TIDAL WETLAND RESTORATION IN CONNECTICUT

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Ecological Restoration is defined as *the intentional alteration of a site to establish the approximate biological, geological and physical conditions that existed in the predisturbance indigenous ecosystem or habitat.* Restoration projects attempt the re-establishment of all the predisturbance characteristics of a site, including plant and animal species and a variety of community attributes such as structure, function, and habitat values. This should not be confused with wetland creation in which a habitat that did not previously exist, at a particular site, is brought into existence.

As previously explained, tides are the primary abiotic factor organizing these complex wetland ecosystems. Most restoration projects in Long Island Sound have targeted salt marshes that were degraded as a result of activities which reduced or eliminated tidal flooding. In such marshes, the tidal marsh plant communities are usually replaced by a monoculture of Phragmites (also called Common Reed, *Phragmites australis*), a characteristic which makes identification of degraded sites quite easy. In some systems Narrow-leaved Cattail (*Typha angustifolia*) may replace the salt marsh species (see Barn Island example below). One of the problems resulting from this vegetation change is a drastic decrease in plant species diversity and reduced access to the marsh by the larger species of waterfowl, shorebirds and wading birds. Restoration of tidal flow is a highly successful method for the removal or suppression of Phragmites, because it is intolerant of salinity levels above 18 parts per thousand (ppt).

The following restoration case studies illustrate various bio-physical changes that result from human activities. Each is also an example of how habitat restoration can proceed. Since the 1970s Connecticut has restored over 600 hectares (1500 acres) of salt marsh, with most of the work supervised by the Department of Environmental Protection (DEP). In New York, restoration efforts have been directed largely towards the south shore of Long Island, where there are many more salt marshes than along the northern, Long Island Sound shore. As a policy, restoration projects are only implemented once it has been shown that the benefits of restoration outweigh the alternative of taking no action at all.

BARN ISLAND WILDLIFE MANAGEMENT AREA, STONINGTON IMPOUNDED MARSHES

The Barn Island Marshes are a series of flooded valley tidal wetlands near the Rhode Island border in Stonington, Connecticut, which have been managed by the State as a hunting area (Fig. 1). In the late 1940s, the Connecticut Board of Fisheries and Game began constructing a series of impoundments across the valley marshes at Barn Island to offset the loss of waterfowl habitat caused by mosquito ditching. Low earthen dikes were built across several marshes, converting upstream, interior portions to non-tidal, shallow water habitat through the ponding of upland stream flows.

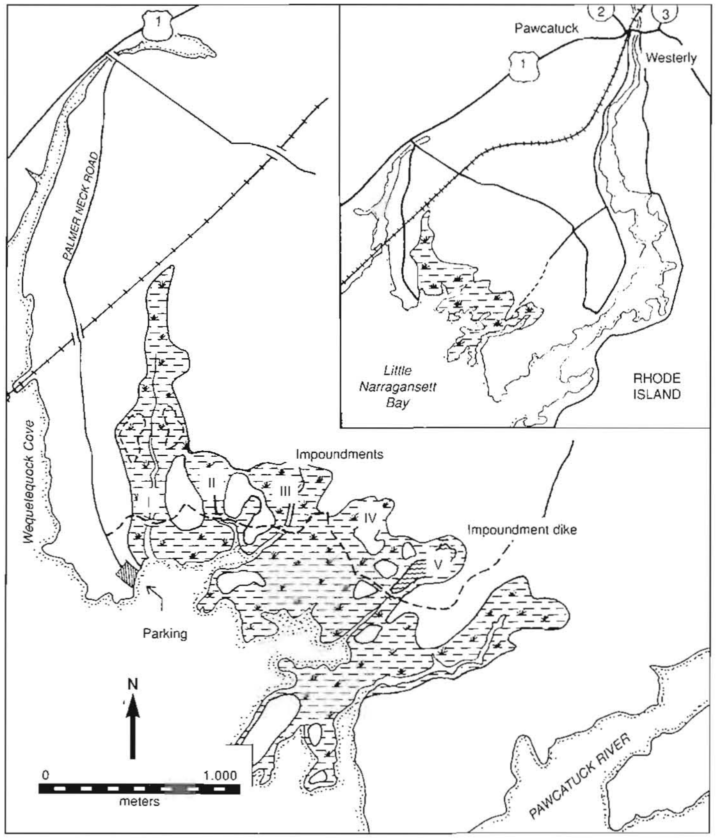

Fig. 1 Map of Barn Island marshes.

Waterfowl use initially increased, but declined over the long term as the new open water habitat was encroached upon by a new set of plants. By the 1970s, the impoundments were dominated by Narrow-leaved Cattail and expanding colonies of Phragmites. The muskrat population also increased dramatically. To reduce the amount of Cattail and Phragmites, which cannot tolerate salt water, in 1978 the DEP installed a four foot wide culvert on the westernmost impoundment (called No. 1). Restoration of tidal flushing resulted in the demise of the cattail and the re-establishment of salt marsh vegetation (Fig. 2). However, this only occurred in the southern part of the marsh, suggesting that the culvert was too small to pass sufficient volumes of saltwater to regularly flood the middle and upper marsh areas. The culvert was also found to restrict drainage of water off the impounded marsh back into the Sound, so a higher than average low tide elevation was maintained behind the dike.

Fig. 2 Aerial view of impoundment 1, Barn Island marshes in 1982 showing dead Cattail and Phragmites on left and reestablished salt marsh vegetation on right.

In 1982, a seven foot diameter culvert was added to the same impoundment, and today nearly all of the Cattail and much of the Phragmites have been replaced by salt marsh vegetation. Two former large open water pannes now support Smooth Cord-grass (*Spartina alterniflora*), and numerous shallow pools attract large numbers of shorebirds and wading birds. Re-establishment of the salt marsh vegetation occurred through spontaneous means and without planting, demonstrating that plant species restoration occurs naturally without the need for implementing expensive and often ineffective planting programs. With the re-establishment of salt marsh vegetation, typical marsh invertebrates and fish recolonized the area. Studies by students and staff at Connecticut College have documented this process of restoration (see Suggested Readings). Using similar methods three other impounded wetlands have been restored at Barn Island.

GREAT HARBOR MARSH/LOST LAKE, GUILFORD
DRAINED AND SUBSIDED MARSH

This 93 hectare (230 acre) complex consists of two major, interconnected wetlands - Great Harbor Marsh downstream of the railroad and State Route 146, and the upstream Lost Lake (32 hectares or 78 acres, also called Three Corner Marsh) (Fig. 3). Great Harbor Marsh is separated from Long Island Sound by a narrow coastal barrier. In the late 1880s the coastal trolley bed was constructed on this beach and in 1916 an elevated dike was constructed with a tide gate installed in the outlet channel to control tidal flooding. This situation persisted for nearly 40 years, when a hurricane destroyed the tide gates and restored full tidal flow in the early 1950s.

The gating and draining of this wetland complex caused a lowering of the water table in the marsh peat by nearly a meter. This exposed the upper portions of peat to oxygen for the first time, and it began to decompose very rapidly. The overall result was a loss of peat, which caused the marsh surface to drop, or subside, at least to 60 centimeters (two feet) below its former elevation. If we use a conservative estimate of a 60 centimeter decrease in elevation across the entire 93 hectare (230 acre) marsh surface, then the total peat loss is projected at over 765,000 cubic meters (1 million cubic yards). To imagine this much volume, think of it as equivalent to raising the height of a football field 140 meters (460 feet).

Due to the subsidence of the peat surface, within several years of the breach approximately 75% of the marsh was converted from a salt marsh community to intertidal flat/shallow water habitat with no marsh vegetation at all. Only that section of Great Harbor marsh adjacent to the barrier beach had sufficient elevation to retain emergent wetland plants. From there, Smooth Cord-

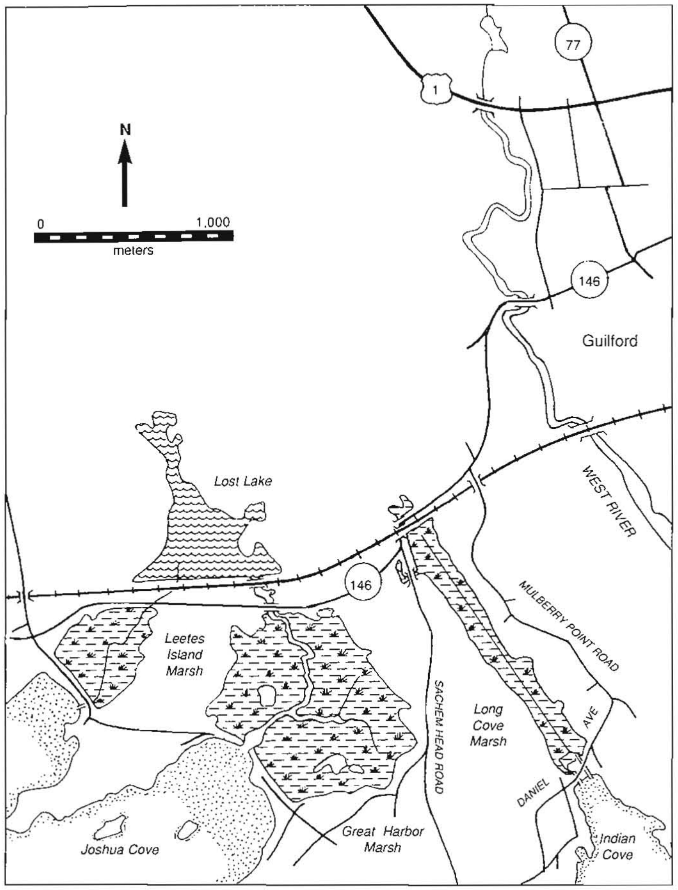

Fig. 3 Map of Great Harbor marsh/Lost Lake and Long Cove.

grass began a gradual but progressive expansion out onto intertidal flat, in an upstream direction. Forty years after the loss of the tide gate, most of the Great Harbor marsh now supports wetland vegetation once again (Fig. 4 and 5). Upstream, the Lost Lake area is still largely devoid of vascular plants to this day.

Great Harbor Marsh has largely restored itself from the standpoint of the amount of wetland that now supports salt marsh vegetation. However, the plant communities are not what they once were. Before tide gates the vegetation was principally a high marsh community, but it is now dominated by the low marsh species Smooth Cord-grass. Draining caused subsidence, but subsequent restoration of full tidal flow to a significantly lower marsh surface did not lead to the re-establishment of the previous plant and animal communities. The lost peat has been replaced by salt water resulting in significant changes in current velocities and flow volumes. The creek has widened from 3 to 27 meters (10 to 90 feet) since the gates came out, a result of the scour from increased current

Fig.4 Great Harbor marsh. In the late 1970's the tidal mud flats were beginning to be colonized by Smooth Cord-grass. (DEP) (A. Rocque)

velocity. Furthermore, the marshland immediately upstream of the inlet has been converted to a 0.5 hectare (1.5 acre) pond. Its current diameter is over 60 meters (200 feet), and enlargement is projected to continue until the tidal exchange volume is reduced through the formation of peat and the subsequent increase in wetland elevation. This process is described in the previous chapter on marsh development.

The nearby Leetes Island marsh in Guilford is another example of a subsided marsh. Studies conducted by the U.S. Army Corps of Engineers have shown that restoration can only be accomplished by building a series of structures that will allow more water to leave the marsh on low tide than enters the marsh on high tide. Without such modifications of the natural tidal cycle, too much water will remain on the marsh at low tide, preventing the establishment of salt marsh plants.

Other examples of degraded marshes caused by tide gates include: Old Field Creek and Cove River, West Haven; West River, Mill River and Morris Creek, New Haven; Sluice Creek, Guilford; and Sybil Creek, Branford. The DEP is working with many of these communities in the development of salt marsh restoration plans.

Fig.5 Great Harbor marsh, same location as Fig. 4 in the late 1980's where a thriving low marsh community had developed. (R. Rozsa)

LONG COVE, GUILFORD - RESTRICTED TIDAL FLOW

Long Cove is aptly named since it occupies a long but narrow valley, approximately one mile in length. With an area of only 17 hectares (43 acres), it is separated from Long Island Sound by a narrow, sandy barrier beach (Fig. 3). The road and bridge on this beach were destroyed in the 1938 hurricane and were reconstructed at a landward position. The bridge was replaced by a 42 inch concrete culvert; a short time later, a second culvert was installed with a tide gate for mosquito control. A linear ditch was excavated in the marsh from the new culvert to the upper reaches of the marsh. Eventually the original culvert filled with sediment and was abandoned.

In an attempt to control mosquito breeding, a two step water management program was developed in the 1940s. The tide gate was closed during the summer months to drain the marsh and reduce insect breeding habitat. After the first hard frost in fall, the gate was opened, and the resulting tidal flows removed sediments that accumulated in the creeks and ditches in the summer months. The alternating cycle of draining and flooding continued for forty years. Phragmites gradually and progressively replaced most of the typical salt marsh vegetation.

By the early 1980s, the tide gate had fallen off, reestablishing year-round tidal flushing. It was observed that most of the marsh area never flooded, even during the highest tides, and it was concluded that the remaining functioning culvert was undersized and restricted tidal flow. On the portions of the marsh which did flood with salt water, Phragmites was replaced by salt marsh plants

The deterioration of this marsh was brought to the attention of the DEP by William Tietjen, a long time resident and member of the Indian Cove Association who had personally witnessed the decline of the marsh since the 1940s. This served as the catalyst for the department's first multi-group partnership in tidal wetland restoration. The partnership included the Town of Guilford, the Guilford Land Trust which owned most of the wetland, the DEP and the Mosquito Control Unit (formally the Mosquito and Vector Control Section) of the Connecticut Department of Health Services. Taking into consideration long term changes to the marsh caused by draining, and recognizing the need to increase water levels only to that extent which would regularly flood the marshland (i.e., several centimeters), the reopening of the abandoned culvert was proposed. The DEP's Coastal Area Management Program (now the Office of Long Island Sound Programs) provided Guilford with a small grant to restore the channel across the beach and construct concrete training walls to the protect the channel. In 1986 the Mosquito Control Unit removed sediment upstream of the culvert and cleaned those ditches necessary to interconnect the culvert with the main channel

Eight years later, nearly all of the Phragmites in the central and upper marsh has been replaced by salt marsh vegetation. Phragmites is stunted and decreasing in abundance in the lower marsh. Approximately two hectares (five acres) of pool habitat have formed in the upstream marsh. It is predicted that much of the open water will be replaced by salt marsh vegetation, but in the interim it functions as significant wildlife habitat for waterfowl, shorebirds and wading birds.

Long Cove illustrates successful restoration of a marsh via partial flow restoration using culverts. Examples of salt marshes that have been restored through the installation of larger culverts to increase tidal flow volumes include: Cat's Island, Milford; Caroline Creek, East Haven; and Palmer Cove, Groton.

HAMMOCK RIVER, CLINTON
RESTORATION VIA TIDAL GATE MANAGEMENT

Upstream of Beach Park Road, on the Hammock River in Clinton, nearly 120 hectares (300 acres) of tidal wetlands, mostly salt marsh, have been drained for salt marsh haying and mosquito control purposes since the early part of this

century (Fig. 6). Gradually the vegetation, dominated by high marsh plant communities, was replaced by Phragmites. Charles Roman, a graduate student at Connecticut College documented the environmental changes that had taken place by the early 1980s. His research demonstrated that the wetland surface had subsided at least 38 centimeters (15 inches) and, when all four tide gates were opened in the fall and winter months, the flooding depth and duration resembled that of the previously discussed Lost Lake case study. During the summer, the tide gates were closed to drain surface water from the marsh, thereby eliminating breeding habitat for the salt marsh mosquito. However, without daily tidal flow sediments accumulated quickly in the ditches, which in turn trapped rainwater, creating an ideal habitat for freshwater mosquitoes.

A cooperative program was begun in 1985 between the DEP and the Mosquito Control Unit to restore the degraded wetlands by utilizing modern

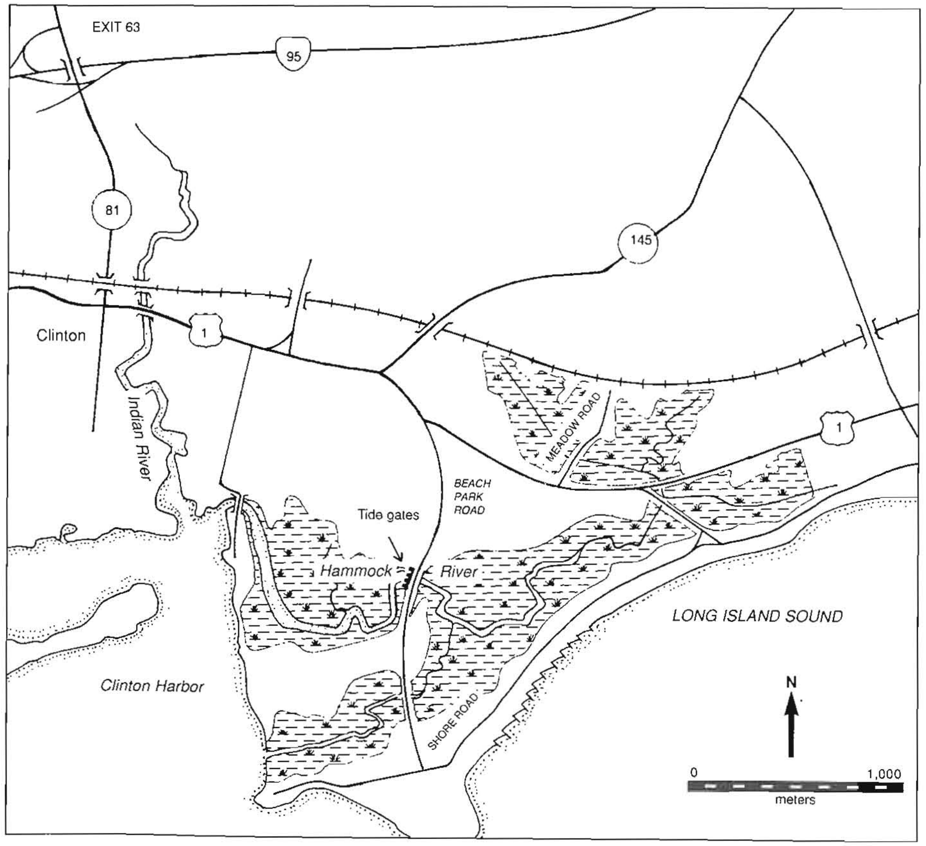

Fig.6 Map of Hammock River marsh

open marsh water management techniques. The plan was to restore tidal flushing during the summer to the extent necessary to maximize the emergent vegetation and minimize the conversion of salt marsh to open water (similar to the Lost Lake scenario). A single tide gate was opened in the spring of 1985 and photo stations were established to measure the replacement of Phragmites by native marsh grasses. Reference stakes were installed against which the reduction in the height of Phragmites could be measured at the end of the growing season. In the fall of 1985, the height reduction of Phragmites was one meter. During the next three years, the annual height reduction averaged 30 centimeters (one foot) (Fig 7). By the fifth and sixth years, Phragmites stopped growing, dead shoots no longer persisted and the exposed peat was being colonized by salt marsh grasses. Local residents reacted favorably to the restoration, remarking on the improving vistas and the return of wildlife such as egrets and waterfowl.

By 1992, Phragmites was decreasing throughout the entire marsh but it was apparent that in all areas, especially that west of Meadow Road, extensive colonies would persist. The next year, a second tide gate was opened to increase the area of marsh flooded, and monitoring stakes were again set out. In the summer of 1994, complaints were received with respect to backyard flooding. Interestingly, no complaints were received about the more extensive flooding during the winter, when all four gates were open. In order to continue this highly successful marsh restoration project, the DEP has received federal funding through the Department of Transportation's Intermodal Surface Transportation Efficiency Act to design and implement a flood protection program for several low-lying properties. To everyone's surprise, no significant mosquito breeding occurred during this restoration. This can be explained by the fact that tides flood nearly all of the marshland on a daily basis, which prevents breeding by the salt marsh mosquito.

The draining of the Hammock River marshes may have caused water quality problems in the river and adjacent Clinton Harbor (see sidebar on p. 62.). Studies have shown that restoring tidal flow can quickly reverse this problem. Restoration of water quality is probably critical to the health of the living resources in this area including the natural oysters beds that line the channel of the Hammonasset River.

This project illustrates how salt marsh restoration can be accomplished at very low cost and through the manual operation of tide gates. Gate adjustments or closures are only necessary in advance of major storm events, making manual operation easy and cost-effective. Manual gate operation is impractical at sites where low-lying properties would be regularly flooded. In those situations, automatic tide gates may be used in which a water level recorder moni-

Fig. 7 Hammock River marsh. Above in 1988, three years after a tide gate was opened, Phragmites height was significantly reduced and patches were dying. Below by 1992 salt marsh vegetation had recolonized portions of the marsh. (R. Rozsa)

tors the height of the tide and triggers the gate to close when the water reaches a pre-determined flood level (Fig. 8). A non-electric self regulating tide gate system which uses one or more floats to sense water elevations was developed by Thomas Steinke, Conservation Director of the Town of Fairfield.

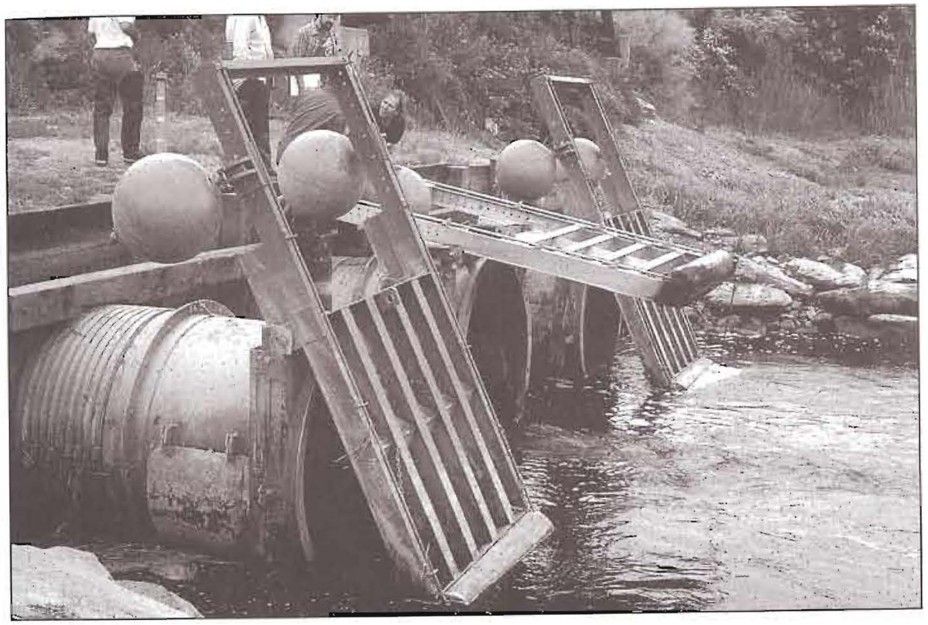

Fig. 8 Self-regulating tide gates. (R. Rozsa)

Marsh Draining Can Affect Water Quality

Studies on Cape Cod and elsewhere have demonstrated that draining salt marsh peat can create several significant water quality problems. Pyrite or iron sulfide, a common soil mineral, produces sulfuric acid when exposed to oxygen. If the soil in question has limited buffering capacity, the pH value in drained marshes can decrease to values as low as 3 to 4. These altered soils are referred to as *acid sulfate soils* and one such site has been located in a drained marsh in the Town of Fairfield. Following rainstorms, runoff from the marsh causes acidic conditions in tidal creeks. In addition, organic compounds in this leachate can consume oxygen, causing hypoxia or anoxia (lowering or complete depletion of oxygen in the water) which can cause fish kills. Reflooding the marsh usually corrects the water pollution problems caused by draining

Tide gate management programs are being used in Pine and Ash Creeks in Fairfield and Groton Long Point, in Groton. At the latter, the Groton Long Point Association manages the tide gates and closes them when a major storm is forecast. Examples of degraded salt marshes that have been restored through complete gate removal include: upper Farm River, East Haven; upper Branford River and Gigamoque Creek, Branford; and Indian River, Clinton.

MUMFORD COVE, GROTON
BURIED AND EXCAVATED MARSH

In the 1950s, an earthen dike was built around a salt marsh located on the eastern shore of Mumford Cove, and sediments dredged from the cove were hydraulically pumped into the southern end of the marsh (Fig. 9). These sediments spread across the marsh in a northerly direction, and excess water returned to the cove via a sluiceway located in the northwest corner. Fill depths across this six hectare (15 acre) marsh ranged from 0.6 to 1.2 meters (two to

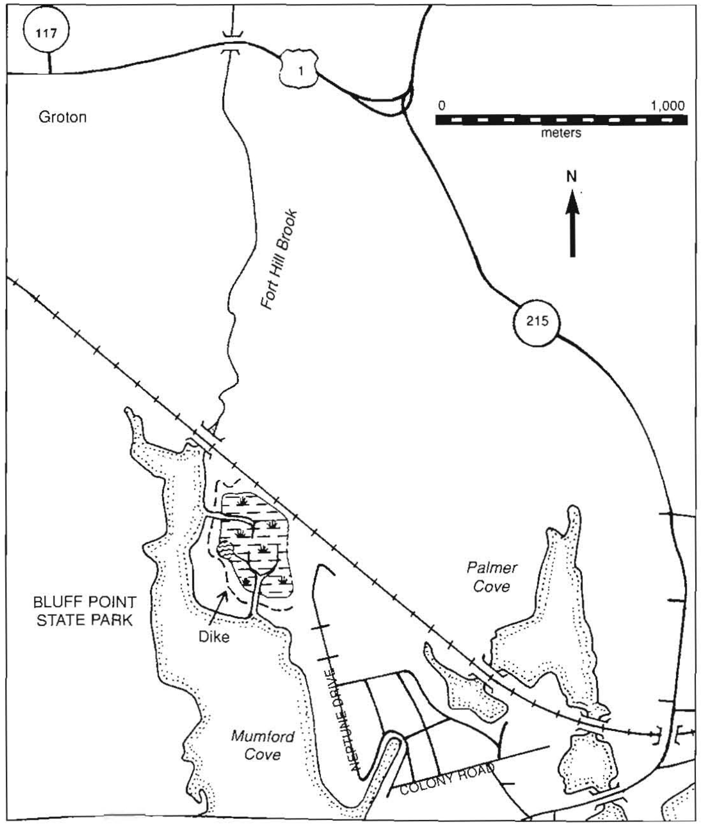

Fig. 9 Map of Mumford Cove

four feet), elevations too high to be flooded by the tides. Phragmites became the dominant plant, and the ponding of rainwater produced large, uncontrollable broods of freshwater mosquitoes.

Restoration began as a DEP and Mosquito Control Unit partnership in the fall of 1989, when the overburden of dredged sediment in the northwest corner was excavated by a lightweight bulldozer and transported to the adjacent uplands. Creeks and ponds were recreated using lightweight excavators (Fig. 10). The following spring, the U.S. Fish & Wildlife Service, through its Partners for Wildlife Program, joined the effort and provided equipment and operators to assist in the restoration. Over the next four years, the remaining wetland was unearthed, tidal creeks restored and wildlife ponds constructed. No planting was done, but vegetation re-established itself through the natural transport of salt marsh plant seed by the tides. Dense beds of the submerged aquatic plant Ditch or Widgeon Grass (*Ruppia maritima*), an important waterfowl food plant, spontaneously established in several of the ponds.

Fig. 10 A low-ground pressure excavator digging a creek during the restoration of a buried marsh. (R. Rozsa)

RESTORATION RULES-OF-THUMB

- re-establishment of regular tidal flushing with saltwater (over 18 parts per thousand of salt) initiates the replacement of Phragmites by salt marsh plants and this conversion normally occurs over a five to ten year period.
- re-establishment of salt marsh plants proceeds spontaneously if a nearby salt marsh is present to supply a seed source. In most cases expensive planting or transplanting programs are not necessary.
- restoration of tidal flows to their pre-disturbance volumes is not always desirable, especially in the case of subsided wetlands.
- marsh restoration will reduce or eliminate mosquito breeding in subsided marshes.
- marsh restoration re-establishes scenic vistas.

SUGGESTED READING

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