various conservation activities undertaken by multiple organizations and agencies.

1. Background

Coastal wetlands including salt marshes are critical ecosystems providing benefits to fish and wildlife, invertebrate animals, and people through resource provisioning, water quality improvement, and coastal defense (Fig. 1). Salt marshes around the world, and especially in the Northeast U.S., are experiencing rapid loss as a result of complex, interacting factors. Accelerating sea level rise is the primary stressor for southeastern New England marshes. Higher high-tides increase the frequency and length of inundation. As a result, soils become waterlogged, and plants become stressed and begin to die back. While some marshes have the natural ability to increase their vertical elevation at the same pace as sea level rise, many marshes in southeastern New England do not have this capacity. This is because these marshes are experiencing especially high rates of sea level rise, have low suspended sediment supply in flooding waters, and are not vertically accumulating biomass at a sufficient rate to match rising seas.

Figure 1. Salt marsh at Ocean View Farm within Allens Pond provides habitat and resources for people and animals, including the threatened species Saltmarsh Sparrow (nest shown here). Photos: Alice Besterman

Horizontal migration of a salt marsh can compensate for an inability to vertically accrete — with the marsh moving inland as an alternative adaptation to sea level rise. Migration is possible where there is a gentle slope between marsh and adjacent uplands. However, in New England the transition between marsh and upland is too steep in many places to allow migration. Along many coastlines hardened infrastructure has been placed into this migration zone, including walls, roads, and buildings, further limiting migration. Rising seas and hardened infrastructure create a "coastal squeeze" on salt marshes, leading to erosion and reducing capacity for adaptation.

Marsh loss is exacerbated by interactions between sea level rise and historic modifications made to marshes by people. Modifications including ditches, "open marsh water management", culverts, and agricultural infrastructure such as embankments have altered the fundamental shape and structure of marshes. Interactions between sea level rise and these modifications can lead to ditch expansion and conversion of vegetated marsh to shallow water areas (Fig. 2).

Figure 2. Types of marsh loss affecting southern New England marshes: ditch expansion (left), interior shallow water expansion (center), edge or bank loss (right). Photos: Rachel Jakuba, Alice Besterman, and Chris Neill.

Other stressors also negatively impact marshes. Nitrogen from agriculture and sewage enters estuaries and floods marshes, decreasing marsh resilience. High nitrogen can enhance microbial decomposition, oxidizing the organic peat in marshes which provides critical elevation capital. High nitrogen also leads to a weakened root structure, and marsh edges can fracture and cleave off as a result. Marsh edges can erode from wind-waves that undercut banks and lead to marsh cleaving (Fig. 2). An overabundance of herbivorous crabs has degraded some New England marshes. There is additional concern among resource managers that extensive burrow networks created by crabs might weaken soil structure in areas where vegetation is stressed or has already died back.

Addressing the problem of marsh loss requires an adaptive, systems approach that considers multiple stressors acting at different spatial and temporal scales. Individual conservation organizations must decide how to invest limited resources, and therefore which marshes and which stressors are most critical to address. Partnership and collaboration provide a mechanism to tackle multiple issues at once. In Buzzards Bay, multiple organizations and agencies working across southern New England have partnered to conserve, adapt, and restore a large salt marsh complex in Allens Pond. In this short report we detail the existing conditions and stressors facing this marsh, the various conservation activities undertaken, and the rationale behind decisions.

2. Allens Pond: Current Condition

Allens Pond is a back-barrier salt pond connected to Buzzards Bay by a narrow tidal inlet (Fig. 3). The marsh in Allens Pond is one of the largest contiguous systems of salt marsh in Buzzards Bay. In addition, it provides some of the most important habitat for Saltmarsh Sparrows in Buzzards Bay, and is used by other marsh-dependent wildlife such as Willet, Diamondback Terrapin, and Seaside Sparrows. The marsh is surrounded by extensive, low-lying, and mostly undeveloped upland and agricultural hay fields.

The salt marshes in Allens Pond exhibit signs of stress similar to many southern New England marshes. The vegetation and elevation within the Ocean View Farm marsh (main focus of this report, Fig. 3) has been studied in detail (Jakuba et al. 2022), and is likely similar to marshes across the Allens Pond complex. Ocean View Farm is dominated by the “low marsh” species *Spartina alterniflora* (73% relative cover), while “high marsh” species less tolerant of flooding (*Distichlis spicata, Juncus gerardii, Spartina patens*) represent only 27% relative cover.

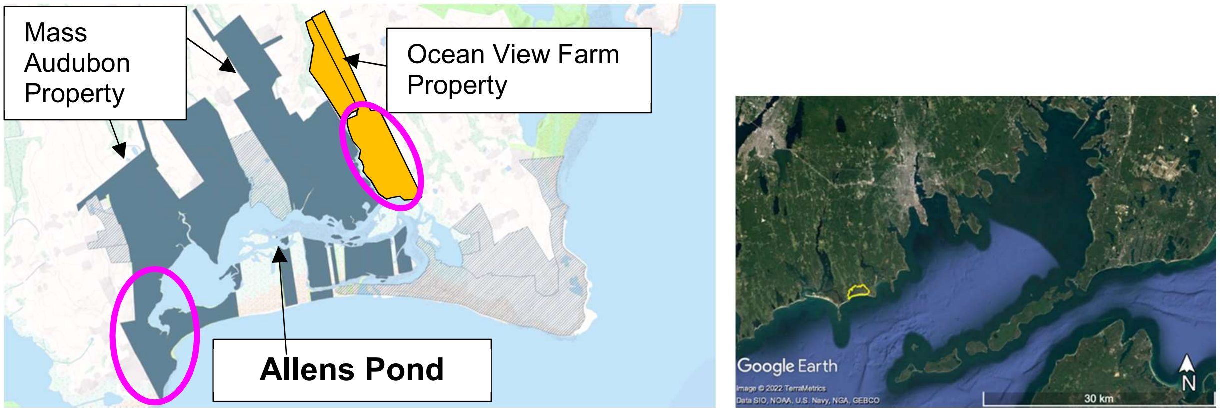

Figure 3. Left: Map of Allens Pond properties and focal zones for conservation. Blue-gray polygons show Mass Audubon-owned properties, the gold polygon shows the Ocean View Farm property with parcels owned by Dartmouth Natural Resources Trust and Round the Bend Farm outlined (boundaries approximate). Magenta circles show the conservation focus areas within Ocean View Farm (upper right) and the western side of Allens Pond (lower left). Map adapted from Mass Audubon Land Conservation StoryMap. Right: Buzzards Bay with Allens Pond marshes outlined in yellow.

The marsh surface is 84% vegetated, with 16% covered by bare peat or shallow water. The Buzzards Bay Coalition (BBC) is currently studying marshes around Buzzards Bay, and the vegetative cover at Ocean View Farm is below the 25th percentile of these marshes. The marsh sits at a relatively low elevation, with only 53% of the platform above mean high water (based on field surveys of elevation). This elevation also places Ocean View Farm below the 25th percentile of marshes around Buzzards Bay.

Despite current conditions at Ocean View Farm, the marsh remains an ecologically important resource. As a result, multiple conservation organizations have recognized Allens Pond as a priority salt marsh within Buzzards Bay for conservation and adaptation projects. These projects address stressors with scale-specific conservation strategies operating at three levels: a watershed-scale inclusive of the entire Allens Pond sub-estuary and sub-watershed, a landscape-scale inclusive of the marsh and its surrounding upland habitats, and a marsh-scale inclusive of the marsh platform (Fig. 4). Organizations have worked individually and in collaboration to tackle multi-scale stressors through land protection, watershed management, and adaptation and restoration.

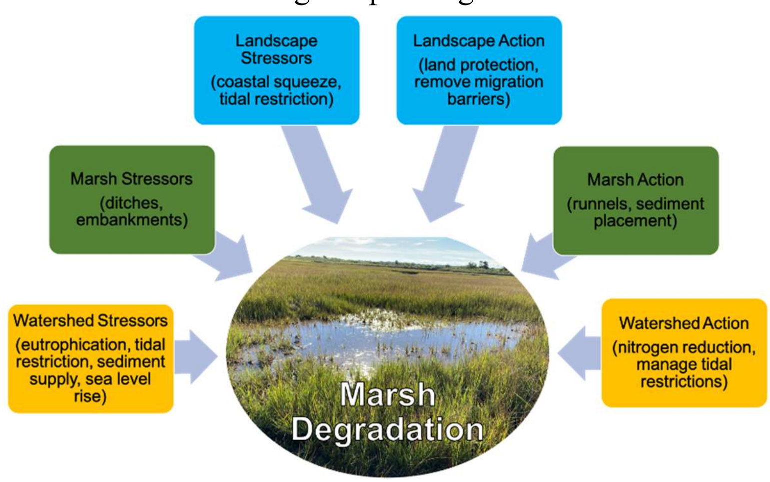

Figure 4. Main stressors on southern New England marshes at three spatial scales (watershed, marsh, landscape), and examples of conservation strategies applied at these same three scales. Note tidal restrictions can stress marshes at a landscape scale (e.g., undersized culvert), or at the scale of a watershed (tidal inlet).

3. Land Protection

Land protection is a critical first step in conservation for watershed, landscape, and marsh scales. Mass Audubon has been growing the Allens Pond Wildlife Sanctuary for decades by acquiring donated parcels of land and establishing conservation restrictions that provide permanent protection for conservation values. The Ocean View Farm property was a key missing piece of protection within Allens Pond. When this property became available for purchase, BBC led a fundraising effort so collaborating organizations could buy the land, and create conservation restrictions. Ownership was transferred and conservation restrictions went into place in 2017. The property includes two parcels, one owned by Round the Bend Farm, and one by Dartmouth Natural Resources Trust (DNRT) (Fig. 3). The conservation restriction for the Round the Bend-owned parcel is held by BBC, and BBC and the Town of Dartmouth jointly hold the conservation restriction on the DNRT-owned parcel. Ocean View Farm includes marsh and upland habitat within the Allens Pond system. Protecting and conserving uplands adjacent to salt marsh is important for enabling marsh migration. The slope between Ocean View Farm marsh and adjacent upland is favorable, so protecting this upland has created an opportunity for migration. Upland land protection mitigates future potential risk from development, including stressors operating at larger spatial scales such as nitrogen-loading.

4. Watershed Management

Conservation strategies applied at a watershed-scale can reduce stress for all of the marshes within that watershed. While the effects of these conservation strategies may be less obvious than in-marsh restoration, they are equally important as a way to reduce stress (e.g., eutrophication, tidal restrictions), and bolster resilience (land-use change, tidal inlet management). For example, land-use change can be an effective tool to reduce nitrogen-loading within a watershed. And while tidal restrictions may apply to smaller-scale features such as undersized culverts, in Allens Pond the entire watershed is affected by the management of the inlet connecting the pond to Buzzards Bay.

4.1. Land Use

After DNRT took ownership of Ocean View Farm they transitioned land-use practices on the property. Previously, the upland was used for traditional agriculture (corn, with fertilizer use). In April 2018 DNRT converted fields from corn to hay (seed mix of 40% alfalfa, 45% timothy, 15% clover), and ceased any use of fertilizers. Mowing was only practiced twice per year, after nesting season to allow fields to be used by migratory birds such as Bobolink. Land use change stopped inputs of nitrogen from this property that would have resulted from traditional agriculture. The vegetation changes also provided habitat for songbirds and other wildlife. A second phase of conversion is underway now, with the goal of facilitating marsh migration. This is described in Section 5.2 below.

4.2. Inlet management

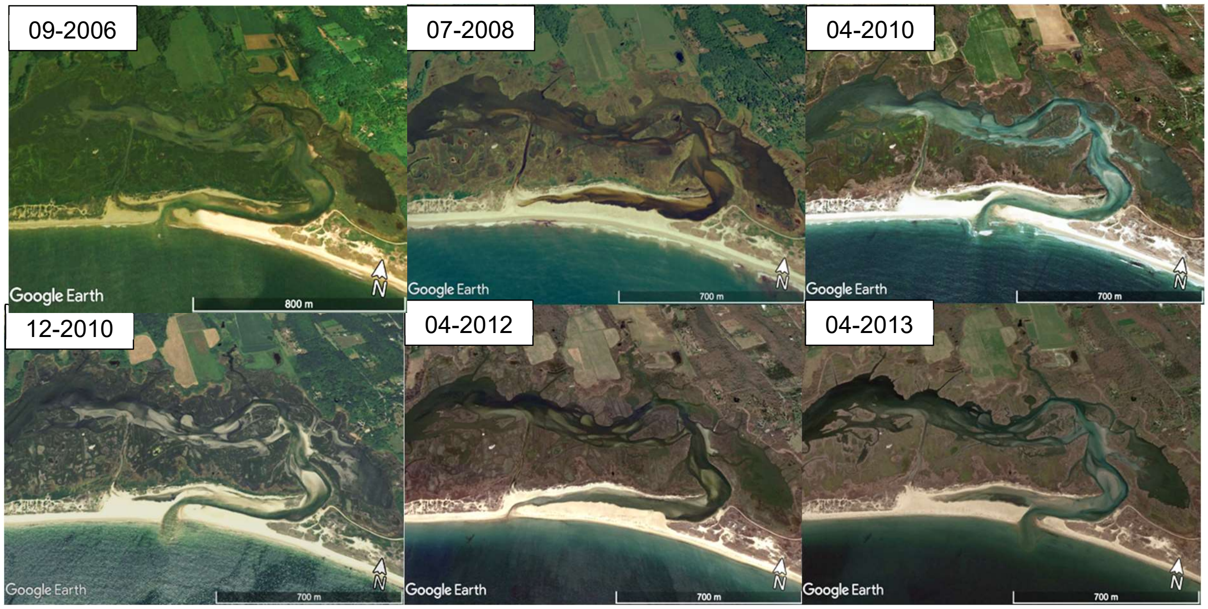

Figure 5. Time series of inlet closure and reopening. Full closures occurred in 2008, 2013, 2017, and 2021. The inlet is reopened at the eastern end of the barrier spit; it then migrates west, narrows and closes.

The tidal inlet presents one of the most direct threats to the salt marshes in Allens Pond; restricted tidal flow into and out of the pond can lead to the system holding water and stressing plants. This process would be stressful on its own, but in interaction with sea level rise presents a serious threat to Allens Pond marshes. The inlet naturally closes every few years and must be dredged to reconnect the pond to Buzzards Bay (Fig. 5). Based on existing documents, current managers believe the inlet has been managed by the local community and Town of Dartmouth cyclically for around 100 years. This cycle may be speeding up (thought to historically occur every 5–8 years, but more occurring every 3–5 years). Current management is led by the Allens Pond Association, a homeowner's group, and Mass Audubon who assists with the reopening and monitoring needed for permits.

Managing flow through the inlet is necessary for conserving salt marsh habitat in Allens Pond. Early in 2008 a full closure occurred, and the inlet remained closed through the growing season (Fig. 5). Back-barrier areas flooded from April through October. The consequences were dramatic[1]. Piping plover nesting was < 25% of a typical year (unpublished data, Mass Audubon), and Saltmarsh Sparrow, Seaside Sparrow, and Willet populations declined. Mass vegetation die-off occurred in the back-barrier salt marshes. It is unknown the exact extent of die-off, and how much of the Ocean View Farm marsh was lost — but the die-off included much of the low marsh throughout the Allens Pond complex. It took around 3 years for vegetation to recover. Saltmarsh and Seaside Sparrow populations took several years to recover. Mosquito breeding increased significantly during the closure, creating public health concerns. Given the ecological and public health importance of managing the inlet, several organizations and regulatory agencies have been

[1] Buchsbaum, R. 2021. Responses and Recovery of Salt Marsh Vegetation and Birds in Southeastern Massachusetts to Two Hydrologic Events: a Tidal Restoration and an Inundation Event. *Estuaries and Coasts*. https://doi.org/10.1007/s12237-021-00918-1

engaged in conversations about how to streamline permitting and ensure sustainable management of the inlet. Since the inlet was reopened in late-2008, it has fully closed and been reopened three times (2013, 2017, 2021).

5. Adaptation and Restoration

Direct techniques can be used within the marsh complex and in adjacent upland areas to help restore salt marsh ecological function and adapt marshes to changing environmental drivers (e.g., climate change). At Ocean View Farm, and other marshes within Allens Pond, adaptation and restoration activities are underway both within the marsh (e.g., runnels to facilitate vegetation and hydrologic restoration), and in adjacent uplands (e.g., vegetation management, runnels to facilitate migration).

5.1. Marsh Platform

Across Allens Pond, marshes are experiencing interior shallow water expansion. On the DNRT-owned Ocean View Farm in-marsh conservation activities have focused on hydrologic restoration. BBC, working in collaboration with Woodwell Climate Research Center (Woodwell), Save The Bay (Narragansett Bay), and Bristol County Mosquito Control Project created runnels to drain surface water (reducing plant stress and mosquito-breeding habitat), and restore tidal hydrology and vegetation in 2020. In addition to creating runnels, clogged ditches were cleared to improve drainage, but only to the depth of a runnel (~ 12”). Runnels and ditch maintenance are also planned for the Mass Audubon-owned western side of Allens Pond (Fig. 3). Sites were selected according to the characteristics listed in Table 1 (Fig. 6).

Figure 6. Wenley Ferguson, Director of Habitat Restoration at Save The Bay, performs initial assessments at a shallow water area, measuring depths across the feature and testing the texture and firmness of the underlying peat. Photo: R. Jakuba.

Figure 7. Creation of runnels at Ocean View Farm. Top and Bottom Left: Bristol County Mosquito Control operator creates a runnel with a low-ground pressure excavator. Bottom Center: Staff and volunteers hand-dig a runnel. Bottom Right: Wenley Ferguson hand digs a runnel. Photos: R. Jakuba, A. Besterman, W. Ferguson.

Table 1. List of characteristics used to select runnel sites within Allens Pond marshes.

Marsh Characteristic	Good Candidate	Poor Candidate
Shallow water areas	• Impounded shallow water area is firm, with intact peat • Evidence of recent formation • Evidence of horizontal spread/expansion	• Impounded shallow water area is soft and covered with layer (>15 cm) of unconsolidated material • Evidence of older formation (40+ years) • Stable border, no signs of horizontal spread/expansion
Microtopography and water flow	• Embankments, levees, ditch spoils, and/or ditch plugs that create barriers to flow	• No evidence of topographic barriers to flow
Elevation	• Platform around shallow water feature is at or above mean high water • Impounded water is less than 20 cm deep	• Platform around shallow water feature is close to mean sea level • Bed of shallow water area sits greater than 20 cm below the platform

Five areas of shallow water were treated with runnels as a part of a controlled experiment (five reference and five runnel sites at Ocean View Farm). Runnels were created in phases, monitoring flow between phases to assess if depths, widths, and lengths of runnels were sufficient to drain shallow water areas. Runnels were excavated to a maximum depth of 12”, and maximum width of 12”. These maximum dimensions were used because they were the best option available using the low-ground pressure excavator. However, other runnel projects in New England have found that runnels dug wider than 12” but dug with the same maximum depth more successfully maintain drainage without regular maintenance, as they do not clog with sediment as easily. A sill was left in each runnel during the initial phase of excavation, acting as a “speed bump” to slow water flow and trap any unconsolidated sediments eroded off the platform. Runnels were constructed to be narrower and shallower where they intersected with unvegetated soils to limit the risk of erosion. Excavation was performed using a combination of a low-ground pressure excavator and hand-digging (Fig. 7). Bristol County Mosquito Control Project led the excavator-work, while staff and volunteers from BBC, Save The Bay, DNRT, and Bristol County Mosquito Control worked to complete hand-digging (Fig. 7).

Peat and salt marsh vegetation excavated from runnels and ditches at Ocean View Farm were used to create small elevated “habitat islands” that revegetate with low or high marsh vegetation depending on elevation (Fig. 8). Once revegetated, these islands can function as future habitat for marsh-nesting birds. The USFWS Atlantic Coast Joint Venture's Saltmarsh Bird Conservation Plan for the Atlantic Coast[2] identifies creating habitat islands, referred to as “microtopography”

[2] Salt Marsh Bird Conservation Plan for the Atlantic Coast. 2019. Atlantic Coast Joint Venture.

or "mounds", as a method to provide nesting area that is less prone to flooding. The methods described above used to create runnels (working in phases, leaving sills, specific depths and widths, and habitat-islands) are best practices developed through more than ten years of runnel projects led by partners. A more in-depth discussion of the theory and practice of runnels is available[3].

Runnels and hydrologic restoration can offer many benefits. The primary goal of this in-marsh technique is to restore tidal hydrology and restore vegetation. Shallow water areas can expand through reinforcing cycles; draining them can stop this process of expansion and prevent further losses. Runnels benefit public health by reducing mosquito larvae through draining water and providing fish better access to the upper marsh platform. They also can be used to reduce the height and density of *Phragmites australis* by increasing salinity of surface water in an area, and the habitat islands created from excavated peat have the potential to benefit nesting birds. As a part of the runnel study at Ocean View Farm, BBC and Woodwell are leading an intensive monitoring program to help quantify runnel efficacy across a range of initial conditions (Fig. 9).

In addition to these ecosystem functions, runnels can "prepare" sites for other adaptation techniques. If upper marsh areas convert to open water, then marsh migration may be less likely to occur even with a favorable slope. Techniques such as sediment placement (not used in Allens Pond) are less likely to be successful when applied to waterlogged soils. Thus, by restoring hydrology, other techniques are more likely to be successful. Using runnels to reconnect tidal flow through topographic barriers (e.g., embankments, ditch spoils) also helps mitigate flooding stress from sea level rise.

Figure 8. A newly created "habitat island" formed from peat excavated while digging a runnel. Photo: A. Besterman.

5.2. Migration Zone

With rising sea level, the need for marshes to increase their elevation is inevitable. This can either occur by increasing elevation *in situ* through natural (sediment and biomass accretion), or human-assisted (sediment placement) methods. *In situ* accretion is unlikely to be sufficient to combat rising seas because sediment supply is low in Buzzards Bay, biomass accretion is likely less than the rate of sea level rise, and sediment placement is not currently an approved technique in Massachusetts. Marshes can also increase their relative elevation through horizontal migration into uplands. Facilitating marsh migration is a major focus of adaptation work in Allens Pond marshes and includes runnels, vegetation management, and hardened-barrier removal. Each of these approaches is described in greater detail below.

[3] Besterman, A.F., Jakuba, R.W., Ferguson, W., Brennan, D., Costa, J.E., & Deegan, L.A. 2022. Buying Time with Runnels: A Climate Adaptation Tool for Salt Marshes. *Estuaries and Coasts*. https://doi.org/10.1007/s12237-021-01028-8

A second phase of runnels is planned on the Ocean View Farm property that will extend higher into the marsh, and into waterlogged areas with high *Phragmites* cover. Bristol County Mosquito Control will lead this phase of excavation in coordination with Save The Bay. Introducing runnels into higher elevation zones can increase salinity and lower the water table, in addition to reducing the cover of invasive *Phragmites*. Runnels can prepare higher elevation soils, hydrology, and vegetation communities for marsh migration.

Figure 9. Buzzards Bay Coalition and Woodwell Climate Research Center Staff study vegetation, invertebrate fauna, and soils at a site with a runnel in 2021. Photo: R. Jakuba

DNRT, Mass Audubon, and Save the Bay have partnered on a project to facilitate marsh migration through multiple methods on both the Ocean View Farm property and western side of Allens Pond. On the Ocean View Farm property, efforts are focused on transitioning and preparing vegetation in the upland and ecotone between marsh and upland. Woody invasive species had colonized the shrub-dominated ecotone between the marsh and hay fields at Ocean View Farm. DNRT, Mass Audubon, and a team of volunteers removed large swaths of invasive woody shrubs (> 2 acres), leaving only native plants along much of the border of Ocean View Farm marsh in 2020. By reducing the density of woody vegetation in this zone, DNRT and Mass Audubon hope to give marsh grasses a competitive advantage to migrate. The next phase of conversion will occur in 2022, when an area of upland currently vegetated with hay will undergo an organic herbicide treatment to remove the hay grasses, and be replaced with native, more salt-tolerant grass species typically found in the marsh transition zone. The seed mix will use 12 species, including Coastal Panic Grass (*Panicum amarum*), Winter Bent Grass (*Agrostis hyemalis*), and Wild Rye (*Elymus canadensis*), as some examples. By re-introducing native, salt tolerant plants, the fields may be more likely to transition to salt marsh as sea level continues to rise than if they remained planted with species that would die with more frequent tidal flooding.

On the western side of Allens Pond, migration facilitation is planned using runnels and by removing hardened barriers to migration. Runnels have not yet been installed, but are planned to extend into the brackish marsh adjacent to the salt marsh in several locations. Removing hardened barriers is an important and widely practiced tool to facilitate migration. This could include the complete removal or relocation of walls, sheds, parking lots, and even buildings. On the western side of Allens Pond, remnant stone walls from historical agricultural-use border the marsh perimeter. Sections of these walls are planned for removal in four locations to allow better opportunity for vegetation transgression with sea level rise, and to reduce the height and density of *Phragmites australis* that dominates the brackish wetlands.

6. Synthesis and Conclusions

6.1 Synergy and Prioritization of Conservation Strategies

Using multiple conservation strategies acting at multiple spatial and temporal scales provides the best chance for helping salt marshes persist through the 21st century and beyond. Some strategies work well in combination, and some may be better to prioritize over others due to trade-offs in time and resources.

Large, watershed-scale hydrologic stressors can supersede landscape- or marsh-scale conservation strategies to affect salt marsh condition and resilience. In the case of Allens Pond, an unmanaged inlet could negate any restoration or conservation actions implemented within the marshes or uplands. The inlet needs to be managed to accommodate present-day and future sea level. If tidal flow becomes too restricted relative to regional sea level much of the intertidal zone could convert to open water. Similarly, watershed-scale stressors such as nitrogen-loading can impact how in-marsh actions like runnels perform. Watershed-scale drivers are important to consider independent from and in interaction with landscape- and marsh-scale conservation strategies.

Figure 10. Staff and interns from Buzzards Bay Coalition, Mass Audubon, Save the Bay, and Dartmouth Natural Resources Trust meet to discuss runnels and other conservation strategies at Ocean View Farm. Photo: R. Jakuba

Landscape-scale and marsh-scale strategies work well in coordination. Land protection is of primary importance among these, without which none of the work currently ongoing or planned at Ocean View Farm could occur. With both marsh and upland protected, coordinated strategies can be used across habitats to promote conservation and adaptation. Runnels are used as both a marsh-scale strategy to restore marsh vegetation, and as a landscape-scale strategy to help facilitate migration. Runnels are used in combination with vegetation management, and hardened-barrier removal to restore current conditions and accommodate future changes. However, it remains important to consider how runnels interact with landscape-scale stressors. For example, interactions between runnels and tidal restrictions from culverts, and between runnels and freshwater inputs from adjacent freshwater wetlands or groundwater seeps, remain important areas of research.

Where marshes are severely degraded, an organization may consider focusing on landscape-scale actions rather than smaller-scale, in-marsh strategies. For example, in one area of Ocean View Farm the marsh platform elevation is low (only about 0.25 m above local mean sea level). As a result, in-marsh runnels may only “buy” a small amount of time for the marsh. Where BBC and partners installed a runnel in this zone, water has successfully drained and some revegetation is occurring. However, the water table is still very high, sitting just below the soil surface. With expected sea level rise and the degraded condition of the peat in this area, the platform may convert to open water much sooner than other parts of the marsh (at the scale of decades), with or without the runnel.

Meanwhile, just upland of this runnel is one of the zones where DNRT removed extensive invasive woody vegetation. Without any additional action or planting, this zone has largely converted to native, salt-tolerant herbaceous species, e.g., Seaside goldenrod. In this example, where a low elevation platform is adjacent to a gentle, favorable slope for migration, an organization with limited resources might preferentially focus on facilitating migration through vegetation management, rather than try to restore tidal hydrology.

A significant benefit to the integrative work occurring at Allens Pond is the expanded pool of resources, expanded community of staff, members and volunteers, and opportunity for knowledge transfer. Our organizations have held site meetings, calls, and workshops through which we have strategized conservation actions (Fig. 10). We have begun sharing data in addition to general knowledge, and have shared volunteer and staff time to accomplish goals together. This model of synergistic conservation work tackling issues across multiple spatial and temporal scales has been productive, and as our efforts begin to show results over the next few years will hopefully prove to be a successful approach to conservation.