

## ***Section 2: Mastering the Lingo -- Restoration Terms and Techniques<sup>1</sup>***

This section covers the concepts and terms of restoration ecology that apply to tidal marshes. The goal is to give citizen activists enough understanding and sophistication in this new field to be effective as advocates for their local wetlands.

Ecological restoration focuses on habitats and areas where ecological function and vigor have been impaired by human activity. The goal of restoration is to develop self-sustaining ecosystems that closely resemble natural systems in structure and function. The policy challenge is to define the functions and benefits sufficiently broadly. Restoration attempts to replicate the complex interactions and functions of a natural ecosystem, is a relatively new field that combines an experimental and inexact blend of science, technology and engineering. As more and more restoration is being undertaken in the United States, however, there are increasing numbers of examples of successful projects.

Tidal marshes are unique, sensitive and precious habitats. They can only function well with full and regular tidal flows flooding and draining them. Regular tidal exchange cycles prevent invasive fresh water plants from crowding out the salt marsh grasses and plants. These tidal marsh plants, in turn, provide the habitat which shelters a vast assemblage of valuable fish, shellfish, birds and other organisms that use salt marshes for all or part of their life cycle. Tidal exchange provides the link between marsh and marine habitats for these organisms.

Restoration of tidal flow to existing and former tidal marshes is the prerequisite for restoration of this habitat. Only with tidal flow can a marsh recover its function and vitality, and only with tidal interchange can a marsh contribute to the larger estuarine and marine ecosystems of which it is an essential part. Restrictive tidal crossings, which cut off full tidal exchange, are a logical starting point for tidal marsh restoration efforts.

A tidal **crossing**, for purposes of this book, is a culvert or bridge that allows tides to flow under a road or manmade structure to a vegetated tidal marsh. Crossings located at the

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<sup>1</sup> Much of this section was adapted from Niedowski, N. 2000 (in press). New York State Salt Marsh Restoration and Monitoring Guidelines.

head of tide, on the natural transition zone between tidal marshes and upland, are not defined as tidal crossings. A **tidal restriction** is a tidal crossing that limits water from freely passing from the upstream to the downstream salt marsh and vice versa. A crossing is restrictive when the opening is too small to allow for equal water levels on both sides of the crossing throughout the tidal cycle. Another type of restriction occurs when a culvert is positioned so high it reduces tidal range by preventing drainage as the tide drops below the culvert and delays flooding as the tide rises. Poor crossing maintenance can lead to channel blockage, causing restrictions. Dams and solid embankments, which block flows, are the ultimate restriction.

It is difficult to modify natural ecosystems. Thorough study of as many aspects as possible of the system to be restored will increase the likelihood of success. Partial successes should be viewed as lessons to help improve restoration techniques.

In broad terms, the goals of habitat restoration may be stated as follows:

1. To the greatest extent practical, achieve functional ecosystems similar in quality to undisturbed sites. Because of many variables and constraints that affect tidal marshes, complete restoration may be neither achievable, nor reasonable.
2. Restore critical habitat for fish, wildlife and plant species, including those listed as threatened, endangered, of special concern or historical interest. Restore habitat for species that are desirable for commercial and/or recreational purposes.
3. Use a regional perspective to integrate and prioritize individual restoration projects and programs within a regional framework.
4. To the extent practical, ensure that the acreage of priority habitats is restored and preserved.

## **Restoration Terms**

To ensure effective communication, it is essential to have a commonly understood vocabulary for the various activities that may be discussed in the context of restoration projects and other habitat modification and restoration work. An overview of some common terms follows<sup>2</sup>:

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<sup>2</sup> Definitions derived from NRC, *Restoration of Aquatic Ecosystems*; Mitsch and Gosselink, *Wetlands* and Niedowski, *Salt Marsh Restoration and Monitoring Guidelines*.

Compensation: Creation or restoration of “equivalent” wetland area and function comparable to areas and functions destroyed or damaged by human activity (such as oil spills as mandated by the Federal Oil Pollution Act of 1990).

Creation: The establishment of a wetland where one formerly did not exist.

Enhancement: Activities conducted in existing wetlands to achieve specific management objectives or provide conditions that previously did not exist and which increase one or more aquatic functions. Enhancement may involve trade-offs between aquatic resource structure, function and value; a positive change in one function may result in a negative impact on other functions.

Function: Various physical, chemical or biological processes which take place in wetlands. Functions that are commonly recognized are food chain production, provision for fish and wildlife habitat, waves and erosion barrier, storm and floodwater storage, nutrient and chemical uptake and exchange.

Management: At present this entails the treatment of wetlands to achieve a targeted goal such as enhancement of fish and wildlife habitat. In the past, "management" almost invariably meant elimination of wetlands by draining, filling, dredging or diking to convert tidal marsh to fresh marsh or open water (such as creating pannes in marsh to encourage bird utilization).

Mitigation: The creation or restoration of wetland to replace or “mitigate” wetland destroyed by development. Mitigation is usually done to satisfy legal mandates of wetland regulation. One example is the creation of artificial wetland as mitigation for destruction of natural wetland by construction.

Reclamation: The alteration of wetlands for the purpose of converting the area to utilitarian human uses. For example, diking or draining a tidal marsh might convert it into agricultural land.

Rehabilitation: The conversion of former wetlands of one type into some other type not previously present. A diked and drained tidal marsh could be converted to a freshwater wetland.

Restoration: Return of an ecosystem to a close approximation of its structure and function prior to disturbance. In the case of tidal wetlands this may be achieved by re-establishing the functions that have been affected by human activity: restriction of tidal flow, filling, draining, altering hydrology or contamination by toxins, freshwater, and/or invasive and exotic species, among others. For this book, restoration is distinguished from rehabilitation or mitigation, which have more narrowly defined meanings and often involve trade offs between damaged or destroyed marsh habitat.

### **Tidal Marsh Disturbance and Post Disturbance Conditions**

Both human activities and natural events can disturb marshes. In order to understand the effect on the marsh during restoration, both of these impacts need to be considered.

#### Human Marsh Disturbances

Hydrologic Changes: Disruption of the hydrologic regime of a tidal marsh, or even minor elevation or gradient changes, can have profound effects on vegetated tidal wetlands. Degradation and loss of upland buffers may cause increased sediment flow, altered ground water elevation and flow, loss of nutrient filtering vegetation, and loss of wildlife habitat for wetland species. Changes in soil and water salinities will affect species composition in tidal wetland and creek communities (such as invasion by common reed). The most dramatic and common cause of hydrologic disruption is restricted tidal connection.

Historically, marshes have been cut off from the tides both inadvertently and deliberately. Inadvertent changes involve construction of roads or railroads across the marsh using causeways, bridges and culverts. Deliberate changes include diking for reclamation, or damming for conversion to freshwater systems (such as ice ponds), or to power tidal mills.

Causeways, bridges and culverts: Roads, railroads and other linear structures have frequently been built on marshes, taking advantage of their level, undeveloped topography to cut from headland to headland along the coast. The causeways built for

these projects acted as dams across the high marsh and prevent sheet flooding on spring tides. Culverts and bridges were typically designed solely with flood control in mind and did not allow for the tidal exchange necessary for marsh vitality. Ill advised dumping of riprap intended to combat the erosion from the increased flow through an undersized crossing, often cause additional restriction.

Dams: Tide mills and ice ponds were built on many inlets along the Maine coast. Although today no mills or ice operations remain in use, the dams and crossings built for these projects continue to restrict flow to marsh or potential marsh areas, providing few, if any, offsetting benefits.

Ditching: Ditching is one of the oldest and most pervasive forms of human marsh disturbance in Maine. The early settlers dug ditches to increase the production of salt hay and improve marshes for grazing. Extensive grid ditches, intended to drain standing water, were dug in salt marshes in the 20th century. This practice occurred during the Depression, ostensibly as a mosquito control measure, but primarily to make work for the unemployed.

Tide gates: Various types of gates or valves have been installed in tidal channels for flood control, mosquito control or reclamation. There are several types of flow control devices. Flap gates swing open to allow drainage from the marsh and close to exclude flood tides. These gates allow water to drain from the marsh, but prevent or restrict inflow of tidal water. Slide gates can be closed manually to exclude storm tides. Automatic tide gates, which use float devices, can be adjusted to allow tidal exchange during normal tides and to close to prevent flooding during extreme high tides.

[[Figure 12- Self regulating Tide Gate (after Dreyer & Niering, 1995)]]

Impoundment: Impoundments are areas of marsh that are converted to open water by diking or installation of weirs to restrict flow of water from the marsh. Impoundment has been used to create waterfowl habitat, but its effectiveness is often impaired when invasive plants such as cattails and common reeds colonize the impoundment. The function of impounded marshes as habitat for fish and shellfish is dramatically impaired, and is eliminated for estuarine species.

Diking: Tidal marshes, especially in Washington County, were diked and tide gated during the nineteenth century for reclamation as agricultural land.<sup>3</sup>

Filling: Many marshes have been filled, either for development or simply as a dumping site for dredge spoil or solid waste. Filling destroys a marsh's original vegetation, ecosystem functions and habitat value.

Pollution: Pollution from oil spills or chronic introduction of oil from outboard motors, marinas and terrestrial sources, especially road runoff, can affect salt marshes. Pesticide residue from agriculture and mosquito control efforts is another type of pollution. Residuals of these pollutants can remain in the marsh sediment and be remobilized by dredging or flooding. Stormwater discharge, especially the first flush from roads, can introduce a wide range of pollutants, including oils, nutrients, and heavy metals. Stormwater may carry excessive sedimentation. Freshwater pulses associated with stormwater can lower salinity levels in the soils below the critical point and make the marsh vulnerable to invasive freshwater plant species.

Shoreline hardening and structures: Bulkheads, revetments and similar structures restrict the natural dynamics of the marsh. The development behind bulkheads and revetments restricts a marsh's ability to transgress in response to rising sea level. Light duty docks, pedestrian catwalks and observation platform can shade marsh plants and reduce their vitality unless they are built sufficiently high above the marsh or with sufficiently open decking.<sup>4</sup>

Sea level rise: Although marshes have kept up with the generally rising sea level for the past several thousand years, the rate of rise is accelerating and marshes' ability to keep pace will be compromised if their tidal exchange is restricted. Upland development adjacent to marshes restricts the marsh's ability to transgress landward with rising sea level, resulting in a net loss of marsh area.

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<sup>3</sup> For an extensive review of these projects see Sebold, 1998

## Natural disturbances

Winter ice, storm, and hurricane disturbances can have dramatic effects on a marsh and significantly affect marsh morphology and vegetation.

Winter ice: Ice, together with storm and tidal movements, can uproot marsh vegetation, sometimes rafting chunks of marsh onto tidal flats where they may begin to form new marsh. Ice may change the marsh elevation by erosion and accretion. Boulders and debris can be deposited on the marsh surface. Ice and winter waterfowl feeding scour and trim marsh vegetation, giving the early spring marsh a crew cut look. The debris from this scouring may be deposited in wrack lines on the high marsh, killing the rooted vegetation and creating openings, or pannes where pioneer plants such as glassworts can colonize.

Storms and Hurricanes: Storm waves can erode and change marshes, altering tidal openings in barrier beaches, eroding protective sandbars, fringing marshes and other shoreline features. Storm surges may deposit sediment and debris on the marsh, dramatically affecting vegetation.

## Post Disturbance Conditions

All ecological consequences of disturbances must be considered in designing a restoration project. For example, a restriction that alters the tidal regime may also cause subsidence of marsh peat, aeration and decomposition of the peat, chemical changes in soil pore water, changed salinity in substrate and creeks, restricted exchange of animals, plants and nutrients with the adjoining estuary and invasion of nuisance plants. This summary of common post disturbance conditions demonstrates that they all derive from changes in the tidal regime. The primary characteristic of a tidal marsh is regular tidal inundation.

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<sup>4</sup> Buchsbaum, Coastal Marsh Management in Kent, ed. *Applied Wetlands Science And Technology* presents guidelines developed for such projects in Massachusetts.

Subsidence: In addition to limiting tidal water exchange, tidal restrictions limit the amount of sediment added to the marsh. Reduced sedimentation and decomposition of dehydrated marsh soil cause the marsh surface to subside below its original level. Restoration of subsided marshes raises special problems because full restoration of tidal flow may create open water rather than vegetated marsh. Close control of tide flooding levels may be required to achieve the goal of revegetation by marsh plants.

Freshwater flooding: Tidal restrictions, levees next to ditches, subsidence and vegetation changes can increase the risk of freshwater flooding of marshes. A degraded marsh is less effective as a barrier to flooding and as a sponge to absorb floodwater, Prolonged flooding (usually in springtime) can affect marsh soils and vegetation, accelerating change to either open water or freshwater habitat.

Changes in salinity: Changes in hydrology, especially tidal restrictions, will affect the marsh's salinity, which in turn may affect all marsh species. Freshwater flooding or rain can dramatically reduce salinity. Conversely, salinity may rise dramatically during dry periods when trapped salt water evaporates.

Changes in vegetation: All of the above changes in water and salinity conditions will have an effect on the vegetation of the marsh. The *Spartina* grasses that dominate Maine salt marshes can thrive only with regular salt water flooding which inhibits the establishment of other, less salt tolerant species. Small changes in the marsh can tip the balance in favor of invasive species such as the common reed ("*Phragmites*"), which often forms a dense monoculture of tall plants (up to 12 feet). This lowers plant diversity and changes the vegetative structure from a low grassy meadow to a tall reedy thicket affecting animal food webs. Reed stands can, also, pose a fire hazard. Although the effect of spreading common reed upon salt-marsh wildlife is not well understood, there is concern that typical salt marsh animals and birds will find it a less favorable habitat.<sup>5</sup>

Soil oxygenation: A lowered marsh water table results in the increase of soil oxygen levels. The oxidation of marsh peat leads to conversion of iron pyrite to sulfuric acid, increased soil acidity and mobilization of potentially bioavailable heavy metals.

## Restoration Strategies

Restoring tidal flow: Restoration of tidal flow is the first prerequisite to tidal marsh restoration. Removing flow restrictions, cleaning crossings and removing undersized culverts and tide gates are the initial steps. Once the obvious barriers have been removed, further measures include plugging ditches to restore sheet flooding of high marsh areas, and removing dikes or spoil levees along ditches to facilitate drainage of the high marsh on ebb tides.

Duration of inundation: The duration of inundation determines the type of marsh vegetation. Smooth cordgrass does best in areas with longer periods of daily inundation where other plants cannot thrive because of excess salinity. Areas with shorter periods of inundation allow colonization by other species.

Resizing crossings: Although complete removal of all crossing restrictions, including berms and fill on the high marsh surface, is the ideal, resizing of crossings is a practical alternative. The sizing decision should be based on complete hydrologic calculations of the flow needed to allow appropriate tidal exchange and sheet flooding of the high marsh. In cases where there is extensive high marsh behind linear fill (such as roads), it may be necessary to install supplemental culverts to allow for full sheet flooding of the high marsh on spring tides. Crossings must accommodate fish as well, and recent data suggests that some fish avoid long dark culverts. Culverts must be set deep enough to avoid creating sills which block flow at lower tide levels.

Although marshland mosquito control is not practiced extensively in Maine, in nearby states, the grid ditching and pesticide methods of the past have been replaced with “open water marsh management”. This approach takes advantage of the voracious appetite of marsh fishes, including mummichogs and other minnows for mosquito larvae. The marsh is managed to provide shallow channels across the high marsh to encourage minnows to forage for mosquito larvae on the high tides and retreat safely to deep-water pools created in the high marsh during low water. Healthy marsh with unaltered tidal circulation and naturally formed pannes will provide fish access to mosquito larvae.

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<sup>5</sup> Dreyer and Niering, *Tidal marshes of Long Island Sound*, p. 38

Restoration of vegetation: In many instances, restoration of tidal flow will result in increased salinity and which will kill off noxious species such as common reed, and allow *Spartina* grasses to recolonize naturally if there are nearby stands to provide propagation material. This process is slow and it may take as many as 20 years for the marsh to return to a stable, saline tidal habitat. If the affected marsh has vigorous stands of common reed, more aggressive control measures such as mowing or cutting, herbicide application and prescribed burning can be taken. These measures can often be coupled successfully with a volunteer-based marsh grass re-planting program. In several areas around the country, re-planting programs have been built into school curricula complete with long term monitoring protocols for students to follow.

Restoration of tidal flow where the marsh surface has subsided may require adjustment of tide levels or regrading to raise the marsh surface.

Low-lying development - A cautionary note: The presence of structures and other human development only slightly above high tide levels may pose a limitation on tidal flows because of concerns about possible flooding. An attractive compromise may be the installation of self-regulating tide gates. These devices, which have been used successfully in Connecticut and Rhode Island marshes, have floats that automatically close the gate when the water level reaches a predetermined level.

[[Insert Figure 12- Self regulating Tide Gate (after Dreyer & Niering, 1995)]]

## **Conclusion**

Numerous salt marshes have been restored in Connecticut, other New England states, and other parts of the country for over more than 20 years. Although manipulation of complex tidal ecosystems may never become an exact science, the lessons learned, if thoughtfully and thoroughly applied in Maine, can improve the likelihood of successful restoration.

Many restrictive tidal marsh crossings are road culverts that require periodic maintenance or replacement. Over time, working with the Maine Department of

Transportation (MDOT) and other road agencies may make it possible to restore optimal flow to many marshes with relatively modest incremental cost and effort.