HABITAT RESTORATION PLAN FOR THE PECONIC ESTUARY

prepared by:

Habitat Restoration Workgroup
Peconic Estuary Program

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1. EXECUTIVE SUMMARY

The Habitat Restoration Workgroup was convened in September, 1997 to implement priorities identified in the draft Peconic Estuary Program Comprehensive Conservation and Management Plan (CCMP). The workgroup was charged with identifying significant natural habitats with potential for enhancement or restoration, developing overall habitat restoration goals, and identifying and prioritizing locations for potential projects. The draft CCMP identified 16 actions to address habitat restoration and direct the Workgroup.

Previous and current restoration activities in the Peconic Estuary have occurred in a wide variety of habitats. To date, approximately 30 sites have been restored or enhanced, and projects generally have been small in size and inexpensive. The Plan provides documentation for previous projects, with brief summaries of work conducted, area restored, costs, and tentative evaluation of success.

Priority restoration needs, based on degree of loss and threats, include restoration of eelgrass beds and terrestrial habitats, such as coastal grasslands and forests. Technologies requiring additional research and experimentation with pilot projects include eelgrass restoration, *Phragmites australis* control techniques, and alternatives to shoreline hardening. Planning and implementing restoration projects in the Estuary is often difficult due to a shortage of technical staff time at the municipal level. Municipalities and habitat types that are underrepresented in the process to date, therefore, should be targeted for technical assistance and project identification.

The Workgroup developed a public nomination process to identify potential restoration locations in the Estuary. A total of 91 sites were nominated during the process. A total of 72 sites appropriate for consideration were evaluated and ranked. The highest ranking projects from each of the five towns are listed separately by habitat type. All projects nominated are listed in this Plan. The nomination and evaluation process will continue in the future.

Information on the nine priority restoration habitat types identified for the Peconic Estuary is provided in the plan. Habitat characterizations, summaries of functions and impacts, discussions of status and trends in the Estuary, and information on restoration methods are included.

Expanded treatment of high priority issues is provided in a series of Special Topics sections, which treat eelgrass restoration, Open Marsh Water Management, common reed control, selection and use of reference sites, development of volunteer-based projects, and alternatives to shoreline hardening.

Several available funding sources for habitat restoration activities are identified and described in the Plan. Guidance is provided for developing Environmental Protection Fund applications for habitat restoration planning.

The need for standardized monitoring is highlighted in the Plan, and suggestions for basic monitoring protocols for several habitat types are provided. Plans for developing a regional habitat restoration database to improve project tracking and information accessibility are also provided.

The estimated cost (see Appendix C) for implementation of the 18 highest priority restoration projects identified in the Habitat Restoration Plan--the 10-year goal of the Peconic Estuary Program--is $4 million. These projects encompass approximately 210 acres of habitat. Accomplishing this goal will require funding levels of approximately $376,000 annually, and restoration of 21 acres of habitat annually, for 10 years.

The estimated cost for implementation of all 72 evaluated projects is $42 million dollars. The total habitat acreage accounted for by all 72 projects is approximately 840 acres. Since 1972, at least 3,300 acres of habitat have been lost in the Peconic Estuary. The Workgroup estimates that costs for restoring the full acreage lost in the Estuary since 1972 would be more than $60 million dollars.

A number of initiatives responding to data gaps and shortcomings, and addressing restoration needs of the Peconic Estuary Program and PEP municipalities, are possible. The Habitat Restoration Workgroup potentially could assist in some of these efforts. Such initiatives may include: periodic reporting on programmatic obstacles and management needs in different PEP jurisdictions; refinement of estimates for habitat restoration costs and historical habitat acreages lost; revision of Estuary-wide measurable goals; solicitation of additional restoration site nominations; and evolution of the Habitat Restoration Workgroup to provide technical assistance to municipalities, as needed.

2. HABITAT RESTORATION WORKGROUP: PURPOSE & OBJECTIVES

The PEP has convened a Habitat Restoration Workgroup (HRWG) to address areas in the Peconics which have the potential for enhancement of existing resources or restoration of habitats which have been lost or degraded. The purpose of this group is to identify and prioritize the significant natural habitats of the system, develop overall habitat restoration goals, identify locations where these habitats can be restored, and develop, in conjunction with public and private landowners, specific restoration projects.

The short-term goal of the HRWG was to identify specific habitat restoration projects within the Peconic Estuary and watershed which are ready for immediate funding. The voters of New York, in November 1996, passed the Clean Water/Clean Air Bond Act (Bond Act), which has as one of its goals the restoration of aquatic habitats. This Act provides $30 million jointly for the Peconic Estuary and South Shore Estuarine Reserve. It is the expectation of the PEP that a portion of those funds will be used for aquatic habitat restoration projects.

The long-term goal (2-3 years) of the Workgroup, to be carried out in parallel with the short-term goal, was to identify the natural habitats throughout these areas which are most in need of restoration as well as to develop criteria for inclusion of projects in a prioritized restoration list. It was hoped that, eventually, the two goals would merge so that projects submitted for Bond Act funding incorporate identified habitats and restoration criteria developed for the Peconic Estuary study area as a whole. The HRWG was also charged with development of habitat-specific restoration criteria as well as criteria for monitoring restoration projects.

The Peconic Estuary Program Natural Resources Subcommittee (see Appendix G for membership) articulated a number of goals and objectives for the habitats and living resources of the estuary in the Comprehensive Conservation and Management Plan (CCMP). The following objective, related to habitat restoration, governs the actions with which the PEP HRWG was charged:

Maintain or increase native species and community diversity, provide connectivity of natural areas, and expand existing natural areas as a means to restore degraded habitats.

Subsequent to the articulation of the restoration objective, priority actions to accomplish the CCMP restoration objective were identified. Actions two through sixteen below are most appropriately viewed as a subset of action number one, the development of a Habitat Restoration Plan. The 16 actions from the CCMP which accomplish the habitat restoration objective are:

1. Develop and implement an estuary-wide Habitat Restoration Plan.

2. Identify priority habitat types for restoration.

3. Inventory restoration opportunities in the PEP area.

4. Develop criteria for selection of restoration sites.

5. Inventory completed, ongoing, and proposed restoration projects in the PEP area.

6. Develop a list of funding sources available for habitat restoration.

7. Develop recommendations for control of common reed (*Phragmites australis*).

8. Identify and prioritize locations where enhancement of eelgrass (*Zostera marina*) is most feasible, based on water quality and other environmental criteria.

9. Develop a quantitative goal for eelgrass restoration based on ongoing monitoring and mapping efforts.

10. Inventory and prioritize a list of restoration projects for which planning work is underway, and recommend these for "fast-tracking" towards Bond Act funding.

11. Develop model guidelines for habitat restoration planning for use by municipalities in applying for Environmental Protection Fund (EPF) monies.

12. Develop and/or utilize cooperative programs with the public for simple, local habitat improvements and enhancements.

13. Implement Open Marsh Water Management (OMWM) for mosquito control and natural habitat management.

14. Develop and implement procedures to track and evaluate restoration efforts in the PEP area using success criteria and monitoring protocols.

15. Develop a regional set of reference sites for habitat restoration monitoring and evaluation.

16. Develop procedures for the management and storage of habitat restoration project and monitoring information from the PEP area.

The Habitat Restoration Workgroup has undertaken the sixteen restoration actions, the results and recommendations of which are compiled and presented in this Habitat Restoration Plan.

3. DISCUSSION AND RECOMMENDATIONS

There have been a wide variety of habitat restoration projects implemented in the Estuary to date, including restoration of eelgrass, intertidal marsh, grassland, freshwater wetland, beach and dune, anadromous fish passage, Open Marsh Water Management (OMWM), and *Phragmites australis* control. Similar to other regions, intertidal marsh restoration is by far the most prevalent type undertaken and is mostly successful. Although Peconic Estuary beach and dune areas are small in number and size, a moderate number of these restorations have also been successfully implemented. Projects of all types generally have been small (less than one acre to several acres in size) and fairly inexpensive (less than $10,000). The exceptions are several OMWM projects and one coastal grassland project, each greater than 50 acres in size. Most projects have been implemented by municipalities and Suffolk County.

There is clearly a need for continuing effort in the Peconic Estuary to restore and maintain the region's natural resource base and visual character. Specifically, the loss of eelgrass in the Estuary has been clearly documented, and the concomitant decline in scallop populations, an important commercial species for the Peconic region, highlights the need for restoration of this habitat. In addition, increased development in eastern Suffolk County demonstrates the need for both ecosystem protection and restoration. Many habitats have been directly replaced with development, or have declined in quality as a result of nearby development and its associated factors, *e.g.*, habitat fragmentation, pollution, eutrophication, increased resource use, and introduction of invasive plant and animal species. Habitats such as coastal grasslands--once widespread on Long Island--and coastal and maritime forest and woodlands are particularly susceptible to degradation from fragmentation and invasive species. These ecosystems support many rare and protected plant and animal species, including grassland and migratory songbirds, and contribute to the rural maritime landscape for which the Peconic region is valued. Restoration opportunities for these important terrestrial habitats should be identified. Finally, the finding that water quality in the Peconic Estuary is excellent but is currently subject to its highest ever nutrient loadings demonstrates the critical role wetland restoration can and must play in maintaining high water quality and its associated environmental and economic benefits.

Although the need for restoration clearly exists, it can be difficult to embark on the planning process. Setting goals, critical at the outset of restoration planning, can present a problem for several habitat types. For example, it is difficult to determine a target acreage for eelgrass restoration in the Estuary. While an overall loss of eelgrass is documented, the total acreage lost cannot be determined. In addition, the area of bottom with substrate and water quality conditions appropriate for eelgrass restoration, and available for planting, is unknown. Setting an acreage based goal for this species, therefore, is not feasible. For intertidal wetlands, acreage lost is easier to determine for a longer timeframe into the past. However, locating areas available for restoration of this habitat--with its prerequisite tidal inundation--seriously limits implementation. Current land uses generally preclude restoration of intertidal wetlands to any kind of historic conditions and acreages.

Due to the nature of potential funding sources and the fact that most proactive restorations take place on public lands, local townships often lead the effort. However, given the difference in staffing, available resources and site characteristics, local efforts vary greatly. Even where restoration goals are clear or tentative plans exist, project development may still not occur. Habitat restoration projects require a significant investment of time by technically competent personnel. The limiting factor in conducting restoration projects in the estuary appears to be staff time available. Currently, this fact is highlighted by a favorable funding climate during which an extremely small number of restoration projects from the Peconic Estuary are being undertaken. A well-conducted restoration project requires planning, design, implementation, and monitoring. At a minimum, each project requires several years of activity before "completion." In many cases, more than five years may be required. Therefore, long after a project has been proposed and funded, it remains on the table requiring periodic attention. With several such projects occurring simultaneously, the available staff time for restoration is soon saturated.

Another significant limiting factor to large-scale restoration in the Peconic Estuary is the fact that most of the shoreline is privately owned. This problem is not easily resolved, but high priority restoration opportunities on private lands should not be ignored. Potential solutions may exist in the form of conservation easements, transfer-of-development-rights, acquisition, or other measures. In addition, there are funding mechanisms available to conduct restoration on private lands.

Some of the problems encountered by restoration planners and practicioners revolve around information gaps and the shortcomings of the current state of the art. For example, eelgrass restoration is an extremely high priority in the Peconic Estuary, yet most attempts at restoration of eelgrass beds have met with failure. New data and information, including mapping of existing eelgrass and establishment of environmental criteria, are necessary before eelgrass restoration in the estuary can be accomplished. Better restoration technologies are critical to ensure success and minimize loss of healthy eelgrass as a result of transplanting.

Other important areas requiring additional research and the development of new technologies are *Phragmites australis* management and control, and alternatives to shoreline hardening. *Phragmites* is particularly difficult to eradicate in brackish and freshwater environments, and unfortunately threatens the existence of rare plant communities, *e.g.*, sea level fen, that are limited to these areas. However, the nutrient retention capacity of this species should indicate that removal proposals require careful evaluation and may not be warranted in certain locations.

The presence of and increase in hardened shoreline in the Peconic region is a significant problem from a natural resources standpoint. The loss of natural shoreline, particularly marsh areas, contributes to a decline in water quality and in commercial and recreational fisheries. In addition, as sea level rises over the coming centuries, hardened shoreline will prevent intertidal habitats from migrating landward, resulting in substantial losses to these ecosystems overall. Some technologies for shoreline protection, incorporating intertidal vegetation into their design, currently exist for use in place of traditional bulkheading and other hard structures. However, many of these technologies can only be used in the presence of extremely low wave energy. A great deal of research and testing of pilot projects is required to develop additional strategies that respond to current technological limitations.

A number of issues became clear during the Habitat Restoration Workgroup's participation in the Comprehensive Conservation and Management Plan (CCMP) process, and subsequent development of the Habitat Restoration Plan for the Estuary. There appears to be moderate willingness to participate in habitat restoration planning on a regional scale in the Peconic Estuary, both on the part of municipalities in the region and the public at large. Some degree of shortfall in municipal participation is undoubtedly attributable to a lack of adequate staff time for undertaking this time consuming process, especially in municipalities without dedicated natural resources offices. Technical assistance for municipalities without dedicated natural resources staff would be beneficial to increasing habitat restoration in the region, and would help mitigate perceived inequalities between municipal entities in terms of receipt of restoration funding and benefits. Public understanding of the benefits and limitations, and the different types of restoration could also be improved.

The Habitat Restoration Workgroup has identified and evaluated potential restoration projects estuary-wide. The group recommends that these identified projects be targeted for planning and implementation. Additional technical assistance, possibly through the Peconic Estuary Program, federal, New York State, and county agencies, or development of partnerships with regional academic institutions, should be provided in order to conduct restoration planning in time to take advantage of current funding opportunities. Effort should also be made to identify restoration opportunities in underrepresented habitat types, such as coastal forest, woodlands and grasslands. In addition, standard project tracking and data storage procedures should be developed and utilized for these and future restoration projects throughout the Estuary.

There are a number of initiatives that could be undertaken in the Estuary to respond to the issues identified above, and to address restoration needs of the Peconic Estuary Program and PEP municipalities. The Habitat Restoration Workgroup could potentially assist the PEP in undertaking some of these efforts. Periodic reporting on programmatic obstacles and management needs for habitat restoration in different PEP jurisdictions could assist the Program Office during CCMP implementation. Estimates of habitat restoration costs and historical habitat acreages lost from the study area could be refined to assist with prioritization of CCMP Actions, particularly those in the natural resources chapter. Measurable goals for habitat restoration in the Estuary may also be reviewed and revised in conjunction with these efforts. Additional rounds of nomination to solicit new restoration sites could be beneficial to maintain public involvement as habitat restoration planning evolves. Finally, the Workgroup could evolve, as needed, to provide technical assistance to municipalities with project planning, implementation, monitoring and evaluation.

4. RESTORATION SITE IDENTIFICATION AND EVALUATION PROCESS

The Peconic Estuary Program Habitat Restoration Workgroup (PEP HRWG) developed a public nomination process to identify regional restoration priorities. This process was selected with the intent to be more inclusive and representative of Peconic Estuary Program stakeholder priorities than would be an internal identification process.

To conduct the nomination, the HRWG developed a nomination form and supporting information package. The package contained a map of the PEP boundary, descriptions of priority restoration habitats, and a cover letter explaining the initiative signed by Janice Rollwagen, Chief of the Environmental Protection Agency (EPA) Region Two Oceans and Estuaries Section and Chair of the PEP Management Committee. This nomination package (see Appendix D) was sent to mailing lists for the PEP Management Committee, Technical Advisory Committee, Local Governments Committee, and Citizens Advisory Committee.

The Habitat Restoration Workgroup also conducted several public outreach initiatives regarding the restoration nomination process. The HRWG co-chairs participated in an episode of The Bay Show (Public Access Television) to increase awareness of HRWG activities and ongoing opportunities to participate in the nomination process. Several local newspapers announced and described the nomination process. A representative of the HRWG also made a presentation to the PEP Citizens' Advisory Committee soliciting assistance in obtaining restoration nominations from citizen stakeholders and organizations.

Prior to receipt of site nominations, the HRWG developed an evaluation methodology designed to provide consistent evaluation of nominations. The Workgroup agreed that a numerical ranking system, although never perfect, would increase objectivity and consistency of evaluation, and allow for a more nuanced assessment than would a qualitative methodology. A numerical system allows the HRWG to weight priority restoration site attributes from a regional perspective, and allows these weights to be explicitly documented. Although all sites are evaluated using the same methodology, only sites of the same habitat type are compared against each other. Therefore, separate rank orders were ultimately developed for tidal wetlands, eelgrass, beaches and dunes, and freshwater wetlands restoration projects, as well as for common reed control projects.

The ranking categories and their attributes were identified, defined, and weighted through group discussion and consensus. Test rankings were conducted on several restoration project proposals that had been evaluated the previous year using Clean Water/Clean Air Bond Act procedures. The HRWG methodology was found capable of discerning high and low ranked projects.

The methodology attempts to account for the myriad factors associated with restoration sites and projects. These include not only ecological but logistical and public/economic benefit factors. These categories and attributes are listed and explained below (see Appendix E for Site Ranking Worksheet).

Ecological

The ecological value of restoring the nominated sites in the manner proposed was evaluated during the ranking process. A restoration project with high ecological value would return an area from a highly degraded state to a historically-justifiable state, providing benefit to State-protected species, ecosystem functions, and the overall ecosystem diversity of the Peconics region. A historically-justifiable habitat is one that existed on the site in the past and is not being created. It was considered extremely important to prevent the loss of any valuable habitat, even of a different type, as a result of a restoration project. In addition, restoration projects that would enhance the size and interconnenctedness of adjacent ecosystems and habitat corridors were considered to have high ecological value. The Ecological subcategories used to rank nominated restoration sites were:

Lost Habitat Value
Level of Degradation
Historical Justification
Proposed Project Size
Habitat Contiguity/Adjacent Land Use
Target Restoration Functions
Promoting Landscape Habitat Diversity
Providing Benefit to State-listed Species
Proximity to State/Local Designated Areas

Logistical

Restoration projects were evaluated using additional factors related to their feasibility and likelihood for success. Projects on public land or private land with protected status are likely to be more feasible and long-lasting than those on private, unprotected land. Projects that were part of ongoing local or regional restoration planning initiatives, had completed a substantial portion of their project planning, or that demonstrated support from community and user stakeholders were considered to be of higher logistical priority than others. Knowledge of the state-of-the-art in restoration technologies and methods, their probability for success, and the degree of post-project maintenance required for different types of restoration were factors considered important in prioritizing nominated projects. The subcategories used for the logistical evaluation were:

Type of Ownership
Relationship to Broad Planning Efforts
Current Stage of Planning Achieved
Committed/Leveraged Funds
Probability of Success
Support from Community/User Groups
Level of Post-restoration Maintenance

Public/Economic Benefit

In addition to ecological and logistical cosiderations, the public value and economic benefit of a proposed restoration project was included in the evaluation methodology. Projects with high public value included those that would enhance appropriate public access to a natural resource as a result of the restoration, or would increase public awareness of the resource through proximity to human activity or through educational initiatives incorporated into the project. Economic benefit was included by evaluating the types of commercial and recreational uses supported by the restoration, and by its benefit to regionally important commercial or recreational species. The subcategories in the Public/Economic benefit category were:

Enhancing Public Access/Awareness
Enhancing Commercial/Recreational Uses
Benefit to Commercial/Recreational Species

Nominated sites received by the group were examined briefly for completeness by one of the HRWG co-chairs. If deemed complete, nominations were set aside and remained unexamined until the HRWG convened for the purpose of evaluation. Several HRWG meetings were devoted to Round One evaluation between October, 1998 and January, 1999. Each site was examined communally by the HRWG according to the numerical ranking system. Group majority consensus was used to select appropriate category scores. Controversial scores were discussed until a relative consensus was achieved. The HRWG systematically applied certain category scores to projects with similar characteristics regardless of nomination form language or personal knowledge of a site. This was done to maintain consistency and increase the equity of the process.

Subsequent to the consensus ranking process, the group selected high and low ranked sites of each habitat type and in two towns to assess field accuracy of the ranking process. The selected Round One sites were visited in April, 1999 by the Habitat Restoration Workgroup and the site nominators, where onsite explanations of environmental conditions, disturbances, and attributes of the proposed project were given. The group also revisited the scores given to each ranking category while onsite and potential alterations were noted and discussed. It was determined that although discrepancies between original scores and the onsite scores existed in some cases, no errors had been made that would alter relative rankings among sites. Therefore, rankings were not changed subsequent to the site visits.

The one exception to the above scenario were the nominated eelgrass sites. The group determined that these could not be accurately ranked without additional knowledge of onsite substrate characteristics and the presence/absence of existing eelgrass beds (see Section 6 for additional information). Site visits to all nominated eelgrass sites for which this information was unavailable were conducted by several members of the Habitat Restoration Workgroup in June, 1999.

Round Two nominations were due in October, 1999 and were evaluated February-March, 2000. The solicitation process was reevaluated prior to Round Two; the mailing list for the Technical Advisory Committee was dropped and lists for baymen, commercial and recreational fishermen and boating organizations, and press contacts were added. Future rounds of restoration site nomination, evaluation, and listing will be planned and implemented as appropriate according to the requirements of the CCMP implementation phase Management Conference structure. This process possibly could occur annually.

All nominated sites from Rounds One and Two are included in this Habitat Restoration Plan. They are listed separately for each habitat type, and articulate highest priority sites in that category for each town (including Brookhaven, East Hampton, Riverhead, Shelter Island, Southampton, and Southold) followed by a simple rank order for the remaining sites. This format allows high priority restoration sites to exist in a given category for each town who nominates a site of that type. Therefore, no single town may dominate the nomination process at the expense of other towns.

Priority listings for eelgrass sites remain an exception to the system articulated above. Field reconnaissance, conducted to gather additional data on sediment type at the nominated eelgrass sites, confirmed the Workgroup's belief that the ranks developed using the standard ranking methodology do not accurately predict the best sites for eelgrass transplantation. Eelgrass restoration remains a highly uncertain activity, and many aspects of the relationship between site conditions and transplant success are not completely understood. The HRWG presents, for the sake of consistency, nominated eelgrass sites as ranked throughout this plan. However, the high uncertainty associated with eelgrass restoration precludes the Workgroup from advocating a rank order for these sites. Case-by-case analysis of site conditions, selected methods, and project timing must be conducted to accurately assess the potential for success.

High priority sites in later planning stages were evaluated for Clean Water/Clean Air Bond Act eligibility. The group will encourage municipalities with such projects to apply for Bond Act funding, and will provide application assistance where appropriate. Municipalities with projects in need of additional planning will be encouraged to apply for Environmental Protection Fund awards. A guide to Environmental Protection Fund restoration project criteria and important components of the habitat restoration planning process is provided in Section 14. In the future, the Habitat Restoration Workgroup will attempt to coordinate priority projects with additional funding sources and provide technical assistance in applying for such awards. An inventory of potential habitat restoration funding sources is provided in Section 13.

5. PRIORITY RESTORATION PROJECTS IN THE PECONIC ESTUARY

Tables 1 and 2, listing rankable and tabled sites from both Round One and Two of nomination, are provided in this section. The tables are organized by habitat type, and include a column with keywords summarizing the types of restoration activities proposed for each site. Additional sorts of the rankable sites are included in Appendix B.

Following Tables 1 and 2, priority restoration sites are listed by habitat type with the highest ranking site in each town listed up front. After the highest ranked site from each town, all other sites in that habitat category follow in rank order. Many categories did not have nominated sites in all PEP study area towns; this is indicated by "no sites nominated". Several habitat categories are not applicable to the Town of Brookhaven; this is indicated by "N/A".

As in Tables 1 and 2, nominated sites that were tabled by the Habitat Restoration Workgroup are listed separately. Sites were tabled when they were unrankable using the HRWG methodology (see Section 4 for additional information). Several nominated projects also fell outside the purview of the Habitat Restoration Workgroup mission (*e.g.*, ecological research, stormwater management). For unrankable projects that are nonetheless consistent with the HRWG mission, additional information on the sites and the proposed restoration methods is required. Nominators whose sites were tabled are encouraged to discuss information needs with the HRWG and resubmit site nominations. Several sites tabled during Round One were resubmitted with additional information during Round Two and were ranked.

An exception in the listings which follow are eelgrass sites. The HRWG believes that the standard ranking methodology was not adequate to predict the best sites for eelgrass transplantation. Eelgrass restoration is a highly uncertain activity, and many aspects of the relationship between site conditions and transplant success are not completely understood. Field reconnaissance, conducted to gather additional data on sediment type at the nominated eelgrass sites, supports the Workgroup's belief. For the sake of consistency, nominated eelgrass sites are presented as ranked throughout this plan. However, the high uncertainty associated with eelgrass restoration precludes the Workgroup from advocating any of the eelgrass restoration sites at this time. Case-by-case analysis of specific site conditions, selected methods, and project timing must be conducted to accurately assess the potential for success.

Table 1. Peconic Estuary Program Restoration Sites, by habitat type

Habitat Type	Site Name	Type of Activity	Town
Alewife	Alewife Brook Alewife Access	dbrs_rmv, inv_rmv	EH
	Lake Montauk Alewife Access	dredge, dbr_rmv, inv_rmv	EH
Beach	Sammi's Beach	grade, plant	EH
	Reel Point	other	SI
	Wades Beach	fill, plant, excav, dredge	SI
Eelgrass*	Northwest Creek Eelgrass	transpl	EH
	Noyack Creek Eelgrass	transpl	SH
	Napeauge Eelgrass	transpl	EH
	Lake Montauk Eelgrass	transpl	EH
	Accabonac Harbor Eelgrass	transpl	EH
	Upper Sag Harbor Cove Eelgrass	transpl	SH
	Bullhead Bay Eelgrass	transpl	SH
	Sag Harbor Cove Eelgrass	transpl	SH
	Paynes Creek Eelgrass	transpl	SH
	Cutchogue Harbor	other	SD
	Three Mile Harbor Eelgrass	transpl	EH
Grassland	Shinnecock Grassland	inv_rmv, burn	SH
	Culloden Grassland	inv_rmv, burn, plant	EH
	Fort Hill Cemetery Grassland	inv_rmv, burn	EH
Phragmites	Cedar Beach Phragmites	excav, inv_rmv, plant	SD
	Alewife Brook Phragmites	inv_rmv	EH
	Accabonac Harbor Phragmites	inv_rmv	EH
	Northwest Creek Phragmites	inv_rmv	EH
	Tidal Sawmill Creek Phragmites	inv_rmv, excav, plant, technol	RH
	East Creek Phragmites	technol, inv_rmv	RH
	Fresh Pond Phragmites	inv_rmv, plant, dredge	EH
	Little NW Creek Phragmites	inv_rmv	EH
	Napeague Phragmites	inv_rmv	EH
	Barnes Meadow Phragmites	inv_rmv, plant	EH
	Fort Pond Phragmites	inv_rmv	EH
	Peconic Edwards Ave. Phragmites	inv_rmv, plant	RH
	Three Mile Harbor Phragmites	inv_rmv	EH
	Lake Montauk Phragmites	inv_rmv	EH
	Gravel Pit (Dog Ponds) Phragmites	inv_rmv, technol, plant	RH
	Browns Point Phragmites	inv_rmv, technol, dbrs_rmv	RH
	Tidal Peconic Phragmites	inv_rmv, plant, technol	RH
	Linns Pond Phragmites	inv_rmv, plant	RH
	Hog Creek Phragmites	inv_rmv	EH
	Broad Cove Phragmites	technol, inv_rmv	RH
	Bay Woods Phragmites	dredge, inv_rmv	RH
	Warner Duck Farm Phragmites	inv_rmv, excav, plant, dbrs_rmv	RH
	Reeves Creek Phragmites	inv_rmv, technol	RH
	Peconic Seep Phragmites	inv_rmv, excav, technol	RH
	Grumman Phragmites	inv_rmv, technol	RH
	Lake Marion Phragmites	dredge, inv_rmv, plant	SD
	Upper Sawmill Creek Phragmites	inv_rmv, excav	RH
	Terry Creek Phragmites	technol	RH
Riverine	Peconic Upper Mills Riverine Habitat	inv_rmv, plant	RH

Table One Continued

Habitat Type	Site Name	Type of Activity	Town
Shorebird	Hicks Island Plover/Tern	veg_rmv	EH
	Mill Creek Enhancement Project	fill, veg_rmv, plant	SH
WQ	Lake Montauk Water Quality	technol	EH
	Accabonac Harbor Road End	excav, grade, inv_rmv, plant	EH
	Oyster Pond Water Quality	omwm	EH
	Accabonac Harbor Flushing	technol, dredge	EH
	Fresh Pond Flow	dredge	EH
Wetland (T)	Davis Creek Wetlands	grade, omwm, plant	SH
	Noyack Creek Wetlands	excav, grade	SH
	Sag Harbor Cove/Paynes Creek Wetl	grade, fill, plant	SH
	Accabonac Harbor Wetlands	dbrs_rmv, grade, plant	EH
	Fort Pond Wetlands	excav, grade, plant	EH
	Nassau Point Wetlands	excav, grade, plant	SD
	Fleets Neck Wetlands	excav, grade, plant	SD
	Cold Spring Pond Wetlands	excav, dbrs_rmv	SH
	Upper Sag Harbor Cove Wetlands	fill	SH
	Cedar/Taylor Island Revegetation	hrd_rmv, plant	SI
	Paynes Creek Wetl Enhancement	plant	SH
	Three Mile Harbor Wetlands	grade, plant	EH
	North Sea Wetlands	grade, plant	SH
	TGA Easement Wetlands	omwm, inv_rmv	SD
	Fish Cove Wetland Enhancement	dbrs_rmv	SH
	North Sea/Alewife Creek Wetlands	omwm	SH
	Lake Montauk Wetlands	excav, grade, plant	EH

Table 2. Peconic Estuary Program Tabled** Sites, by habitat type

Habitat Type	Site Name	Type of Activity	Town
Wetland (F)	Lily Pond Freshwater Wetland	other	SI
	Matt's Pond Freshwater Wetland	other	SI
	Pine Swamp Freshwater Wetland	other	SI
Miscellaneous	Miamogue Point Acquisition	other	RH
	Lake Marion Study	other	SD
	Hay Beach/Salt Pond	other	SI
Phragmites	Hawks/Kings Creek	technol, inv_rmv	RH
SAV	Fort Pond SAV	transpl	EH
WQ	Fort Pond Water Quality	technol	EH
	Stormwater 1-Wildwood Lake	technol	SCo
	Stormwater 2-Gardiners Bay	technol	SCo
	Stormwater 3-Hashamomuck Beach	technol	SCo
	Stormwater 4-Terry & Sawmill Creeks	technol	SCo
	Stormwater 5-County Highways	technol	SCo
	Bay Home Road End	technol, plant	SD
	Marratooka Road End	technol, plant	SD
	Nassau Point Road End	technol, plant	SD
	Pequash Road End	technol, plant	SD
	West Neck Harbor Water Quality	technol, other	SI

KEYS TO TABLES

Keyword	**Type of Activity**
burn	controlled burning, designed to enhance ecological conditions, *e.g,* in fire-dependent communities
dbrs_rmv	debris removal
dredge	removal of material from the aquatic environment, usually to enhance water circulation
excav	fill, stands of Phragmites, or other material will be removed from the area
fill	material will be added to area, usually to achieve appropriate elevations and grades
grade	grading of area to appropriate elevations, usually designed to enhance tidal flushing
hrd_rmv	removal of shoreline hardening structures
inv_rmv	invasive species removal, usually manual (*i.e.*, cutting or mowing)
omwm	manipulations of existing ditches to enhance site hydrology
other	non-restoration activities, including public education, land acquisition, and research
plant	restoration site will be planted rather than revegetated naturally
technol	application of water quality improvement technology, such as catchment basins or culverts
transpl	transplantation; taking vegetation from one site for use in restoration of another site
veg_rmv	vegetation removal; usually to enhance shorebird nesting habitat by setting back succession

Code	**Town**
BR	Brookhaven
EH	East Hampton
RD	Riverhead
SI	Shelter Island
SH	Southampton
SD	Southold
SCo	Suffolk County

* The Habitat Restoration Workgroup (HRWG) believes that the ranks developed for the nominated eelgrass restoration sites using the ranking methodology do not accurately predict the best sites for eelgrass transplantation. Field reconnaissance, conducted to gather additional data on sediment type at the nominated eelgrass sites, confirms this belief. Eelgrass restoration is highly uncertain, and many aspects of the relationship between site conditions and transplant success are not well understood. For the sake of consistency, nominated eelgrass sites are presented as ranked throughout this plan. However, the high uncertainty associated with eelgrass restoration precludes the Workgroup from advocating any of the eelgrass restoration sites at this time. Case-by-case analysis of specific site conditions, selected methods, and project timing must be conducted to accurately assess the potential for success.

** Sites were tabled when they were unrankable using the HRWG methodology. Several nominated projects also fell outside the purview of the Habitat Restoration Workgroup mission (*e.g.*, ecological research, stormwater management). For unrankable projects that are nonetheless consistent with the HRWG mission, additional information on the sites and the proposed restoration methods is required. Several sites tabled during Round One were resubmitted with additional information during Round Two and were ranked.

PRIORITY RESTORATION PROJECTS BY HABITAT TYPE

TIDAL WETLANDS

Highest Priority Projects		Other Sites
East Hampton:	Accabonac Harbor	Noyack Creek, Southampton
Shelter Island:	Cedar/Taylor Island	Sag Harbor Cove/Paynes Creek, Southampton
Southampton:	Davis Creek	Fort Pond, East Hampton
Southold:	Nassau Point	Fleets Neck, Southold
		Cold Spring Pond, Southampton
		Upper Sag Harbor Cove, Southampton
		Paynes Creek Enhancement, Southampton
		Three Mile Harbor, East Hampton
		TGA Easement, Southold
		North Sea Wetlands, Southampton
		Fish Cove, Southampton
		North Sea/Alewife Creek, Southampton
		Lake Montauk, East Hampton

BEACHES AND DUNES

Highest Priority Projects		Other Sites
East Hampton:	Sammi's Beach	Hicks Island Plover/Tern, East Hampton
Shelter Island:	Reel Point	Wades Beach, Shelter Island
Southampton:	Mill Creek Enhancement	

COASTAL GRASSLANDS

Highest Priority Sites		Other Sites
East Hampton:	Culloden Grassland	Fort Hill Cemetery, East Hampton
Southampton:	Shinnecock Grassland	

ESTUARIES AND ESTUARINE EMBAYMENTS

Highest Priority Sites		Other Sites
East Hampton:	Lake Montauk	Oyster Pond, East Hampton
		Accabonac Harbor Flushing, East Hampton
		Fresh Pond Flow, East Hampton
		Accabonac Harbor Road End, East Hampton

COMMON REED (*PHRAGMITES AUSTRALIS*) CONTROL

Highest Priority Projects

East Hampton: Alewife Brook
Riverhead: Tidal Sawmill Creek
Southold: Cedar Beach

Other Sites

Accabonac Harbor, East Hampton
Northwest Creek, East Hampton
East Creek, Riverhead
Little Northwest Creek, East Hampton
Fresh Pond, East Hampton
Napeague, East Hampton
Barnes Meadow, East Hampton
Fort Pond, East Hampton
Peconic Edwards Ave., Riverhead
Three Mile Harbor, East Hampton
Lake Montauk, East Hampton
Browns Point, Riverhead
Gravel Pit (Dog Ponds), Riverhead
Tidal Peconic, Riverhead
Linns Pond, Riverhead
Hog Creek, East Hampton
Broad Cove, Riverhead
Bay Woods, Riverhead
Warner Duck Farm, Riverhead
Reeves Creek, Riverhead
Peconic Seep Stream, Riverhead
Grumman, Riverhead
Lake Marion, Southold
Upper Sawmill Creek, Riverhead
Terry Creek, Riverhead

RIVERINE HABITAT AND MIGRATORY CORRIDORS

Highest Priority Projects

East Hampton: Alewife Brook Access
Riverhead: Peconic Upper Mills

Other Sites

Lake Montauk Access, East Hampton

FRESHWATER WETLANDS

All Freshwater Wetland nominations were tabled. However, see "Common Reed Control" and "Riverine Habitat" listings for related projects.

INTERTIDAL MUDFLATS AND SANDFLATS

There were no nominated intertidal mudflat restoration projects.

COASTAL FORESTS

There were no nominated coastal forest restoration projects.

EELGRASS *

Highest Priority Projects

East Hampton: Northwest Creek
Southampton: Noyack Creek
Southold: Cutchogue Harbor

Other Sites

Napeague Harbor, East Hampton
Lake Montauk, East Hampton
Accabonac Harbor, East Hampton
Bullhead Bay, Southampton
Upper Sag Harbor Cove, Southampton
Sag Harbor Cove, Southampton
Paynes Creek, Southampton
Three Mile Harbor, East Hampton

TABLED NOMINATED SITES **

Fort Pond SAV, East Hampton
Fort Pond Water Quality, East Hampton
Hawks/Kings Creek, Riverhead
Miamogue Point Acquisition, Riverhead
Matt's Pond, Shelter Island
Lily Pond, Shelter Island
Pine Swamp, Shelter Island
Hay Beach/Salt Pond, Shelter Island
West Neck Harbor Water Quality, Shelter Island
Lake Marion Study, Southold
Road End projects 1 - 4, Southold
Stormwater projects 1 - 5, Suffolk County

* The Habitat Restoration Workgroup (HRWG) believes that the ranks developed for the nominated eelgrass restoration sites using the ranking methodology do not accurately predict the best sites for eelgrass transplantation. Field reconnaissance, conducted to gather additional data on sediment type at the nominated eelgrass sites, confirms this belief. Eelgrass restoration is highly uncertain, and many aspects of the relationship between site conditions and transplant success are not well understood. For the sake of consistency, nominated eelgrass sites are presented as ranked throughout this plan. However, the high uncertainty associated with eelgrass restoration precludes the Workgroup from advocating any of the eelgrass restoration sites at this time. Case-by-case analysis of specific site conditions, selected methods, and project timing must be conducted to accurately assess the potential for success.

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PRIORITY RESTORATION PROJECTS BY TOWN

East Hampton

1. Sammi's Beach
2. Hicks Island Plover/Tern
3. Alewife Brook Alewife Access
4. Accabonac Harbor Wetlands
5. Fort Pond Wetlands
6. Lake Montauk Alewife Access
7. Northwest Creek Eelgrass
8. Culloden Grassland
9. Lake Montauk Water Quality
10. Alewife Brook Phragmites
11. Accabonac Harbor Road End
12. Accabonac Harbor Phragmites
13. Napeauge Eelgrass
14. Northwest Creek Phragmites
15. Oyster Pond Water Quality
16. Lake Montauk Eelgrass
17. Accabonac Harbor Flushing
18. Accabonac Harbor Eelgrass
19. Three Mile Harbor Wetlands
20. Fort Hill Cemetery Grassland
21. Fresh Pond Flow
22. Little NW Creek Phragmites
23. Fresh Pond Phragmites
24. Napeague Phragmites
25. Barnes Meadow Phragmites
26. Fort Pond Phragmites
27. Lake Montauk Wetlands
28. Three Mile Harbor Eelgrass
29. Three Mile Harbor Phragmites
30. Lake Montauk Phragmites
31. Hog Creek Phragmites

Riverhead

1. Tidal Sawmill Creek Phragmites
2. East Creek Phragmites
3. Peconic Edwards Ave. Phragmites
4. Gravel Pit (Dog Ponds) Phragmites
5. Browns Point Phragmites
6. Tidal Peconic Phragmites
7. Linns Pond Phragmites
8. Peconic Upper Mills Riverine
9. Broad Cove Phragmites
10. Bay Woods Phragmites
11. Warner Duck Farm Phragmites
12. Reeves Creek Phragmites
13. Peconic Seep Phragmites
14. Grumman Phragmites
15. Upper Sawmill Creek Phragmites
16. Terry Creek Phragmites

Shelter Island

1. Cedar/Taylor Island Revegetation
2. Reel Point Beach
3. Wades Beach

Southampton

1. Davis Creek Wetlands
2. Noyack Creek Wetlands
3. Sag Harbor Cove/Paynes Creek Wetl
4. Shinnecock Grassland
5. Mill Creek Beach Enhancement
6. Noyack Creek Eelgrass
7. Cold Spring Pond Wetlands
8. Upper Sag Harbor Cove Wetlands
9. Paynes Creek Eelgrass
10. Upper Sag Harbor Cove Eelgrass
11. Bullhead Bay Eelgrass
12. Sag Harbor Cove Eelgrass
13. Paynes Creek Wetl Enhancement
14. North Sea Wetlands
15. Fish Cove Wetland Enhancement
16. North Sea/Alewife Creek Wetlands

Southold

1. Nassau Point Wetland
2. Fleets Neck Wetland
3. Cedar Beach Phragmites
4. Cutchogue Eelgrass
5. TGA Easement Wetland
6. Lake Marion Phragmites

6. PRIORITY RESTORATION HABITAT TYPES IN THE PECONIC ESTUARY

Submerged Aquatic Vegetation (SAV)

Characterization

This habitat consists of beds of rooted plants as well as attached and unattached macrophytes, growing in shallow, quiet waters below the spring low tide level. Temperate SAV beds are composed primarily of two rooted seagrass species: eelgrass (*Zostera marina*) and widgeon-grass (*Ruppia maritima*). In the Peconics region, eelgrass beds are primarily found east of Shelter Island and are most abundant in Gardiner's Bay and Block Island Sound. A number of red, green and brown macroalgal species, including sea lettuce (*Ulva lactuca*), green fleece (*Codium fragile*), lacy redweed (*Euthora cristata*), brushy redweed (*Cystoclonium purpureum*), and rockweed (*Fucus* spp.), are found throughout the estuary. Eelgrass beds occur most frequently in sheltered estuarine areas, while widgeon-grass is found in lower salinity zones and small tidepools.

Functions

Submerged plants support abundant populations of small invertebrates, which are a food source for waterfowl and some terrestrial species. SAV enhances sediment stability by reducing/absorbing bottom current velocity, oxygenates bottom waters, provides important microhabitat by adding three-dimensional structure to the bottom, and is an important source of primary production and organic detritus, the base of the benthic food chain. Phytoplankton are concentrated in SAV beds as a result of the baffling effect on current energies by the canopy, making these areas important for secondary production.

Eelgrass provides essential post-larval attachment sites for bay scallop (*Argopecten irradians*). Blue mussel (*Mytilis edulis*) larvae have been observed to settle on eelgrass blades in some areas. Other invertebrate species often found in eelgrass beds include brittlestars, clams, spider crabs (*Libinia* spp.), hermit crab (*Pagurus longicarpus*), knobbed whelk (*Busycon carica*), blue crab (*Callinectes sapidus*), green crab (*Carcinus maenas*), rock crab (*Cancer irroratus*), seven-spine shrimp (*Crangon septemspinosa*), and common slippershell (*Crepidula fornicata*). Lobster, mud crabs, shrimp, and eels are sometimes observed in Peconics region SAV beds.

SAV beds also provide nursery for juvenile finfish, and juvenile and adult feeding grounds. Fish utilizing eelgrass beds include three-spine stickleback (*Gasterosteus aculeatus*), four-spine stickleback (*Apeltes quadricus*), grubby (*Myxocephalus aenaeus*), winter flounder (*Pleuronectes americanus*), northern pipefish (*Syngnathus fuscus*), mummichog (*Fundulus heteroclitus*), oyster toadfish (*Opsanus tau*), and sea robins (*Prionotus* spp.). Species utilizing SAV beds only at night include tautog (*Tautoga onitis*), Atlantic tomcod (*Microgadus tomcod*), Atlantic cod (*Gadus morhua*), and scup (*Stenotomus chrysops*).

In general, there are few direct grazers on temperate SAV species. Fauna observed sometimes to feed directly on eelgrass shoots and seeds include urchins, green turtle (*Chelonia mydas*), and waterfowl species such as mute swan (*Cygnus olor*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), and northern pintail (*Anas actua*). Eelgrass beds are an important winter food source for brant (*Branta bernicla*).

Impacts

SAV beds are susceptible to turbidity, which decreases light penetration and therefore decreases plant productivity and health. SAV habitats are also susceptible to increased nitrogen loading, which enhances the growth of phytoplankton and epiphytic algae, again decreasing light penetration into the water column or into the photosynthetic apparatus of the plant, respectively. Any activities contributing to increased sedimentation or nutrient loads, such as from storm sewers or septic systems, should be avoided in the vicinity of SAV beds. SAV beds can also be physically damaged by recreational and commercial boating activities, *e.g.*, anchoring and grounding, and by some shellfishing practices, *e.g.*, bullraking and scallop dredging.

North Atlantic eelgrass beds of the estuarine environment have been largely decimated by the slime mold "wasting disease" that first appeared in the 1930s. Peconics region eelgrass beds were further impacted by periodic brown tide blooms, which have occurred sporadically since 1985.

Status and Trends

The Peconic Estuary study area contains approximately 98 km^2 (~24,000 acres) of SAV beds (the total water area of the estuary is 404 km^2, or 100,000 acres). According to Cashin Associates (1996), eelgrass comprises the majority of SAV biomass present in the estuary. Eelgrass is reported to account for an average dry weight biomass (DWB) of 370 g m^{-2} in the Peconic Estuary study area as a whole. Eelgrass beds are primarily located east of Shelter Island. In this region, Cashin Associates (1996) report an average DWB of 435 g m^{-2}. There are, however, some eelgrass beds found in Southampton embayments, including Bullhead Bay and Sag Harbor Cove. According to this study, there is a general decline in eelgrass abundance occurring in the Peconic Estuary at the present time (Cashin, 1996).

SAV Restoration

Eelgrass restoration involves transplantation of eelgrass plants into areas exhibiting appropriate habitat criteria for eelgrass. Eelgrass plants are often harvested from existing eelgrass beds for this purpose, but may also be raised from seed or by clonal propagation for use in transplanting projects.

Parameters influencing transplant success include water clarity (light attenuation coefficient, K_d; concentration of Chlorophyll *a*, Chl *a*; total suspended solids, TSS), substrate characteristics (grain size), nutrient concentrations (dissolved inorganic nitrogen, DIN; dissolved inorganic phosphorus, DIP), wave exposure and tidal current speed at the site. Factors such as time of year, transplanting method, propagule vigor, extent of bioturbation, and disturbances to the site, *e.g.*, shellfishing, will also influence transplant success.

Planting may occur by any of a number of methods depending on site characteristics and project budget. The most commonly employed types of planting unit are plugs, peat pots, groups of bare-root plants attached to a staple, and small diameter (20 cm) sods. Fertilizer may be used and has variable effects on plant survival and growth (Fonseca *et al*., 1998). Planting may require SCUBA diving, depending on the depth of the planting site. Post-planting protection may be necessary to prevent bioturbation and disturbances to the site from shellfishing and other activities (see Section 7, Special Topics: Eelgrass Restoration, for additional information).

Tidal Wetlands

Characterization

Tidal wetlands constitute some of the most diverse and biologically productive habitats of the coastal region. A transition zone between terrestrial and tidal open water ecosystems, they are comprised of both low and high salt marsh, brackish and freshwater tidal marshes, and tidal creeks.

Low marsh (classified by the New York State Department of Environmental Conservation as Intertidal Marsh, IM) is submerged at high tide but exposed at low tide. The low marsh zone is dominated by smooth cordgrass (*Spartina alterniflora*), a species that normally grows between mean sea level and mean high water. Smooth cordgrass can grow to three meters (10 feet) in height. Few other species are present in the low marsh; species of algae such as rockweed (*Fucus vesiculosus*), green algae (*Enteromorpha* spp.), and sea lettuce may be present between cordgrass stems. Glasswort (*Salicornia europaea*) can sometimes be found in this zone in low densities.

High marsh, which is only periodically flooded during spring and flood tides, is dominated by a mix of salt-meadow cordgrass (*Spartina patens*) and short-form smooth cordgrass, with lesser amounts of spikegrass (*Distichlis spicata*), and black grass (*Juncus gerardii*). High marsh may also support switchgrass (*Panicum virgatum*), sea-lavender (*Limonium carolinianum*), saltmarsh plantain (*Plantago maritima*), seaside gerardia (*Agalinis maritima*), and glassworts (*Salicornia* spp.).

Brackish tidal marshes have salinities ranging from a high of around 18 ppt to nearly fresh water (0.5 ppt). These habitats are varied and exhibit high plant diversity, supporting plants such as spikerush (*Eleocharis rostellata*), rose-mallow (*Hibiscus moscheutos*), bulrushes (*Scirpus* spp.), sea-lavender, saltmarsh aster (*Aster tenuifolius*), seaside goldenrod (*Solidago sempervirens*), seaside arrowgrass (*Triglochin maritimum*), twig rush (*Cladium mariscoides*), and switchgrass.

Freshwater tidal marshes are dominated by emergent aquatic species, such as arrowheads (*Sagittaria* spp.) and pickerelweed (*Pontederia cordata*), with cattail (*Typha latifolia*), bulrushes, and sedges (*Carex* spp.) found at higher elevations. Freshwater tidal marshes are distinguishable from brackish marshes due to the presence of certain plant species restricted to freshwater: spatterdock (*Nuphar luteum*), sweetflag (*Acorus americanus*), blue flag (*Iris versicolor*), and a significantly higher density of sedges.

Tidal creeks frequently occur in conjunction with coastal marshes. These creeks flow sinuously through marsh vegetation, and have vertical banks that may erode and slump into the water. Tidal creeks also bring seawater into the back marsh, and transport wrack, detritus and aquatic species into and out of the area.

Functions

There are a number of bird species that nest in tidal marshes, including marsh wren (*Cistothorus palustris*), sharp-tailed sparrow (*Ammodramus caudacutus*), red-winged blackbird (*Agelaius phoeniceus*), black-crowned night heron (*Nycticorax nycticorax*), Canada goose, American black duck (*Anas rubripes*), and sometimes clapper rail (*Rallus longirostris*) and willet (*Catoptrophorus semipalmatus*).

Many more birds depend on tidal marshes for food, feeding on small fish, invertebrates, insects, and vegetation. This group includes Canada goose, which breeds and winters in salt marshes near ice-free, shallow water, and American black duck, both a permanent and migratory resident in the Peconics region, which requires nearby open water and thick marsh vegetation. Green-backed heron (*Butorides striatus*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), glossy ibis (*Plegadis falcinellus*), tree swallow (*Tachycineta bicolor*), and terns (*Sterna* spp.) also feed in tidal wetlands. Northern harrier (*Circus cyaneus*) and short-eared owl (*Asio flammeus*) hunt in marshes for small mammals like meadow vole (*Microtus pensylvanicus*).

Characteristic fishes in tidal creeks and flooded marsh areas include Atlantic silverside (*Menidia menidia*), sheepshead minnow (*Cyprinodon variegatus*), and mummichog. Many fish species reside in salt marshes for most of their life cycle, including mummichog, striped killifish (*Fundulus majalis*), and sheepshead minnow. Atlantic silverside spawn in salt marshes. Other fish depend on the salt marsh habitat as a nursery area including winter flounder, tautog, sea bass (*Centropristes striata*), alewife (*Alosa pseudoharengus*), menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), mullet (*Mugil cephalus*), sand lance (*Ammodytes americanus*), and striped bass (*Morone saxatilis*).

Invertebrate macrofauna are an important component of tidal salt marsh systems, providing food for many birds and fish of the marsh, as well as contributing to the structural and functional characteristics of the habitat. The macrofauna are significant consumers of algae, detritus, and smaller invertebrates; infauna rework and aerate marsh sediments and increase microbial activity and the diversity of these populations through feeding. Among those macrofauna most frequently observed in salt marshes are ribbed mussel (*Geukensia demissa*), fiddler crabs (*Uca* spp.), and salt marsh snail (*Melampus bidentatus*).

Tidal wetlands perform many functions, including sediment trapping, nutrient and organic matter cycling, flood conveyance, reduction of wave energy during storms, provision of breeding, nursery and feeding habitat, and migratory stopover grounds. Tidal wetland vegetation and substrates assimilate and break down nutrients and contaminants from surface runoff and groundwater. Tidal wetlands supply much of the organic matter that forms the basis of the food chain in the coastal aquatic environment: as marsh vegetation decays, a steady supply of nutrients and detritus is released into surrounding waters, promoting the secondary production of fish, shellfish, crustaceans, and birds.

Intertidal marsh areas are a critical habitat for the larval and juvenile stages of many fish and invertebrate species, and are used for spawning by adults of these species. For example, marine species such as winter flounder, bluefish, and anadromous species such as striped bass use tidal creeks and wetlands as nursery areas. Furthermore, tidal wetlands provide foraging and nesting habitat for many bird species, including waterfowl and wading birds. Brackish and salt marshes are an important feeding habitat for the diamondback terrapin (*Malaclemys terrapin).*

Impacts

Activities that cause disruptions in the hydrologic regime, or cause even minor elevational or gradient changes, can have profound negative impacts on tidal wetlands. Degradation and loss of upland buffers may cause increased erosion, increased nutrient loadings to coastal waterbodies, and loss of wildlife habitat for wetland edge species. Changes in ambient soil and water salinities will affect species composition in tidal wetlands and creek communities, *e.g.*, invasion by common reed (*Phragmites australis*). Other activities that negatively affect salt marshes include ditching, diking, fill, excavation, channel dredging, misuse of pesticides and herbicides, and stormwater discharge. Tidal creeks are affected by alterations to bank structure, *e.g.*, bulkheading, and by inlet manipulation.

Status and Trends

A total of 5,679 acres in the Peconic region are categorized as “estuarine wetlands”, which encompass salt marsh, *Phragmites*-dominated marsh, salt shrub swamp, flooded former forest areas, streambed, and estuarine tidal flat/beach. Approximately 3,591 of these acres are considered emergent salt marsh. Only 8% of surveyed estuarine emergent marshes were found to be *Phragmites* dominated (Tiner *et al*., 1998).

According to Tiner *et al.* (1998), between 1972 and 1994 approximately 115 acres of salt and brackish marshes (including estuarine emergent and scrub-shrub swamp) were lost. Salt and brackish marsh losses therefore represent 45% of the total wetland loss in the Peconic Estuary (256 acres of total wetlands lost) during this period. The largest causes of loss were erosion by marine processes, dredging, and filling for home and lawn construction. Wetland buffer (500 feet) loss occurred primarily in upland forest habitats as a result of golf course and residential housing construction (Tiner *et al*., 1998).

Tidal wetland losses between 1976 and 1987 were also documented by the Long Island Regional Planning Board (1990). According to this survey, 21 acres of tidal wetland were lost in the Peconics during this period. Ten acres were lost on the North Fork, 9 acres on the South Fork, and 1 acre each lost from the Peconic River/Flanders Bay drainage basin and from Shelter Island. This lost acreage represents only 0.5% of the total natural resource losses documented (in all categories) for this period.

It should be noted that the most extensive wetland losses in the Peconic Estuary occurred prior to 1972. Unfortunately, little documentation exists for these losses and the status and trends in wetlands prior to 1972 cannot be analyzed.

Tidal Wetlands Restoration

Tidal wetlands restoration often involves reintroduction of tidal flow into areas restricted from tides by tide gates, dikes, undersized culverts, or fill. To restore such areas, gates and dikes may be removed, culverts may be resized, or fill may be removed and the area regraded and planted. Bridges or other elevated structures may be constructed to replace roadbed and other transportation corridor fill. Salt marshes that have been ditched for mosquito control may often be partially restored using an alternative mosquito control technique called open marsh water management (OMWM, see Section 8 for additional information). Individual site characteristics and project goals will determine the most appropriate restoration techniques.

A determination must be made regarding whether to allow natural revegetation of the salt marsh or to assist vegetative recovery by planting. The following factors should assist in making this decision: surrounding land uses and their potential to contribute disturbances or invasive species; isolation of the site from similar, natural sites that could act as seed sources; the time of year the restoration will be accomplished; hydrologic considerations such as timing and duration of inundation, water level fluctuations, and flushing; and the characteristics of site substrates and any substrate augmentations planned (Kentula *et al.*, 1993).

Planting growing or dormant plants, or plant propagules, is the most reliable method for salt marsh restoration projects (Broome *et al.*, 1988; Garbisch *et al.*, 1975). *Spartina alterniflora* may be planted using single stems (no soil around roots) or plugs (intact root and soil mat included). Transplants of *S. alterniflora* are generally grown from seed in pots or flats, either in a greenhouse or outdoors when temperatures permit (Broome, 1990; Broome *et al.*, 1988). Plants propagated from local seed stock should be used whenever possible.

Hand-planting is generally required for intertidal vegetation. Planting should occur in spring or early summer (*e.g.*, May-June; Broome, 1990). Planting holes should be ~15 cm in depth, 5-7 cm in diameter. A soil auger of appropriate diameter may be used for this purpose (Broome *et al.*, 1988). Also effective is a long-handled shovel, which may be employed to create a V-shaped planting hole by inserting the blade into the ground and pushing the handle away from the digger (NYSG/CCE Marine Program, 1999). Stems or plugs of *Spartina alterniflora* are then inserted into the planting hole. Soil should be firmly pressed around the plant to prevent dislodging by waves (Broome, 1990).

Better results are achieved when a slug of fertilizer containing both nitrogen and phosphorus (approximately one ounce per plant), is added during planting (Garbisch *et al.*, 1975; Broome, 1990; Broome *et al.*, 1983; NYSG/CCE Marine Program, 1999). Slow release fertilizers are the most effective and widely used (Broome *et al.*, 1983; Broome, 1990; Broome *et al.*, 1988).

The spacing of plants is important to the success of vegetation re-establishment. Broome *et al.* (1986) found that plans for marsh plant spacing should be based on the harshness of the restoration environment. One foot plant spacing is commonly used in New York for *Spartina alterniflora*, to ensure adequate planting density and to increase the ease by which the quantity of plants needed for a given area may be calculated (1 plant/1 foot means, *e.g.*, 100 plants are required for a site 100 square feet in size).

Vegetation at the restoration site, either planted or naturally re-established, may be damaged by grazing and foraging activities of waterfowl and other wildlife. Floating debris deposited on the marsh may also impact restoration success. Exclusion fencing and/or debris barriers may be required to prevent vegetative losses. Large debris such as logs, however, will not be excluded by barriers and may still cause significant damage to the salt marsh. Periodic visual assessments of the marsh should be conducted to allow for timely mitigation of such disturbances.

Many tidal wetlands have also been degraded by aggressive stands of common reed (see Section 9, Special Topics: Common Reed for additional information). Control of common reed is possible, but most methodologies have been reported with widely differing success rates. Common modes of common reed control include salt water inundation, prescribed burning, cutting and mowing, use of plastic covers, and application of herbicide.

Beaches and Dunes

Characterization

Beaches and dunes are formed through erosion and deposition of sand by wind, waves, tides, and currents. These areas are highly dynamic composed of unconsolidated and unstable sand and gravel sediments and subject to large fluctuations in salinity and moisture.

Sand beaches are largely without vegetation. Where vegetation occurs, the community is dominated by beachgrass (*Ammophila breviligulata*) and may also include species such as seabeach knotweed (*Polygonum glaucum*), sea rocket (*Cakile edentula*), and seaside spurge (*Euphorbia polygonifla*).

Primary dunes front the beach, and support a variety of plant species, including beachgrass, seaside goldenrod, beach rose (*Rosa carolina*), beach pea (*Lathyrus japonicus*), and others.

Secondary dune areas form behind the primary dunes and support the lichens *Cladina submitis* and *Cetraria arenaria*, and shrubs such as bayberry (*Myrica pensylvanica*) and beach-plum (*Prunus maritima*).

Tertiary dune complexes behind secondary dunes are now rare (as a result of human development), but where they occur they support tree species such as pitch pine (*Pinus rigida*), eastern red cedar (*Juniperus virginiana*), and American holly (*Ilex opaca*).

Functions

Maritime beaches provide important nesting habitat for shorebirds like piping plover

(*Charadrius melodus*), least tern (*Sterna antillarum*), common tern (*Sterna hirundo*), roseate tern (*Sterna dougallii*), American oystercatcher (*Haematopus palliatus*), and black skimmer (*Rhynchops niger*). Diamondback terrapin nest in beach and dune habitats. Horseshoe crabs (*Limulus polyphemus*) annually lay their eggs on beaches, providing an important food source for migratory birds.

Piping plover nest singly, near least tern colonies on undisturbed beaches with sparse vegetation. Dredged material and pebble areas may also be used for nesting. This species arrives mid-March, and departs by the end of August. Plover chicks feed independently.

Least tern breed in small colonies on beaches, dredged materials, or open shoreline with approximately 20% cover by vegetation in nests that are scrapes in the substrate. This species arrives early in May, and departs in early September.

Common tern breed in large colonies that are formed linearly along the wrack line on offshore islands, barrier beaches, and dredged material areas with little vegetation. Nests are generally scrapes or small piles of dead vegetation. Recently common tern have been observed to nest in salt marshes. This species arrives in early May, and departs in early September.

Roseate tern breed in large colonies and generally co-inhabit common tern colonies. Roseate terns have more specific nesting habitat requirements, preferring dense vegetation or crevices in rocks, and are almost always found on offshore islands. This species arrives mid-May, and departs in early September.

American oystercatcher breeds on sandy islands with shells, pebbles, and sparse vegetation. This species nests in scrapes, and requires nearby mudflats for feeding. Black skimmer breed in sandy areas with little vegetation, and often co-occur with common tern colonies.

Diamondback terrapin is the only living turtle species found exclusively in brackish coastal marshes. This turtle dwells in salt-marsh estuaries, tidal flats, and lagoons behind barrier beaches, and is a highly aquatic species seen out of water for an extended period of time only when nesting. Nests are cavities dug at sandy edges of marshes, in beach and dune areas above the high-tide line. Females lay from 4-18 eggs in July and may have more than one clutch per nesting season. The diamondback terrapin hibernates from November through March.

Peregrine falcon (*Falco peregrinus*) winter along the Atlantic coast on barrier beaches and hunt for birds in dune areas. Northern harrier may also hunt for small mammals among the dunes.

Beachgrass is critical in beach and dune environments for trapping sand and building dunes, maintaining movement and integrity of the physical habitat and protecting adjacent terrestrial areas from flooding and erosion during high tides and storms. Embayments behind barrier beach and dune systems are protected from ocean conditions and therefore are low energy environments, making them ideal nursery areas for many aquatic species. Dunes also provide a reservoir of sand for the beach.

Impacts

Activities that disrupt sediment supply and transport threaten beach and dune habitats. Shoreline structures such as docks, bulkheads, and jetties alter wave energy and circulation patterns and affect accretion and erosion rates. Shoreline hardening also prevents the transgression of the beach as sea level rise, leading eventually to beach loss. Significant pedestrian traffic or recreational vehicle use in beach and dune areas can result in loss of dune vegetation, increased erosion from wind and storm events, and can easily eliminate nesting diamondback terrapin and shorebird populations. Fencing and annual posting of these areas can help protect nesting species. Introduction or attraction of domestic or feral animals to the area during the breeding season can negatively affect nesting, and breeding activities, and the survival and development of young birds or terrapin.

Status and Trends

According to the Peconic Estuary Program Natural Resources Subcommittee, the biggest threat to beaches in the Peconic Estuary is shoreline hardening, including bulkheads, rip-rap, groins, and jetties (Bortman & Niedowski, 1998, p.37). Beach loss often occurs gradually over decades where shorelines are hardened. Such structures change accretion rates and patterns, prevent landward migration of intertidal habitats, increase shoreline erosion, and scour shallow water areas. The Peconic Estuary Program is sponsoring a shoreline hardening documentation project to assess the quantity of all shoreline affected by hardening in the estuary, and to provide a baseline against which future trends may be evaluated.

Some current information on beach loss is available from Tiner *et al.* (1998). This study reports that between 1972 and 1994, 5.73 acres of estuarine tidal beach were lost, converted to deepwater habitat, upland forest, residential lawns, and commercial buildings. The Long Island Regional Planning Board (1990) documented 12 acres of beach loss and 4 acres of dune loss in the Peconics between 1976 and 1987. According to this study, 7 acres of beach loss occurred on Shelter Island, 4 acres in the Peconic River/Flanders Bay drainage basin, and 1 acre on the North Fork. Three acres of dune losses derived from Shelter Island, and 1 acre from the South Fork Fork.

Beach and Dune Restoration

Dredged material is often used to replenish eroded beaches. Beach nourishment, however, is generally a temporary solution to erosion and is very costly. Dunes may be protected and restored by planting with American beach grass. Beach grass assists in maintaining dune structural integrity by anchoring sand and minimizing erosion. Beach grass planting should take into consideration prevailing wind and wave direction and intensity, beach width, and sand texture. Although beach grass may also be planted from October 15 through April 15, in general, beach grass plantings should be planned for early spring. Planting is best accomplished using bare root culms (2-3 culms per hole) placed at one foot interval spacing. The use of snow fencing in conjunction with beach grass planting serves to protect newly-planted areas from pedestrian and vehicle access, and will also assist in trapping additional sand on the site.

Some types of beach and dune restoration are designed to restore shorebird nesting habitats, especially for least terns and piping plover. This type of restoration often involves maintenance of vegetation at an early stage of succession, *i.e.*, preventing natural maturation of the habitat into upland. Removal of vegetation and the addition of substrates of an appropriate texture are techniques commonly employed to enhance shorebird nesting habitat.

Non-tidal Freshwater Wetlands

Characterization

Freshwater wetlands include the transition zone between non-tidal aquatic habitats and adjacent terrestrial communities (*e.g.*, lacustrine and riverine wetlands), as well as isolated palustrine systems. In these areas the water table is at, or near, the surface of the soil for much of the year. Alternatively, water may be trapped above the water table by clay layers in the soil.

Forested freshwater wetlands, such as swamps and scrub-shrub wetlands, may be dominated by trees, such as red maple (*Acer rubrum*) and Atlantic white cedar (*Chamaecyparis thyoides*); or shrubs, such as swamp azalea (*Rhododendron viscosum*), highbush blueberry (*Vaccinium corymbosum*), and buttonbush (*Cephalanthus occidentalis*).

Non-forested freshwater wetlands such as marshes, bogs and fens are dominated by floating and emergent species including sedges, pond-lily, arrowleaf (*Peltandra virginica*), sweetflag, cattails (*Typha* spp.), and bulrushes.

In the coastal zone, freshwater wetlands are often found in conjunction with coastal plain pond habitats, a rare natural community in New York State. These groundwater-fed ponds occur in kettle holes and shallow depressions, and contain abundant aquatic vegetation. Pond shore plant species include pipewort (*Eriocaulon aquaticum*), horned rush (*Rhyncospora macrostachya*), sundews (*Drosera* spp.), bladderworts (*Utricularia* spp.), and others.

Functions

Freshwater wetlands usually exhibit high species diversity, due to habitat heterogeneity and the presence of abundant live vegetation and detrital organic matter. Freshwater wetlands provide habitat for a variety of amphibians including frogs, toads, and salamanders. Many species of turtles are found in these habitats. Bird species inhabiting or utilizing freshwater wetlands include red-winged blackbird, common yellowthroat (*Geothlypis trichas*), and swamp sparrow (*Melospiza georgiana*). Yellow warbler (*Dendroica petechia*) are found in wet areas where there is low, brushy growth. Species including American redstart (*Setophaga ruticilla*), grey catbird (*Dumetella carolinensis*), white-eyed vireo (*Vireo griseus*), red-eyed vireo (*Vireo olivaceus*), eastern towhee (*Pipilo erythropthalamus*), and Carolina wren (*Thryothorus ludovicianus*) are found in forested wetlands and coastal swamp forests of the Peconics.

Coastal plain ponds provide habitat for chain pickerel (*Esox niger*) and banded sunfish (*Enneacanthus obesus*). Some coastal plain ponds are documented breeding sites for tiger salamander (*Ambystoma tigrinum*).

Freshwater wetlands aid in ground water recharge and the storage of flood waters, and provide critical habitat for many rare plant and animal species. These habitats contribute to maintaining and enhancing water quality through trapping and recycling nutrients, and absorbing heavy metals, toxins, and other compounds. Wetlands may also seasonally release a substantial quantity of nutrients and organic matter to adjacent areas.

Impacts

A primary historical impact to non-tidal freshwater wetlands has been filling, resulting in an altered hydrologic regime or total loss of habitat. Activities causing changes in wetland hydrology, including excessive groundwater withdrawal, lowering of the water table, diversion of surface runoff, and sedimentation, affect nutrient cycling and species composition of the plant community. Changes in aerobic/anaerobic conditions in wetland soils can impact nutrient and metals cycling, and breakdown and retention of organic matter. Many wetlands have been affected by channelization for transportation infrastructure. In altered wetlands, high contaminant loading can exceed wetland absorptive capacity, causing degradation and leaching into adjacent surface waters or groundwater. Wetland vegetation aids in the storage of flood waters, therefore removal or disturbance of wetland vegetation can lead to exacerbated flood hazards.

Impacts to or removal of upland buffers contiguous with non-tidal freshwater wetlands can also lead to negative environmental consequenes. Buffer removal may cause increased erosion and flow of sediment into the wetland and adjacent surface waters, changing wetland elevations and causing turbidity. The loss of nutrient filtering vegetation may lead to eutrophication in the waterbody; an altered wetland nutrient regime will favor different species and may lead to shifts in dominance. Buffer removal means wildlife habitat for wetland edge species is lost, and migration into and out of the wetland area by mobile species is decreased or prevented.

Freshwater wetlands are negatively affected by invasive species, including common reed and purple loosestrife (*Lythrum salicaria*), which encroach wetland areas when they are disturbed. The presence of invasive species decreases species diversity, changes patterns of nutrient cycling, and alters habitat value of wetland areas.

Status and Trends

According to Tiner *et al.* (1998), there are 3,418 acres of palustrine wetlands in the Peconic Estuary watershed. Approximately 75% of this acreage is vegetated. Palustrine wetlands included in the this survey are forested wetlands (both deciduous and evergreen; 32% of the total), scrub-shrub wetlands (both deciduous and evergreen; 36% of the total), emergent marsh (10% of the total), farmed wetlands, moss-lichen marsh, and unconsolidated bottom. *Phragmites australis* dominates about 27% of the palustrine emergent marshes in the estuary.

Between 1972 and 1994, about 12 acres of forested palustrine wetlands in the Peconic Estuary watershed were lost to agriculture. Residential housing eliminated approximately 2 acres of palustrine emergent marsh. Approximately 30 acres of palustrine emergent, scrub-shrub, and forested wetlands were converted to flooded pond habitat during this period. Wetland buffer

(500 feet) loss occurred primarily in upland forest habitats, as a result of golf course and residential housing construction (Tiner *et al*., 1998).

The Long Island Regional Planning Board (1990) found that between 1976 and 1987, 26 acres freshwater wetland were lost in the Peconic region. This account for only approximately 0.6% of natural resource losses (in all categories surveyed) from this period. Out of the total freshwater wetland area lost, 12 acres derived from the South Fork, 9 acres from the Peconic River/Flanders Bay drainage basin, 4 acres from Shelter Island, and 1 acre from the North Fork (Long Island Regional Planning Board, 1990).

Freshwater Wetlands Restoration

Freshwater wetlands restoration most frequently will involve activities designed to recreate the former hydrology of the site. This may include excavation and regrading to achieve appropriate water table depth and inundation elevations, as well as planting with native wetland vegetation. Other methods of restoring freshwater wetland hydrology include plugging drainage ditches or redirecting a diverted flow or replacing flow with another water source. Hydrology may be restored to impounded (flooded) wetlands by the removal or alteration of the impoundment structure. In many of these cases, wetland vegetation will recolonize the area naturally. However, in areas where there is the danger of invasive vegetation, planting may assist in preventing domination of the site by non-native or opportunistic plants.

One such invasive species that is particularly problematic in freshwater environments is common reed (see Section 9, Special Topics: Common Reed for additional information). Control of this species is considerably more difficult in such habitats because salt water flooding is not a viable option. Common reed control methods include cutting, mowing, prescribed burning, use of plastic covers, prolonged flooding, and herbicide. Common reed control in freshwater systems should be carefully investigated and planned, with adequate understanding of probable causes for the presence of *Phragmites* in the area as well as the likelihood for return of this species subsequent to treatment.

Coastal Grasslands

Characterization

Coastal grasslands occur on glacial outwash plains with nutrient-poor, well drained soils. These communities are under the influence of a maritime climate consisting of moderate temperatures, a long frost-free season, ocean winds, and salt spray. From precolonial times through the present, many kinds of anthropogenic activities have assisted in creating and maintaining coastal grasslands. Purposeful clearing of upland areas and the use of grassy areas for livestock grazing are included among these activities. Coastal grasslands are naturally fire-dependent systems, with periodic fire continually restarting vegetative succession. Many remnants of this habitat are found today along railways, where there are periodic fires caused by sparks. Grasslands are also created and maintained naturally by fires started by lightning.

Coastal grasslands are characterized by turf-forming grasses, such as common hairgrass (*Deschampsia flexuosa*), little bluestem (*Schizachyrium scoparium*) and poverty grass (*Danthonia spicata*), with greater than 50% cover. Atlantic golden aster (*Pityopsis falcata*) and Indian grass (*Sorghastrum nutans*) may also be found. Low heath and heath-like shrubs may be present at low densities, such as bearberry (*Arctostaphylos uva-ursi*), beach heather (*Hudsonia tomentosa*), bayberry, lowbush blueberry (*Vaccinium angustifolium*), and beach plum.

Where greater than 50% ground cover is comprised of heath or heath-like shrubs the community is classified as maritime heathland. In heathlands, grass species do not form a turf; common species include common hairgrass, little bluestem, asters, Pennsylvania sedge (*Carex pensylvanica*), and New England blazing star (*Liatris scariosa* var. *novae-angliae*). Grasslands and heathlands generally occur together in a mosaic.

Coastal grasslands in Eastern Long Island support populations of many state- and federally-listed plant species, including white milkweed (*Asclepias variegata*), bird's foot violet (*Viola pedata*), sandplain gerardia (*Agalinis acuta*), bushy rockrose (*Helianthemum dumosusm*), Nantucket juneberry (*Amelanchier nantucketensis*), silvery aster (*Aster concolor*), lance-leaved loosestrife (*Lysimachia hydrida*), orange fringed orchid (*Platanthera ciliaris*), sandplain flax (*Linum intercursum*), pine barren gerardia (*Agalinis virgata*), and many others. Several of these plant populations are nationally and even globally rare.

Functions

Grasslands provide habitat for a number of birds, including bobolink (*Dolichonyx oryzivorus*), bobwhite (*Colinus virginianus*), and eastern bluebird (*Sialia sialis*). A number of declining grassland bird species depend on this type of habitat for breeding and feeding. Savannah sparrow (*Passerculus gramineus*), eastern meadowlark (*Sternella magna*), song sparrow (*Melospiza melodia*), and horned lark (*Eremophila alpestris*) are permanent residents, feeding on insects and seeds. Savannah sparrow requires vegetation of moderate height, while eastern meadowlark prefers open meadow areas. Song sparrow are adapted to a wide range of habitats.

Species present only during the breeding season (approximately April through August) include grasshopper sparrow (*Ammodramus savannarum*), vesper sparrow (*Pooecetes gramineus*), northern rough-winged swallow (*Stelgidopteryx serripennis*), and upland sandpiper (*Bartramia longicauda*). Grasshopper sparrow prefers short grasses with minimal litter or patches of bare ground. This species feeds on grasshoppers and caterpillars, weeds, and sometimes grass seed. Vesper sparrow prefers sparsely vegetated grasslands with short grasses, and eats beetles, grasshoppers, caterpillars, ants and seeds. Horned lark inhabit wide open areas with short grasses and bare ground. Northern rough-winged swallow nests near watercourses such as streams or rivers, but feeds in coastal grasslands. Upland sandpiper prefers a mixture of short and tall grasses, and feeds on grasshoppers, crickets, weevils, waste grains, and seeds.

Birds of prey such as northern harrier, red-tailed hawk (*Buteo jamaicensis*), rough-legged hawk (*Buteo logopus*), American kestrel (*Falco sparverius*), common barn owl (*Tyto alba*) and short-eared owl hunt for mice and voles in grasslands. Red-tailed hawk hunt in open field areas. Rough-legged hawk subsist on mice and shrews found in brushy fields, open meadows, and marshes. Americal kestrel will eat insects as well as small mammals and hunt in open areas. Common barn owl hunts in a wide variety of habitats, including marshes, meadows, and fields.

Heathlands are often inhabited by yellow-rumped warbler (*Dendroica coronata*) in winter, which feeds on insect eggs and larvae, as well as bayberries. Blue-winged warbler (*Vermivora pinus*) also breed and feed in heathlands.

Several rare insects inhabit coastal grasslands and heathlands, including regal fritillary (*Speyeria idalia*), coastal barrens buckmoth (*Hemileuca maia maia*), coastal heathland cutworm (*Abagrotis crumbi benjamini*), and American burying beetle (*Nicrophorus americanus*).

Impacts

Although some anthropogenic activities have contributed to creating and maintaining grasslands, they also have contributed to the decline of these areas. Development threatens coastal grasslands, and most have already been lost. Development has also degraded grasslands through disturbance, exposure to toxic chemicals, introduction of exotic species, and trampling by off-road vehicles and horses. Maintenance of railway and roadway corridors with herbicides and mowing regimes contributes to the loss of rare plants. Use of bridle trails in grasslands increases compaction of soil and erosion, and contributes to the spread of exotic and nuisance species when seeds are transported in horse manure. The introduction of alien topsoil during development also leads to introduction and spread of invasive species.

Suppression of fires causes different plant species to be favored and leads to succession into shrublands and woodlands. Many of the rare plants found in coastal grassland are fire-dependent, and are outcompeted by other species when natural fires are suppressed. Changes in vegetation also lead to a loss of characteristic biota, including many rare and declining species. Controlled burns are necessary for restoration and management of coastal grasslands.

Status and Trends

Grasslands existing in the Peconics region today are relict fragments of a once extensive community covering most of the Montauk Peninsula. The grassland community still exists at Conscience Point National Wildlife Refuge and Shinnecock Hills in Southampton, NY; and at Shadmoor Ditch Plains, Montauk Downs, Big Reed Oyster Pond, and Hither Hills in East Hampton, NY. Grasslands have been lost mainly as a result of development. Vegetative succession has also been a factor in the disappearance of this community type.

According to the Long Island Regional Planning Board (1990), a total of 105 acres of grassland ("maritime flora") were lost in the Peconics between 1976 and 1987. This represents about 3% of total natural resource losses (from all categories surveyed) during this time frame. The bulk of the grassland losses (~102 acres) came from the Shinnecock Hills area in Southampton, NY (Long Island Regional Planning Board, 1990).

The Long Island Regional Planning Board (1990) also documents the loss of 151 acres of "old field" during the 1976-1987 period. This acreage accounts for approximately 4% of total natural resource losses during that time frame.

Coastal Grasslands Restoration

Grassland restoration generally involves arresting successional development of vegetation by some means. Prescribed burns should be planned with particular consideration paid to habitat requirements of critical or target species, particularly grassland birds, as well as to the area's size, the rate of litter build-up, and soil type and moisture content. Timing of burns should be planned to maximize benefit to target vegetation, *e.g.*, warm season grasses, and for compatibility with appropriate weather conditions.

Nearby human development may prevent the use of prescribed burning as a restoration technique. Mowing may be a viable alternative to prescribed fire at sites where woody vegetation is not dominant. Other techniques for grassland restoration include manual removal of successional or invasive vegetation using a brush hog or similar equipment. Sites requiring removal of woody vegetation may in addition require soil preparation, amendment, and seeding or planting. Mowing may be included in the maintenance regime for such restored sites. Non-annual treatments are generally preferable (depending upon the target restoration species), and large sites may benefit from annual rotation of different restoration treatments on various subtracts within the larger site.

Estuaries and Estuarine Embayments

Characterization

Estuaries are places where freshwater and seawater mix at the mouths of rivers. The lower reaches of the Peconic River and Flanders Bay exemplify the estuarine habitat. Typical salinities in an estuary range from 18-25 parts per thousand (ppt).

Estuarine embayments exhibit the salinity characteristics of an estuary, but are semi-enclosed waterbodies with low wave action and an increased rate of sediment accumulation. Harbors and bays can be classified as estuarine embayment habitats. Estuarine embayments may support submerged aquatic vegetation (SAV), including eelgrass and widgeon grass.

Coastal salt ponds also exhibit an estuarine salinity regime. These brackish ponds can be formed when a barrier beach closes off an embayment. Storms may periodically overwash or break the barrier, making the pond saline until the sandspit reforms. Vegetation surrounding coastal salt ponds is a mixture of brackish and salt marsh species, including salt-meadow cordgrass, switchgrass, common reed, three-square bulrush (*Scirpus americanus*), dwarf spikerush (*Eleocharis parvula*), saltmarsh fleabane (*Pulchea odorata*), and rose-mallow.

Functions

The protected nature of estuarine embayments makes them good developmental areas for finfish, scallops, and several listed species of sea turtles. Fish inhabiting coastal salt ponds are a food source for foraging terns. These open water areas are also important winter habitat for many species of waterfowl, including white-winged scoter (*Melanitta fusca*), oldsquaw (*Clangula hyemalis*), scaup (*Aythya marila*, *Aythya affinis*), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), American black duck, Canada goose, red-breasted merganser (*Mergus serrator*), canvasback (*Aythya valisineria*), and American widgeon (*Anas americana*). Osprey (*Pandion haliaetus*) feed in estuarine embayments and estuaries during the breeding season, and mute swan is a year-round resident.

Estuaries and estuarine embayments receive nutrients and organic detrital material from river, stream, and groundwater inflow, as well as from terrestrial runoff. These inputs result in high levels of secondary production supporting a complex food web. The dynamic gradient of saline to fresh water across an estuary results in higher species diversity, from the overlap of freshwater, saltwater, and brackish plant and animal species occurring in the area. Estuaries and estuarine embayments are subject to intense human use, including commercial and recreational shellfishing and finfishing, outdoor education, research, recreational boating, marinas, mooring areas, and other activities. Important commercial and recreational shellfisheries are supported by estuarine embayments and their associated habitats, including populations of bay scallop and clams.

Impacts

Estuarine embayments can be more vulnerable to nutrient and contaminant loadings than other areas subject to greater tidal flushing because of their narrow inlets and/or limited flushing capacity. Higher nutrient loadings can result in eutrophic conditions, algal blooms, decreased light penetration, and hypoxia. Sediment-bound contaminants may impact the estuarine food web, because these embayments are areas of high deposition, and the estuarine food chain is largely supported by detritus and detritivores. Dredging activities also can contribute major disturbances to the estuarine embayment environment, by increasing turbidity, disturbing the sediment profile, and interfering with fish and wildlife.

Status and Trends

The monitored embayments in the Peconic Estuary in general have excellent water quality (Draft Peconic Estuary Program Nutrient Module, 1999). This assessment is based on concentrations of total nitrogen (TN) and dissolved oxygen (DO). There were no significant demonstrable changes in surface water quality (as measured by TN concentrations) in the Peconic Estuary between 1988 and 1996. Less than 3% of Estuary area exceeds recommended TN guidelines, and in general there are no “serious” violations of recommended DO concentrations (Draft PEP Surface Water Quality Summary, 1998). However, the Draft PEP Nutrient Module (1999) concludes that nitrogen loading to the Estuary is at an all-time high due to increased residential development and the use of highly soluble fertilizers.

Point sources of nutrients such as the Riverhead Sewage Treatment Plant (STP), the Sag Harbor STP, and the Corwin Duck Farm in Riverhead make several embayments near these facilities a high priority for water quality improvements. The tidal Peconic River and western Flanders Bay, Meetinghouse Creek, and East Creek in Riverhead are considered "Mitigation Priorities" by the Peconic Estuary Program. Central and eastern Flanders Bay, West Neck Bay in Shelter Island, Sag Harbor in East Hampton, the East Creek complex in Southold, the Town Creek complex in Southold, and Northwest Creek in East Hampton are considered "Stressed/Threatened Waters" (Draft PEP Nutrient Module, 1999).

No water quality impairments resulting from the presence of toxic materials have been identified in Peconic Estuary waters. However, limited monitoring for toxic materials in the water column has been conducted. Some surface water samples from the North Fork contain Aldicarb, a pesticide formerly used for potatos; surface water samples from several locations contain MTBE, a gasoline additive. Currently, state-wide health advisories for consumption apply only to the following estuarine species: the hepatopancreas, or "tomalley", of marine crabs and lobsters due to cadmium and PCBs; and waterfowl due to PCBs, mirex, and chlordane (Draft PEP Toxics Module, 1997).

Approximately 4% of the total Peconic Estuary area and 14% of the Estuary's productive shellfish area are affected by coliform bacteria exceedances. Year-round closures to shellfishing affect 2,723 acres of bottom, while seasonal closures affect 2,048 acres of bottom. Most human pathogens causing shellfish closures are derived from stormwater runoff, malfunctioning onsite disposal systems, and vessel discharges. The planktonic red tide organism, *Alexandria tamarensis*, has been recorded in Peconics embayments but no red tides have been documented. Shellfish diseases such as MSX and dermo have not been documented in the Peconic Estuary. The only non-human pathogen having caused significant impact on the estuary is *Labyrinthula zosterae*, the slime mold that caused past outbreaks of eelgrass "wasting disease" (Draft PEP Pathogens Module, 1997).

Brown tide, caused by the microalgal species *Aureococcus anophagefferens*, has caused substantial impacts in the Peconic Estuary and its embayments since the first bloom occurred in 1985. By 1982 the Peconic Estuary scallop harvest, at 150,000 to 500,000 pounds per year, accounted for 28% of United States landings. Post-bloom harvests in the late 1980s dropped to approximately 300 pounds per year. In 1994, the scallop harvest had rebounded to pre-bloom levels at 266,448 pounds. In 1995 there was another brown tide bloom, and by 1996 the scallop harvest had dropped to only 53 pounds. Other species were also adversely affected by brown tide events, including hard clams, oysters, and finfish (Draft PEP Brown Tide Module, 1997).

Tiner *et al*. (1998) found that 287 new docks were constructed in the Peconic Estuary between 1972 and 1994; 61 docks were removed during the same period. This net increase of 226 docks potentially represents a concurrent significant increase in boat traffic, recreational fishing, and their related environmental impacts.

Estuarine Embayment Restoration

Estuarine embayment restoration can include actions designed to ameliorate water quality, enhance natural circulation, increase tidal flushing, and improve or increase habitat availability for estuarine species. Most estuarine embayment habitat restoration actions, therefore, are indirect. Water quality may be improved through the reduction of sediment and contaminant loadings from stormwater runoff. Techniques include expansion of vegetated buffer areas, and construction of reed beds and other nutrient removal technologies. Circulation patterns may be improved in estuarine embayments by minimizing shoreline hardening and the presence of permanent structures such as jetties, breakwaters, docks, and mooring fields. Innovative vegetated shoreline stabilization structures should be explored for use in appropriate areas to provide habitat, improve water quality, and maintain natural circulation patterns.

Riverine Habitat and Migratory Corridors

Characterization

Rivers, streams, creeks, and their tributaries encompass a diverse assemblage of habitat types, influenced by physical structure, chemical characteristics, and biogeography. These habitats include both large and small, tidal and non-tidal freshwater systems.

Adjacent land uses and type of land cover in the river's watershed, *e.g.*, agricultural, urban, or forested, affect both physical and chemical characteristics of the river habitat, including water quality, species abundance and usage, rates and patterns of flow, and sedimentation. Physical characteristics such as flow rates and patterns, substrate type (*e.g.*, rocky, sandy), and the presence of refugia for fish and invertebrate species are critical elements in determining habitat value of rivers and streams. Important chemical parameters affecting the habitat value of river habitat include turbidity, pH, oxygen content, nutrient concentrations and cycling patterns, and contaminant concentrations.

River ecosystems include the woodlands and wetlands in their watersheds. These areas may be characterized by marshes, swamps, or woodlands. Emergent marsh vegetation found in riparian habitats includes cattails, pondweeds (*Potamogeton* spp.), pickerelweed, arrowhead (*Sagittaria latifolia*), bur-reed (*Sparganum eurycarpum*), river bulrush (*Scirpus fluviatilis*), and wild rice (*Zizania aquatica*). Riparian swamps and woodlands may also support shrubs such as buttonbush and trees such as tupelo or gum (*Nyssa* spp.), red maple, sugar maple (*Acer saccharinum*), box elder (*Acer negundo*), black ash (*Fraxinus nigra*), and white ash (*Fraxinus americana*).

Functions

Riparian vegetation, including wetlands and woodlands, contributes to the quality of aquatic habitat by providing cover, bank stability, temperature regulation, and a supply of organic matter to the river.

Both riparian wetlands and woodlands provide food and refugia for a variety of terrestrial and bird species. Riverine wetlands and woodlands support birds such as mallard, wood duck (*Aix sponsa*), teals (*Anas crecca*, *Anas discors*), marsh wren (*Cistothoris palustris*), belted kingfisher (*Megaceryle alcyon*), common yellowthroat, Canada goose, Louisiana waterthrush (*Seiurus motacilla*), bank swallow (*Riparia riparia*), and cerulean warbler (*Dendroica cerulea*).

Common resident fish species in Peconic region rivers, creeks and streams include brown bullhead (*Ictalurus nebulosus*), northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), rock bass (*Ambloplites rupestris*), black crappie (*Pomoxis nigromaculatus*), pumpkinseed (*Lepomis gibbosus*), and carp (*Cyprinus carpio*). Alewife utilize a number of creeks and streams in eastern Long Island. Many fauna found in riparian areas migrate in and out of the habitat during different portions of their life cycles.

Decomposition and transport of organic matter derived from terrestrial and emergent vegetation in riparian habitats contributes to the nutrient and organic matter cycling regime in the habitat. Riparian wetlands and woodlands also assist in improving water quality by taking up both nutrients and contaminants, and allowing sediment to settle out. Riparian vegetation assists in preventing erosion of the river bank by dissipating the energy of rainfall and other pulsed flows. Wetlands are especially proficient at storage and conveyance of flood waters.

River systems function as material and nutrient transport systems from upstream to downstream areas. Migratory fish use river corridors as spawning and nursery areas. Migratory fish support recreational and commercial fishery activities. Rivers and riparian areas also provide important migratory corridors and feeding and nesting habitat for many bird species, including ducks, geese, rails, wading birds, and songbirds.

Impacts

Both nonpoint and point source pollution can result in hypoxia or anoxia, localized contaminant loadings, eutrophication, and domination by pollution-tolerant nuisance species. Nonpoint source pollution can be derived from from terrestrial runoff and groundwater contamination. Point source pollution often comes from sewage treatment plants or industrial discharges.

River corridors are also negatively impacted by the placement of dams or other structures blocking access of migratory species, like alewife. These species are prevented from reaching spawning grounds upstream of such blockages, leading to population declines. Culverts may impede migratory access when they alter water velocities or when scour around the culvert results in an increase in elevation, or “perching”, of the culvert above the water’s surface. Inadequately sized or blocked culverts may also result in an insufficient water volume in the channel.

Buffer loss and devegetation of riverbanks can lead to pollution of river water, as well as increased erosion, siltation, and turbidity. Bulkheading and poor development practices can cause substantial riparian devegetation. Dredging will also lead to increased turbidity, and can remobilize contaminated sediments that were buried. Siltation of gravel bottoms can eliminate spawning areas and smother eggs. Feeding by some fish species is impeded by increased turbidity. Development activities, as well as channelization, impoundment, diversion, and water extraction affect the rates and patterns of river flow. Changes in river flow can lead to changes in the size and shape of the river basin. Slower rates of flow will increase siltation and make the river more shallow. Decreased water depth will lead to higher temperatures in the river. Faster rates of flow can deepen the channel and steepen river banks. The habitat value of the river is thereby altered because different rates and patterns of flow favor different species.

Status and Trends

Road crossings, flow restrictions, and small dams have substantially altered rivers and streams in the Peconic Estuary Program study area. However, additional documentation of the locations of these structures, and their impact on river and stream habitats, is needed.

Brookhaven National Laboratory (BNL) has had a profound effect on the environmental quality of the Peconic River. BNL is a 5,265 acre site located in Upton, NY, surrounding the river's headwaters. The area was originally developed for occupation by the U.S. Army as Camp Upton during World Wars I and II. It has been operated by the Department of Energy since 1977. Facilities cover approximately 1,000 acres of the site, and include a former landfill, a hazardous waste management facility, and a sewage treatment plant (BNL OUV Remedial Investigation Report, 1998).

Treated effluents from the BNL sewage treatment plant are discharged into the headwaters of the Peconic River. Impacts to the Peconic River ecosystem from current technology employed by the treatment plant are believed to be minimal. However, historical discharges and impacts have been the subject of recent study. Some technologies designed to minimize environmental impacts were introduced only as recently as 1998, *e.g.*, upgrading the sewage treatment plant from primary to tertiary treatment. In addition, hold-up tanks that allow analysis of wastewater prior to discharge have not existed during the entire history of the facility. Further, accidental discharges from sewer lines that carry wastes from the laboratories and operations facilities to the sewage treatment plant have been suspected (BNL OUV Remedial Investigation Report, 1998).

Both surface water and sediment samples from the Peconic River on the BNL site were recently examined to determine the extent of contamination resulting from historical discharges. Ten inorganic analytes, including high levels of copper, mercury, silver, and lead, were found at concentrations exceeding the chosen screening concentrations in Peconic River waters. Fifteen inorganic analytes, including silver, mercury, and copper, were found to exceed screening concentrations in Peconic River sediments. In addition, the pesticides Arochlor-1254, DDT, DDD, DDE, chlordane, and endosulfan were also found in excess of screening concentrations in Peconic River sediments. PCBs exceeding screening concentrations were also found in sediments (BNL OUV Remedial Investigation Report, 1998).

Soils and groundwater at the BNL site were also examined. Soil sampling revealed that elevated concentrations of inorganics and the radionuclide cesium-137 were the primary concern. Groundwater monitoring found concentrations of aluminum, iron, and manganese at very high concentrations; trichloroethane and the radionuclide tritium were found in low concentrations in groundwater at the site (BNL OUV Remedial Investigation Report, 1998).

Ecological risk assessments were performed based on these data. It is believed that aquatic communities are most at risk from silver, copper, and mercury contamination. Sediment toxicity tests revealed that the bioavailability of the contaminants was low; however, benthic invertebrates may be at risk in areas of high mercury or silver concentrations. The largest potential risk to terrestrial plants is posed by chromium and silver contamination in the soils. Food chain models show that risks to target species exist as a result of mercury, PCBs, DDT, and silver, especially through consumption of contaminated fish by piscivorous consumers. Remedial action objectives have been developed by Brookhaven National Laboratory articulating the need to protect the Peconic River ecosystem, and to prevent exposure to contaminants and their bioaccumulation in aquatic species (BNL OUV Remedial Investigation Report, 1998).

River Restoration

Restoration of migratory passage for anadramous species is the primary type of river restoration available in the Peconic Estuary. This type of restoration involves removing or mitigating a barrier in a river, stream, or creek impeding the annual migration of fish such as alewife. Barriers to migration include dams, tide gates, culverts, and insufficient water volume.

A number of mitigation techniques are available for restoration of migratory access around dams, including dam removal, breach passage, notch passage, and fish ladders. Breach passage and notch passage involve partial dam removal or placement of a notched passageway in the dam, respectively. Fish ladders are structures creating a series of pools increasing in elevation from the base to the top of the dam. This type of structure slows the flow of water and provides passage to anadromous and catadromous species. Selecting the appropriate fish passage structure depends on the size and characteristics of the barrier as well as behavioral characteristics of the target species. In some cases, fish “heaves” may be organized to manually move a fish run past a migratory impediment using buckets or other similar vessels.

In rivers with substantially altered flow regimes, including channelized rivers and those subject to industrial discharges, restoration may be accomplished by reestablishment of a natural flow regime. Streamflow is linked with most physical and chemical characteristics of rivers, including water temperature, channel geomorphology, habitat diversity, and therefore limits the distribution and abundance of riverine organisms. Attributes of streamflow include the magnitude of discharge, the frequency (of a given magnitude), the duration (of specified flow conditions), the timing or predictability (of specified flow conditions), and the rate of change or flashiness (of changes in flow from one magnitude to another). Reintroducing natural patterns in these streamflow attributes will improve ecological conditions in rivers and assist in restoring habitat (Poff *et al.*, 1997).

Shallow water habitat may be improved for some species by providing additional cover in the form of overhangs, partially submerged branches and tree trunks, and boulders. In addition, revegetation of riverbanks that were formerly armored or eroded will stabilize sediments and provide additional riverine habitat.

Intertidal Mudflats and Sandflats

Characterization

Intertidal mudflats are comprised of sandy or muddy substrates lying between low and high tide, and are entirely exposed during low tide. The chemical properties of intertidal mudflats are primarily determined by substrate grain size, *i.e.*, fine or coarse.

In estuarine systems, mudflats do not generally support any rooted vegetation but are characterized by communities of micro- and macroalgae. These algal communities often form extensive mats on the surface. Intertidal mudflats also support important bacterial communities.

Functions

Intertidal flat substrate serves as a location for primary production by microalgae and macroalgae, and a location where primary production is consumed and converted to animal biomass (secondary production). High rates of decomposition also occur in flats sediments and therefore substantial nutrient regeneration and recycling occurs. Organic detritus from adjacent habitats, such as salt marshes and SAV beds, is also transformed into animal biomass on intertidal mudflats and sandflats, particularly benthic invertebrates. The flora and fauna of intertidal flats support a complex food web including crabs, shrimps, benthic and pelagic fish species, seabird and shorebird species, and sea turtles. Oyster reefs and mussel beds are frequently found in mudflat and sandflat habitats. These reefs often are colonized along their margins by other invertebrate macrofauna because the structural characteristics of reefs and hard shell beds often minimize predation by crabs.

Macroinvertebrates found in estuarine intertidal mudflats include softshell clam (*Mya arenaria*), hard clam (*Mercenaria mercenaria*), razor clam (*Ensis directus*), mud snail (*Ilyanassa obsoletus*), mud crabs (*Panopeus* spp.), marsh crab (*Sesrma reticulatum*), green crab, and blue crab. Horseshoe crab feed on intertidal flat fauna, and juvenile horseshoe crabs generally spend their early years in the intertidal flat habitat before migrating further offshore as adults. Fiddler crab species forage on intertidal flats at low tide for epibenthic algae and detritus. In sandy areas with no emergent vegetation around the high tide mark, *Uca pugilator* is found exclusively. In muddy areas and where smooth cordgrass grows at higher elevations, *Uca pugnax* is more commonly found. Common periwinkle (*Littorina littorea*), though more common in rocky intertidal areas, may be found associated with rock weeds in the upper mudflat zone. Many worms, polychaetes, gastropods, and other deposit feeders feed on microalgae and bacteria attached to sediment grains on the intertidal flat surface. Below the surface oxidized zone, bacteria are adapted to an anoxic environment and convert particulate organic matter to forms useable by deep-feeding deposit feeders.

Many fishes feed in intertidal flat areas during tidal inundation, including Atlantic silversides, killifishes, flounders, mullet, menhaden, spot, sea robins, bay anchovy (*Anchoa mitchilli*), and others. Menhaden, mullet, and sheepshead minnow feed mainly on the abundant organic detritus, phytoplankton, and algae of intertidal flat areas. Other killifishes, Atlantic silversides, bay anchovy, sea robins and spot feed on small crustaceans (amphipods, isopods, and copepods), juvenile and larval organisms, and fecal pellets. Flounders feed on a variety of crustaceans, molluscs, fishes, and other invertebrates.

Common wading birds of Peconics region intertidal mudflats are wading birds such as great egret, snowy egret, glossy ibis, yellow-crowned night heron (*Nycticorax violaceus*), black-crowned night heron, green-backed heron, and sometimes little blue heron (*Egretta caerulea*) and least bittern (*Ixobrychus exilis*). These species eat fishes, crustaceans, fiddler crabs, molluscs, and worms. Other mudflat feeders include probing shorebirds like plovers, killdeer, and sandpipers; and aerial-searching birds such as common tern, least tern, black skimmer, and gulls. When mudflats are indundated, diving waterbirds such as double-crested cormorant (*Phalacrocorax auritus*) and pied-billed grebe (*Podilymbus podiceps*) may utilize these areas. Osprey will also hunt for fish in shallow waters over inundated flats.

Impacts

Dredging to maintain boat channels may expose or destroy buried organisms. Disposal of dredged material may bury epibenthic organisms. Areas disturbed by dredged material are subsequently colonized by opportunistic benthic species, altering species diversity, abundance, and distribution. Most colonizers are epibenthic, and post-disturbance subsurface sediments often become and remain anoxic due to a lack of bioturbation. Sediment resuspension can clog filter-feeding mechanisms in many macrobenthic species, including the commercially important bivalve molluscs. Sediment resuspension and turbidity can substantially decrease primary production through light attenuation, potentially leading to hypoxia in bottom waters and the sediment column and decreasing overall habitat quality. Propeller dredging by individuals will also have these same effects.

Status and Trends

There are few major intertidal flat areas in the Peconics region. In this area, the mudflat and sandflat habitat is most frequently found fringing tidal wetland areas and adjacent to gently sloping bay beaches and sandy islands. Tiner *et al*. (1998) report that the Peconics region encompasses 1,590 acres of estuarine "unconsolidated shore" areas, a classification category including both estuarine tidal flats and beaches. This accounts for about 27% of the total estuarine wetlands in the region.

Intertidal Mudflat and Sandflat Restoration

Few restoration techniques are associated with intertidal mudflats and sandflats. In general, therefore, these habitats should be regarded as a preservation priority in the Peconic Estuary. Simple enhancements including debris removal may be appropriate in some mud or sand flats. Planning for mudflats as part of salt marsh restoration projects may also increase the quantity of mudflats in the Estuary. Manipulation of tidal inlets and flow regimes will influence the extent of mudflat and sandflat habitat in an embayment. However, appropriate applications of such techniques will be limited. Improvements in water quality will benefit mussel and oyster reefs associated with these habitats.

Coastal Forest Communities

Characterization

This category includes a variety of habitats, ranging from woodland communities with intermediate tree cover, such as pine barrens, to maritime forest communities with greater than 60% canopy cover. In addition, the moorlands, a successional dwarf forest community, is included.

Pine barrens habitats are generally characterized by pitch pine, scrub oak (*Quercus ilicifolia*), white oak (*Quercus alba*), and other oak species. The open canopy of pitch pine and scrub oak is interspersed with a heath layer of ericaceous shrubs and forbs and open sandy areas, and the maintenance of this community is fire-dependent. Declining wild lupine (*Lupinus perennis*) is found in pine barrens. These communities occur on infertile, well-drained, sandy soils, and may encompass grassland areas near dunes which support prairie grasses and a rich array of other species.

An important but rare coastal forest community is the moorlands. Moorlands are a dwarf forest community comprising a mosaic of grasslands and successional heath and shrublands. In New York State the moorlands are found only on Montauk Peninsula in eastern Long Island. Moorlands contain bearberry, beach heather, lowbush blueberry, black cherry (*Prunus serotina*), bayberry, shadbush (*Amelanchier canadensis*), and other plant species. Dense stands of shrubs are often often entwined with wild grape (*Vitis labrusca*) and poison ivy (*Toxicodendron radicans*); where sufficient light reaches the ground, grasses and woodland herbs may be found.

Several other forest communities are found in the coastal and maritime regions of New York. Oak dominated and co-dominated forests can be classified generally as "maritime" or "coastal". Maritime forests are found in immediate proximity to the marine environment and are therefore often strongly influenced by salt spray, high winds, dune deposition, shifting substrate, and overwash. These forests usually exhibit stunted trees with contorted branches and wilted leaves, and often occur in narrow bands less than 50 meters wide (Hunt, 1997).

Coastal forests, by contrast, occur within the coastal plain, but are not in immediate proximity to the marine environment. Trees in coastal forests are usually not stunted or deformed, and can occur in wide matrices or large patches (Hunt, 1997).

Maritime oak forests may occur on exposed bluffs and sand spits, often bordering salt marshes. Generally these forests are dominated by two or more oak species, such as post oak (*Quercus stellata*), black oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), or white oak. There is a dense shrub thicket in maritime oak forests, composed of bayberry, black huckleberry (*Gaylussacia baccata*), black cherry, and often catbrier (*Smilax rotundifolia*).

Coastal oak forests occur on sandy or loamy sand soils on outwash plains and moraines in the Atlantic coastal plain. Usually coastal oak forests are dominated by two or more species of oak, with community variations based on the co-dominant species. Typical co-dominants are beech (*Fagus gradifolia*), holly, hickory (*Carya* spp.), or laurel (*Kalmia latifolia*). There may be a sparse shrub layer including blueberry and black huckleberry, with sedges occurring in the groundlayer.

Coastal oak-heath forest is a patchy hardwood forest found on dry, well-drained, sandy soils.

This community is co-dominated by scarlet oak, white oak, and black oak; chestnut oak (*Quercus montana*) may also be present. American chestnut (*Castanea dentata*) was common in this community before the chestnut blight, and sprouts of this species are often found.

Coastal oak-beech forest supports co-dominant oaks and beech on dry, loamy sand. Black oak and white oak are the most common oak species; red oak (*Quercus rubra*), sugar maple, and paper birch (*Betula papyrifera*) occur at low densities and are considered key indicator species of this community.

Coastal oak-holly forest is a mixed deciduous-evergreen community found on somwwhat moist, well-drained silts and sandy loams. Canopy trees include black oak, black gum (*Nyssa sylvatica*), red maple, and beech; holly is abundant in the subcanopy. Low growing vines, shrubs such as witch hazel (*Hamamelis virginiana*) and highbush blueberry, and groundlayer herbs such as New York fern (*Thelypteris noveboracensis*) and star flower (*Trientalis borealis*) will also be present.

Coastal oak-hickory forest occurs on loamy sand substrates, and is characterized by co-dominant oaks and hickories, including pignut hickory (*Carya glabra*), mokernut hickory (*Carya tomentosa*), and sweet pignut hickory (*Carya ovalis*). Often, the subcanopy consists of flowering dogwood (*Cornus florida*) and highbush blueberry with a diverse groundlayer herb community. In some Peconics region communities, sassafras (*Sassafras albidum*), American beech (*Fagus grandifolia*), pitch pine, white pine (*Pinus strobus*), or red maple may also be present, with a diverse understory of lowbush blueberry, huckleberry, laurel, American holly, shadbush and flowering dogwood.

Coastal oak-laurel forests are patchy and low in diversity, with a broadleaf canopy and evergreen subcanopy, occurring on sandy and gravelly soils. The dominant oak is typically scarlet oak, with a shrublayer characterized by continuous cover of the evergreen heath, mountain laurel and a sparse herbaceaous layer.

Maritime post-oak forests often border salt marshes or occur on exposed bluffs and sandspits. These communities include post oak and other oaks, as well as a low density of red cedar. A dense understory contains bayberry, black huckleberry, and black cherry and thickets of catbrier.

Several variants on maritime and coastal forest communities have dominant species other than oak. Maritime holly forest, a globally rare community, occurs behind dunes and shows stunted growth as a result of salt spray. The dominant species are holly; sassafras, shadbush, and black oak may also be found. Vines such as Virginia creeper (*Parthenocissus quinquefolia*), poison ivy, catbrier, and grape are common in the understory. Groundlayer herbs including wild sasparilla (*Aralia nudicaulis*) and starflower (*Smilacina stellata*) are also present.

Maritime red cedar forest occurs on dry coastal sites, and is characterized by nearly pure stands of Eastern red cedar.

White pine forest, the only native Long Island remnant of which is found in the northwest woods area of East Hampton, occurs on dry, sandy soils. This community is dominated by white pine in almost pure stands, with sparse representation by oaks, hickories, and pitch pine. Pure stands of white pine have little understory; mixed stands exhibit an understory comprising ericaceous shrubs such as blueberries, huckleberries, azaleas, and mountain laurel.

Functions

Coastal forest communities provide habitat for many plants, animals, and insects. Some support a diverse array of declining, rare, or listed species. Pine barrens are habitat for insect species of statewide importance, such as the coastal barrens buckmoth, the Aureolaria seed borer (*Rhodocia aurantiago*), and the frosted elfin (*Incisalia irus*). Some bird species associated with pine barrens communities include prairie warbler (*Dendroica discolor*), pine warbler (*Dendroica pinus*), whip-poor-will (*Caprimulgas vociferus*), brown thrasher (*Toxostoma rufum*), and eastern towhee.

Bird species characteristic of coastal oak forests include vireos, woodpeckers, eastern towhee, grey catbird, tufted titmouse (*Parus bicolor*), black-capped chickadee (*Parus atricapillus*), northern oriole (*Icterus galbula*), house wren (*Troglodytes aedon*), brown thrasher, and eastern bluebird. White-tailed deer (*Odocoileus virginianus*) are also a characteristic animal of maritime and coastal oak forests.

Coastal oak-beech forests commonly provides breeding habitat for grey catbird, eastern wood pewee (*Contopus virens*), black-capped chickadee, red-eyed vireo, American robin (*Turdus migratorius*), wood thrush (*Hylocichla mustelina*), American redstart, tufted titmouse, scarlet tanager (*Piranga olivacea*), and blue-grey gnatcatcher (*Polioptila caerulea*).

Coastal oak-laurel forest commonly provides habitat for scarlet tanager, ovenbird (*Seiurus aurocapillus*), black-and-white warbler (*Mniotilta varia*), white-breasted nuthatch (*Sitta carolinensis*), northern oriole, grey catbird, wood thrush, and eastern towhee.

Coastal oak-heath habitat commonly supports pine warbler, scarlet tanager, whip-poor-will, American redstart, vireos, great-crested flycatcher, black-and-white warbler, eastern wood pewee, wood thrush, and hairy woodpecker (*Picoides villosus*).

Maritime oak-holly forest supports black-and-white warbler, prairie warbler, blue-winged warbler, whip-poor-will, black-capped chickadee, common yellowthroat, eastern towhee, ovenbird, grey catbird, brown thrasher, and Northern oriole.

The white pine forest commonly provides habitat for birds such as chuck-wills-widow (*Caprimulgus carolinensis*), hermit thrush (*Catharus guttatus*), brown creeper (*Certhia americana*), great-crested flycatcher (*Myiarchus crinitus*), ovenbird, black-capped chickadee, pine warbler, grey catbird and broad-winged hawk (*Buteo platypterus*). Black-throated green warbler (*Dendroica virens*) was recently documented breeding in East Hampton's white pine forest for the first time in more than a half century.

Pitch pine and mixed oak forests support pine warbler, yellow-throated warbler (*Dendroica dominica*), hooded warbler (*Wilsonia citrina*), red-breasted nuthatch (*Sitta canadensis*), eastern towhee, whip-poor-will, chuck-will's-widow, ovenbird, black-capped chickadee, black-and-white warbler, and blue jay (*Cyanocitta cristata*). Sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk, and great horned owl (*Bubo virginianus*) may also be found in this habitat.

Coastal forest communities play an important role in groundwater recharge and filtration, as well as soil stabilization. Forest canopy dissipates the energy of rainfall, preventing erosion. The canopy also shades the ground and prevents drying and erosion of the soil. Root masses contribute by stabilizing soil. Roots also aerate soil, contribute to water percolation, and support important microbial communities. Decomposing litter from forest vegetation provides nutrients and organic detritus to the forest ecosystem, and is also transported to coastal watercourses and waterbodies. Forests retain stormwater runoff, particularly when trees are in leaf and can absorb large quantities of water.

Impacts

A major threat to coastal forest communities is fragmentation. Maintaining contiguous tracts of forest provides connectivity of habitat for mobile species, and preserves overall wildlife diversity. Forest interior birds are dependent on larger tracts of woodland and forest to provide the isolated interior areas they require breeding and wintering habitat.

Suppression of natural ecological processes essential for many maritime forest communities, *e.g.*, fire, prevents sustainability of these communities. Rare communities such as the pine barrens are fire-dependent, requiring periodic, non-catastrophic blazes to halt vegetative succession and release certain seeds.

Invasive species also present a threat to the integrity of coastal and maritime forests and rare communities like the moorlands. Tree species such as Norway maple (*Acer platanoides*), tree-of-heaven (*Ailanthus altissima*), and black locust (*Robinia pseudoacacia*) crowd out native trees and shrubs and prevent the growth of native seedlings. Vines such as asiatic bittersweet (*Celastrus orbiculatus*), Japanese honeysuckle (*Lonicera japonica*), exotic wisterias (*Wisteria sinensis*, *Wisteria floribunda*), and porcelainberry (*Ampelopsis brevipedunculata*) kill trees, shrubs, and sometimes the groundlayer by covering and shading them. Catbrier, an indigenous vine, is exhibiting increased aggressiveness in Peconics region forest communities. More research is needed to determine the causes for this change in dominance. Japanese knotweed (*Polygonum cuspidatum*) is an herbaceous perennial forming large clumps up to ten feet in height, found primarily in open areas where it effectively competes for light and eliminates other species. Multiflora rose (*Rosa multiflora*) is an extremely aggressive shrub species that is prevalent in open areas and retards forest development. Shrubs such as wineberry (*Rubus phoenicolasius*), tartarian honeysuckle (*Lonicera tartarica*), Russian olive (*Elaeagnus angustifolia*), and autumn olive (*Elaeagnus umbellata*) displace native shrubs and understory. Invasive terrestrial species gain access into indigenous forests by landscaping and gardening practices employing non-native plants. Increased fragmentation of coastal forest communities increases the ability of non-native plants to invade from adjacent areas. Disturbance also favors opportunistic, non-native species.

Status and Trends

Documented losses in Peconic Estuary natural resources between 1976 and 1987 came overwhelmingly from forest areas. In this region, a total of 2,943 acres of forest were lost during this time frame, with 1,461 forest acres lost on the South Fork, 750 acres lost on the North Fork, 395 acres lost on Shelter Island, and 337 acres lost from the Peconic River/Flanders Bay drainage basin. The forest category accounts for approximately 73% of all losses in natural resources (other categories were freshwater wetland, tidal wetland, maritime flora, dunes, beach, old field, farmland, and bluff habitat) during this time period (Long Island Regional Planning Board, 1990).

Coastal Forest Restoration

Opportunities for coastal forest restoration in the Peconics primarily involve removal of debris and control of invasive, nuisance vegetation. Large debris from illegal dumping, *e.g.*, refrigerators or abandoned cars, may be removed to enhance aesthetic integrity and to discourage chronic dumping at a single site.

Invasive species are often difficult to eradicate. Some exotic species may be mechanically removed by cutting, hand-pulling, mowing, or other physical techniques. Tartarian honeysuckle may be removed through grubbing, pulling, and cutting over several years. Small populations of wisteria may be removed through grubbing, or by cutting repeatedly as close as possible to the root collar. Multiflora rose may be prevented from spreading by repeated mowing; large bushes are difficult to remove by hand and must be knocked over using a bulldozer. Japanese knotweed may be controlled manually by cutting stalks and digging out rhizomes, but is extremely labor intensive and frequently not completely effective.

In many cases, however, herbicides may be the only effective method of invasive species control. For example, tree species such as Norway maple, black locust, and Russian olive can generally be removed only through use of herbicide. Vines such as porcelain-berry, oriental bittersweet, wisteria, and Japanese honeysuckle may be controlled to some degree through cutting and hand-pulling, but complete removal is difficult and these species often will resprout. Therefore, combined mechanical and chemical regimes are often employed. Japanese honeysuckle has been controlled using a combined burning and herbicide treatment. The herbaceous perennial Japanese knotweed may be controlled by combining a cutting regime with application of herbicide. All herbicides must be selected and used with care and applied by state-certified herbicide applicators.

Reduction of forest degradation may be achieved by limiting access to some forest areas. Some trails and roads may be discontinued and revegetated to reduce habitat fragmentation. Fire-dependent communities such as the pine barrens may be restored using carefully-planned prescribed burns. Forest restoration may also include planting. Bare spots caused by illegal logging or other disturbances within forests may also be revegetated through planting.

Planting may be accomplished using bare root seedlings, containerized seedlings, stem cuttings, or transplanted saplings or larger trees. All types of plantings should consist of native species grown locally. Bare root seedlings are widely used and easily produced but may exhibit lower survival under harsh conditions or handling than containerized seedlings. Containerized seedlings consist of a seedling surrounded by a mass of soil, contained in styrofoam, plastic, or biodegradable pots or bags. They are more difficult to plant than bare root seedlings and may be several times more costly. Some tree species may be vegetatively propagated using cuttings that are either directly planted, or are rooted in a nursery before planting as bare root seedlings at the restoration site. In some instances, saplings or larger trees may be transplanted to the site. This method is often prohibitively expensive, and survival and growth of transplanted individuals is affected by the stress of the process.

The development of undergrowth is important for restoring functions and appropriate ecological structure of a forest community. Undergrowth species may be planted directly, or understory development may be facilitated using topsoil transported from a nearby donor forest. Appropriate species should sprout from the seedbank of the donated topsoil. This procedure also assists in the development of mycorrhizal fungi and soil infauna communities.

The success of forest planting projects depends on a number of factors, including substrate properties and control of nuisance plants and herbivores. Stabilization of substrates is important to prevent erosion, and may be achieved through careful planning of topographic relief and grading. Bulk density and compaction of soils influences the rooting volume available to planted trees, a factor related to a tree's ability to gain anchorage and to exploit moisture and nutrients. The texture of substrates also influences the extent of root penetration. Substrate macroorganisms, which may be lacking in disturbed sites, assist in maintaining appropriate soil structure. Organic matter and nutrients in soils at disturbed sites may be insufficient for adequate tree nutrition.

Substrates with suboptimal properties may require manipulation and amendment. Fertilization should be conducted during the initial plantings only. Planting of herbaceous vegetation at a forest restoration site may be beneficial both in controlling erosion and sedimentation, and in ameliorating soil nutritive value. However, herbaceous vegetation should not compete with planted tree speces for nutrients or space, and should be native to the region.

Nuisance plants at a planting site may include weedy, opportunistic species, perennial turf grasses, perennial cover crops, exotic species, and even preferred native species that effectively compete with target restoration species. If nuisance vegetation is present, it should be removed from the site during the substrate preparation stage. Disking is often considered effective for this purpose. Application of herbicides may also be necessary, but should occur only after careful planning and by a certified operator.

Herbivores may also substantially affect planting sites. Deer, raccoons, and rabbits consume tree seedlings. Rodents may browse the base of young trees and damage them. Squirrels and chipmunks exhume seeded acorns. To help minimize herbivore damage, tree planting sites should be fenced. Control of herbaceous vegetation by mowing or disking around young trees, or in a "buffer zone" around the restoration site, can assist in preventing rodent access. If herbivory is intense, protection for individual trees may be required, *e.g.*, chicken wire sheaths.

References

Bortman, M.L. & N. Niedowski. 1998. Characterization report of the living resources of the Peconic Estuary. Prepared for the Peconic Estuary Program Natural Resources Subcommittee.

Broome, S.W. 1990. Creation and restoration of tidal wetlands of the southeastern United States. Pp. 37-72 *in* Kusler, J.A. & M.E. Kentula, eds., Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.

Broome, S.W., E.D. Seneca & W.W. Woodhouse, Jr. 1983. The effects of source, rate and placement of nitrogen and phosphorous fertilizers on growth of *Spartina alterniflora* transplants in North Carolina. Estuaries 6: 212-226.

Broome, S.W., E.D. Seneca & W.W. Woodhouse, Jr. 1986. Long-term growth and development of transplants of the salt marsh grass *Spartina alterniflora*. Estuaries 9: 63-74.

Broome, S.W., E.D. Seneca & W.W. Woodhouse, Jr. 1988. Tidal marsh restoration. Aquat. Bot. 32: 1-22.

Brookhaven National Laboratory Final Operable Unit Five (BNL OUV) Remedial Investigation Report. 1998. Prepared by International Technology Corporation with support from Geraghty and Miller, Inc. for Brookhaven National Laboratory, Brookhaven Science Associates, Upton, NY. BNL contract no. 710617.

Cashin Associates. 1996. Peconic Estuary Program final submerged aquatic vegetation study. Prepared for the Peconic Estuary Program. 374 pp.

Chesapeake Bay Program. 1995. Guidance for protecting submerged aquatic vegetation in Chesapeake Bay from physical disruption. Prepared by the Submerged Aquatic Vegetation Workgroup of the Living Resources Subcommittee, Chesapeake Bay Program. EPA 903-R-95-013, CBP/TRS139/95. August, 1995.

Fonseca, M.S., W.J. Kenworthy, & G.W. Thayer. 1998. Guidelines for the conservation and restoration of seagrasses in the United States and adjacent waters. NOAA Coastal Ocean Program Decision Analysis Series No. 12. November, 1998.

Garbisch, E.W., Jr., P.B. Woller & R.J. McCallum. 1975. Salt marsh establishment and development. Technical Memorandum 52(114). U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.

Hunt, D.M. 1997. Classification of Oak-Dominated and Co-Dominated Forests. New York Natural Heritage Program. October 1, 1997.

Kentula, M.E., R.P. Brooks, S.E. Gwin, C.C. Holland, A.D. Sherman & J.C. Sifneos. 1993. An approach to improving decision making in wetland restoration and creation. Edited by

A.J. Hairston. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Long Island Planning Regional Board. 1990. BTCAMP contract work completion, Task 2B6--Changes in environmental resources from 1976 to 1987/88.

Peconic Estuary Program (PEP). 1999. Draft Comprehensive Conservation and Management Plan. Office of Ecology, Suffolk County Department of Health Services, County Center, Riverhead, NY. September, 1999.

Poff, N. L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, & J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 41(11): 769-784.

Suffolk County Department of Health Services (SCDHS). 1998. Peconic Estuary Program-Surface Water Quality Nitrogen, Dissolved Oxygen, and Submerged Aquatic Vegetation Habitat. October 1, 1998.

Tiner, R.W., D.B. Foulis, G.S. Smith, J. Swords, S. Schaller, & D. Peterson. The Peconic watershed-recent trends in wetlands and their buffers. Prepared for the Peconic Estuary Program by the U.S. Fish and Wildlife Service, Ecological Services Unit, National Wetlands Inventory Program, Hadley, MA. July, 1998.

7. SPECIAL TOPICS: EELGRASS (*ZOSTERA MARINA*) RESTORATION

Eelgrass (*Zostera marina* L.) is an important submersed aquatic plant that stabilizes sediments, improves water quality and provides habitat for numerous species of fish and shellfish (Phillips, 1984; Thayer *et al.,* 1984). Due to wasting disease, nuisance algal blooms and human disturbance of the near shore environment, this species has suffered numerous acute and chronic die-offs over the last century (Cottam, 1933; Smith, 1946; Cottam & Munro, 1954). According to Cashin Associates (1996), there has been a general decline in eelgrass abundance occurring in the Peconic Estuary. Historically, eelgrass beds existed throughout the entire Estuary from the Peconic River east to Gardiners Bay. Today, most extant beds are located east of Shelter Island in Orient Harbor, Long Beach Bay, Gardners Bay, Northwest Harbor and numerous small embayments along the north shore of East Hampton town (Cashin Associates, 1996). There are, however, several localized meadows west of Shelter Island at Bullhead Bay, Mill Creek and, until recently, Sag Harbor Cove. According to the PEP draft CCMP the Estuary contained approximately 8.5 km^2 of eelgrass in 1994. However, the document points out that one report indicates that there was approximately 13.5 km^2 of eelgrass in Gardiners Bay alone five years earlier (Dennison *et al*., 1989).

Anthropogenic Disturbances

Eutrophication

While nutrient availability limits the growth of seagrass plants (Roberts *et al*., 1984; Short, 1987), nutrients also have been a primary cause of seagrass decline in recent decades (Short & Wyllie-Echeverria, 1996). High nutrient loading, or eutrophication, in coastal waters results in phytoplankton blooms resulting in decreased light penetration into the water column, hindering seagrass production. Eutrophication will also increase the growth of epiphytes attached to eelgrass blades, shading the leaves and hindering production (Cashin Associates, 1996). Species such as red or green macroalgae, which absorb nutrients more quickly than *Zostera marina*, may competitively exclude eelgrass under eutrophic conditions (Cashin Associates, 1996).

Eutrophication may also impact eelgrass as a result of this species' high nitrate uptake efficiency. *Zostera marina* lacks a mechanism to terminate nitrate uptake, apparently evolved due to historical nitrogen limitation (Cashin Associates, 1996). It is thought that excess nitrate in eelgrass impairs carbohydrate metabolism, resulting in impaired plant health and decline in shoot production (Cashin Associates, 1996).

High concentrations of nutrients in coastal waters are derived from sewage discharges; groundwater inputs; atmospheric deposition; terrestrial runoff from agricultural lands, golf courses, and lawns; boat wastes; and other sources.

Dredging

Dredging is generally conducted to create or maintain navigational channels. Unregulated, this activity may have a substantial impact on seagrass beds, both directly and indirectly (Short &

Wyllie-Echeverria, 1996; Churchill *et al.*, 1978). Dredging in eelgrass meadows directly removes vegetation; indirect effects are caused by increased turbidity from both dredging and dredged material disposal. Settling of resuspended sediments following dredging may smother nearby SAV beds (Lockwood, 1990). These effects may be mitigated by environmental conditions at a given site, especially current velocity; high current velocities will flush suspended sediments out of the area, potentially allowing a quicker recovery of vegetation and populations of benthic fauna (Dolah *et al*., 1984). However, some observations indicate that recovery of vegetation following dredging does not occur naturally (Lockwood, 1990). Dredging also may hinder natural shifts in distribution that occur over time in patchy seagrass beds. Areas deepened by dredging, even if currently unvegetated, are often rendered unsuitable for future colonization, reducing the overall seagrass habitat acreage (Lockwood, 1990). Disposal of dredged material from creation and maintenance of navigation and other channels can bury seagrass beds (Lockwood, 1990; Short & Wyllie-Echeverria, 1996).

Commercial & Recreational Uses

Propeller cuts from recreational boating are an extremely common disturbance to seagrass beds in shallow waters (Orth, 1976; Chesapeake Bay Program, 1995; Short & Wyllie-Echeverria, 1996). Regrowth following propeller cuts has been found to be slow for southern seagrass species, *e.g.*, *Thalassia testudinum* (Zieman, 1976). In fact, propeller scars are such persistent features that they are often used by local fisherman to relocate productive fishing holes and navigation channels (Zieman, 1976). Moore & Orth (1997) cite research on the impacts of one meter wide propeller scars on eelgrass beds which indicates that eelgrass recovery in these scars requires three to five years.

Boating also causes turbulence, which may resuspend sediment and thereby decrease light penetration. Chronic turbidity in and around marinas and areas of high boat traffic may reduce available habitat for seagrasses. Also, the increased agitation of the water that results from high boat traffic, in the form of turbulence and current velocity, may prevent revegetation of denuded seagrass beds (Lockwood, 1990). The use of shallow draft personal water craft greatly increases the opportunity for disturbance of the shallow littoral zone.

Other impacts related to recreational boating are caused by the facilities associated with this activity, including marinas, moorings, docks, and floats (Lockwood, 1990). Moorings for boats damage seagrass beds by leaving denuded areas in the meadow caused by the movement of the anchor chain (Short & Wyllie-Echeverria, 1996; Bortman & Niedowski, 1998). Docks, floats, and other marina structures can cause shading of SAV beds, reducing growth and survival. This effect is most pronounced when structures are oriented in an east-west direction (Lockwood, 1990).

Harvesting techniques such as clam and scallop dredging and raking can negatively impact seagrass beds both directly and indirectly (Short & Wyllie-Echeverria, 1996). Clam dredging can substantially increase turbidity (depending on grain size), and frequently occurs in or near SAV beds (Chesapeake Bay Program, 1995). This increase in turbidity decreases light penetration to seagrass, and increased sedimentation may result in SAV bed burial. Circular scars from clam dredging using hydraulic escalators have been observed throughout

Chincoteague Bay, VA (Moore & Orth, 1997). These scars are denuded of vegetation even within adjoining areas of dense eelgrass growth. Moore & Orth (1997) note that the size of clam dredging scars and the massive sediment disturbance they cause probably means recovery time will be significantly longer than for propeller scars. In the Peconics region of Long Island, damage to eelgrass beds has been observed due to scallop and clam dredging and repeated raking (Bortman & Niedowski, 1998).

Aquaculture activities can also impact seagrass beds. Permanent floats and rafts associated with these activities may shade beds, decreasing growth and survival of SAV. Mechanical dredging for hard clams can impact eelgrass if conducted on or near existing meadows. Proliferation of large finfish net pens could effect the nutrient status and bottom characteristics of localized areas in the Estuary.

Natural Disturbances and Variability

Salinity

Salinity is a particularly important parameter for *Zostera marina*. This species of seagrass has a discrete range of optimum growth conditions with regard to salinity. Growth can occur in salinities between 10 ppt to 35 ppt (full strength seawater); optimum conditions are above 20 ppt (Fonseca *et al*., 1985). Salinity also appears to influence distribution of reproductive strategies in eelgrass populations. In general, low salinities enhance the germination of seeds (Phillips *et al*., 1983).

Currents

The effects of current velocity on different environmental factors in seagrass meadows are many. Current velocity affects oxygen evolution, momentum exchange, nutrient availability, and temperature and light regimes in the meadow. Preliminary studies indicate that increases in current velocity potentially result in increased seagrass production (Fonseca & Kenworthy, 1987). Currents may also affect meadow development, and the dispersal of seedlings and mature shoots. Most of these relationships are controlled by the current velocity-canopy interaction, which affects the diffusion boundary layer thickness and turbulence in the seagrass canopy (Fonseca & Kenworthy, 1987).

Currents & Nutrient Uptake

Increases in current velocity lead to a decreased boundary layer thickness (thickness of the layer of water at the plant surface through which exchange of properties occurs only *via* diffusion), therefore water column nutrients should be more available to seagrasses. Currents will also impact nutrient content in the sediments of SAV beds and influence bed properties (e.g., texture): in areas of higher velocity, less nutrients accumulate in the sediments, leading to a more highly developed root mass, increased absorptive root surface area, and increased sediment stability (Fonseca & Kenworthy, 1987). In areas of increased current, detritus produced by the seagrass meadow is removed by strong water movements, resulting in a low nutrient environment in the sediments. Conversely, low velocity environments are sinks for detritus produced by the bed itself, and higher nutrient concentration may be expected in bed sediments (Fonseca *et al.*, 1983).

Currents & Turbulence

The effect of the current velocity-canopy interaction on turbulence is also important. As turbulence increases, the flux of momentum and heat increases more slowly. The reduction of turbulence by the seagrass canopy may also play an important role in nutrient uptake capability of the SAV bed (Fonseca & Kenworthy, 1987).

Currents & Light Transmission

Light transmission is influenced by the degree of canopy bending that occurs in response to current velocity. Canopy bending can result in significant self-shading; therefore, there is an upper limit to the positive correlation between current velocity and photosynthesis. Fonseca & Kenworthy (1987) cite a variety of research into this subject, and report that flow velocities greater than 50 cm s^{-1} (cm per second) caused a dramatic decline in the standing stock of *Zostera marina*. At this velocity, the *Z. marina* canopy is bent to 80-84% of the canopy height at zero velocity, and therefore self-shading is expected to be significant. In addition, beyond the 50 cm s^{-1} velocity, the ability of the SAV bed to reduce turbulence is probably eliminated (Fonseca & Kenworthy, 1987). Light transmission is also affected by the wave and current regime at a seagrass bed through sediment resuspension (Fonseca, 1990).

Currents & Reproductive Strategy

Currents influence sexual reproduction of seagrasses because water movement is the only method available for transfer of pollen between male and female flowers. Sufficient current velocities are also required to transport seeds out of the canopy to a more favorable deposition site. Mature, flowering shoots and rhizome fragments may also be dislodged by water motion and transported to new sites, where they reattach and reproduce (Fonseca & Kenworthy, 1987).

Currents & Bed Development

Growth and development of SAV beds are affected by currents. While seagrasses grow in a wide variety of current regimes—growth in maximum velocities of 120-150 cm s^{-1} have been reported (Fonseca *et al.*, 1983)—variation in the current regime influences the size, shape, and pattern of growth of the bed. Higher current velocites result in ellipsoid beds, oriented perpendicular to the water flow, with greater vertical relief (Fonseca *et al.*, 1983; Fonseca & Kenworthy, 1987). Sediment accretion occurs at the outer edge of such beds, resulting in raised ridges, while scouring occurs in the bed center, forming a "halo" of growth. Often, high velocity currents in seagrass beds cause an irregular, patchy pattern of growth across the bottom (Fonseca, 1990); Fonseca *et al.* (1983) observe that continuity of seagrass cover is inversely related to current velocity. Seagrass meadows in low energy environments, on the other hand, are expansive and exhibit low vertical relief. The outer edges of low energy meadows are irregularly shaped and are controlled by a random combination of erosion and deposition over time (Fonseca & Kenworthy, 1987).

Currents & Habitat Value

Finally, habitat utilization is influenced by current flow in a seagrass meadow. Low flow environments provide a more complex, three-dimensional habitat for the epibenthos and small fishes. Fauna in high flow environments need adaptations for these conditions, *e.g.*, ability to cling, increased size, or ability to live within the sediments. The bending of the canopy under high current flows is expected to affect fish feeding strategies, providing better shelter for prey items and requiring more energy from feeding fish (Fonseca *et al*., 1983).

Substrate properties

Eelgrass tolerates a wide array of substrate types, from soft mud to sandy gravel (Cashin Associates, 1996). Generally, the most common substrate encountered in eelgrass beds is mixed mud and sand (Cashin Associates, 1996). Fonseca *et al*. (1985) cite research findings that naturally established seagrass growth is not limited by sediment type. Several eelgrass parameters have shown significant differences when the plants were experimentally grown in mud (high organic) *vs*. sand (low organic) substrate (Short, 1987). Leaf biomass; maximum shoot height; leaf and rhizome weight per shoot; leaf area per shoot; and growth in terms of leaf length per shoot and per leaf length per day were each significantly greater for plants grown in mud as compared to sand. Eelgrass leaf and rhizome nitrogen content were also significantly higher in mud-grown plants than in sand-grown plants. All of these factors are attributed to the differences in sediment nitrogen resources among substrate types (Short, 1987). Therefore, the chemical profile, particularly nutrient content, of the substrate appears to be a significant affect eelgrass presence and growth.

Bioturbation

Bioturbation may affect the distribution and survival of seagrasses (Davis *et al*., 1998). Burrowing and foraging activities of crabs, shrimp, rays, and worms can bury seagrass with reworked sediment, or uproot whole plants. However, borrowing can also enhance growth of roots SAV by redistributing nutrients and organic matter and oxidizing the rhizosphere. Digging for infaunal bivalves by rays in Chesapeake Bay has been observed to significantly reduce eelgrass abundance through uprooting, and turbidity caused by the long sediment plumes ray foraging creates (Orth, 1976). Horseshoe crabs have been observed to dig holes in eelgrass beds in New Hampshire (Short & Wyllie-Echeverria, 1996). Davis *et al*. (1998) quantified the effects of green crab foraging on transplanted eelgrass populations using mesocosm experiments, and found that while this species was not specifically attracted to eelgrass, their presence in eelgrass beds could result in up to 39% loss of viable shoots within one week. These authors note that field densities of green crab exceed the experimental densities at which most damage occurred; therefore, this species can have a substantial impact on distribution and survival of eelgrass in areas where it is found (Davis *et al*., 1998).

Grazing

In addition to bioturbation effects, some crab species directly consume seagrass seeds and seedlings, *e.g.*, blue crab, hermit crab, and calico crab (*Ovalipes ocellatus*; Davis *et al*., 1998;

Bortman & Niedowski, 1998). Hermit and calico crabs exhibit active predation on eelgrass seeds and seedlings (up to 93% consumed) when no other food source is present. However, consumption drops to ~5% of seeds and seedlings when other food, such as clam and scallop bits, is present (Wigand & Churchill, 1988).

Waterfowl are also direct grazers of *Zostera marina* and *Ruppia maritima* in temperate ecosystems (Short & Wyllie-Echeverria, 1996); species most frequently considered seagrass herbivores include mute swan, whistling swan (*Cygnus columbianus*), brant, Canada goose, widgeon (*Anas penelope*), pintail (*Anas acuta*), and mallard (Thayer *et al*., 1984; Nienhuis & Groenendijk, 1986; den Hartog, 1987). On the east coast of the United States, brant grazes on *Zostera marina*, which may account for up to 80% of its diet. As a result of the eelgrass decline in the 1930s, this species of waterfowl has shifted its dietary preference to *Ruppia maritima* and *Ulva lactuca* (Thayer *et al*., 1984). Grazing may influence standing crop, rate of plant material turnover, and faunal interactions within SAV beds. Waterfowl grazing in temperate seagrass systems occurs during fall and winter, when plants are shedding leaves. Therefore, standing crop of seagrasses may be significantly reduced by grazing. Dramatic reductions in standing crop can subsequently alter distribution and abundance of waterfowl in the area over the course of the winter (Thayer *et al*., 1984; Nienhuis & Groenendijk, 1986).

Indirect grazing impacts may result from grazing on algal epiphytes attached to seagrass leaves. These epiphytes compete with seagrasses for both light and nutrients, and excessive epiphyte growth will impede seagrass growth (van Montfrans *et al*., 1984). Therefore, removal of this attached growth can allow for greater light to reach the blades of the grass, enhancing growth.

Water Temperature

Seasonal variations in water temperature may affect the growth of seagrasses *via* their affect on photosynthesis and respiration. Temperature affects the rate at which both biochemical processes occur. Photosynthesis is also, of course, dependent on light; this relationship is most commonly expressed using a P-I curve (photosynthesis *vs*. irradiance curve). While temperature does not impact the P-I curve within normal physiological temperature limits, when the high end of the temperature limit is approached, the P-I curve exhibits a decreased initial slope, *i.e.*, more light is required to produce the same level of photosynthesis (Bulthuis, 1987).

Temperature & Maximum Photosynthesis

The maximum photosynthetic rate (P_{max}, the maximum rate occurring on the P-I curve) is not related to light intensity, but is affected by temperature. Therefore, as temperature increases, the maximum photosynthetic rate increases until a "maximum P_{max}" is reached, reflecting the optimum temperature for photosynthesis. Temperature optimums at light saturation range from 25-35 degrees Celsius (Bulthuis, 1987); Marsh *et al*. (1986) observed light-saturated net photosynthesis in *Zostera marina* increasing with temperature to a maximum of 25-30 degrees Celsius, and a subsequent decrease above 35 degrees Celsius (Great Harbor, Woods Hole, MA).

Temperature & Respiration

Respiration rates are also affected by temperature. As temperature increases, the rate of respiration increases. In seagrasses, this effect has been observed to be variable, but the general relationship was observed. For example, Marsh *et al*. (1986) observed dark respiration increasing with temperature from 5-30 degrees Celsius. Because of the respiration-temperature and photosynthetic rate-temperature relationships, the compensation irradiance (the amount of light at which net photosynthesis—gross photosynthesis minus respiration—is zero) increases as temperature increases (Balthuis, 1987). This means that more light is required to obtain the same amount of photosynthesis, and therefore a positive standing stock of carbon, at higher temperatures (Balthuis, 1897; Marsh *et al*., 1986). The relationship between optimum temperature for photosynthesis (the "maximum P_{max}") and irradiance exhibits declining optimum temperatures (by as much as 30 degrees Celsius) with decreasing irradiance; therefore, seagrasses in low light environments will exhibit low optimum temperatures for photosynthesis.

Seasonal Effects of Temperature Variations

The seasonal effects of the compensation irradiance-temperature relationship are apparent. Temperate seagrasses experience significantly higher temperatures in the summer than in the winter; therefore these seagrasses require more light during the summer to maintain a positive carbon balance than during winter. This effect will be most pronounced in seagrasses living at or near their minimum light requirements. Winter conditions will be more favorable for photosynthesis in low light environment seagrasses than summer conditions. The resultant impact on seagrass growth of these various relationships has been widely debated, although temperature appears to be an important variable in influencing seasonal growth rates (Balthuis, 1987).

Variations in Light

Survival and distribution of *Zostera marina* appears to be controlled mainly by the daily light period, *i.e.*, the duration of the daily period during which the quantity of light useable for photosynthesis that is received by the eelgrass plant (PPFD, Photosynthetic Photon Flux Density) equals or exceeds the quantity such light required to saturate the photosynthetic apparatus (H_{sat}, the daily period during which PPFD equals or exceeds the photosynthetic saturation point) of the eelgrass (Dennison & Alberte, 1985). Fonseca (1990) explains this concept: seagrasses can only use so much light per unit time, therefore they must have sufficient light over a longer period of time than if they could use all the light received. Dennison & Alberte (1985) show that eelgrass growth responses do not occur as a result of changes in light intensity without concurrent changes in the daily light period. Response to daily light period manipulations is of a saturation-type: eelgrass growth rates increased with increasing light period up to ~10 hours, after which point growth rates remained relatively constant with increasing light period (up to ~16 hours; Dennison & Alberte, 1985). The maximum depth limit for eelgrass growth, controlled by daily light period, can be roughly predicted by the Secchi disk depth (the depth at which a white and black or all white disk just disappears from view as it is lowered in the water column, Chesapeake Bay Program, 1995; Dennison, 1987; Fonseca, 1990). For the northeast coast, *Zostera marina* has been reported growing down to 11 m (Dennison, 1987).

Seasonal Effects of Light Variations

There are pronounced seasonal trends in daily light period (measured in Great Harbor, Woods Hole, MA; Dennison, 1987): The longest light periods occur in April; with periods increasing rapidly during the spring, and decreasing slowly throughout the summer. The shortest light periods occur in November-December. Gross photosynthesis by eelgrass peaked in July, and was high between April through September. Net photosynthesis (Gross photosynthesis minus respiration) by eelgrass increased during the spring, peaked in May, and declined slowly throughout the summer and fall (Dennison, 1987). This pattern follows the seasonal trend observed in daily light period.

Ice

Winter ice may have a major influence on the distribution and life history of eelgrass (Robertson & Mann, 1984). Intertidal and shallow areas are most affected by scouring and rafting of sea ice in winter (Davis *et al*., 1998; den Hartog, 1987). Movement of ice may remove whole eelgrass plants or shear off leaves, creating bare mud areas or areas dominated by eelgrass stubs (Short & Wyllie-Echeverria, 1996). Depth of ice relative to water depth in an area appears to control life history: In areas where ice depth is greater than water depth, whole plants will generally be removed, and therefore allocate less biomass to their below-ground parts. Such plants occur annually, overwintering as seeds. By contrast, where depth of ice is less than than water depth, plants are more likely to have leaves sheared than be removed. These plants invest more resources in below-ground biomass production and occur perennially (Robertson & Mann, 1984; Phillips *et al*., 1983).

Storms & Hurricanes

Large storms and hurricanes can cause "blowouts" in seagrass meadows as a result of heavy wave action and increased current velocities, which scour the bottom and remove plants (Thorhaug, 1987; Short & Wyllie-Echeverria, 1996). These weather events also resuspend sediments, causing prolonged turbidity and potentially depositing excess sediment on seagrass beds, smothering them (Short & Wyllie-Echeverria, 1996).

Wasting Disease

The "wasting disease" struck North Atlantic populations of eelgrass in 1931 (den Hartog, 1987; Bortman & Niedowski, 1998). Along the Atlantic coast an estimated 90% of the eelgrass population was lost (Cashin Associates, 1996). The "wasting disease" phenomenon is thought to be caused by the slime mold *Labyrinthula macrocystis*, which causes brown or black spots to develop on eelgrass leaves, eventually turning the leaf black and resulting in defoliation (Cashin Associates, 1996; den Hartog, 1987). Rhizomes also show discoloration, but survive for up to a year; it is the repeated defoliation that exhausts the plant's resources, resulting in mortality (den Hartog, 1987).

Other factors have been blamed for wasting disease, including climatic stresses like precipitation extremes, high summer water temperatures, and mild winters; as well as recurring disturbance cycles related to solar activity (den Hartog, 1987).

Brown Tide

Brown tide is caused by extensive blooms of the phytoplankton *Aureococcus anophagefferens*, an organism capable of reproducing every 3-8 hours, resulting in concentrations of 1-2 million cells per milliliter (Smith & Tettlebach, 1995). Concentrations of this magnitude were observed during the brown tide events in 1985, 1986, and 1987 in the Peconic Bays, and extensive areas of eelgrass were lost as a result of shading (Smith & Tettlebach, 1995; Cashin Associates, 1996). The cause or causes for an onset of brown tide are still unknown; however, research may implicate certain micronutrients, seasonal patterns of flushing and tidal exchange, and precipitation levels. It does not appear that nutrient loading is related to brown tide blooms (Cashin Associates, 1996). Groundwater discharges have also been identified as a possible parameter influencing harmful algal blooms, by altering the ratio of different nitrogen species in the water column.

Impacts on Eelgrass Beds

Decline in Photosynthesis

Shading submerged aquatic vegetation causes a decline in photosynthesis. However, the detrimental impacts of shading are not limited to situations of continuous lack of light. In fact, shading during any portion of the day diminishes the daily light period experienced by the plants; as described above, it is this parameter, and not absolute light intensity, that controls growth. The duration and timing of the partial shading will depend on the size, shape, and orientation of object throwing the shadow. For example, the shading effect of docks and floats is most pronounced when structures are oriented in an east-west direction (Lockwood, 1990).

Change in Species Composition

Changes in the environmental parameters of a habitat effect in turn the species composition. Eelgrass meadows become dominated by green fleece or sea lettuce under more disturbed conditions (Cashin Associates, 1996). It is thought that green fleece does not directly compete with eelgrass, but rather moves into habitat that has been vacated by eelgrass due to unsuitability. Sea lettuce, by contrast, has been observed to displace eelgrass under nutrient rich conditions (Cashin Associates, 1996).

Changes in species composition are thought to substantially impact the habitat value of a seagrass bed (Cashin Associates, 1996). The value of eelgrass habitat relative to unvegetated habitat has been documented for fishes and decapod crustaceans (Heck *et al*., 1989); benthic macrofauna including bay scallop and blue mussel (Heck *et al*., 1995); and fish and shrimp (Fonseca *et al*., 1990). The influence of plant structure on the habitat value of different species of seagrass for both epifauna and infauna was reviewed by Orth *et al*. (1984). However, targeted research on the habitat value of eelgrass relative to seaweeds like green fleece and sea lettuce, among others, has not been conducted.

Devegetation

The loss of submerged aquatic vegetation not only eliminates valuable habitat (Heck *et al*., 1989; Heck *et al*., 1995; Fonseca *et al*., 1990; Orth *et al*., 1984), but affects physical and chemical parameters of the water column and the benthic environment. Fonseca & Cahalan (1992) demonstrated that seagrasses may substantially reduce wave energy depending on species, plant height, and size and configuration of the meadow. Ward *et al*. (1984) have shown that concentrations of suspended particulate matter in seagrass beds are significantly lower than in adjacent unvegetated areas.

Substrate Instability

Loss of submerged aquatic vegetation in an area removes the stable root and rhizome mat anchoring sediments in place, as well as the canopy, which reduces flow velocities above the sediments and therefore increases sedimentation.

Eelgrass Restoration

Restoration Theory

The restoration of eelgrass meadows is like any other type of ecological restoration and relies on re-establishing the dominant vegetation within its historic range. Once established, it is widely assumed that the restored area will become functionally equivalent to natural systems over time. Unlike upland restorations, planting eelgrass is complicated by the need to work in water and constrained by ambient water quality and bottom conditions. Parameters influencing transplant success include water clarity (light attenuation coefficient, K_d; concentration of Chlorophyll *a*, Chl *a*; total suspended solids, TSS), substrate characteristics (grain size), nutrient concentrations (dissolved inorganic nitrogen, DIN; dissolved inorganic phosphorus, DIP), wave exposure and tidal current speed at the site. Fonseca *et al.* (1998) state that a maximum tidal current speed of 50 cm sec^{-1} is applicable to seagrasses in most settings. Factors such as time of year, transplanting method, propagule vigor, extent of disturbance by aquatic and semi-aquatic species (hereafter referred to as bioturbation), and human-induced disturbance such as shellfishing and recreational boating, influence transplant success (Short & Wyllie-Echeverria, 1996). Fonseca *et al.* (1994) caution that "disturbance imposed after planting…, subobtimal environmental conditions at a chosen site, and the skill of those performing the planting can combine to make planting success…tenuous."

Habitat Requirements

Habitat requirements for eelgrass and other SAV have been defined for several areas including the Chesapeake Bay (Batuik *et al*., 1992). Draft eelgrass habitat criteria for the Peconic Estuary have been developed and are listed below. These criteria represent estimates of the maximum values for eelgrass survival.

K_d (m^{-1})	0.75 +/- 0.05
DIN (mg/L)	0.02
DIP (mg/L)	0.02
Chl *a* (µg/L)	5.5 +/- 0.5

For comparison, the Chesapeake Bay Program (1995) reports the following maximal criteria for polyhaline (> 18 parts per thousand) SAV beds:

K_d (m^{-1})	1.5	**TSS (mg/L)**	15
DIN (mg/L)	0.15		
DIP (mg/L)	0.02		
Chl *a* (µg/L)	15		

Restoration Methods

Since there is no horticultural source of eelgrass, propagules or planting units (PUs) are commonly gleaned from existing beds. Planting may occur by any of a number of methods depending on site characteristics and project budget. Local work has demonstrated that SCUBA gear is required for every aspect of eelgrass transplants except for the shallowest sites under ideal conditions. Post-planting protection may be necessary to prevent losses attributed to bioturbation, shellfishing and recreational boating. However, protection has been utilized sparingly in the Peconic Estuary.

Restoration techniques can be conveniently divided into two categories based on the source of PUs: clonal propagation (Division) and sexual propagation (Seeds). Clonal propagation relies on the use of divisions or existing plants and can be further distinguished as techniques that utilize transplants from existing beds or stranded shoots collected on beaches. The use of seeds involves direct sowing in the bottom or establishment of a nursery that produces adult plants from seed. As attractive as this latter alternative may appear, the details of such a nursery have yet to be worked out for any region of this country. Tissue culture, a variation of clonal propagation at the cellular or tissue level would appear to have great potential for producing large numbers of plants, has not been applied to *Zostera*.

Division

Propagation of eelgrass by clonal means can be divided into those divisions produced by deliberate removal from an existing meadow (*e.g.*, plugs and sods) and those deriving from natural forces such as wave scour and bioturbation or unintentional human activities such as shellfishing or recreational boating. Transplants are those plants intentionally collected from natural beds for use in restoration. Stranded robust shoots (SRS) are those shoots that originate from some other means.

Transplants

Most eelgrass restoration efforts nationwide have relied on transplanting live shoots or sods from healthy donor meadows to areas where the grass historically occurred. The most commonly employed techniques have been the staple, plug/peat pot, and core methods (Phillips, 1960; Fonseca *et al.,* 1982; Fonseca *et al.*, 1998). Davis and Short (1997) have devised a modification of the staple method utilizing bamboo "staples." A single, unachored, bare root transplant method has also been developed recently (Orth *et al.*, 1999).

Depending on the experience of the restorationist and conditions at the restoration site, transplants have met with mixed results. Several projects have been successful south of New Jersey and on the west coast in Washington State (Fonseca *et al.*, 1994; Fredette *et al.*, 1985). However, work in the northeast, including the Peconic Estuary, has been only marginally successful. For this reason, and the fact that the collection of donor material may be impacting existing meadows, many have discontinued large-scale transplants.

Stranded Robust Shoots

A technique that has not been employed in the Peconic Estuary, but may hold promise for this region is the collection, propagation and planting of live shoots that wash up on the beach. Large amounts of dislodged viable eelgrass plants (SRS) with rhizome and roots intact wash up on local beaches as a result of bioturbation, heavy weather, shellfishing and recreational boating activities. Left alone, these shoots dry out within a matter of hours or days and are incorporated into the beach profile as a result of wave mixing and sand accretion. Collection, culture and division of these plants would appear to offer a readily available, low-cost source of eelgrass transplants. In the Pacific Northwest, Wyllie-Echeverria *et al.* (in prep), are using SRS of eelgrass, collected from wrack lines, to restore damage resulting from the deployment of a submarine cable. Preliminary results of this work are favorable (Wyllie-Echeverria, personal communication).

Once these plants are collected they can either be held in a nursery setting for growth and division or planted directly into a suitable receiving area using traditional or modified transplant techniques. It would appear that the minimal requirements necessary for handling SRS would be an outdoor flowing seawater tank for holding live shoots prior to deployment in the field.

Seeds

In light of the low success rate and high cost of eelgrass transplants in the north east, many eelgrass scientists have turned to the use of seeds for restoration purposes. The simplest method and the one that has received the most attention is direct sowing. Germination of seeds in a nursery although attractive, has yet to be the focus of much research.

Direct Sowing

Several studies have discussed the collection and sowing of wild eelgrass seed (Churchill *et al.*, 1978; Orth *et al.*, 1994; Granger *et al.*, 1996; Thom & Wyllie-Echeverria, 1997). However, to date, this method of eelgrass restoration has met with limited success (Orth *et al.*, 1994). One possible explanation lies in the consumption of seed by invertebrates and waterfowl (Wigand & Churchill, 1988; Fishman & Orth, 1996; Wyllie-Echeverria *et al.*, in prep). Physical disruption of the bottom by any means could easily lead to loss of seeds. Harwell and Orth (1999) have shown that if seeds are protected from benthic predators, increases in seedling presence result but the study did not track seedlings to maturity. The University of Rhode Island recently completed a study of seed release from flowering shoots held in flowing sea water tanks and the effects of planting depth, density and sediment organic matter composition on seedling establishment in the field (Granger *et al.*, in press). Based on this work URI looks to develop an underwater "plow" that would improve the success rate for *in situ* planting of seeds (Brian Maynard, personal communication).

Seeds have been collected in the Peconic Estuary and surrounding waters for the 25 or more years (Churchill *et al.*, 1978). The same researcher has developed a reliable method of maturing collected flowering shoots using covered outdoor pools to improve germination. Similar work using a modification of the outdoor holding tank method has been utilized as part of the Delaware Inland Bays Program.

Nursery Production

Recent efforts have indicated that it is possible to germinate and grow eelgrass seedlings from Orient Harbor and Northwest Harbor under controlled conditions in the laboratory for up to two months (Pickerell & Wyllie-Echeverria, unpublished). However, use of supplemental lighting and closed tanks complicated scale-up of this method. Anecdotal reports from a local shellfish hatchery indicate that naturally recruited eelgrass seeds will germinate in on-bottom shellfish growing trays under ambient winter conditions (John Aldred, personal communication). Based on this evidence and that of other eelgrass researchers in the region, the use of outdoor, flowing seawater tanks in ambient sunlight should provide a more effective alternative to indoor culture.

Production of seedling and mature plants for the purposes of restoration will lead to the need for enhanced planting methods. Although the source of the plant material is different, the techniques used for planting will be based on improvements to current transplant methods.

Eelgrass Restoration in the Peconics

The first eelgrass planting demonstration project in the Peconic Estuary was sponsored by the PEP and focused on transplants in the Town of East Hampton (Hasbrouck & Pickerell, 1994). This cooperative effort between the East Hampton Town Natural Resources Department and Cornell Cooperative Extension, Marine Program utilized the traditional staple method (Fonseca *et al.*, 1982) and a modification of this method using wooden stakes in place of the metal wires. One goal of this original work was to determine the most suitable sediment type to receive transplants. During that first year, transplants were harvested from Northwest Harbor and Lake Montauk, during mid-summer, for planting at two sites in Three Mile Harbor and two in Accabonac Harbor. The results of the pilot study indicated that fine, sandy sediment with organic matter was the only bottom type suited to this type of planting. Soft mud, though capable of supporting healthy natural growth, proved impractical since it was easily disturbed by divers and was not sufficiently dense to hold the planting units in place. The use of the metal landscape staples proved more effective than the wooden stake method attempted. An additional problem encountered (in Accabonac Harbor) was the proliferation of a brown macroalgae (possibly *Desmarestia* or *Ectocarpus* spp.) at one of the sites that entirely smothered the transplants preventing light penetration.

The general lack of success using the staple method caused the group to abandon this method for a system that was more stable in the bottom and less disruptive to the transplanted shoots. During 1998 and 1999, a modified coring method (Phillips, 1960) was employed using a 20cm diameter sod cutter. These efforts focused on Napeague Harbor and indicated that large intact clumps of rhizome with sediment intact could be successfully established in and adjacent to an existing meadow. Mid-summer and fall plantings focused in interior areas and the deep water edge habitats. Successful establishment of sods into interior openings in the existing bed indicated that this very labor intensive technique was effective. Monitoring of donor areas also indicated natural revegetation within months of harvest. However, despite the success of this method, uncontrolled recreational clamming threatens both the transplants and the natural meadow in Napeague Harbor. Based on recent observations, there has been a loss of up to1m along the deepwater edge of this bed resulting from clamming.

Conclusions

There is much to learn about the ecology of *Zostera marina* in the Peconic Esutary. At this time, there is a general lack of basic parameters such as the phenology, standing crop biomass, substrate and water quality requirements of this plant. There is a great need to collect long term data on parameters such as ambient light levels, current velocity, sediment texture and organic matter concentration. Comprehensive mapping of existing beds along with detailed investigations of the spread or shrinkage of these areas will enhance our understanding of the status and requirements of this species. This information will be useful in developing a eelgrass restoration plan.

Restoration efforts to date have met with limited success. Transplants have not met their goal of enhancing existing meadows in most cases. In fact, one could argue that some of this work has been detrimental to the resource. In order to allow for continued experimental plantings, it is necessary to develop an alternative source or sources of planting units that will not further deplete the existing resource. Refinement of a SRS salvage or seed-based nursery system will alleviate the need to take from natural stock for enhancement purposes. Until an alternative source is developed, transplanting projects should be avoided.

References

Aldred, J. Personal Communication, Town of East Hampton Shellfish Hatchery manager.

Batuik, R.A., R. J. Orth, K.A. Moore, W.C. Dennison, J.C. Stevenson, L.W. Staver, V. Carter, N.B. Rybicki, R. E. Hickman, S. Kollar, S. Birber and P. Heasley. 1992. Chesapeake Bay submerged aquatic vegetation habitat requirements and restoration targets: A technical synthesis. U.S. EPA. Contribution No. 68-WO-0043.

Bortman, M.L. & N. Niedowski. 1998. Characterization report of the living resources of the Peconic Estuary. Prepared for the Peconic Estuary Program Natural Resources Subcommittee.

Bulthuis, D.A. 1987. Effects of temperature on photosynthesis and growth of seagrasses.

Aquatic Botany 27: 27-40.

Cashin Associates. 1996. Peconic Estuary Program final submerged aquatic vegetation study. Prepared for the Peconic Estuary Program. 374 pp.

Chandler & W.C. Dennison. 1987. Effects of light on seagrass photosynthesis, growth and depth distribution. Aquat. Bot. 27: 15-26.

Chesapeake Bay Program. 1995. Guidance for protecting submerged aquatic vegetation in Chesapeake Bay from physical disruption. Prepared by Submerged Aquatic Vegetation Workgroup of the Living Resources Subcommittee, Chesapeake Bay Program. EPA 903-R-95-013 CBP/TRS139/95. August 1995.

Churchill, A.C. 1983. Field studies on seed germination and seedling development in *Zostera marina* L. Aquatic Botany 16: 21-29.

Churchill, A.C., A.E. Cok & M.I. Riner. 1978. Stabilization of subtidal sediments by the transplantation of the seagrass *Zostera marina* L. N.Y. Sea Grant Report NYSSGP-RS-78-15.

Cottam, C. 1933. Disappearance of eelgrass along the Atlantic Coast. The Plant Disease Reporter. 17(6): 46-53.

Cottam, C. and D. A. Munro. 1954. Eelgrass status and environmental relations. Journal of Wildlife Management 18(4): 449-460.

Davis, R.C. & F.T. Short. 1997. Restoring eelgrass, *Zostera marina* L., habitat using a new transplanting technique: The horizontal rhizome method. Aquatic Botany 59: 1-15.

Davis, R.C., F.T. Short & D.M. Burdick. 1998. Quantifying the effects of green crab damage to eelgrass transplants. Restoration Ecology 6(3): 297-302.

den Hartog, C. 1987. "Wasting disease" and other dynamic phenomena in *Zostera* beds. Aquatic Botany 27: 3-14.

Dennison, W.C. 1987. Effects of light on seagrasses: Photosynthesis, growth and depth distribution. Aquatic Botany 27: 15-26.

Dennison, W.C. & R.S. Alberte. 1985. Role of daily light period in the depth distribution of *Zostera marina* (eelgrass). Mar. Ecol. Prog. Ser. 25: 51-61.

Dennison, W.C. & R.S. Alberte. 1986. Growth and photosynthesis of *Zostera marina* (eelgrass) transplants along a depth gradient. J. Exp. Mar. Biol. Ecol. 101: 257-282.

Dennison, W.C., G.J. Marshall & C. Wigand. 1989. Effect of "Brown Tide" shading on eelgrass (*Zostera marina* L.) Distributions. In "Novel Phytoplankton Blooms." Chapter 37.

Pp. 675-692.

van Dolah, R.F., D.R. Calder & D.M. Knott. 1984. Effects of dredging and open-water disposal on benthic macroinvertebrates in a South Carolina estuary. Estuaries 7(1): 28-37.

Fishman, J.R. & R.J. Orth. 1996. Effects of predation on *Zostera marina* seed abundance. J. Exp. Mar. Biol. Ecol. 198: 11-26.

Fonseca, M.S. 1990. Regional analysis of the creation and restoration of seagrass meadows. Pp. 171-194 in Kusler, J.A. & M.E. Kentula, eds., Wetland creation and restoration: The status of the science. Island Press, Washington, D.C.

Fonseca, M.S. 1987. Habitat development applications: Use of seagrass transplanting for habitat development on dredged material. Pp. 145-150 in M.C. Landin and H.K. Smith, eds., Beneficial uses of dredged material, proceedings of the first interagency workshop, 7-9 October, 1986, Pensacola, FL. USACE Tech. Rep. D-87-1.

Fonseca, M.S. & J.A. Cahalan. 1992. A preliminary evaluation of wave attenuation by four species of seagrass. Est. Coast. Shelf Sci. 35: 565-576.

Fonseca, M.S. & J.S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and distribution. Mar. Ecol. Prog. Ser. 29:15-22.

Fonseca, M.S. & W.J. Kenworthy. 1987. Effects of current on photosynthesis and distribution of seagrasses. Aquatic Botany 27: 59-78.

Fonseca, M.S., W.J. Kenworthy, F.X. Courney and M.O. Hall. 1994. Seagrass planting in the southeastern united states: methods for accelerating habitat development. Restoration Ecology Vol. 2 No. 3, pp 198-212.

Fonseca, M.S., W.J. Kenworthy & G.W. Thayer. 1998. Guidelines for the conservation and restoration of seagrasses in the United States and adjacent waters. Prepared by NOAA National Marine Fisheries Service Southeast Fisheries Science Center, Beaufort, NC for U.S. Department of Commerce NOAA Coastal Ocean Office, Silver Spring, MD. Decision Analysis Series No. 12, November 1998.

Fonseca, M.S., W.J. Kenworthy & G.W. Thayer. 1982. A low cost planting technique for eelgrass (*Zostera marina* L.). Coastal Engineering Technical Aid No. 82-6. U.S. Army Engineer Coastal Engineering Research Center, Ft. Belvoir, VA.

Fonseca, M.S., J.C. Zieman, G.W. Thayer & J.S. Fisher. 1983. The role of current velocity in structuring seagrass meadows. Est. Coast. Shelf Sci. 17: 367-380.

Fonseca, M.S., W.J. Kenworthy, D.R. Colby, K.A. Rittmaster & G.W. Thayer. 1990. Comparisons of fauna among natural and transplanted eelgrass (*Zostera marina*) meadows:

Criteria for mitigation. Mar. Ecol. Prog. Ser. 65: 251-264.

Fonseca, M.S., W.J. Kenworthy, G.W. Thayer, D.Y. Heller & K.M. Cheap. 1985. Transplanting of the seagrasses *Zostera marina* and *Halodule wrightii* for sediment stabilization and habitat development on the east coast of the United States. Technical Report EL-85-9. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T.J., M.S. Fonseca, W.J. Kenworthy and S. Wyllie-Echeverria. 1985. An investigation of eelgrass (*Zostera marina*) transplanting in San Francisco Bay, CA. U.S. Army Corps of Engineers, San Francisco District.

Granger, S., S. Nixon, M. Traber and R. Keyes. 1996. The application ofhorticultural techniques in the propagation of eelgrass (*Zostera marina*)from seed. Page 377. In Kuo, J., R. C. Phillips, D. I. Walker and H. Kirkman, eds., Seagrass Biology: Proceedings of an international workshop. Nedlands, Western Australia: Faculty of Sciences. University of Western Australia.

Granger, S.L., M.S. Traber and S.W. Nixon. (in press). "Observations on the propagation of *Zostera marina* L. from seed." in Seas in the millenium. University of Rhode Island, Graduate School of Oceanography. Narragansett, Rhode Island.

Harrison, P.G. 1990. Variations in success of eelgrass transplants over a five year period. Env. Conserv. 17(2): 157-163.

Heck, K.L., Jr., K.W. Able, C.T. Roman & M.P. Fahay. 1995. Composition, abundance, biomass and production of macrofauna in a New England estuary: Comparisons among eelgrass meadows and other nursery habitats. Estuaries 18(2): 379-389.

Harwell, M. C. and R. J. Orth. 1999. Eelgrass (*Zostera marina* L.) seed protection for field experiments and implications for large-scale restoration. Aquatic Botany 64(1):51-61.

Hasbrouck, E. and C. H. Pickerell 1994. Unpublished reports to the Town of East Hampton Trustees.

Heck, K.L., Jr., K.W. Able, M.P. Fahay & C.T. Roman. 1989. Fishes and decapod crustaceans of Cape Cod eelgrass meadows: Species composition, seasonal abundance patterns and comparison with unvegetated substrates. Estuaries 12: 59-65.

Homziak, J., M.S. Fonseca, & W.J. Kenworthy. 1982. Macrobenthic community structure in a transplanted eelgrass (*Zostera marina*) meadow. Mar. Ecol. Prog. Ser. 9: 211-221.

Lockwood, J.C. 1990. Seagrass as a consideration in the site selection and construction of marinas. Environmental management for marinas conference, September 5-7, 1990, Washington, D.C. Technical Reprint Series, International marina Institute, Wickford, Rhode Island.

Marsh, J.A., Jr., W.C. Dennison & R.S. Alberte. 1986. Effects of temperature on photosynthesis and respiration in eelgrass (*Zostera marina* L.). J. Exp. Mar. Biol. Ecol. 101: 257-267.

Maydard, B. 1999. Personal communication. University of Rhode Island, Assistant Professor.

Mazzella, L. & R.S. Alberte. 1986. Light adaptation and the role of autotrophic epiphytes in primary production of the temperate seagrass, *Zostera marina* L. J. Exp. Mar. Biol. Ecol. 100: 165-180.

McLaughlin, P.A., S.A. Treat, A. Thorhaug & R. Lemaitre. 1983. A restored seagrass (*Thalassia*) bed and its animal community. Environ. Cons. 10: 247-254.

Moore, K.A. & R.J. Orth. 1997. Report to the Virgina Marine Resources Commission: Evidence of widespread destruction of submersed aqautic vegetation (SAV) from clam dredging in Chincoteague Bay, Virginia. October 28, 1997.

Moore, K.A., R.J. Orth & J.F. Nowak. 1993. Environmental regulation of seed germination in *Zostera marina* L. (eelgrass) in Chesapeake Bay: Effects of light, oxygen, and sediment burial. Aquatic Botany 45: 79-91.

Nienhuis, P.H. & A.M. Groenendijk. 1986. Consumption of eelgrass (*Zostera marina*) by birds and invertebrates: an annual budget. Mar. Ecol. Prog. Ser. 29: 29-35.

Olesen, B. & K. Sand-Jensen. 1994. Biomass-density patterns in the temperate seagrass *Zostera marina*. Mar. Ecol. Prog. Ser. 109: 283-291.

Orth, R. 1976. The demise and recovery of eelgrass, *Zostera marina*, in the Chesapeake Bay, Virginia. Aquatic Botany 2: 141-159.

Orth, R.J., M. Luckenback & K.A. Moore. 1994. Seed dispersal in a marine macrophyte: Implications for colonization and restoration. Ecol. 75(7): 1927-1939.

Orth, R.J., M.C. Harwell & J.R. Fishman. 1999. A rapid and simple method for tranplanting eelgrass using single, unachored shoots. Aquatic Botany 64: 77-85.

Orth, R.J., K.L. Heck, Jr. & J. van Montfrans. 1984. Faunal communities in seagrass beds: A review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries 7(4a): 339-350.

Orth, R. J., M. Luckenbach and K. A. Moore. 1994. Seed dispersal in a marine macrophyte: implications for colonization and restoration. Ecology 75(7):1927-1939

Phillips, R.C. 1976. Preliminary observations of transplanting and a phenological index of seagrasses. Aquatic Botany 2: 93-101.

Phillips, R.C. 1974. Transplantation of seagrasses, with special emphasis on eelgrass, *Zostera marina*. Aquaculture 4: 161-176.

Phillips, R.C. 1984. The ecology of eelgrass meadows in the Pacific Northwest, a community profile. US Fish and Wildlife Service. FWS/OBS-84/24. Washington, D.C.

Phillips, R.C., W.S. Grant & C. P. McRoy. 1983. Reproductive strategies of eelgrass (*Zostera marina* L.). Aquatic Botany 16: 1-20.

Pickerell, C. H. and S. Wyllie-Echeverria. 1998. Unpublished data collected related to: Winter germination trials of *Zostera marina* seeds at the Cornell Marine Laboratory in Southold, New York.

Roberts, M.H., R.J. Orth & K.A. Moore. 1984. Growth of *Zostera marina* seedlings under laboratory conditions of nutrient enrichment. Aquatic Botany 20: 321-328.

Robertson, A.I. & K.H. Mann. 1984. Disturbance by ice and life-history adaptations of the seagrass *Zostera marina*. Mar. Biol. 80: 131-141.

Short, F.T. 1987. Effects of sediment on seagrasses: Literature review and mesocosm experiment. Aquatic Botany 27: 41-57.

Short, F.T. 1983. The seagrass, *Zostera marina* L.: Plant morphology and bed structure in relation to sediment ammonium in Izembek lagoon, Alaska. Aquatic Botany 16: 149-161.

Short, F.T. & S. Wyllie-Echeverria. 1996. Natural and human-induced disturbances of seagrasses. Environmental Conservation 23(1): 17-27.

Short, F.T. & C.P. McRoy. 1984. Nitrogen uptake by leaves and roots of the seagrass *Zostera marina* L. Bot. Mar. 27: 547-555.

Smith, J.D. 1946. Eelgrass. The Nassau County Historical Journal 9(2): 76-82.

Smith, C.F. & S. Tettlebach. 1995. Bay scallop restoration Western Peconic Bay Project Report. Prepared by Cornell Cooperative Extension of Suffolk County, Riverhead, NY and Natural Science Division Long Island University, Southampton, NY for the Peconic Estuary Program, Suffolk County. October 1995.

Thayer, G.W., W.J. Kenworthy & M.S. Fonseca. 1984. The ecology of seagrass meadows of the Atlantic coast: A community profile. FWS/OBS-84/02. U.S. Fish and Wildlife Service. 147 pp.

Thayer, G.W., M.S. Fonseca & W.J. Kenworthy. 1990. Seagrass transplantation: Is it a viable habitat mitigation option? Pp. 194-204 in Lasor & Medina, eds., Beneficial uses of dredged material. Proceedings of the Gulf Coast Regional Workshop, April, 1988, Galveston, TX. Technical Report D-90-3. U.S. Army Corps of Engineers, Environmental Effects of Dredging Program.

Thayer, G.W., K.A. Bjorndal, J.C. Ogden, S.L. Williams, J.C. Zieman. 1984. Role of larger herbivores in seagrass communities. Estuaries 7(4a): 351-376.

Thom, R. M. and S. Wyllie-Echeverria. 1997. Active and passive mitigation strategies for impacts to eelgrass from ferry terminal construction. Pp. 102-128 in C.A. Simenstad, R. M. Thom and A. M. Olson, eds., Mitigation between regional transportation needs and preservation of eelgrass beds (Volume I). Research Report: WA-RD 421.1. Washington State Transportation Center. University of Washington. Seattle, WA.

Thorhaug, A. 1987. Review of seagrass restoration efforts. Ambio 15(2): 110-116.

van Montfrans, J., R.L. Wetzel & R.J. Orth. 1984. Epiphyte-grazer relationships in seagrass meadows: Consequences for seagrass growth and production. Estuaries 7(4a): 289-309.

Ward, L.G., W.M. Kemp & W.R. Boynton. 1984. The influence of waves and seagrass communities on suspended particulates in an estuarine embayment. Mar. Geo. 59: 85-103.

Wigand, C. & A.C. Churchill. 1988. Laboratory studies on eelgrass seed and seedling predation. Estuaries 11(3): 180-183.

Wyllie-Echeverria, S., T. Turner and T. Wyllie-Echeverria (in prep). Eelgrass (*Zostera marina* L.) restoration on Shaw Island, Washington: innovative approaches to seagrass restoration.

Zieman, J.C. 1976. The ecological effects of physical damage from motorboats on turtle grass beds in southern Florida. Aquatic Botany 2: 127-139.

8. SPECIAL TOPICS: OPEN MARSH WATER MANAGEMENT

Open Marsh Water Management (OMWM) has proved a beneficial tool for the reduction of mosquitoes and the restoration of degraded tidal marshes. The impetus behind converting open ditched marshes to OMWM marshes has a foundation in both the drive to reduce pesticide use and the restoration of degraded tidal marshes. Environmentalists and mosquito control biologists agree that the practice of grid ditching marshes for mosquito control is no longer the best course of action.

The need for mosquito control, resulting in the establishment of grid ditching, is well documented. Mosquitoes have always plagued coastal communities as a nuisance and a potential health threat (Reiter, 2000; Zucker, 1996). Mosquito-borne disease outbreaks would often result in the deaths of hundreds, and sometimes thousands, in cities along the Atlantic coast (Crans, 1992). Periodic outbreaks of malaria and yellow fever also regularly occurred on Long Island with similar devastating results. Grid ditching was found to be an effective tool for reducing mosquito numbers and the prevalence of mosquito-borne diseases (Richards, 1938; Taylor, 1938). Ditching lowers the water table in the marsh, draining it of any standing surface water and the associated mosquito breeding pools.

Over time, pesticides were developed to control mosquitoes and the diseases they transmit. When yellow fever and malaria were locally eradicated, the focus of mosquito control shifted from disease prevention to nuisance control. As the need for mosquito control diminished from the standpoint of public health, so too did the staff and budgets of mosquito control programs. Cost reduction strategies were developed by mosquito control districts seeking to limit the use of expensive pesticides, resulting in new, more natural methods for reducing mosquito breeding, including OMWM. Mosquito control districts in New Jersey were the first to utilize OMWM as an effective onsite mosquito reduction method.

OMWM utilizes and manipulates existing grid ditches in salt marshes to create a natural, biological system for mosquito control. The underlying principle of OMWM is to create an aquatic system where natural predators in the marsh are given access to the developing mosquito larvae. To accomplish this goal, mosquito control ditches within a marsh are plugged at their ends to create connected linear tidal ponds. Killifish, such as the mummichog, a primary mosquito larvae predator, reside in these ponds and keep mosquito populations in check by consuming developing larvae.

A characteristic of most grid-ditched marshes is their “lawn-like” appearance. These marshes tend to consist of monocultures of *Spartina patens* on the marsh surface and *Spartina alterniflora* along the ditch edges and bay front. Although these tidal wetland plants are ecologically very important species, the absence of wetland plant diversity and the lack of tidal ponds and pannes, limit overall habitat value for wildlife. One of the unexpected benefits observed in completed OMWM systems is the restoration to a more natural, ecologically mixed habitat. The restoration of the natural tidal regime allows the formation of pannes and tidal ponds. Stands of sedges, rushes, and additional species of marsh vegetation colonize the site, a sign of an ecologically robust wetland. In addition, by increasing the salinity of the marsh and maintaining water table elevations, OMWM can help to restore ditched marshes that are being invaded by common reed.

Wading birds and waterfowl are found to prefer OMWM areas over ditched marshes, due to the higher diversity of vegetation and topography. OMWM areas often combine several important ecological zones within a limited space, providing wildlife with more diverse offerings for foraging and nesting. These may include open water habitats, shallow wading areas for foraging, and taller stands of various grasses, sedges and rushes for food, nesting and protection from predators.

In addition to its use for mosquito control and restoration of marsh hydrology, OMWM has recently been used to reduce coliform loading to tidal waters. Given the considerable edge habitat inherent in a ditched marsh, wildlife feeding and resting activitiy is often artificially concentrated along the ditches. When this occurs and fecal material is deposited as a result of wildlife usage, coliform bacteria may be transported to adjacent waters during ebb tides. To prevent this, researchers have installed dams at several ditched marshes in the Peconic Estuary. Dam placement is determined by flow patterns in existing ditches and the results of intensive coliform water sampling within and immediately seaward of the ditches. Damming ditches creates a more natural hydrology whereby water is retained on the surface of the marsh allowing for natural attenuation of contaminants through sedimentation, sunlight (UV) and filtering. In two areas in the Peconic Estuary (Acabonack Harbor and Northwest Creek in East Hampton, NY), short-term improvements in water quality have resulted in changes in the status of shellfishing certification. However, the long term benefits of this work are not clear.

The following sections summarize the guidelines that should be followed when planning an area for OMWM. OMWM should only be considered for tidal marshes that have already been ditched, are severely degraded, or that pose an extreme mosquito nuisance or potential health threat to local residents. Enhancement of grid-ditched wetland using OMWM will greatly reduce the need for additional mosquito control, but may not eliminate it. Monitoring of the marsh for wildlife usage, mosquito numbers and environmental conditions should start before the project begins and continue regularly for several years after the project.

The main components of an OMWM system are mosquito ditches, fish reservoirs, ditch plugs, and existing site hydrology. The following paragraphs will briefly discuss some of the key features of each component, concerns that need to be addressed in planning an OMWM project, and the best methods to construct these features. Proper planning is key to any project, and having plans, permits and crews coordinated can be a complex and time-consuming process. The project planners should involve regulatory agencies early on, before permits are applied for, to minimize delays in obtaining required permits.

Before ditch plug construction begins, existing mosquito grid ditches should be cleared of any debris that may prevent uninhibited fish access into the marsh. A rotary type ditcher is preferred, due to its ability to clean the ditch without changing the topography of the marsh surface. Equipment, including excavators for plug construction and rotary ditchers for ditch maintenance, should be designed to exert a ground pressure of two pounds per square inch (psi) or less.

Killifish are effective predators of mosquito larvae within ditches, but there may be pannes or pools of water on the marsh surface that remain inaccessible. Shallow spur ditches, or connector ditches, for fish passage need to be incorporated into the OMWM plan to give killifish access to known mosquito breeding areas on the marsh surface. These ditches should remain open for several tidal cycles after cleaning to allow flushing of sediments. Sediments, if left in ditches, can cause anoxic conditions that lead to loss of killifish populations.

In addition, fish reservoirs need to be established to provide refuge during periods of extreme low tides or from foraging wading birds. These reservoirs consist of ponds at least three feet deep that taper into shallow wading areas for bird usage. Alternativey, existing mosquito ditches can be cleaned and enlarged to serve as fish reservoirs. When digging fish reservoirs, it is important not to break through the peat mat to the underlying sand layer or the pond will drain down and possibly dry out. If larger ponds are to be constructed as fish reservoirs, small islands can be situated in these areas to increase bird-nesting opportunities.

The ditch plugs in an OMWM system need to be capable of holding water in the mosquito ditches at approximately the height of the marsh surface. During periods of storm or moon tides, when the marsh surface floods, the plugs need to be strong enough to keep water levels in the marsh at the proper height as the tide recedes. To achieve this goal, ditch plugs should be constructed twenty to fifty feet in length on the main ditches leading to the waterbody. Shorter ditch plugs may be necessary when fill availability is limited. If the back pressure on a plug is expected to be substantial, *e.g.*, during a storm or when short plugs are installed, sheeting can be installed on the waterbody-facing side of the ditch plug to increase stability. Final plug height should be at least the level of the marsh surface, and possibly slightly higher during construction to account for settling.

If measured oxygen levels within the plugged ditch are not high enough to support killifish, a shallow spur ditch should be cut through the top of the plug to allow more frequent tidal flooding with oxygenated water. Muskrats may become a problem in an OMWM marsh when they burrow through ditch plugs, causing plug failure. To minimize muskrat damage, a plywood or wire mesh barrier may be erected across the ditch plugs to prevent muskrat burrowing.

Freshwater inputs into a marsh proposed for OMWM need to be evaluated before implementation begins. If excess freshwater is retained on the marsh surface, common reed or cattail may encroach into areas vegetated by tidal wetland plants. Freshwater from upland sources may be drained off the marsh by leaving open several selected mosquito ditches leading directly to the waterbody. If freshwater inputs are excessive, perimeter ditching around the upland tidal border should be considered. The ends of the perimeter ditch should allow runoff to empty into the waterbody, or into an open tidal ditch leading to open water.

The Peconic Bay Estuary has several ditched and/or degraded tidal marshes that may benefit from OMWM implementation. Areas appropriate for OMWM may include: Flanders/Hubbard County Park, Flanders (Southampton Town); Long Beach Bay State Tidal Wetlands, Orient (Southold Town); Conscience Point National Wildlife Refuge, North Sea (Southampton Town); Napeague State Park, Napeague (East Hampton Town); and Indian Island County Park, Riverhead (Riverhead Town). While this is not a complete listing of all areas where OMWM should be considered, it encompasses many of the larger tracts of publicly held marshland within the Peconic Estuary Program study area.

References

Crans, W.J. 1992. A history of malaria in New Jersey. Proceedings of the seventy-ninth annual meeting of the New Jersey Mosquito Control Association, Inc., pp. 115-122.

Reiter, P. 2000. From Shakespeare to Defoe: Malaria in England in the little ice age. Emerg Infect Diseases [serial online] Jan-Feb 2000 [cited 2000 May 4]; 2(1). National Center for Infectious Diseases, Centers for Disease Control and Prevention. Available from: URL: http://www.cdc.gov/ncidod/EID/eid.htm

Richards, A.G. 1938. Mosquitos and mosquito control on Long Island, New York, with particular reference to the salt marsh problem. New York State Museum Bulletin, No. 316, pp. 85-180. The University of the State of New York, Albany, September, 1938.

Taylor, N. 1938. A preliminary report on the salt marsh vegetation of Long Island, New York. New York State Museum Bulletin, No. 316, pp. 21-84. The University of the State of New York, Albany, September, 1938.

Zucker, J.R. 1996. Changing patterns of autochthonous malaria transmission in the United States: a review of recent outbreaks. Emerg Infect Diseases [serial online] Jan-Mar 1996 [cited 2000 May 4]; 2(1). National Center for Infectious Diseases, Centers for Disease Control and Prevention. Available from: URL: http://www.cdc.gov/ncidod/EID/eid.htm

9. SPECIAL TOPICS: COMMON REED (*PHRAGMITES AUSTRALIS)*

Common Reed Habitat

Common reed is typically found in brackish environments associated with *Spartina*, *Carex*, *Typha*, and *Juncus* species. Common reed can occur almost anywhere associated with water. Its more frequent occurrence in brackish areas is not preferential but a result of its competetive edge over freshwater species when waters are slightly saline; similarly, this species will outcompete salt marsh species when waters are slightly fresh. Observed maximum salinity tolerances from 10 to 30 parts per thousand (ppt) have been reported, with 10 to 18 ppt a more commonly observed range. Common reed will also outcompete other vegetation in shallow, stagnant waters with poorly aerated sediments (Marks, Lapin & Randall, 1993).

Reproduction by this species is primarily vegetative. *Phragmites* is a colony forming, or clonal, species, spreading horizontally above and below ground through growth of its rhizomes. New roots and aboveground shoots are produced at nodes of the rhizomes. Stolons, or aboveground rhizomes, produced by *Phragmites australis* are capable of spreading up to 30 feet per year (Tiner, 1998). *Phragmites australis* also flowers and sets seed between July and September, and seeds are dispersed between November and January. Investigations indicate that most seed produced by common reed plants is not viable (Tucker, 1990; Cross and Fleming, 1998; Tiner, 1998). Once seeds are set, nutrients are translocated to rhizomes and the aboveground portions of plants die back for the winter.

Natural History of Common Reed

Common reed is an indigenous species of the northeast United States, evidence of its presence having been found in sediment cores 3000 years old (Niering and Warren, 1977). In the twentieth century many populations of common reed exhibited extremely aggressive growth, forming vast monocultures and replacing more diverse, often rare plant communities. Currently, there remains some uncertainty regarding the natural history of this species and the cause of its sudden expansion. Similarly, there remains high uncertainty regarding when and how to manage common reed in coastal environments.

The aggressive form of *Phragmites australis* is believed to be a genetically different stock native to Europe transported to North America in ship ballast (Besitka, 1996; Casagrande, 1997; R. Rozsa, personal communication). Recent research indicates that the invasive, European form is phenotypically distinct from the native version (Besitka, 1996); current studies are underway at Yale University (Principal Investigator Professor K. Vogt/Research Assistant K. Sullivan) to establish genotypic differences between live, invasive examples of *Phragmites* and historical examples of native *Phragmites* (C. Rilling, personal communication).

Disturbances Favoring Common Reed

Anthropogenic disturbance has increased the quantity of favorable common reed habitat in the United States. Filling and construction activities that alter an area's morphology and soil characteristics, including increases in elevations or decreases in tidal inundation, promote the growth of *Phragmites australis*. Common reed is adept at invading bare, sandy patches caused by excessive sedimentation. The proliferation of paved surfaces also contributes to the creation of bare areas because it promotes flashy passage of water through the environment, destabilizing substrates. Runoff containing deicing salts increases soil salinity, favoring common reed. High concentrations of nutrients, especially nitrates, also appear to favor this species, although European declines of *Phragmites australis* have been partially blamed on eutrophication.

Impacts caused by Common Reed

Common reed shades other indigenous vegetation, and hinders germination and growth by other species through shading and dense accumulation of litter. *Phragmites* monocultures alter detrital cycling patterns because *Phragmites*' woody stalks exhibit a slower rate of decomposition (Graneli, 1989). Slow degradation of *Phragmites* litter raises the elevation of an invaded marsh, decreasing tidal flooding and further enhancing habitat suitability for this species (T. Diers, personal communication). *Phragmites* monocultures are also more susceptible to wildfires when the dead, woody litter from stalks accumulates (Niering & Warren, 1980; Tiner, 1998; Marks, Lapin & Randall, 1993). Accumulation of litter and dense stands of common reed often alter the hydrology of small creeks, streams and ditches. Such alterations may increase siltation of these areas and influence soil salinities in the area (Tiner, 1998).

Mammalian and avian diversity are low in *Phragmites* stands. This is partly caused because this species provides inferior nesting habitat for many marsh birds (Howe *et al.*, 1978), including seaside sparrow, sharp-tailed sparrow, and willet. Such birds are marsh specialists adapted to nesting in short grasses like *Spartina patens* and *Distichlis spicata* (Benoit, 1997; Benoit & Askins, 1999). Common reed stands are often a physical barrier for large birds, including waterfowl, shorebirds, and egrets, that would otherwise feed in shallow pools found on marsh surfaces (Rozsa, unpublished).

Phragmites australis monocultures can also provide breeding habitat for large broods of mosquitos. Mosquito control techniques, such as aerial spraying, are often ineffective in dense stands of common reed. The density of these stands prevents the herbicide spray from reaching mosquito breeding pools (Tiner, 1998; Marks, Lapin & Randall, 1993). Also, manual spraying for mosquito control can be more difficult in thick stands of common reed.

Phragmites may also detract from an area's scenic quality. The culms of this species can reach 14 feet in height (Tiner, 1987; Eastman, 1995), shielding panoramas from view. Common reed invasion has caused this type of problem in Boston's Back Bay Fens, designed by Frederick Law Olmstead (Tiner, 1998; Marks, Lapin & Randall, 1993).

Values of Common Reed

In some cases, *Phragmites* control is not necessary. Since this species is indigenous to marsh habitats, eradication is not always warranted. Stable stands, *i.e.*, those that are neither increasing in size nor invading adjacent habitat, may often be considered a natural and appropriate part of the plant community.

A variety of recent research on the effects of *Phragmites australis* on habitat value indicate that this species may be more valuable to the estuarine ecosystem than previously thought. *Phragmites* has a high capacity for nutrient assimilation. Concentrations of ammonium in substrate porewaters are lower in areas where *Phragmites* is the dominant species than in areas dominated by other indigenous marsh vegetation (Chambers, 1997; Findlay *et al*., 1997; Windam, 1997). Rates of denitrification have also been found to be lower in plots where *Phragmites* has been removed than prior to removal or in plots of other wetland species (Findlay *et al*., 1997). The presence of this species, as with other species of wetland vegetation, also assists in preventing erosion and sedimentation.

While some declining bird species are negatively affected by *Phragmites* invasion, stands of this species are not entirely devoid of habitat value (Holt & Buschbaum, 1999; Tiner, 1998). For example, marsh wren and swamp sparrow are marsh specialists that prefer tall, reedy vegetation (Benoit, 1997). For certain bird species the presence of *Phragmites* has been observed to make little difference in use of an area. Observations also indicate that stands of common reed provide a good screen for waterfowl.

In a comparison of a *Phragmites*-dominated marsh and a restored *Spartina* marsh in the Connecticut River, equivalent fish numbers and biomass were found in the two marshes. Fish were larger and species diversity higher in the *Phragmites australis* marsh (Rilling *et al*., 1998d; Rilling, 1998c). A comparison of nekton use in both types of marsh in the Chesapeake Bay also demonstrate comparable degrees of species diversity, total abundance, biomass, and productivity (Meyer *et al*., 2000). Fell *et al.* (1998) show that mummichogs have comparable feeding strategies and receive comparable nutritional quality in *Phragmites australis* marsh and *Spartina* marsh. *Phragmites australis*, shown through stable isotope analysis, contributes to the food webs leading to mummichogs (Wainright *et al*., 2000), bay anchovy, and white perch (Weinstein *et al*., 2000).

Invertebrate populations also appear not to differ in their use of *Phragmites* stands *versus* *Phragmites*-free areas. Studies using the common estuarine species fiddler crab (*Uca pugnax*), grass shrimp (*Palaemonetes pugio*), and larval mummichog found no preference by these species for *Phragmites* or *Spartina* stems, preferring only stems of any kind over bare substrates (Weis *et al*., 1999). Fell *et al*. (1998) found that invertebrates were abundant in *Phragmites australis* marshes.

Assessment of Common Reed

Stands of common reed should be assessed for stability before control methods are planned and implemented. In addition, the historical extent of *Phragmites* in an area, regardless of current stand stability, should be assessed and should influence the decision making process. The expansion of a stand of this species may have ceased, but the stand may still warrant control to restore historical plant communities and ecological functions that occurred in the area. Decisions on control must occur on a site specific basis giving consideration to these factors and to area characteristics and adjacent land uses. In some cases where *Phragmites* control is warranted it will not be feasible to implement such plans because of these factors. Also, proposed control methods often will be associated with substantial impacts to other plant and animal species in the area, and therefore may not be worth implementing.

If available, historical aerial photography may be used to determine trends in *Phragmites* coverage at a given location (Marks, Lapin & Randall, 1993). Land-based photographs and anecdotal reports may also assist in establishing historical presence. To assess stability, the following parameters should be monitored over several growing seasons: percent aerial cover by *Phragmites*; stem density; culm height, especially at periphery of stand; and trends in species diversity among other plants in the community. In a single growing season, stability may be roughly assessed by monitoring growth beyond a set of markers delineating the front edge of a stand at the beginning of the season. A disputed indicator of expanding stands is the presence of long rhizomes spreading over new areas of the marsh surface; further information on this indicator is needed.

Considerable care should be exercised in selecting a control method for *Phragmites australis* populations. Unfortunately, it is not appropriate to advocate a single method in all cases. Site specifics and project goals must be examined to determine which method or methods will be most effective and least disruptive. For example, the time windows for sensitive species in the area and control method implementation should not coincide. Adjacent land uses at a site may preclude certain control strategies, like prescribed burning or flooding. Also, the size of the *Phragmites australis* stand may also influence selection of control methods, *e.g.*, cutting or mowing may not be feasible for extremely large sites. Particular attention should also be paid to the likelihood of a return of the *Phragmites* after the control project is terminated, *e.g.*, in freshwater or brackish systems and in disturbed areas without mitigation. These and other factors must be carefully examined prior to project planning once it has been determined that a *Phragmites* stand warrants control. Details and planning considerations associated with commonly used *Phragmites australis* control methods are presented in this section.

Control Methods for Common Reed

Where control is warranted in estuarine environments, the most basic method involves reintroducing regular tidal flooding (Rozsa, 1995). *Phragmites* seeds cannot sprout in salinities >10 parts per thousand (ppt) and most *Phragmites* plants cannot tolerate salinities >18 ppt. It is important to take flood considerations into account when planning for removal of tidal restrictions; self-regulating tide gates and other technologies, often expensive, may be required to balance ecosystem restoration with adjacent land use. Other methods for increasing tidal flow to a formerly flooded area involve simple measures such as removing blockages in culverts. After tidal inundation has been reintroduced, it may take many years to completely eliminate *Phragmites*, but stand height can be reduced by one to three feet per year. Salt marsh vegetation often will naturally recolonize the site.

At some sites, such as areas near freshwater seeps, removal of tidal restrictions alone will not be effective. In these situations, an effective common reed control technique involves creation of 24" wide by 36" deep perimeter ditches dug at the upland edge of unrestricted tidal marshes. These perimeter ditches are then connected to grid ditches subject to tidal flooding. This drains fresh water and increases salt water flow into the back marsh, raising soil salinity (T. Diers, personal communication). In brackish marshes where saving rare vegetation is a priority, other control techniques are required.

Common reed is found in freshwater as well as estuarine areas. Therefore, several additional techniques for the removal of *Phragmites australis* are available for control of this species for use in areas where reintroduction of tidal flow is not possible. Regardless of the technique selected, effective control of *Phragmites australis* requires knowledge of the plant's life cycle and its local growing season in order to most appropriately select and schedule control treatments (Cross & Fleming, 1989). Also, the likelihood for return of *Phragmites* after control strategies have been implemented, due to site characteristics or ongoing disturbances, should be carefully considered during the planning phase. Disturbances contributing to the presence of common reed should be identified and minimized prior to the implementation of any control strategy in order to maximize the likelihood for success.

Cutting and mowing are techniques frequently employed to control common reed. Conflicting reports are given for the best season to conduct mowing and cutting. Some researchers report that mowing may be conducted in either the winter or spring. Winter mowing has produced stunted growth in the following year, possibly as a result of interference with oxygen uptake mechanisms. Spring mowing immediately following the first appearance of shoots (around April) has resulted in stunted and low density of new shoots (OLISP, 1998). However, some reports cite increased growth of *Phragmites australis* following winter and spring mowing (Cross & Fleming, 1989; Tiner, 1998). Summer mowing or cutting may be the most consistently effective strategy. Cutting *Phragmites* plants after tasseling, *i.e.*, late July, may produce the most stress. This method should be conducted for several consecutive years for maximum effect.

All cut materials must be removed from the restoration site to prevent establishment of new *Phragmites* plants from cut pieces of rhizome. Some practitioners indicate that cuttings may be mulched or disked on site (Capotosto, 1997; Tiner, 1998; Cross & Fleming, 1989), although this practice is not reccommended by others. Mulching or disking may not prevent plant regeneration from rhizome fragments, and can cause a significant increase in project costs. Low ground pressure equipment should be used when manual cutting or mowing is not feasible.

Research from Connecticut College has shown that mowing used in combination with herbicide application or flow restoration may elicit better results (C. Rilling, personal communication). Mowing or cutting and removal of litter subsequent to herbicide application removes combustible plant debris, minimizing a fire hazard and allowing reestablishment of other vegetation. Mowed or cut stands of *Phragmites* may be flooded for a prolonged period (~ 4 months), generally during the growing season. This latter strategy requires spring mowing, and such prolonged flooding may not be feasible in many areas. Mowing or cutting may also be followed by the use of a temporary clear or black plastic cover (Marks, Lapin & Randall, 1993; Tiner, 1998). It is thought that high temperatures under the plastic are the primary cause of *Phragmites* mortality resulting from this strategy. More information on long-term effectiveness of plastic covers used on mowed or cut *Phragmites* is needed.

Controlled burning may be employed in cases where a supply of dry, combustible litter is accumulated (OLISP, 1998). This strategy, therefore, may only be employed periodically (in alternate years at its most frequent). Controlled burning in *Phragmites* stands can be dangerous because there is a potential for remote spot burns to break out in the area (Tiner, 1998).

Conflicting reports are also given regarding the optimal season to conduct controlled burns. The Office of Long Island Sound Programs (1998) recommends burning simultaneous with new shoot emergence in the spring (around April). However, others have reported enhanced *Phragmites* growth from spring and winter burns (Thompson & Shay, 1985; Thompson & Shay, 1989; Cross & Fleming, 1989; Tiner, 1998; Marks, Lapin & Randall, 1993). It is hypothesized that enhanced growth after burns during these seasons is caused by elimination of shade, exposure of burned soil, nutrient enhancement from ash deposits, and generation of viable plant fragments (Weinstein, 1996). Mid to late-summer (late in the growing season) burning may be the most consistently effective alternative. For burning to be most effective in reducing common reed growth, root burn should occur; burns penetrate the roots most easily during this period (Cross & Fleming, 1989). *Phragmites* may also be vulnerable to late summer (July/August) burns because translocation of nutrients to roots may have begun (Tiner, 1998). Burn timing must be planned with potential effects on wildlife, *e.g.*, nesting birds, in mind.

Controlled burning may be used most effectively in combination with other control strategies. Burning subsequent to herbicide application removes dead stems and litter, assisting revegetation by other plant species (Marks, Lapin & Randall, 1993). Burns may also be followed by prolonged manual flooding of the area (~ 4 months), generally during the growing season. Prolonged flooding of this nature would follow emergence (spring) burns, and may not be feasible in many areas.

Chemical control of *Phragmites* can be effective. When chemical control is used in combination with other control strategies, the likelihood for success increases. The most frequently used herbicide targeting common reed exhibits extremely low toxicity to aquatic organisms and humans, and does not persist in the environment. Chemical control should nevertheless be carefully considered before being selected as a control strategy. The New York State Department of Environmental Conservation is authorized to approve or disapprove the use of pesticides and herbicides in aquatic environments (see 6 NYCRR Chapter IV, Subchapter A-Pesticide Control, Part 327). Certification is also required for pesticide and herbicide application. In addition, the Peconic Estuary Program Comprehensive Conservation and Management Plan recommends that loadings of pesticides and herbicides within the estuary be reduced (Chapter Six, Toxics Management Plan).

Herbicides that have been used to control common reed include amitrole, dalapon, and glyphosate (Cross & Fleming, 1989). All three of these chemicals listed above are absorbed through plant leaves and are translocated to rhizomes (CCE, 1998a,b,c). Amitrole (Rhone Poulenc Agricultural Company, Research Triangle Park, NC; CCE, 1998b) is effective on both flooded or dry sites; Amitrole is, however, a Restricted Use Pesticide (RUP), and may be purchased and used only by certified applicators. Amitrole is considered a probable human carcinogen (CCE, 1998b). Dalapon (BASF Corporation, Agricultural Product Group, Research Triangle Park, NC; CCE, 1998c) and glyphosate, both general use pesticides, are not as effective on flooded sites but do work on moist or dry sites. Rates of application for Amitrole range from 2-12 lb. per acre, generally occurring during the summer. Dalapon has been used at rates ranging from 15-30 lb. per acre, applied throughout the growing season (Cross & Fleming, 1989). The third herbicide, glyphosate, will be further discussed below under one of its trade names, Rodeo (Monsanto Agricultural Company, St. Louis, MO; CCE, 1998a).

The herbicide Rodeo is the most common herbicide employed for *Phragmites* control, and can be effective in controlling monocultures of this plant. Rodeo is a moderately toxic herbicide containing glyphosate, the same active ingredient as Roundup, the common lawn and garden herbicide. The glyphosate in Rodeo is not, however, pre-mixed with a surfactant. As described above, this nonselective herbicide is absorbed through plant leaves and translocated to plant roots, where it disrupts an enzyme essential to protein production. Cell disruption, decreased growth, and death of the plant root and rhizome eventually follow (Rilling, 1998a).

Rodeo should be applied to actively growing plants following pollination and tasseling (between July and September; Magee, 1981; Marks, Lapin & Randall, 1993). All plants do not tassel simultaneously, and several treatments during the flowering period may be necessary (OLISP, 1998; Rilling, 1998a). Rodeo is generally applied at a rate of 4-6 pints per acre (Cross & Fleming, 1989; Rilling, 1998a). Cross & Fleming (1989) report that some researchers found an increased effectiveness when Rodeo applications were split, *i.e.*, administering two doses at ½ the dosage rather than a single full dosage. The second application should occur 15-30 days after the first (Cross & Fleming, 1989).

Rodeo should be applied during warm, sunny weather with no rain forecast for a minimum of 12 hours. Low wind conditions are also necessary to prevent spray drift onto non-target vegetation (OLISP, 1998; Rilling, 1998a). Late summer (around August) is a good target period for satisfying many of the above conditions. Rodeo has been applied using techniques ranging from manual spray equipment transported by backpack, to aerial application from a helicopter. Size of stand, accessibility, and proximity to rare plant species or other priority vegetation must be considered when planning herbicide application (Cross & Fleming, 1989). Wilting and yellowing generally begins within a week following application, and browning and deterioration of roots should be complete within 6-8 weeks (Rilling, 1998a). Removal of plants after shoots turn brown will assist recolonization by other plant species.

Rodeo is highly adsorbent on substrates with high organic content, where it becomes inert, and non-volatile. Rodeo is degraded into natural products, *e.g.*, carbon dioxide, nitrogen gas, phosphate, and water, by soil microorganisms between 1 and 174 days (CCE, 1998a; Weinstein, 1996; Rilling, 1998a). Because glyphosate is strongly adsorbed to suspended organic materials, it has a half life of 12 days to 10 weeks in natural waters (CCE, 1998a; Rilling, 1998a). For this reason it is recommended that Rodeo be mixed with distilled water prior to application to minimize adsorbance onto particulate organic materials in tap or other water, decreasing the effectiveness of application.

Rodeo has been approved by the U.S. EPA for use in aquatic systems (Cross & Fleming, 1989). The protein production enzyme disrupted by glyphosate is found only in plants (Rilling, 1998a). Rodeo is therefore considered of low toxicity for humans, birds, mammals, fishes, and aquatic invertebrates (Rilling, 1998a; CCE, 1998a). There is low potential for accumulation of glyphosate in the environment or in animal tissues. No reproductive, teratogenic, mutagenic, carcinogenic, or organ toxicity effects have been found in field and laboratory evidence. Acute toxic effects are limited to eye irritation. Oral LD50 values for glyphosate range from 1,500 mg/kg to over 10,000 mg/kg for mice, rabbits and goats (CCE, 1998a).

Rodeo must be mixed with a surfactant prior to application. The surfactant acts as a wetting agent, changing surface bonding properties and allowing glyphosate to be absorbed. Without a surfactant, the herbicide "balls up" on the leaf surface (CCE, 1998a; C. Rilling, personal communication). Some surfactants used with glyphosate (*e.g.*, Induce or Chemsurf 90) may have toxic effects for humans and the environment. For example, the surfactant additive found in Roundup is a modified tallow amine toxic to fish (CCE, 1998a). Roundup should therefore not be used for the control of *Phragmites australis* in aquatic environments. Limited test data appears to indicate that other surfactants are relatively non-toxic, *e.g.*, X-77, LI-700, and Kinetic (Weinstein, 1996). Selection of an appropriate surfactant for Rodeo should be carefully researched; see Weinstein (1996) for additional information on surfactants.

A biological control program for *Phragmites australis* is currently under development. Initial research has focused on insects accidentally introduced into North America. The most promising species discovered to date is the rhizome-feeding moth *Rhizedra lutosa*. This species is one of approximately 15 insect herbivore species that are specific to *Phragmites australis* that were accidentally introduced and are now widespread in North America. Potential European species are also undergoing research. Several promising biological control agents have been identified in Europe, including rhizome and stem mining moths and a stem fly. Additional resources are required for research into these species, especially host specificity (McCauley, 1999; Blossey, 1999).

References

Allen, E.A., P.E. Fell, M.A. Peck, J.A. Gieg, K.R. Guthke & M.D. Newkirk. 1994. Gut contents of common mummichogs, *Fundulus heteroclitus* L. in a restored impounded marsh and natural reference marshes. Estuaries 17: 462-471.

Besitka, M.A.R. 1996. An ecological and historical study of *Phragmites australis* along the Atlantic coast. Master of Science Thesis, Department of Bioscience and Biotechnology, Drexel University, Philadelphia, PA.

Benoit, L. 1997. Impacts of *Phragmites* on tidal marsh birds. Abstract, *Phragmites* workshop, Institute of Ecosystem Studies, Millbrook, NY. April 29, 1997.

Benoit, L.K. & R.A. Askins. 1999. Impact of the spread of *Phragmites* on the distribution of birds in Connecticut tidal marshes. *In*: Yale School of Forestry and Environmental Studies, Greater New England symposium on the ecology of invasive species: Presentations, posters, and discussion of current scientific research on invasive animals and plants of the New England region, February 27, 1999.

Blossey, B. 1999. Program development and cost estimate. Based on: Developing biological control of *Phragmites australis*: a workshop. Co-sponsored by U.S. Fish and Wildlife Service North American Waterfowl Management Plan, Hadley, MA and Biological

Control of Non-Indigenous Plant Species Program, Cornell University, Ithaca, NY. Workshop held in Amherst, MA, May 6-7, 1999. Overview dated May 17, 1999.

Boone, J., E. Furbish, and K. Turner. 1987. Control of *Phragmites communis*: Results of burning, cutting, and covering with plastic in a North Carolina marsh. National Park Service, U.S. Department of the Interior. CPSU Technical Report No. 41.

Capotosto, P. 1997. *Phragmites* control by herbiciding and mulching on the lower Connecticut River. Abstract, *Phragmites* workshop, Institute of Ecosystem Studies, Millbrook, NY. April 29, 1997.

Casagrande, R.A. 1997. Potential of European insects to control North American *Phragmites*. Abstract, *Phragmites* workshop, Institute of Ecosystem Studies, Millbrook, NY. April 29, 1997.

Chambers, R. 1997. Sediment effects on *Phragmites* spread. Abstract, *Phragmites* workshop, Institute of Ecosystem Studies, Millbrook, NY. April 29, 1997.

Cornell Cooperative Extension (CCE). 1998a. Glyphosate. Extoxnet (Extension Toxicology Network) Pesticide Information Profile. http://pmep.cce.cornell.edu/profiles/extoxnet/. Cornell Cooperative Extension Offices of Cornell University, Ithaca, NY. September 30, 1998.

Cornell Cooperative Extension (CCE). 1998b. Amitrole. Extoxnet (Extension Toxicology Network) Pesticide Information Profile. http://pmep.cce.cornell.edu/profiles/extoxnet/. Cornell Cooperative Extension Offices of Cornell University, Ithaca, NY. September 30, 1998.

Cornell Cooperative Extension (CCE). 1998c. Dalapon. Extoxnet (Extension Toxicology Network) Pesticide Information Profile. http://pmep.cce.cornell.edu/profiles/extoxnet/. Cornell Cooperative Extension Offices of Cornell University, Ithaca, NY. September 30, 1998.

Cross, D.H. & K.L. Fleming. 1989. Control of *Phragmites* or common reed. U.S. Fish and Wildlife Service, Waterfowl Management Handbook, Fish and Wildlife Leaflet 13.4.12.

Eastman, J. 1995. The Book of Swamp and Bog: Trees, Shrubs, and Wildflowers of Eastern Freshwater Wetlands. Stackpole Books, Mechanicsburg, PA. 237 pp.

Fell, P.E., S. Weissbach, D. Jones, M. Fallon, J. Zeppieri, E. Faison, K. Lennon, K. Newberry & L. Reddington. 1998. Does invasion of oligohaline tidal marshes by reed grass, *Phragmites australis* (Cav.) Trin ex Steud., affect the availability of prey resources for the mummichog, *Fundulus heteroclitus* L.? Journal of Experimental Marine Biology and Ecology 222: 59-77.

Findlay, S., P. Groffman, C. Wigand, & P. Templer. 1997. *Phragmites* effects on nitrogen cycling. Abstract, *Phragmites* workshop, Institute of Ecosystem Studies, Millbrook, NY. April 29, 1997.

Graneli, W. 1989. Influence of standing litter on shoot production in reed, *Phragmites australis* (Cav.) Trin. Ex. Steudel. Aquatic Botany 35: 99-109.

Hellings, S.E. & J.L. Gallagher. 1992. The effects of salinity and flooding on *Phragmites australis*. J. Applied Ecol. 29: 41-49.

Holt, E.R. & R. Buschbaum. 1999. Bird use of *Phragmites australis* in coastal marshes of northern Massachusetts. *In*: Yale School of Forestry and Environmental Studies, Greater New England symposium on the ecology of invasive species: Presentations, posters, and discussion of current scientific research on invasive animals and plants of the New England region, February 27, 1999.

Howe, M.A., R.B. Clapp & J.S. Weske. 1978. Marine and coastal birds. Marine EcoSystems Analysis (MESA) Program, MESA New York Bight Atlas Monograph 31, New York Sea Grant Institute, Albany, NY. 87 pp.

Levin, L.A, D. Talley & G. Thayer. 1996. Succesion of macrobenthos in a created salt marsh. Mar. Ecol. Prog. Ser. 141: 67-82.

Magee, D.W. 1981. Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast. The University of Massachusetts Press, Amherst, MA. 245 pp.

Marks, M., B. Lapin, and J. Randall. 1994. *Phragmites australis* (*P. communis*). Threats, management, and monitoring. Natural Areas Journal 14: 285-294.

McCauley, J.F. 1999. Executive Summary. Developing biological control of *Phragmites australis*: a workshop. Co-sponsored by U.S. Fish and Wildlife Service North American Waterfowl Management Plan, Hadley, MA and Biological Control of Non-Indigenous Plant Species Program, Cornell University, Ithaca, NY. Amherst, MA, May 6-7, 1999.

Meyer, D.G., J.M. Johnson & J.W. Gill. 2000. A comparison of nekton use of *Phragmites australis* and *Spartina alterniflora* marshes in Chesapeake Bay, USA. Mar. Ecol. Prog. Ser. In press.

Niering, W.A. & R.S. Warren. 1977. Our dynamic tidal marshes: vegetation changes as revealed by peat analysis. Connecticut Arboreum Bulletin 12. 22 pp.

Niering, W.A. & R.S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. BioScience 30: 301-307.

Office of Long Island Sound Programs (OLISP). 1998. Tidal Wetlands. Draft characterization document for the Long Island Sound Study Habitat Restoration Plan. Connecticut Department of Environmental Protection, Hartford, CT.

Rilling, C. 1998a. Tidal wetland restoration--Use of the herbicide Rodeo to control common reed. Technical report of the Connecticut Department of Environmental Protection, Office of Long Island Sound Programs, April 17, 1998.

Rilling, C. 1998b. Tidal wetland restoration--Use of a surfactant with herbicide Rodeo to control common reed. Technical report of the Connecticut Department of Environmental Protection, Office of Long Island Sound Programs, June 15, 1998.

Rilling, G.C. 1998c. Use of tidal brackish wetlands by fishes in the lower Connecticut River: a comparison of *Phragmites australis*-dominated *vs. Phragmites*-free marshes. Poster presentation at: Concepts and Controversies in Tidal Marsh Ecology, April 5-9, 1998, Cumberland County College, Vineland, NJ.

Rilling, G.C., P.E. Fell & R.S. Warren. 1998d. Fish use of brackish high marsh areas in the lower Connecticut River: A comparison of a *Phragmites australis*-dominated vs. A restored marsh. Final Report to Connecticut Department of Environmental Protection, Long Island Sound Program. 40 pp.

Rozsa, R. 1995. Tidal Marshes of Long Island Sound: Ecology, History, and Restoration. Dreyer, G.D. & W.A. Niering, eds. Bulletin No. 34 of the Connecticut College Arboretum. December, 1995.

Rozsa, R. Unpublished. Common reed (*Phragmites australis*)--Invasive species profile. Office of Long Island Sound Programs, Connecticut Department of Environmental Protection. Unpublished.

Thompson, D.J. & J.M. Shay. 1989. First-year response of a *Phragmites* marsh community to seasonal burning. Can. J. Bot. 67: 1448-1455.

Thompson, D.J. & J.M. Shay. 1985. The effects of fire on *Phragmites australis* in the Delta Marsh, Manitoba. Can. J. Bot. 63: 1964-1969.

Tiner, R.W., Jr. 1987. A Field Guide to Coastal Wetland Plants of the Northeastern United States. The University of Massachusetts Press, Amherst, MA.

Tiner, R. 1998. Managing common reed (*Phragmites australis*) in Massachusetts: An introduction to the species and control techniques. Prepared by the U.S. Fish and Wildlife Services for Massachusetts Wetlands Restoration and Banking Program, Executive Office of Environmental Affairs, Boston, MA, December 1998.

Van der Toorn, J. & J.H. Mook. 1982. The influence of environmental factors and management of stands of *Phragmites australis*. I. Effects of burning, frost, and insect damage on shoot density and shoot size. J. Applied Ecol. 19: 477-499.

Wainwright, S.C., M.P. Weinstein, K.W. Able & C.A. Currin. 2000. Relative importance of benthic microalgae, phytoplankton, and the detritus of smooth cordgrass (*Spartina* *alterniflora*) and the common reed (*Phragmites australis*) to brackish marsh food webs. Mar. Ecol. Prog. Ser. 200: 77-91.

Weinstein, M.P. 1996. Restoration of degraded salt marshes: The use of Rodeo for initial *Phragmites* control. Prepared for the Public Service Electric and Gas Company Estuary Enhancement Program, New Jersey, July 10, 1996.

Weinstein, M.P., S.Y. Litvin, K.L. Bosley, C.M. Fuller & S.C. Wainwright. 2000. The role of tidal salt marsh as an energy source for marine transient and resident finfishes: a stable isotope approach. Trans. Amer. Fish. Soc. 129: 797-810.

Weis, J.S., J.Tan, C. Cherilus, L. Dounacvskaia, & C. Peterman. 1999. *Phragmites* or *Spartina* as habitat: do the estuarine species care? *In*: Yale School of Forestry and Environmental Studies, Greater New England symposium on the ecology of invasive species: Presentations, posters, and discussion of current scientific research on invasive animals and plants of the New England region, February 27, 1999.

Weisner, S.E.B. & W. Graneli. 1989. Influence of substrate conditions on the growth of *Phragmites australis* after a reduction in oxygen transport to below-ground parts. Aquatic Botany 35: 71-80.

Windam, L. 1997. Effects of *Phragmites australis* invasion on dissolved nitrogen retention in brackish tidal marshes. Abstract, *Phragmites* workshop, Institute of Ecosystem Studies, Millbrook, NY. April 29, 1997.

10. SPECIAL TOPICS: ALTERNATIVES TO SHORELINE HARDENING

There are several types of hardened shoreline used in the coastal zone mainly for erosion control and land stabilization, including bulkheads, seawalls, revetments, riprap, and gabions. Bulkheads and seawalls are vertical structures or partitions, built parallel to the shoreline, to prevent sliding of the land behind the structure and to provide an obvious demarcation between land and water (Pile Buck, 1992; Mulvihill *et al*., 1980). Revetments are sloped facings placed parallel to the shoreline that protect land against erosion by wave action, currents, or weather. Riprap refers to the placement of large stones as a facing on shore protection structures such as revetments, used to dissipate wave energy. Gabions are another type of energy dissipation facing consisting of mesh enclosures filled with earth or stones (Mulvihill *et al*., 1980).

In the Peconic estuary, shoreline hardening has incrementally impacted natural resources by preventing establishment of native species and altering littoral drift. The PEP is currently documenting all hard shoreline structures in the region. This information is critical in accurately assessing the cumulative effects of shoreline hardening on the natural resources of the estuary.

Hardened shorelines alter the hydrological dynamics of the area, including wave energy and patterns of flow (Pilkey, 1988; MacDonald *et al*., 1994; Byrne, 1995). Often, scouring occurs at the toe of these structures, and may eventually lead to failure of the structure. Bulkheads cause the greatest degree of scouring due to reflection of wave energy seaward from the bulkhead face. During storms, additional inland damage may be expected because of this failure to dissipate wave energy. Bulkheads also decrease the transfer of detritus between the terrestrial and aquatic environments, and can lead to lower productivity, diversity, and number of organisms. Water column conditions adjacent to bulkheads are also unfavorable for settling and survival of larvae, *e.g.*, clams and oysters. The vertical nature of bulkheads greatly reduces intertidal habitat. The cumulative loss of intertidal wetlands from bulkheading is linked to changes in estuarine fisheries and waterfowl populations (Mulvihill *et al*., 1980).

Revetments, due to their sloping nature, do not generally eradicate intertidal habitat, but do change the characteristics of this habitat zone, *e.g.*, the change in substrate type will favor some species over others. Revetment slopes also tend to dissipate wave energy rather than reflect it, reducing erosion. Riprap and other irregularly-faced revetments may provide habitat for a diverse array of organisms, although initial construction results in direct loss of intertidal habitats and resident species, and the numbers and kinds of species will change (Mulvihill *et al*., 1980). While both revetments and bulkhead protect land behind the structure, neither can provide any protection to the seaward area. As a result, these areas continue to erode back until they reach the hard structure. Where shoreline hardening structures are located landward of marshes, sea level rise will eventually eradicate marsh habitat, as these areas will be unable to migrate landward of the bulkhead (Titus *et al*., 1991; Titus, 1991; Rozsa, 1995; Teal, 1986).

An additional impact derived from hardened shoreline is associated with wood preservatives used on many of these structures. Chromated copper arsenate (CCA), creosote, and pentachlorophenol are all used to preserve wood in the marine environment (Pile Buck, 1990). CCA is currently the principal chemical compound used for wood preservation. This compound has been shown to cause toxic effects in benthic invertebrates (Weis *et al.*, 1996; Brooks, 1996). Recycled plastics may be a legitimate replacement for pressure-treated wood and other materials used to construct hard shorelines. Nosker, Greenburg, and Weis (1992) observe higher productivity and overall species health near recycled plastic structures as compared to CCA-treated lumber structures, similar to the untreated control lumber structure.

Today, there are a number of softer technologies that can provide alternatives to the traditional hard structures described previously. These include biodegradable, non-biodegradable, and other materials and techniques. Among these are the use of coconut fiber or jute matting in conjunction with plantings, use of removable gabions, low sill bulkheading, and innovative, hybrid structures incorporating vegetation into revetment or bulkhead-type matrices.
Coconut fiber mats are one type of biodegradable technology that may be employed as an alternative to hard structures. These materials are selected for their high tensile strength and water retention properties in addition to degradability. Coconut fiber mats may be used in conjunction with vegetation, which can be planted both within the weave and in areas behind the mat. These mats may be preplanted in a nursery setting for later deployment at a restoration site. Coconut fibers will biodegrade in the marine intertidal environment over 2-3 years, allowing sufficient time for the development of full root systems and aboveground cover in planted areas. However, these mats are most appropriate for use in lower energy environments. Jute matting is a similar to coconut fiber matting in its uses and properties. Jute mats are generally coarse grained with holes to facilitate plantings, and are biodegradable. In general, jute matting degrades at a slightly more rapid rate than coconut fiber matting.

Use of biodegradable matting may require more space than is available for shore protection. This technology is meant to mimic a natural shoreline and, therefore, generally consists of a gentle slope over a wide area. Shoreline proposed for bulkheading generally will not be associated with a wide area available for installation of protective technologies. In such cases, strategies that mimic the verticality of bulkheads may be required. At a minimum, the use of low sill bulkheads should occur. Also, technologies currently exist that employ vegetation in a bulkhead-like structure, mimicking a standard bulkhead or seawall.

Because intertidal vegetation offers natural wave protection through dissipation of energy and storage of flood waters, plantings can be used as part of alternative strategies for shore protection. Root systems help bind soil and the aboveground portion of the plant protects soil from wind and rain induced erosion, and dissipates wave energy. Intertidal species, such as *Spartina alterniflora*, are adapted to the dynamic tidal environment and therefore are appropriate for use along the shore.

A number of factors interact to determine site suitability for vegetated shore protection strategies. Chief among these factors is the severity of the wave climate, which depends on fetch, shore configuration, wind patterns, boat traffic, offshore depth, and tidal currents. The wave energy will determine which alternate protection strategies are appropriate at a given site (USACE, 1981). Some types of soft technologies will not succeed in high energy environments. Other factors influencing success of vegetation-based strategies include soil type, salinity, oxygen content, exposure to direct sunlight, shore width, and sediment supply (Knutson & Woodhouse, 1983).

Hybrid structures consisting of a lumber or recycled plastic matrix which incorporates vegetation have been used in the estuarine environment to replace standard bulkheading. This type of technology has only been proven in a highly specific setting, *e.g.*, in marina areas located in sheltered embayments, and will require additional testing under alternative conditions before widespread use can occur. Conducting such pilot projects, as well as research into other hybrid structures and soft shoreline protection strategies, is critical. Where shorelines are proposed for hardening and favorable environmental conditions exist (a low energy environment), however, existing hybrid technologies should be considered a viable alternative.

References

Brooks, K.M. 1996. Evaluating the environmental risks of the use of CCA in the aquatic environment. Estuaries. 19(2):296-305.

Byrne, D.M. 1995. The effects of bulkheads on fish distibution and abundance: A comparison of littoral fish and invertebrate assemblages at bulkheaded and non-bulkheaded shorelines in a Barnegat Bay lagoon. Nacote Creek Research Station, New Jersey Division of Fish, Game and Wildlife, Port Republic, New Jersey.

Knutson, P.L. & W.W. Woodhouse, Jr. 1983. Shore stabilization with salt marsh vegetation. Coastal Engineering Research Center, United States Army Corps of Engineers, Fort Belvoir, VA. Special Report No. 9, January 1983.

Macdonald, K., Simpson, D., Paulson, B., Cox, J., and J. Gendron. 1994. Shoreline armoring effects on physical coastal processes in Puget Sound, Washington. Coastal Erosion Management Studies, Volume 5. Shorelands and Water Resources Program, Washington Department of Ecology, Olympia, Washington.

Mulvihill, E.L., C.A. Francisco, J.B. Glad, K.B. Kaster, R.E. Wilson, O. Beeman & L. R. Shanks. 1980. Biological impacts of minor shoreline structures ont he coastal environment: state of the art review. Volume I. Prepared by Beak Consultants, Inc., Portland, OR for the National Coastal Ecosystems Team, Office of Biological Services, United States Fish and Wildlife Service, USDOI, Washington, DC. Report FWS/OBS-77/51, March 1980.

Pile Buck, Inc. 1990. Bulkheads, marinas and small boat facilities. Pile Buck, Inc., Jupiter, FL.

Pile Buck, Inc. 1992. Breakwaters, jetties, bulkheads and seawalls. Pile Buck, Inc., Jupiter, FL.

Pilkey, O.H., and H.L. Wright. 1988. Seawall versus beaches. Journal of Coastal Research, Special Issue 4:41-64.

Rozsa, R. 1995. The future--some emerging tidal wetland issues. *In*: Tidal Marshes of Long Island Sound: Ecology, History, and Restoration. Dreyer, G.D. & W.A. Niering, eds. Bulletin No. 34 of the Connecticut College Arboretum. December, 1995.

Teal, J. & M. Teal. 1969. Life and Death of the Salt Marsh. Ballantine Books, New York, NY.

Titus, J.G. 1991. Greenhouse effect and coastal wetland policy: How Americans could abandon an area the size of Massachusetts at minimum cost. Environmental Management 15: 39-58.

Titus, J.G., R.A. Park, S.P. Leatherman, J.R. Weggel, M.S. Greene, P.W. Mausel, S. Brown, C. Gaunt, M. Trehan, & G. Yohe. 1991. Greenhouse effect and sea level rise: The cost of holding back the sea. Coastal Management 19: 171-210.

United States Army Corps of Engineers (USACE). 1981. Low-cost shore protection. Final report of the Shoreline Erosion Control Demonstration Program (Section 54). Prepared by Moffatt & Nichol, Engineers, Long Beach, CA for the Office of the Chief Engineer, USACE, Washington, DC. August 1981.

Weis, J.S. & P. Weis. 1996. The effects of using wood treated with chromated copper arsenate in shallow-water environments: A review. Estuaries 19(2A):306-310.

Weis, J.S., Weis, P., Greenberg, A. and T.J. Nosker. 1992. Toxicity of construction materials in the marine environment: A comparision of CCA and recycled plastic. Archives Environmental Contamination and Toxicology 22:99-106.

11. SPECIAL TOPICS: SELECTING AND USING REFERENCE SITES

Identification and study of reference sites are critical to the process of habitat restoration. These sites are generally high quality examples of a habitat that are used to assist design and evaluation of restoration projects in a nearby area. A reference site provides an example of the ecological structure and function of a habitat in its current context. Absent the use of a reference site, it is impossible to establish realistic restoration goals during the project planning process, or track restoration progress.

Reference sites are used in both research and habitat restoration activities. For habitat restoration projects, reference sites are used to track baseline changes in the ecosystem, *e.g.*, disease and cyclical changes, to demonstrate conditions that are not attributable to restoration activities. The reference site often provides the model of ecosystem functioning that a restoration attempts to attain. Long term data from a reference site are also of great utility for habitat restoration, as changes associated with natural variability can be elucidated.

In ecological research, the reference site is the control site, and provides a baseline against which changes caused by an experimental treatment or human impacts are measured. The reference site can also provide a focus for data collection efforts of multiple research projects. The cumulative result of data collection focused at a single site over time will provide comprehensive understanding of the system. Such interrelated data sets also enable researchers to investigate correlations among factors.

A number of considerations are important in selecting a site as a research or restoration reference. The primary ecological consideration is degree of similarity to proposed or existing conditions at the restoration site. Degree of similarity will be defined by factors such as: climate and hydrology; adjacent land uses and human activities at the site itself; site history; vegetation types present as well as their size, morphology, zonation, and proportions; soils and substrates; ecosystem functions; and fish and wildlife present (Thom & Wellman, 1996).

Land ownership is a primary logistical consideration for site selection. Publicly owned lands will be most accessible for monitoring on a regular, long-term basis. Reference sites that receive minimal disturbance are preferable for recording “natural”, baseline conditions, and many publicly owned lands exist relatively undisturbed (*e.g.*, nature preserves, sanctuaries). Since public lands are protected from most development, the degree and nature of disturbance occurring onsite will generally remain stable over time.

The Draft Peconic Estuary Program Framework for Developing a Living Resources Research and Monitoring Plan (Bortman, 2000) calls for the development of a suite of reference sites for the Peconic Estuary. These reference sites, which would represent different habitats found throughout the region, can subsequently be used both for making comparative analyses and gauging restoration projects. Several suites of sites have already been identified in the Peconic region by various entities, and may be appropriate as a basis for developing the Peconic Estuary Program reference sites list.

The New York Natural Heritage Program identified a set of reference wetland ecological communities on Long Island. Several of these sites are found in the Peconics region, including: highbush blueberry bog thicket at Hither Hills North, East Hampton; coastal plain pond shore at Long Pond and Crooked Pond, Southampton; pine barrens shrub swamp and highbush blueberry bog thicket in Sears Bellows Wetlands, Southampton; salt shrub, high salt marsh, salt panne, and low salt marsh at Hubbard Creek Marsh, Southampton, coastal plain pond shore at Peasys Pond and Jones Pond, Riverhead; and pine barrens shrub swamp in the Peconic River headwaters wetlands, Riverhead.

The Natural Heritage Program has also identified significant natural communities in the Peconic Estuary region (Pleuthner, 1995). High quality occurrences of these communities, using the criteria of the NHP, may make good reference sites for restoration projects. The communities identified include: brackish intertidal shore, brackish tidal marsh, coastal plain atlantic white cedar swamp, coastal plain pond, coastal plain pond shore, coastal plain poor fen, coastal salt pond, high salt marsh, low salt marsh, maritime grassland, maritime heathland, maritime interdunal swales, maritime oak-holly forest, maritime red cedar forest, pine barrens shrub swamp, pitch pine-oak-heath woodland, and salt panne. Excellent or good examples are identified in the Peconics region for all of these significant communities.

Designated and proposed New York State Department of State Significant Coastal Fish and Wildlife Habitats (SCFWH) in the Peconic Estuary may assist in identification of reference sites. Approximately 40 sites are located in the PEP study area, encompassing a wide variety of habitat types. Designated and proposed SCFWH areas include a range of ecosystem types from entirely aquatic (*e.g.*, Shelter Island Eastern Shallows) to entirely terrestrial (*e.g.*, Hither Hills Uplands), encompassing salt marsh, freshwater wetlands, coastal and maritime forests and woodlands, coastal plain ponds, riverine habitats, and others.

These various Peconic region sites may be examined against inventories of public lands, including state, county, and municipal parks and preserves, to provide an initial list of possible long term reference sites. Federal areas such as National Wildlife Refuges and National Seashores, and private lands such as those held by the Nature Conservancy and the Peconic Land Trust, may also be appropriate.

References

Bortman, M.L. 2000. Draft Peconic Estuary Program framework for developing a living resources research and monitoring plan. Prepared by the Nature Conservancy for the Peconic Estuary Program, February 2000.

Pleuthner, R.A. 1995. Rare plants, rare animals and significant natural communities in the Peconic Estuary. Prepared by the New York Natural Heritage Program, Latham, NY for the Suffolk County Department of Health Services, Riverhead, NY.

Thom, R.M. & K.F. Wellman. 1996. Planning aquatic ecosystem restoration monitoring programs. Prepared by Battelle Marine Sciences Laboratory, Sequim, WA and Battelle Seattle Research Center, Seattle, WA for the U.S. Army Corps of Engineers, Institute for

Water Resources, Alexandria, VA and Waterways Experiment Station, Vicksburg, MS. IWR Report 96-R-23, December 1996.

12. SPECIAL TOPICS: VOLUNTEER-BASED PROJECTS

Many habitat restoration projects are not appropriate for large scale use of volunteer labor. Some restoration projects may be extremely complex, require specific scientific expertise, occur over sizeable territory, or be governed by tight timelines. Nevertheless, volunteers have long been carrying out water quality monitoring projects (USEPA, 1998) and there are many roles they can also play in habitat restoration. Indeed, programs like the Long Island Sound Study are counting on volunteer groups to conduct small-scale habitat restoration projects.

In the area of water quality monitoring, the goals and objectives of volunteer projects vary greatly. However, "virtually all volunteers hope to educate themselves and others about water quality problems and thereby promote a sense of stewardship for the environment" (USEPA, 1996). Indeed, some of the great benefits of involving volunteers in habitat restoration projects are introducing them to the art and science of habitat restoration and having volunteers serve as ambassadors to the rest of their community about the need to restore coastal habitats. Many government agencies have limited time and staff to devote to habitat restoration. Volunteers can assist these groups in getting the work done, often leading to a sense of stewardship for the project and the local environment.

A number of Peconic Estuary organizations involve volunteers in restoration projects, including Cornell Cooperative Extension, the Nature Conservancy, Group for the South Fork, Long Island Shore and Beach Preservation Association, and the Peconic Land Trust. Expansion of these activities is certainly possible.

Many good examples of volunteer-based projects are available from the Long Island Sound region. The organization Save the Sound, Inc. (Stamford, CT) recently reported that 50 volunteers from the Harding Park and Soundview communities in Bronx, NY planted salt marsh grasses to restore an important wetland along the Bronx River. That effort included a public awareness program to reach out to residents of the Bronx and to educate them about the need to protect and restore the shore of Long Island Sound in the Bronx. In Bridgeport, the same organization teamed up with teachers and high school students at the Bridgeport Vocational Aquaculture School in an innovative project where the students established a nursery and cultivated marsh grasses which were later transplanted to a nearby restoration site. Save the Sound, Inc. has additional projects planned for the year 2000.

The Long Island Sound Study (LISS) encourages volunteer participation in their restoration and enhancement activities through a small grants program. Each year, LISS offers grants to community groups to help them conduct projects related to the Study's restoration goals. Both the United States Environmental Protection Agency and the New York State Department of Environmental Conservation contribute to the grants program, which is administered by New York Sea Grant. A request for proposals is mailed to community groups each year. Details on the process are available from New York Sea Grant. A similar program could be initiated for the Peconic Estuary Program to increase community involvement in habitat restoration.

There are other sources of habitat restoration funding that encourage volunteer participation. The

American Sportfishing Association's FishAmerica Foundation has a grant program for citizen-driven restoration projects. The program seeks to accomplish meaningful on-the-ground restoration of marine, estuarine and riparian habitats, including salt marshes, seagrass beds, and freshwater habitats important to anadromous fish species. To be funded, a project must involve community participation through an educational or volunteer component tied with restoration activities. Funding typically ranges between $5,000 and $25,000.

The Five-Star Challenge Grants program administered by the U.S. Environmental Protection Agency seeks to involve schools, youth groups, local businesses, conservation organizations and local citizens groups in restoration projects. Awards range between $5,000 and $20,000. The Suffolk County Department of Labor working with the Peconic Land Trust and Cornell Cooperative Extension are involving youth-at-risk in restoring Hashamomuck Pond wetlands under this program.

The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) offers community-based restoration grants. The grant program encourages local efforts to restore fish habitats, and encourages partnerships with Federal agencies, states, local governments, non-governmental and non-profit organizations, businesses, industry and schools to carry out locally important habitat restorations to benefit living marine resources. A project recently funded through this source is the Pattersquash Creek Salt Marsh Restoration, Mastic Beach, NY. Local schools and the Mastic Beach Property Owner's Association will help restore the marsh and monitor the project's success.

State and municipal agencies often lack time and money to monitor projects over the long term. Volunteers, if appropriately trained, can play an important role in this project component. Many environmental indicators are items which volunteers can monitor. The top 10 parameters monitored in estuaries by volunteer programs nationally are: water temperature, dissolved oxygen (DO), and salinity (all tied for first place); secchi transparency, pH, nitrogen, turbidity, chlorophyll, rainfall, and aquatic vegetation. In estuaries where shellfish are harvested, bacteria are another frequently-monitored parameter (USEPA, 1998). The ten most commonly measured parameters monitored by volunteers in wetland environments nationally are: aquatic vegetation, birds, flow/water level, wildlife, exotic/invasive species, amphibians, habitat assessment, pH, terrestrial vegetation, and water temperature (USEPA, 1998).

Some habitat restoration projects in New York are beginning to incorporate volunteer monitoring. For example, Ducks Unlimited has been restoring duck habitat in the South Shore Estuary, and is looking for volunteers to monitor waterfowl use of these areas. Volunteers are also being used to count fish in fish ladders, in an effort to evaluate the success of shad restoration projects in the Mid-Atlantic. The New York/New Jersey Harbor Estuary Program (NY/NJ HEP), another regional entity actively involved in habitat restoration work, suggests that volunteers may be trained to monitor the following tidal wetland parameters: percent cover, stem density, plant height, signs of disease or pests, ribbed mussel counts, fiddler crab burrows, presence and duration of stay of saltwater-fish-feeding birds, and presence and duration of stay of benthic-invertebrate-feeding birds.

Training volunteers for such monitoring activities is critical. Numerous manuals and training programs already exist for volunteers used in water quality monitoring. There is a need to develop similar materials for habitat restoration projects. Save The Sound, Inc. has published the Long Island Sound Conservation Blueprint, which serves to introduce community groups to habitat restoration, and outlines the many steps involved in planning and completing a project. Needed still are more step-by-step guidelines for conducting specific habitat restoration projects. Sea Grant and Cornell Cooperative Extension of Suffolk County Marine Program have begun developing such materials. In 1999, three fact sheets were written to encourage volunteer groups to become involved in habitat restoration projects. These are "Planting Smooth Cordgrass," "Planting American Beach Grass," and "Planting Native Coastal Grasses," topics selected because these projects are quite suitable for volunteer labor. Additional fact sheets are needed for other types of projects. Volunteers can play a role in restoring most of the habitats identified for restoration by the Peconic Estuary Program.

Volunteer programs need coordination and administrative support. This can be somewhat time consuming and requires commitment from the organization working with volunteers. Effective volunteer programs typically rely on organized communication networks that strive to keep volunteers motivated and involved.

The use of volunteers in habitat restoration and enhancement projects may be expanded if appropriate steps are taken to guide volunteer participation. Suggestions for increasing the involvement of volunteers in Peconic Estuary habitat restoration projects include:

- **Development of additional educational materials**
  Educational materials should include the rationale for restoring a habitat type, guidelines for planting or other activities associated with the restoration project, information on how to maintain a project if maintenance is needed, and information on how to monitor a project to ensure success.

- **Development of organized training programs**
  Training programs should be organized that will provide hands-on experience in habitat restoration work. Governments and agencies conducting habitat restoration projects should be linked with environmental and citizens' groups that could become participants in the projects.

- **Small grants program**
  A small grants program like the one offered to community groups by the Long Island Sound Study should be assembled for the Peconic Estuary Program.

- **Development of technical assistance directory**
  A directory of where to obtain help and technical assistance with restoration projects should be assembled to assist community groups with their projects, including potential sources of funding for community based-projects.

It is doubtful that volunteers, working by themselves, will be able to conduct many habitat restoration projects. However, working with local governments and with state and Federal agencies, they should be able to contribute substantially to a wide variety of restoration projects.

There are sources of funding available that encourage a volunteer component in restoration projects. Monitoring and evaluation of restoration projects is one area in which volunteers can play an important role. For volunteers to effectively become involved, however, they will need training. Development of educational materials for volunteers is necessary.

Resources for Volunteers

These USEPA resources are available at: http://www.epa.gov/owow/monitoring/vol.html

- Starting out in volunteer water monitoring. 1998. EPA 841-B-98-002.
- Volunteer estuary monitoring: a methods manual. 1993. EPA 842-B-93-004.
- Introduction to the national directory of volunteer environmental monitoring programs. Fifth Edition. 1998.
- The volunteer monitor's guide to quality assurance project plans. 1996. EPA 841-B-96-003.
- The Volunteer Monitor: the national newsletter of volunteer water quality monitoring.

Also available:

- Volunteer wetland monitoring: a preliminary compendium of resources. USEPA Office of Water. Available at: http://www.epa.gov/owow/wetlands/wqual/vmcom.html

- Fifteen things you can do to make a difference in your watershed. USEPA Office of Water. Available at: http://www.epa.gov/owow/watershed/earthday/earthday.html

References

United States Environmental Protection Agency (USEPA). 1996. The volunteer monitor's guide to quality assurance project plans. Office of Wetlands, Oceans and Watersheds. EPA 841-B-96-003, September 1996.

United States Environmental Protection Agency (USEPA). 1998. Introduction to the national directory of volunteer environmental monitoring programs. Fifth Edition. Office of Wetlands, Oceans and Watersheds.

13. POTENTIAL SOURCES OF HABITAT RESTORATION FUNDING

The following table of funding mechanisms for habitat restoration includes information on the agency or organization offering funds, who is eligible for funding under each program, funding levels available, application deadlines, each program's mission and areas of consideration, and contact people. The contact information provided in the table was verified by telephone by the Habitat Restoration Workgroup during the development of this plan.

Name of Program	***Lead Agency/ Organization***	***Eligible Applicants***	***Funding***	***Deadline***	***Program Description***	***Primary Contact***	***Type of Habitats***
North American Wetland Conservation Act (Small Grants)	North American Wetlands Conservation Council	Federal, State and Local government agencies, conservation groups and private indusry	Varies, local match required	Dec.	Foster partnerships to protect, restore and enhance wetlands. Provides matching grants	Keith A. Morehouse, Small Grants Coordinator NAWWO (703) 358-1784 http://www.eswr.com/f02269.txt	Wetlands
Wetlands Reserve Program (WRP)	USDA, NRCS	Owners of farmed wetlands and cropland converted from wetlands prior to December 23, 1985	Varies, private match required	None	Purchase easements an provide cost-share funds and technical assistance for wetlands restoration on private lands. Focuses on restoration of farmed or converted wetlands	Allan Connell, USDS Natural Resources Conservation Service (NRCS) (631) 727-2315 http://www.wl.fb-net.org/	Wetlands and adjacent habitat
Wildlife Habitat Incentives Program	USDA, NRCS	Owners and managers of private land	Varies	N/A	Restoration of grassland and riparian areas, buffer strips, fish stream improvement, wetland restoration and wildlife upland habitat management	Allan Connell, USDS Natural Resources Conservation Service (NRCS) (631) 727-2315 http://www.ny.nrcs.usda.gov/programs/whip1.htm	All habitats
Clean Water Act 319(h) Wetland and Riparian Projects	NYSDEC	Counties, municipalities, soil and water conservation districts and others	Varies	N/A	Grants for development and implementation of watershed plans that address nonpoint source pollution. Must have a wetland or riparian area component.	Karen Chytalo NYSDEC (631) 444-0431 http://www.epa.gov/OWOW/NPS/guide.html	Wetland and riparian areas

Name of Program	***Lead Agency/ Organization***	***Eligible Applicants***	***Funding***	***Deadline***	***Program Description***	***Primary Contact***	***Type of Habitats***
Five-Star Restoration Challenge Grants	USEPA	Community-based partnerships that involve local government and tribal agencies, conservation organizations, youth corps, local businesses and schools to support wetland and streamside restoration projects.	Varies, local match required	February 1	The program emphasizes collaborative strategies built around improving the health of watersheds and the quality of the communities they sustain.	Abigail Friedman National Assoc. of Counties (202) 393-6226 http://www.epa.gov/OWOW/wetlands/restore/5star/	Most coastal and riparian habitats
NY Environmental Protection Fund – Local Waterfront Revitalization Program	NYS Department of State	Municipalities located in the State's coastal waters or designated inland waterway which meets criteria.	Varies, 25-50% local match	N/A	Funds waterfront revitalization, natural resources restoration, nonpoint source pollution. Support appropriate water dependant uses. Improvement and expansion of public access.	Charles McCaffrey NYSDOS (518) 474-6000 http://www.dos.state.ny.us/cstl/epfba1.html	All coastal habitats
NYS Clean Air/Clean Water Bond Act	NYSDEC	Municipal Governments and State Agencies, Soil and Water Conservation Districts	Varies, local match required	N/A	Funds restoration of habitats for the purposes of improving water and air quality	Scott Hughes NYSDEC (631) 444-0462 http://www.dec.state.ny.us/website/bondact/index.html	All coastal habitats
FishAmerica Community-Based Restoration Program	American Sportfishing Association, Fish America Foundation and NOAA	Citizens groups, Federal, State and local government agencies	$5K-$25K match helpful	Varies	Funds salt marsh, seagrass bed and freshwater habitat reastoration	www.asafishing.org/programs/conservation/fishamerica	Habitats important to estuarine and anadromous fishes
Intermodal Surface Transportation Efficiency Act (ISTEA)	Department of Transportation	Incorporated groups, municipalities and state agency or authority	Varies, minimum of 20% local match	January	Transportation enhancement activities including mitigation of water pollution, wetlands restoration and constructed wetlands	http://www.istea.org/	Habitats impacted by transportation

14. ENVIRONMENTAL PROTECTION FUND AWARDS FOR HABITAT RESTORATION PLANNING

The Environmental Protection Fund provides $110 million a year for a number of environmental activities. Any municipality located on the state's coastal waters or on a designated inland waterway is eligible, although some restrictions apply. Since 1994, the New York State Department of State (NYS DOS) Division of Coastal Resources has awarded over $6 million to waterfront communities under the Environmental Protection Fund. Planning, design, feasibility studies, and construction projects that advance preparation and implementation of Local Waterfront Revitalization Programs can be funded on a 50/50 matching basis. In addition, the Division of Coastal Resources establishes priorities each year for the use of funds. Recent priorities included:

- Local Waterfront Revitalization Program Preparation/Implementation;
- Intermunicipal Waterbody Management Plan Preparation/Implementation;
- Waterfront Redevelopment;
- Innovative Use of Dredged Material; and
- Public Coastal Education and Tourism.

The NYS Department of Environmental Conservation, the NYS Department of Agriculture and Markets, and the NYS Office of Parks, Recreation and Historic Preservation also award Environmental Protection Fund grants.

Many restoration sites nominated for the Peconic Estuary are an immediate priority, but are not ready for implementation. These projects will be encouraged to apply for Environmental Protection Fund awards, or other available funds, to complete the project planning. Such projects may subsequently be eligible for Clean Air/Clean Water Bond Act funding (administered by the New York State Department of Environmental Conservation) for the implementation phase. The following projects require additional project planning and may be appropriate for Environmental Protection Fund awards:

Environmental Protection Fund Appropriate Projects

Restoration Site:	Located in:
Sag Harbor Cove/Paynes Creek Wetlands	Southampton
Noyack Creek Wetlands	Southampton
Fort Pond Wetlands	East Hampton
Lake Montauk Alewife Access	East Hampton
Shinnecock Grassland	Southampton
Nassau Point Wetlands	Southold
Cedar Beach Phragmites	Southold
Fleets Neck Wetlands	Southold

Environmental Protection Fund Appropriate Projects *cont.*

Restoration Site:	**Located in:**
Lake Montauk Water Quality	East Hampton
Culloden Grassland	East Hampton
Mill Creek Enhancement Project	Southampton
Cold Spring Pond Wetlands	Southampton
Oyster Pond Water Quality	East Hampton
Tidal Sawmill Creek Phragmites	Riverhead
Upper Sag Harbor Cove Wetlands	Southampton
Cedar/Taylor Island Bulkhead Revegetation	Shelter Island
Accabonac Harbor Flushing	East Hampton
Paynes Creek Enhancement Project	Southampton
East Creek Phragmites	Riverhead
Fort Hill Cemetery Grassland	East Hampton

A number of the proposed restoration projects are less urgent funding priorities; or may require further study or additional information before planning could begin. In some cases, other activities may be required prior to project planning, *e.g.*, site clean-up or sludge removal. At such time when additional studies or other information are available, however, these projects may be appropriate for the Environmental Protection Fund. Some of these projects may also be appropriate for other funding mechanisms. These projects are:

Projects Requiring Additional Activities

Restoration Site:	**Located in:**
Fresh Pond Phragmites	East Hampton
Little NW Creek Phragmites	East Hampton
North Sea Wetlands	Southampton
Reel Point	Shelter Island
Napeague Phragmites	East Hampton
Barnes Meadow Phragmites	East Hampton
TGA Easement	Southold
Fort Pond Phragmites	East Hampton
Fish Cove Wetland Enhancement Project	Southampton
North Sea/Alewife Creek Wetlands	Southampton
Lake Montauk Wetlands	East Hampton
Peconic Edwards	Riverhead
Three Mile Harbor Phragmites	East Hampton
Lake Montauk Phragmites	East Hampton

Projects Requiring Additional Activities *cont.*

Restoration Site:	**Located in:**

Gravel Pit (Dog Ponds)	Riverhead
Browns Point	Riverhead
Tidal Peconic	Riverhead
Linns Pond	Riverhead
Peconic Upper Mills	Riverhead
Hog Creek Phragmites	East Hampton
Wades Beach	Shelter Island
Bay Woods	Riverhead
Broad Cove	Riverhead
Warner Duck Farm	Riverhead
Reeves Creek	Riverhead
Peconic Seep	Riverhead
Grumman	Riverhead
Lake Marion	Southold
Upper Sawmill Creek	Riverhead
Terry Creek	Riverhead

NYS DOS EPF Project Criteria

All EPF applications are reviewed according to the criteria below. Fulfillment of all criteria is not required for a successful application, however, addressing as many criteria as possible during preparation of an EPF application will enhance the chances of receiving a grant award.

Public Value

A project with public value improves or expands visual and/or physical access to the waterfront; provides a facility of regional importance; expands water-dependent recreation; or enhances the character of the community and the visual environment.

Proposed habitat restoration projects may be publicly valuable in a number of ways. Control or removal of common reed may expand physical access to the waterfront, and enhance the area's visual environment. Restoration of habitats capable of supporting historical or current sustainable human uses contributing to the character of the community, *e.g.*, shellfishing, finfishing, or salt hay production, provides public value. Habitat restoration that contributes to the maintenance of activities such as shellfishing and finfishing should be considered to expand water-dependent recreation. Considering means for appropriate public outreach and education after the project is completed can also enhance public value.

Natural Resource Value

Natural resource value expresses a project's capacity to protect, enhance, or restore outstanding natural areas and scenic resources, designated significant coastal fish and wildlife habitats, scenic areas of statewide significance, wetlands, and/or water quality.

The Peconic Estuary Program Habitat Restoration Plan includes a detailed discussion of ecological project selection criteria. These criteria are compatible with Environmental Protection Fund natural resource value criteria. Wetland restoration is a priority of both the Peconic Estuary Program and the Environmental Protection Fund. Funding applications should emphasize, where appropriate, the status of a proposed restoration site as a state or locally designated area of natural resource significance, or its relationship to such an area. Designated areas of natural resource significance are high protection and restoration priorities. Proposed restoration projects not themselves designated may nonetheless respond to the natural resource value criterion. Restoration of non-designated areas may provide protective buffers around designated areas, may assist in improving water quality in designated areas, or may provide contiguous habitat for priority species dependent on nearby designated areas.

Economic Value

Projects with economic value generate economic activity and create immediate and future jobs; support water-dependent commercial and industrial uses; involve leveraging of financial resources, including the use of private funds or services for public purposes; attract new development to developed centers; contribute to restoration of the municipality's tax base; make efficient use of public investments and infrastructure; and/or coordinate maintenance of navigation and public use of the waterfront.

Habitat restoration projects may respond to the economic value criteria in terms of their contribution to the restoration or maintenance of sustainable economic activities like commercial shellfishing and finfishing. Commercial species depend on a variety of intertidal and subtidal habitats, and restoring or enhancing such habitats can be integral to the economic sustainability of activities dependent on these species. Improving visual quality of developed and formerly developed areas through revegetation, improving water quality, and repopulation by indigenous fauna contributes to commercial revitalization by attracting compatible uses and activities. Restoration of habitats contributing a community's historical character may also enhance touristic value.

Relation to Regional Coastal Management Programs

Projects are evaluted on their ability to advance intermunicipal efforts to resolve shared coastal problems. Projects responding to regional goals and objectives are a high EPF priority. The Peconic Estuary Program Habitat Restoration Plan is one effort at conducting this type of project prioritization. Therefore, proposed projects identified through Peconic Estuary Program activities repond to the regional program criterion. Municipalities are also encouraged to identify joint restoration projects including those geared toward improving the condition of shared embayments and watersheds, and restoring habitat and creating intermunicipal corridors for highly mobile and migratory species.

Local Commitment

Projects successfully demonstrating local commitment advance approved or substantially completed Local Waterfront Revitalization Programs; build on previous grant projects awarded by the Department of State; and/or have support from a broad sector of the community.

Peconic Estuary region municipalities are encouraged to prepare and implement Local Waterfront Revitalization Plans (LWRPs). LWRPs involve active local participation in identification and prioritization of a community's critical natural resources and their public value. High priority habitat restoration projects are identified in LWRPs and are a higher priority for EPF awards. Proposed habitat restoration projects may also respond to the local committment criterion by involving volunteers or providing in-kind staff services. Leveraging private funds can also demonstrate local committment.

Innovation & Comprehensiveness

Innovative and comprehensive projects present innovative approaches to waterfront problems and opportunities; incorporate more than one eligible grant activity; and/or expand the options for beneficial use of dredged material by demonstrating innovative but proven management measures, techniques and technologies, planning methods, or studies of the management of dredged material.

Municipalities are most likely to receive EPF funding when proposals reflect adequate consideration of the above evaluation criteria. Proposed projects of substantial ecological value enhance their application viability if attention is also given to other factors.

EPF Habitat Restoration Planning

Habitat restoration planning under EPF grant awards involves, at a minimum, the steps outlined below. Considering these components prior to making a funding application may assist an applicant in developing a strong EPF project.

Site Reconnaissance

Site reconnaissance will be the first step in the preparation of a habitat restoration plan funded through the Environmental Protection Fund. This reconnaissance must include, at a minimum, the following:

- Site survey showing extent of project boundary
- Identification of ownership/grant/lease status of any underwater lands incorporated into the design
- Identification of soil types
- Topographic and/or hydrologic surveys
- List of plant and animal species relying on the habitat, based on existing information and field surveys

- Characterization of site disturbance(s) and assessment of cause(s)
- Description of ecological communities on site and assessment of functional quality
- Identification of fixed-point photo stations for routine monitoring

The product that will ultimately result from the site reconnaissance is a map (or maps) showing the above information and any other appropriate information. Additional information, and the scale of the map or maps, will be identified by the municipality, the Department of State, and/or a consultant during a project scoping session after EPF funding has been awarded.

Restoration Plan

Based on site reconnaissance and other existing information about the site, a restoration plan will be prepared. This plan will be reviewed by the Department of State, and must include at a minimum:

- Description of habitat functions to be achieved or improved
- Identification of target plants, animals, and/or natural communities to be restored
- Hydrologic modifications planned, where applicable
- Exact elevations to be achieved, where applicable
- Planting list with numbers and planting densities of appropriate native plants
- Equipment to be used
- Temporal restrictions for proposed work based on life cycles and seasonal sensitivity to disturbances

Other issues that may be considered important in justifying site selection and plan preparation include site access, surrounding land uses, ownership of the site and/or the surrounding land, historical evidence of the proposed habitat, documentation of success for the restoration method(s) proposed, and degree and duration of post-project maintenance.

Monitoring Program

A Memorandum of Understanding (MOU) will often be required as part of the EPF award for implementation of a restoration project. The MOU outlines an agreement between the State of New York and the grant recipient that the project will be monitored for a minimum of five years after construction. Therefore, habitat restoration plans developed using EPF grants should include a project monitoring program. A standard monitoring protocol is outlined in the MOU and may be tailored to specific project tasks through mutual agreement between the grant recipient and the State of New York. The municipality should always include monitoring considerations when applying for grant funds to demonstrate commitment to project success. In the event that expected project objectives are not accomplished during the five year period of maintenance and oversight, additional work may be required to respond to specific project failures.

The MOU Monitoring Agreement requires annual monitoring reports from the municipality detailing the work performed during and after project implementation. An analysis and discussion determining success rates for vegetation establishment and improvement of habitat functions will also be required. A final report after the full five year monitoring period with a overview and assessment of project success is also stipulated. This report should include discussion of difficulties, uncertainties, and suggested improvements for future projects such as changes in planting strategy, monitoring, or methodology for habitat function(s) assessment.

Permits and Approvals

Permits and/or approvals may be required in order to implement the restoration plan that is ultimately developed using the awarded EPF grant. Consideration of potential permit requirements prior to submission of an EPF application will help clarify project constraints, design options, and other potential issues. Permitting jurisdictions may include:

- Federal agencies such as the U.S. Army Corps of Engineers pursuant to the Rivers and Harbors Act of 1899 and the Sections 401 and 404 of Clean Water Act, and the U.S. Coast Guard for aids to navigation;

- the NYS Department of State, pursuant to the consistency provisions of the Federal Coastal Zone Management Act;

- other State agencies such as the NYS Department of Environmental Conservation pursuant to Articles 15, 24, or 25, or 34 of the NYS Environmental Conservation Law or the NYS Navigation Law; the NYS Office of General Services pursuant to the Public Lands Law; the NYS Office of Parks, Recreation, and Historic Preservation or the State Historic Preservation Officer pursuant to the NYS Parks, Recreation and Historic Preservation or Navigation Law; and

- municipal agencies.

15. PROJECT TRACKING AND DATA STORAGE

Restoration projects must be monitored over time to verify project success, identify unexpected outcomes, and document project failures. Unfortunately, an adequate monitoring program often is not developed during the project planning process, and in many cases, does not occur at all. The Peconic Estuary Program Habitat Restoration Workgroup recommends the development and implementation of habitat-specific, standardized monitoring protocols for all restoration projects. At a minimum, it is necessary to collect quantitative data on biotic conditions at sites prior to initiation of restoration activities. With this data it would be possible to determine project success or failure at a later date.

Although monitoring protocols should be tailored to the goals and objectives of each restoration project, there are nevertheless several generic monitoring protocols designed to insure adequate collection of baseline data and assist in standardizing data collection efforts. The New York State Department of State Division of Coastal Resources and New York State Department of Environmental Conservation have jointly issued guidelines for monitoring salt marsh restoration projects and *Phragmites australis* control projects (Niedowski, 2000). Fonseca, Kenworthy & Thayer (1998) explain methods and parameters for monitoring seagrass restoration projects. Kentula *et al*. provide a detailed discussion and listing of parameters for monitoring freshwater wetlands restoration projects. Finally, procedures for developing individual monitoring programs for aquatic ecosystem restoration projects are explicitly documented in Thom & Wellman (1996). These resources represent a point of departure for developing tailored project monitoring protocols, and their use provides insurance that adequate baseline monitoring of restoration projects will occur.

Storage and accessibility of data and information on local restoration projects are significant issues. Ideally, information would be kept in a permanent, centralized, and easily accessible location in the region. It would be expected that project managers would forward monitoring data and other information to the PEP Program Office for storage and dissemination. A location and process for receiving, filing, managing, and disseminating restoration project information is required as part of post-CCMP implementation. The Suffolk County Department of Health Services Office of Ecology, which currently houses the PEP Office, has the capacity to add the Habitat Restoration Plan information and project listings to the PEP web page. However, setting up and maintaining a long-term, comprehensive repository of restoration project data would require additional staff and office resources. The Program Office will also utilize the Environmental Protection Agency's Restoration Project Directory to disseminate information on Peconic Estuary restoration projects (http://www.epa.gov/owow/wetlands/restore/rpd-2.htm). Decisions on the post-CCMP implementation and PEP structure are required before we can plan for the PEP restoration project database.

A simple GIS restoration project database is being developed by the Southern New England / New York Bight Coastal Program Office (SNEP) of the U.S. Fish and Wildlife Service (USFWS) for the Peconic Estuary Program. This database identifies completed as well as nominated projects in the PEP watershed, and will be available through the PEP Program Office. Additionally there is a large regional initiative to develop a comprehensive database that will track proposed, ongoing, and completed projects, recording successes and failures to further knowledge in the restoration field. When the program is developed further, the USFWS will incorporate the PEP data into this framework. Adequate PEP Program Office computer space and GIS staff time will be required to serve and update the PEP database, and further USFWS participation is subject to SNEP commitment to other priority projects.

References

Fonseca, M.S., W. Judson Kenworthy, & G.W. Thayer. 1998. Guidelines for the conservation and restoration of seagrasses in the United States and adjacent waters. NOAA Coastal Ocean Program Decision Analysis Series No. 12. U.S. Department of Commerce National Oceanic and Atmospheric Administration Coastal Ocean Office, Silver Spring, MD. November 1998.

Kentula, M.E., R.P. Brooks, S.E. Gwin, C.C. Holland, A.D. Sherman, & J.C. Sifneos. 1993. An approach to improving decision making in wetland restoration and creation projects. Ann J. Hairston, ed. Wetlands Research Program, U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR. C. K. Smoley, Inc., Boca Raton, FL.

Niedowski, N. 2000. Salt Marsh Restoration and Monitoring Guidelines. Prepared for the New York State Department of State Division of Coastal Resources and New York State Department of Environmental Conservation Bureau of Fish, Wildlife and Marine Resources.

Thom, R.M. & K.F. Wellman. 1996. Planning aquatic ecosystem restoration monitoring programs. Evaluation of Environmental Investments Research Program, IWR Report 96-R-23. U.S. Army Corps of Engineers Institute for Water Resources, Alexandria, VA. December 1996.

16. RESTORATION PROJECT INVENTORY & ABSTRACTS

A variety of habitat restoration projects have already been conducted in the Peconic Estuary. The following tables, organized by habitat type, summarize work that is ongoing or completed. Habitat types covered are: beaches and dunes, eelgrass, freshwater wetlands, coastal grasslands, and tidal wetlands. In the tables, a brief summary of the restoration actions and post-project maintenance, as well as information (where available) on project size, costs, beginning and end dates, and contact people are included. Asterisked projects are profiled in greater detail in the project abstracts following the table. The projects selected for an extended profile are considered good examples of restoration for that habitat type. These abstracts contain a detailed summary of restoration methods, project results, and conclusions and lessons learned from each project.

Habitat Type	***Site***	***Action***	***Maintenance***	***Size (acres)***	***Cost/ Funding***	***Year Initiated***	***Status (end date)***	***Contact Person***
Beach/Dunes	Gerard Drive, East Hampton	Bare-root beach grass planting into sand adjacent to existing growth on upper beach. Transplants dug from local stock. Success based on plant establishment: Establishment successful.	String fence through first summer	0.25	<$500 Town	Spring 1996	Ongoing	Larry Penny, East Hampton Town Natural Resources Dept. (EHTNRD) (631) 324-0496 Accabonac Harbor Protection Committee Tim Sullivan (631) 324-3627
	Louse Point, East Hampton	Bare-root beach grass planting into sand adjacent to existing growth on upper beach. Transplants dug from local stock. Success based on plant establishment: Establishment successful.	String fence through first summer	0.25	<$500 Town	1996	Ongoing	Larry Penny, EHTNRD (631) 324-0496
	Gin Beach, East Hampton	Bare-root beach grass planting into sand adjacent to existing growth on upper beach. Transplants dug from local stock. Success based on plant establishment: Establishment successful.	String fence through first summer	0.10	<$500 Town	1997	Complete	Larry Penny, EHTNRD (631) 324-0496
	New Suffolk, Southold	Bare-root beach grass planting into sand adjacent to existing growth on upper beach. Transplants from nursery stock. Success based on plant establishment: Establishment mostly successful.	String fence through first summer	0.10	<$500 PEP	1997	Complete	Chris Pickerell, Cornell Cooperative Extension, Marine Program (CCE) (631) 852-8660
	Mattituck Park District, Southold	Bare-root beach grass planting into sand adjacent to existing growth on upper beach. Transplants from nursery stock. Success based on plant establishment: Establishment only partially successful.	None	0.10	<$500 PEP	Spring 1997	Complete	Chris Pickerell, CCE (631) 852-8660
	Robins Island Landing, Southold	Bare-root beach grass planting into newly deposited sand on upper beach in and around large stone. Transplants from nursery stock. Success based on plant establishment: Establishment mostly successful.	Permanent snow fence	0.50	? Private	1997	Complete	Peter Trexler, Belvedere Property Management (BPM) (631) 734-5134
	Second Causeway, Shelter Island	Bare-root beach grass planting into newly deposited sand (over large rocks) on upper beach. Transplants from nursery stock. Success based on plant establishment: Establishment successful.	String fence through first summer	1.0	?	1999	Complete	Town of Shelter Island (631) 749-0291

Habitat Type	***Site***	***Action***	***Maintenance***	***Size (acres)***	***Cost/ Funding***	***Year Initiated***	***Status (end date)***	***Contact Person***
Eelgrass	Three Mile Harbor*, East Hampton	Bundled bare-root shoots attached to metal staples and wooden stakes. Transplants collected from Northwest Harbor and Lake Montauk. Planted into unvegetated coarse and fine sediments. Success based on eelgrass presence the following year: Partially successful (~30%).	Regular observation, Marked with PVC tubes	0.1	<$2,000 PEP	June 1994	Complete	Larry Penny, EHTNRD (631) 324-0496 Chris Pickerell, CCE (631) 852-8660 Emerson Hasbrouck, CCE (631) 727-3910
	Accabonac Harbor, East Hampton	Bundled bare-root shoots attached to metal staples and wooden stakes. Transplants collected from Northwest Harbor and Lake Montauk. Planted into unvegetated coarse and fine sediments. Success based on eelgrass presence the following year: Unsuccessful.	Regular observation, Marked with PVC tubes	0.1	<$2,000 PEP	June 1994	Complete	Larry Penny, EHTNRD (631) 324-0496 Chris Pickerell, CCE (631) 852-8660 Emerson Hasbrouck, CCE (631) 727-3910
	Little Northwest Creek, East Hampton	Bundled bare-root shoots attached to metal staples and wooden stakes. Transplants collected from Northwest Harbor. Planted into unvegetated coarse and fine sediments. Success based on eelgrass presence the following year: Unsuccessful.	Observation, Marked with PVC tubes	0.1	<$2,000 PEP	June 1995	Complete	Larry Penny, EHTNRD (631) 324-0496 Chris Pickerell, CCE (631) 852-8660 Emerson Hasbrouck, CCE (631) 727-3910
	Napeague Harbor, East Hampton	20 cm diameter intact sods transplanted to the perimeter and open areas in the center of an existing bed along the eastern shoreline and an open sandy flat near the south end of the Harbor. All transplants from Napeague. Success based on eelgrass presence the following year: Mostly successful (~75%) (eastern shore). Unsuccessful (sandy flat).	Regular observation, Mapped with GPS, Perimeter of bed and planting sites marked with PVC tubes	0.1	<$2,000 PEP	June and Sept. '97-'98	Complete	Larry Penny, EHTNRD (631) 324-0496 Chris Pickerell, CCE (631) 852-8660 Emerson Hasbrouck, CCE (631) 727-3910
	Three Mile Harbor, East Hampton	20 cm diameter intact sods transferred to the perimeter of an existing bed. Transplants from Napeague. Success based on eelgrass presence the following year: TBD.	Observation of sod establishment	0.1	<$2,000 PEP	October 1999	Planting Complete Monitoring Summer 2000	Larry Penny, EHTNRD (516) 324-0496 Chris Pickerell. CCE (516) 852-8660

Habitat Type	*Site*	*Action*	*Maintenance*	*Size (acres)*	*Cost/ Funding*	*Year Initiated*	*Status (end date)*	*Contact Person*
Freshwater Wetlands	Robins Island*, Southold	A groundwater-fed freshwater pond completely filled with Phragmites was excavated to original depth and diameter. Fill including Phragmites biomass was buried nearby in a lined pit. Following excavation, native emergent species (nursery stock) were planted throughout the shoreline. Success based on establishment of proper hydrology and shoreline vegetation and elimination of common reed: Successful.	Checked regularly for new Phragmites growth. New growth removed	1	?	Summer 1996	Complete (Fall 1996)	Peter Trexler, BPM (631) 734-5134

Habitat Type	*Site*	*Action*	*Maintenance*	*Size (acres)*	*Cost/ Funding*	*Year Initiated*	*Status (end date)*	*Contact Person*
Coastal Grassland	Orient Point County Park*, Southold	Clearing or woody overgrowth in a former farm field using a bullldozer, discing with a tractor, followed by seeding with native warm season grasses. Seed from nursery stock. Success based seeding success of warm season grasses and control of forbs and woody growth: Mostly successful.	Annual mowing plus removal of forbes and new woody growth	50	$53,700 USEPA + inkind	Spring & Summer 1998 1999 2000	Ongoing	Lisa Holst, New York State Department of Environmental Conservation (NYSDEC) (631) 444-0469
	Maratooka Grassland, Mattituck, Southold	Clearing of woody overgrowth with a bulldozer, land preparation inlcuding discing and seeding with switchgrass. Hand seeded. Organ grinder. Seed from nursery stock. Success based seeding success of warm season grasses and control of forbes and woody growth: Mostly successful.	First mowing Sept.(high) after July 15 Every 3yrs.	1	$4,720 seed $450 mowing $25/yr Wildlife Habitat Incentive Program (WHIP)	June 1999	Ongoing 1999-2008	Allan Connell, USDA, Natural Resources Conservation Service (NRCS) (631) 727-2315

Habitat Type	***Site***	***Action***	***Maintenance***	***Size (acres)***	***Cost/ Funding***	***Year Initiated***	***Status (end date)***	***Contact Person***
Tidal Wetlands	Pussy's Pond*, Springs, East Hampton	Phase 1 - Partial excavation of Phragmites-dominated soils on the shore of a brackish tidal pond. The shoreline was re-graded to intertidal elevation and planted with native transplants of cordgrass and salt hay grass. Phase II - Complete excavation of Phragmites-dominated soils and backfilled with clean fill. Seeded with local native seeds. Success based on establishment of native vegetation and elimination of common reed: Partially successful.	Seasonal removal of Phragmites shoots originating from buried rhizome fragments	0.50	$5,000 Waterfowl USA	1994	Complete	Bob Miller Waterfowl USA Chris Pickerell, CCE (631) 852-8660
	Accabonac Harbor, East Hampton	Removal of asphalt and concrete debris from an intertidal shoreline. Success based on establishment of native vegetation: TBD.	None	0.10	<$500 Town	1997	Complete	Larry Penny, EHTNRD (631) 324-0496
	Accabonac Harbor OMWM*, East Hampton	Open marsh water management (OMWM) for restoration of natural hydrology and coliform bacteria reduction. Selected mosquito ditches were plugged using combination of plywood and sandbags. Ditch selection based size and coliform levels in repeated water samples. Success based dam stability, reduction in coliform loading to the Harbor and conditional opening of the area to shellfishing: Successful.	Replace sandbags where necessary	50	? Accabonac Harbor Protection Committee, East Hampton Trustees, USFWS	1994	Ongoing	Larry Penny, EHTNRD (631) 324-0496 Emerson Hasbrouck, CCE (631) 727-3910
	Northwest Creek OMWM, East Hampton	OMWM for restoration of natural hydrology and coliform bacteria reduction. Selected mosquito ditches were plugged using combination of plywood and sandbags. Ditch selection based size and coliform levels in repeated water samples. Success based dam stability, reduction in coliform loading to the Harbor and conditional opening of the area to shellfishing: Partially successful.	Replace sandbags where necessary	50	? EH Trustees, USFWS	1994	Ongoing	Larry Penny, EHTNRD (631) 324-0496 Emerson Hasbrouck, CCE (631) 727-3910

Habitat Type	*Site*	*Action*	*Maintenance*	*Size (acres)*	*Cost/ Funding*	*Year Initiated*	*Status (end date)*	*Contact Person*
Tidal Wetlands Continued	Northwest Creek OMWM, East Hampton	OMWM for restoration of natural hydrology and coliform bacteria reduction. Selected mosquito ditches were plugged using combination of plywood and sandbags. Ditch selection based size and coliform levels in repeated water samples. Success based dam stability, reduction in coliform loading to the Harbor and conditional opening of the area to shellfishing: Partially successful.	Replace sandbags where necessary	50	? EH Trustees, USFWS	1994	Ongoing	Larry Penny, EHTNRD (631) 324-0496 Emerson Hasbrouck, CCE (631) 727-3910
	Three Mile Harbor Drive, East Hampton	Planting bare-root cordgrass into a highly disturbed roadway cut into the marsh. Transplants gleaned from local stock in Three Mile Harbor. Success based on plant establishment: Very successful.	Permanently fenced to vehicular traffic	0.25	<$500	April 1996	Complete	Larry Penny, EHTNRD (631) 324-0496
	Gerard Point, East Hampton	Planting nursery propagated cordgrass into open areas in and adjacent to the existing marsh Success based on plant establishment: Successful.	Fenced	0.25	$750 East End Institute	July 1999	Complete	Larry Penny, EHTNRD (631) 324-0496 Chris Pickerell, CCE (631) 852-8660
	Cassidy Preserve, Hashamomuck Pond, Southold	Excavation and re-grading of hydraulic dredge spoil, creation of intertidal pools and replacement of common reed with smooth cordgrass Success based on proper elevations, maintenance of water in pools and elimination of common reed: Successful.	Following creation of an "as-built" plan, portions of the site were re-graded to inhibit common reed re-colonization	5 of 23	~$30,000 USEPA	June 1999	Phase I Complete Additional work (Phase II) planned for the future. Grants pending	Chris Pickerell, CCE (631) 852-8660 John Halsey, President Peconic Land Trust (631) 283-3195
	Downs Creek, Cutchogue	Removal of concrete and other debris within an intertidal marsh to allow for natural re-vegetation and prevent future dumping Success based on natural re-vegetation of the site by cordgrass: Successful.	Signage	0.10	Private	1996	Complete	Roy Haje EN-Consultants (631) 283-6360

Habitat Type	Site	Action	Maintenance	Size (acres)	Cost/ Funding	Year Initiated	Status (end date)	Contact Person
Tidal Wetlands Continued	Long Beach Bay, Orient Southold	Culvert replacement and enlargement to increase salinity behind a dike at multiple points. OMWM for water quality improvement. Reductions in storm water inputs to surface waters. Success based on increased salinity behind dike and reductions in coliform bacteria counts in adjacent open waters: TBD.	Salinity and tidal elevation monitoring. Repair of leaky dams	200+	$253,000 USFWS	1999	Ongoing	Chris Pickerell, CCE (631) 852-8660 Emerson Hasbrouck, CCE (631) 727-3910
	Fish Cove Bridge, North Sea Harbor, Southampton	Planting of cordgrass to mitigate new bridge construction. Plantings included nursery propagated peat pots. Success based on establishment of cordgrass: Successful.	?	0.10	?	1995	Complete	Gary Gentile, New York State Department of Transportation. (631) 952-6219
	Otter Pond, Sag Harbor	Planting of native marsh grasses to prevent erosion and improve aesthetics. Propagules included nursery stock. Success based on establishment of grasses: Partially successful.	?	0.10	Private	1997	Complete	Village of Sag Harbor
	Broad Cove, Aquabogue, Riverhead	Restoration of intertidal marsh through cordgrass plantings, restoration of a tidal creek and opening of manmade tidal salt ponds to tidal flow. Success based on establishment of grasses, stability of new creek and increased flushing of tidal ponds: Sandbar plantings mostly unsuccessful, creek restoration successful, flushing successful.	Minimal fencing, regular photographs	5.0	Private	1994	Complete	Chris Pickerell, CCE (631) 852-8660
	Chase Creek, Shelter Island	Planting of cordgrass to mitigate bridge improvements. Plants includeed nursery propagated peat pots. Success based on establishment of cordgrass: Successful.	?	0.10	?	1996	Complete	Gary Gentile, New York State Department of Transportation (631) 952-6219

COMPLETE PROJECTS - SELECTED ABSTRACTS

Project Name:	Orient Point Maritime Grassland Restoration
Habitat Type:	Coastal Grassland
Location:	Orient Point County Park, Southold
Size:	50 acres
Sponsors:	Suffolk County Parks, NYSDEC, Southold Town, USFWS and USEPA
Contact Person(s):	Lisa Holst, NYSDEC (631) 444-0469 Robert Parris, USFWS (631) 286-0485 James McMahon, Town of Southold (631) 765-1892 Bill Sickles, Suffolk County Parks (631) 854-4949
Start/End Date:	Spring 1998/2000
Cost:	Total $53,700: $20,700(EPA grant)/$33,000 in kind

Methods:

Prior to restoration, this site was overgrown with successional cool season grasses and numerous woody shrubs and small trees including bayberry, groundsel bush and eastern red cedar. Given the size of the site, clearing and planting were spread over three years beginning in 1998 and ending in 2000. The initial plan of work called for the use of a tractor-mounted brush hog to clear the woody material, but the density and size of the growth precluded this. As an alternative, the site was selectively cleared with a bulldozer that simultaneously removed above and below ground biomass of the larger woody material. To avoid removing the largest of the trees and shrubs and to afford the site some protection from heavy wind, numerous small islands and the perimeter of the area were left intact. Site preparation for seeding included disking and rolling. Seeding (commercial source) was accomplished during the first year using a hand-operated seed spreader. For the second year a tractor mounted seed drill was utilized. Seed application rates were 20-25 pounds pure live seed per acre for both years. Mowing was conducted annually to keep down woody growth and herbaceous weeds.

Results:

Following clearing of the first third of the site and hand seeding, establishment of the switchgrass was satisfactory despite the drought. However, several openings in the switchgrass cover allowed for some re-establishment of seaside goldenrod. Clearing and machine planting of the second third (during 1999) resulted in excellent establishment. The last section will be cleared and planted in the spring of 2000.

Conclusion:

This project is generally considered a success. It appears that the project managers were correct in avoiding areas with heavy growth which would have greatly complicated and delayed the project. Use of a mechanized seed drill appears to be the most efficient means of planting warm season grasses for such projects.

COMPLETE PROJECTS - SELECTED ABSTRACTS

Project Name:	Three Mile Harbor Eelgrass Planting
Habitat Type:	Eelgrass
Location:	Three Mile Harbor, East Hampton
Size:	0.1 acres
Sponsors:	Peconic Estuary Program (USEPA)
Contact Person(s):	Larry Penny, EHNRD (631) 324-0496 Chris Pickerell, CCE (631) 852-8660 Emerson Hasbrouck (631) 727-3910
Start/End Date:	June 1994/1999
Cost:	Total $2,000/$1,000 in kind

Methods:

As part of a multi-harbor eelgrass planting project, two areas in the Three Mile Harbor were planted during mid summer of 1994 using bare root transplants collected from Northwest Harbor and Lake Montauk. Transplant preparation (in the lab) involved bundling three bare root shoots together onto a metal landscape staple or small wooden stake using metal twist ties and a protective cardboard sleeve to prevent damage to the shoots. Shoots were collected and prepared during one day and planted on the following day. Transplants were planted out into hard and soft bottom areas near existing grass beds using a submersible PVC frame to establish a grid. Planting was accomplished by gently pushing the metal staples or wooden stakes into the bottom, in a hole created with a dive knife, to a depth sufficient to bury the rhizomes. Transplant sites were marked using short section of PVC pushed in at the center of each area. Transplants were monitored in the weeks immediately after planting and for five consecutive summers.

Results:

Initial plant establishment and new shoot production were initially very good in the hard bottom transplant site. The soft bottom area was abandoned during planting due to low visibility and inability to anchor the plugs. In the fall after transplant all grass, including surrounding natural beds, appeared to disappear. Follow up observations two, three, four and five years post transplant indicated some survival in the hard bottom area.

Conclusion:

Although this is one of the most successful eelgrass projects conducted to date in the Peconic Estuary, it can hardly be considered a significant success. Use of the bare-root plug technique has fallen out of use in favor of 20cm intact plugs which have met with considerably more success during plantings at Napeague Harbor in East Hampton. Bare-root transplant technique is not recommended for future work in the region until the cause of transplant failure can be determined. Additional site selection criteria need to be developed to improve success. Ideally, an alternative and less destructive sources of transplant stock should be investigated and utilized for future restoration efforts.

COMPLETE PROJECTS - SELECTED ABSTRACTS

Project Name:	South Pond Restoration, Robins Island
Habitat Type:	Freshwater Wetland (Pond)
Location:	Robins Island, New Suffolk, Southold
Size:	1 acre
Sponsors:	Belvedere Property Management
Contact Person(s):	Peter Trexler, BPM (631) 734-5134
Start/End Date:	Summer 1996/Fall 1996
Cost:	Unknown (Privately Funded)

Methods:

Organic sediment laden with common reed rhizomes was excavated from a pond that had completely filled with organic matter. In order to dispose of the sediment without spreading common reed to other areas on the island, a large in ground receiving area was created in an adjacent field. To prevent spread of the rhizomes and seeds, a PVC-liner and cover were utilized. After filling and covering, the receiving area was backfilled with clean fill from the original pit. Once excavated, the pond filled naturally to design depth of approximately at least 3 feet. The restoration was completed by planting the pond edge with a diverse assemblage of emergent hydrophytes. The adjacent upland was planted with native facultative and upland shrubs as a transition to the pond. Numerous "snags" were pulled into the pond to create hiding and resting areas for wildlife.

Results:

Restoration of an open water pond with associated flora was completely successful. The pond appears natural in ever aspect except for the fact that the plant diversity is greater than most natural ponds. Several years after restoration only a few small common reed shoots were observed.

Conclusion:

Although this project was highly successful, the high cost may make a project of this type impractical in most situations. However, in this case there was no other alternative available to restore the pond to an open water system.

COMPLETE PROJECTS - SELECTED ABSTRACTS

Project Name:	Pussy's Pond
Habitat Type:	Brackish Marsh/Phragmites Removal
Location:	Springs, East Hampton
Size:	0.25 acre
Sponsors:	Waterfowl USA, East Hampton Chapter
Contact Person(s):	Bob Miller, Waterfowl USA Chris Pickerell, CCE (631) 852-8660
Start/End Date:	June 1994
Cost:	Unknown (Privately Funded)

Methods:

Pussy's Pond is connected to Accabonac Harbor through a culvert under Old Stone Highway. Mean tidal amplitude is approximately 1.5 feet with a mean salinity range of 0-18 ppt. In order to restore the historic shoreline and remove dense growth of common reed that was filling in the Pond, 1,300 cubic yards of fill containing *Phragmites* rhizomes was removed from northern shoreline using an excavator. All fill was taken to an approved upland site by the Town of East Hampton. Following excavation down to a depth of approximately 2-3 feet, the intertidal shoreline was re-graded to a slope of 1 on 10 or less. Planting was accomplished using plant material collected by the Town of East Hampton and propagated at Cornell University. Collected plants (*Spartina alterniflora*) were planted bare root. Propagated plants (*Spartina patens*) were in fiber pots. Slow release fertilizer was incorporated in the planting hole of all plants.

Results:

Plant establishment was excellent for all species. Almost 100% vegetation coverage was achieved in 12 months. However, common reed was present at several points along the shoreline. Natural recruitment of salt marsh bulrush (*Scirpus robustus*) and other native species occurred during the second year of growth.

Conclusion:

The project was successful in establishing native grasses including cordgrass and salt hay grass. Natural recruitment added to the diversity of vegetation. However, incomplete removal of common reed rhizomes, buried during initial excavation activities, and the inability to remove all adjacent stands is a significant threat to the project. Each year, the common reed density increases in the restored area. Grazing pressure from Canadian geese, that selectively remove native emergent hydrophytes in favor of *Phragmites*, is a significant threat to the project. Without human intervention, this site may revert to a nearly pure stand of common reed in approximately 10 years.

COMPLETE PROJECTS - SELECTED ABSTRACTS

Project Name:	Accabonac Coliform OMWM
Habitat Type:	Salt Marsh
Location:	Accabonac Harbor, East Hampton
Size:	50 acres
Sponsors:	Town of East Hampton, Cornell Cooperative Extension, Marine Program
Contact Person(s):	Larry Penny, EHNRD (631) 324-0496 Emerson Hasbrouck (631) 727-3910
Start/End Date:	Summer 1996
Cost:	$30,000 (current costs for similar OMWM projects are significantly lower)

Methods:

Due to high levels of coliform, the Harbor was uncertified for shellfishing. This project was designed to prevent coliform-laden waters from flowing directly into open waters of Accabonac Harbor. Prior to initiation of OMWM, periodic water sampling (for coliform counts) was used to identify ditches that were polluting the Harbor. Based on these results and the interconnectedness of existing ditches, a damming plan was devised to retain flood tide waters on the surface of the marsh. Dams were constructed with hand tools using plywood sheeting installed across the ditch with sand bags for support on either side. In order to increase stability and enhance appearance, cordgrass shoots were incorporated into many of the dams.

Results:

Most dams were successful in holding water on the marsh between high tides. Those dams that leaked were repaired using additional sand bags. Most of the dams planted became vegetated with cordgrass in one to two growing seasons. Water sampling in the open waters immediately seaward of the formerly open ditches indicated that coliform loading to the Harbor was reduced by the dams. In two areas in the Peconic Estuary (Acabonack Harbor and Northwest Creek in East Hampton, NY), short-term improvements in water quality have resulted in changes in the status of shellfishing certification. However, the long term benefits of this work are not clear.

Conclusion:

The success of this project in improving water quality in Accabonac Harbor indicates that existing mosquito ditches can serve as conduits for coliform-laden water. OMWM, including selective damming of ditches, can be effective in reducing pollution from the ditches. Although the plywood dams were successful, subsequent work at this site and others indicated that sand bags alone were sufficient in most cases.

APPENDIX A

SPECIES CITED IN THE HABITAT RESTORATION PLAN

Plants

American chestnut (*Castanea dentata*)
American beech (*Fagus grandifolia*)
American holly (*Ilex opaca*)
American beachgrass (*Ammophila breviligulata*)
arrowhead (*Sagittaria latifolia*)
arrowleaf (*Peltandra virginica*)
asiatic bittersweet (*Celastrus orbiculatus*)
Atlantic golden aster (*Pityopsis falcata*)
Atlantic white cedar (*Chamaecyparis thyoides*)
autumn olive (*Elaeagnus umbellata*)
bayberry (*Myrica pensylvanica*)
beach heather (*Hudsonia tomentosa*)
beach pea (*Lathyrus japonicus*)
beach rose (*Rosa carolina*)
beach-plum (*Prunus maritima*)
bearberry (*Arctostaphylos uva-ursi*)
beech (*Fagus gradifolia*)
bird's foot violet (*Viola pedata*)
black locust (*Robinia pseudoacacia*)
black gum (*Nyssa sylvatica*)
black oak (*Quercus velutina*)
black grass (*Juncus gerardii*)
black huckleberry (*Gaylussacia baccata*)
black cherry (*Prunus serotina*)
black ash (*Fraxinus nigra*)
bladderworts (*Utricularia* spp.)
blue flag (*Iris versicolor*)
box elder (*Acer negundo*)
brushy redweed (*Cystoclonium purpureum*)
bulrushes (*Scirpus* spp.)
bur-reed (*Sparganum eurycarpum*)
bushy rockrose (*Helianthemum dumosusm*)
buttonbush (*Cephalanthus occidentalis*)
catbrier (*Smilax rotundifolia*)
cattail (*Typha latifolia*)
chestnut oak (*Quercus montana*)
Chinese wisteria (*Wisteria sinensis*)
common reed (*Phragmites australis*)
common hairgrass (*Deschampsia flexuosa*)
dwarf spikerush (*Eleocharis parvula*)
eastern red cedar (*Juniperus virginiana*)
eelgrass (*Zostera marina*)
flowering dogwood (*Cornus florida*)
glasswort (*Salicornia europaea*)
green fleece (*Codium fragile*)
green algae (*Enteromorpha* spp.)
highbush blueberry (*Vaccinium corymbosum*)
horned rush (*Rhyncospora macrostachya*)
Indian grass (*Sorghastrum nutans*)
Japanese wisteria (*Wisteria floribunda*)
Japanese knotweed (*Polygonum cuspidatum*)
Japanese honeysuckle (*Lonicera japonica*)
lacy redweed (*Euthora cristata*)
lance-leaved loosestrife (*Lysimachia hydrida*)
laurel (*Kalmia latifolia*)
little bluestem (*Schizachyrium scoparium*)
lowbush blueberry (*Vaccinium angustifolium*)
mokernut hickory (*Carya tomentosa*)
multiflora rose (*Rosa multiflora*)
Nantucket juneberry (*Amelanchier nantucketensis*)
New England blazing star (*Liatris scariosa* var. *novae-angliae*)
New York fern (*Thelypteris noveboracensis*)
Norway maple (*Acer platanoides*)
orange fringed orchid (*Platanthera ciliaris*)
paper birch (*Betula papyrifera*)
Pennsylvania sedge (*Carex pensylvanica*)
pickerelweed (*Pontederia cordata*)
pignut hickory (*Carya glabra*)
pine barren gerardia (*Agalinis virgata*)
pipewort (*Eriocaulon aquaticum*)
pitch pine (*Pinus rigida*)
poison ivy (*Toxicodendron radicans*)
pondweeds (*Potamogeton* spp.)
porcelainberry (*Ampelopsis brevipedunculata*)
post oak (*Quercus stellata*)
poverty grass (*Danthonia spicata*)
purple loosestrife (*Lythrum salicaria*)
red oak (*Quercus rubra*)
red maple (*Acer rubrum*)
river bulrush (*Scirpus fluviatilis*)
rockweed (*Fucus vesiculosus*)
rose-mallow (*Hibiscus moscheutos*)
Russian olive (*Elaeagnus angustifolia*)
salt-meadow cordgrass (*Spartina patens*)
saltmarsh aster (*Aster tenuifolius*)
saltmarsh bulrush (*Scirpus robustus*)
saltmarsh fleabane (*Pulchea odorata*)
saltmarsh plantain (*Plantago maritima*)
sandplain gerardia (*Agalinis acuta*)
sandplain flax (*Linum intercursum*)
sassafras (*Sassafras albidum*)
scarlet oak (*Quercus coccinea*)
scrub oak (*Quercus ilicifolia*)
sea lettuce (*Ulva lactuca*)
sea rocket (*Cakile edentula*)
sea-lavender (*Limonium carolinianum*)

seabeach knotweed (*Polygonum glaucum*)
seaside arrowgrass (*Triglochin maritimum*)
seaside goldenrod (*Solidago sempervirens*)
seaside gerardia (*Agalinis maritima*)
seaside spurge (*Euphorbia polygonifla*)
sedges (*Carex* spp.)
shadbush (*Amelanchier canadensis*)
silvery aster (*Aster concolor*)
smooth cordgrass (*Spartina alterniflora*)
spatterdock (*Nuphar luteum*)
spikegrass (*Distichlis spicata*)
spikerush (*Eleocharis rostellata*)
star flower (*Trientalis borealis*)
starflower (*Smilacina stellata*)
sugar maple (*Acer saccharinum*)
sundews (*Drosera* spp.)
swamp azalea (*Rhododendron viscosum*)
sweet pignut hickory (*Carya ovalis*)
sweetflag (*Acorus americanus*)
switchgrass (*Panicum virgatum*)
tartarian honeysuckle (*Lonicera tartarica*)
three-square bulrush (*Scirpus americanus*)
tree-of-heaven (*Ailanthus altissima*)
tupelo (*Nyssa* spp.)
turtlegrass (*Thallasia testudinum*)
twig rush (*Cladium mariscoides*)
Virginia creeper (*Parthenocissus quinquefolia*)
white milkweed (*Asclepias variegata*)
white pine (*Pinus strobus*)
white oak (*Quercus alba*)
white ash (*Fraxinus americana*)
widgeon-grass (*Ruppia maritima*)
wild lupine (*Lupinus perennis*)
wild grape (*Vitis labrusca*)
wild sasparilla (*Aralia nudicaulis*)
wild rice (*Zizania aquatica*)
wineberry (*Rubus phoenicolasius*)
witch hazel (*Hamamelis virginiana*)

Birds

American kestrel (*Falco sparverius*)
American widgeon (*Anas americana*)
American black duck (*Anas rubripes*)
American robin (*Turdus migratorius*)
American oystercatcher (*Haematopus palliatus*)
American redstart (*Setophaga ruticilla*)
bank swallow (*Riparia riparia*)
belted kingfisher (*Megaceryle alcyon*)
black skimmer (*Rhynchops niger*)
black-and-white warbler (*Mniotilta varia*)
black-capped chickadee (*Parus atricapillus*)
black-crowned night heron (*Nycticorax nycticorax*)
black-throated green warbler (*Dendroica virens*)
blue jay (*Cyanocitta cristata*)
blue-grey gnatcatcher (*Polioptila caerulea*)
blue-winged warbler (*Vermivora pinus*)
blue-winged teal (*Anas discors*)
bobolink (*Dolichonyx oryzivorus*)
bobwhite (*Colinus virginianus*)
brant (*Branta bernicla*)
broad-winged hawk (*Buteo platypterus*)
brown thrasher (*Toxostoma rufum*)
brown creeper (*Certhia americana*)
bufflehead (*Bucephala albeola*)
Canada goose (*Branta canadensis*)
canvasback (*Aythya valisineria*)
Carolina wren (*Thryothorus ludovicianus*)
cerulean warbler (*Dendroica cerulea*)
chuck-wills-widow (*Caprimulgus carolinensis*)
clapper rail (*Rallus longirostris*)
common goldeneye (*Bucephala clangula*)
common barn owl (*Tyto alba*)
common tern (*Sterna hirundo*)
common yellowthroat (*Geothlypis trichas*)
Cooper's hawk (*Accipiter cooperii*)
double-crested cormorant (*Phalacrocorax auritus*)
eastern bluebird (*Sialia sialis*)
eastern meadowlark (*Sternella magna*)
eastern wood pewee (*Contopus virens*)
eastern towhee (*Pipilo erythropthalamus*)
glossy ibis (*Plegadis falcinellus*)
grasshopper sparrow (*Ammodramus savannarum*)
great egret (*Casmerodius albus*)
great horned owl (*Bubo virginianus*)
great-crested flycatcher (*Myiarchus crinitus*)
greater scaup (*Aythya marila*)
green-backed heron (*Butorides striatus*)
green-winged teal (*Anas crecca*)
grey catbird (*Dumetella carolinensis*)
hairy woodpecker (*Picoides villosus*)
hermit thrush (*Catharus guttatus*)
hooded warbler (*Wilsonia citrina*)
horned lark (*Eremophila alpestris*)
house wren (*Troglodytes aedon*)
least bittern (*Ixobrychus exilis*)
least tern (*Sterna antillarum*)
lesser scaup (*Aythya affinis*)
little blue heron (*Egretta caerulea*)
Louisiana waterthrush (*Seiurus motacilla*)
mallard (*Anas platyrhynchos*)
marsh wren (*Cistothorus palustris*)

mute swan (*Cygnus olor*)
northern pintail (*Anas actua*)
northern rough-winged swallow (*Stelgidopteryx serripennis*)
northern oriole (*Icterus galbula*)
northern harrier (*Circus cyaneus*)
oldsquaw (*Clangula hyemalis*)
osprey (*Pandion haliaetus*)
ovenbird (*Seiurus aurocapillus*)
peregrine falcon (*Falco peregrinus*)
pied-billed grebe (*Podilymbus podiceps*)
pine warbler (*Dendroica pinus*)
pintail (*Anas acuta*)
piping plover (*Charadrius melodus*)
prairie warbler (*Dendroica discolor*)
red-breasted merganser (*Mergus serrator*)
red-breasted nuthatch (*Sitta canadensis*)
red-eyed vireo (*Vireo olivaceus*)
red-tailed hawk (*Buteo jamaicensis*)
red-winged blackbird (*Agelaius phoeniceus*)
roseate tern (*Sterna dougallii*)
rough-legged hawk (*Buteo logopus*)
savannah sparrow (*Passerculus gramineus*)
scarlet tanager (*Piranga olivacea*)
sharp-shinned hawk (*Accipiter striatus*)
sharp-tailed sparrow (*Ammodramus caudacutus*)
short-eared owl (*Asio flammeus*)
snowy egret (*Egretta thula*)
song sparrow (*Melospiza melodia*)
swamp sparrow (*Melospiza georgiana*)
tree swallow (*Tachycineta bicolor*)
tufted titmouse (*Parus bicolor*)
upland sandpiper (*Bartramia longicauda*)
vesper sparrow (*Pooecetes gramineus*)
whip-poor-will (*Caprimulgas vociferus*)
whistling swan (*Cygnus columbianus*)
white-breasted nuthatch (*Sitta carolinensis*)
white-eyed vireo (*Vireo griseus*)
white-winged scoter (*Melanitta fusca*)
widgeon (*Anas penelope*)
willet (*Catoptrophorus semipalmatus*)
wood thrush (*Hylocichla mustelina*)
wood duck (*Aix sponsa*)
yellow warbler (*Dendroica petechia*)
yellow-crowned night heron (*Nycticorax violaceus*)
yellow-rumped warbler (*Dendroica coronata*)
yellow-throated warbler (*Dendroica dominica*)

Fish

alewife (*Alosa pseudoharengus*)
Atlantic tomcod (*Microgadus tomcod*)
Atlantic cod (*Gadus morhua*),
Atlantic silverside (*Menidia menidia*)
banded sunfish (*Enneacanthus obesus*)
bay anchovy (*Anchoa mitchilli*)
black crappie (*Pomoxis nigromaculatus*)
bluefish (*Pomatomus saltatrix*)
brown bullhead (*Ictalurus nebulosus*)
carp (*Cyprinus carpio*)
chain pickerel (*Esox niger*)
four-spine stickleback (*Apeltes quadricus*)
grubby (*Myxocephalus aenaeus*)
largemouth bass (*Micropterus salmoides*)
menhaden (*Brevoortia tyrannus*)
mullet (*Mugil cephalus*)
mummichog (*Fundulus heteroclitus*)
northern pike (*Esox lucius*)
northern pipefish (*Syngnathus fuscus*)
oyster toadfish (*Opsanus tau*)
pumpkinseed (*Lepomis gibbosus*)
rock bass (*Ambloplites rupestris*)
sand lance (*Ammodytes americanus*)
scup (*Stenotomus chrysops*)
sea bass (*Centropristes striata*)
sea robins (*Prionotus* spp.)
sheepshead minnow (*Cyprinodon variegatus*)
smallmouth bass (*Micropterus dolomieui*)
striped bass (*Morone saxatilis*)
striped killifish (*Fundulus majalis*)
tautog (*Tautoga onitis*)
three-spine stickleback (*Gasterosteus aculeatus*)
winter flounder (*Pleuronectes americanus*)

Mammals

meadow vole (*Microtus pensylvanicus*)
white-tailed deer (*Odocoileus virginianus*)

Reptiles

diamondback terrapin (*Malaclemys terrapin*)
green turtle (*Chelonia mydas*)

Amphibians

tiger salamander (*Ambystoma tigrinum*)

Aquatic invertebrates

bay scallop (*Argopecten irradians irradians*)
blue mussel (*Mytilis edulis*)
blue crab (*Callinectes sapidus*)
calico crab (*Ovalipes ocellatus*)
common slippershell (*Crepidula fornicata*)
common periwinkle (*Littorina littorea*)
fiddler crabs (*Uca* spp.)
fiddler crab (*Uca pugilator*)
fiddler crab (*Uca pugnax*)
green crab (*Carcinus maenas*)
hard clam (*Mercenaria mercenaria*)
hermit crab (*Pagurus longicarpus*)
horseshoe crab (*Limulus polyphemus*)
knobbed whelk (*Busycon carica*)
marsh crab (*Sesrma reticulatum*)
mud crabs (*Panopeus* spp.)
mud snail (*Ilyanassa obsoletus*)
razor clam (*Ensis directus*)
ribbed mussel (*Geukensia demissa*)
rock crab (*Cancer irroratus*)
salt marsh snail (*Melampus bidentatus*)
seven-spine shrimp (*Crangon septemspinosa*)
softshell clam (*Mya arenaria*)
spider crabs (*Libinia* spp.)

Insects

American burying beetle (*Nicrophorus americanus*)
aureolaria seed borer (*Rhodocia aurantiago*)
coastal barrens buckmoth (*Hemileuca maia maia*)
coastal heathland cutworm (*Abagrotis crumbi benjamini*)
frosted elfin (*Incisalia irus*)
regal fritillary (*Speyeria idalia*)

APPENDIX B

RANKABLE RESTORATION SITES, ALTERNATIVE LISTINGS

HIGHEST TO LOWEST RANK

Habitat Type	Site Name	Keywords	Town
Beach	Sammi's Beach	grade, plant	EH
Wetland	Davis Creek Wetlands	grade, omwm, plant	SH
Shorebird	Hicks Island Plover/Tern	veg_rmv	EH
Alewife	Alewife Brook Alewife Access	dbrs_rmv, inv_rmv	EH
Wetland	Sag Harbor Cove/Paynes Creek Wetlands	grade, fill, plant	SH
Wetland	Noyack Creek Wetlands	excav, grade	SH
Wetland	Accabonac Harbor Wetlands	dbrs_rmv, grade, plant	EH
Wetland	Fort Pond Wetlands	excav, grade, plant	EH
Alewife	Lake Montauk Alewife Access	dredge, dbr_rmv, inv_rmv	EH
Grassland	Shinnecock Grassland	inv_rmv, burn	SH
Wetland	Nassau Point	excav, grade, plant	SD
Eelgrass*	Northwest Creek Eelgrass	transpl	EH
Phrag	Cedar Beach Phragmites	excav, inv_rmv, plant	SD
Wetland	Fleets Neck	excav, grade, plant	SD
WQ	Lake Montauk Water Quality	technol	EH
Grassland	Culloden Grassland	inv_rmv, burn, plant	EH
Phrag	Alewife Brook Phragmites	inv_rmv	EH
Shorebird	Mill Creek Enhancement Project	fill, veg_rmv, plant	SH
WQ	Accabonac Harbor Road End	excav, grade, inv_rmv, plant	EH
Phrag	Accabonac Harbor Phragmites	inv_rmv	EH
Eelgrass*	Noyack Creek Eelgrass	transpl	SH
Eelgrass*	Napeauge Eelgrass	transpl	EH
Wetland	Cold Spring Pond Wetlands	excav, dbrs_rmv	SH
Phrag	Northwest Creek Phragmites	inv_rmv	EH
WQ	Oyster Pond Water Quality	omwm	EH
Phrag	Tidal Sawmill Creek	inv_rmv, excav, plant, technol	RH
Eelgrass*	Lake Montauk Eelgrass	transpl	EH
Wetland	Upper Sag Harbor Cove Wetlands	fill	SH
Wetland	Cedar/Taylor Island Revegetation	hrd_rmv, plant	SI
WQ	Accabonac Harbor Flushing	technol, dredge	EH
Eelgrass*	Accabonac Harbor Eelgrass	transpl	EH
Eelgrass*	Sag Harbor Cove Eelgrass	transpl	SH
Eelgrass*	Paynes Creek Eelgrass	transpl	SH
Eelgrass*	Upper Sag Harbor Cove Eelgrass	transpl	SH
Eelgrass*	Bullhead Bay Eelgrass	transpl	SH
Wetland	Paynes Creek Enhancement Project	plant	SH
Phrag	East Creek	technol, inv_rmv	RH
Wetland	Three Mile Harbor Wetlands	grade, plant	EH
Eelgrass*	Cutchogue Harbor	other	SD
WQ	Fresh Pond Flow	dredge	EH
Grassland	Fort Hill Cemetery Grassland	inv_rmv, burn	EH

Highest to Lowest Rank, Continued

Phrag	Fresh Pond Phragmites	inv_rmv, plant, dredge	EH
Phrag	Little NW Creek Phragmites	inv_rmv	EH
Wetland	North Sea Wetlands	grade, plant	SH
Beach	Reel Point	other	SI
Phrag	Napeague Phragmites	inv_rmv	EH
Phrag	Barnes Meadow Phragmites	inv_rmv, plant	EH
Wetland	TGA Easement	omwm, inv_rmv	SD
Phrag	Fort Pond Phragmites	inv_rmv	EH
Wetland	Fish Cove Wetland Enhancement	dbrs_rmv	SH
Wetland	North Sea/Alewife Creek Wetlands	omwm	SH
Wetland	Lake Montauk Wetlands	excav, grade, plant	EH
Eelgrass*	Three Mile Harbor Eelgrass	transpl	EH
Phrag	Peconic Edwards	inv_rmv, plant	RH
Phrag	Three Mile Harbor Phragmites	inv_rmv	EH
Phrag	Lake Montauk Phragmites	inv_rmv	EH
Phrag	Gravel Pit (Dog Ponds)	inv_rmv, technol, plant	RH
Phrag	Browns Point	inv_rmv, technol, dbrs_rmv	RH
Phrag	Tidal Peconic	inv_rmv, plant, technol	RH
Phrag	Linns Pond	inv_rmv, plant	RH
Riverine	Peconic Upper Mills	inv_rmv, plant	RH
Phrag	Hog Creek Phragmites	inv_rmv	EH
Beach	Wades Beach	fill, plant, excav, dredge	SI
Phrag	Bay Woods	dredge, inv_rmv	RH
Phrag	Broad Cove	technol, inv_rmv	RH
Phrag	Warner Duck Farm	inv_rmv, excav, plant, dbrs_rmv	RH
Phrag	Reeves Creek	inv_rmv, technol	RH
Phrag	Peconic Seep	inv_rmv, excav, technol	RH
Phrag	Grumman	inv_rmv, technol	RH
Phrag	Lake Marion	dredge, inv_rmv, plant	SD
Phrag	Upper Sawmill Creek	inv_rmv, excav	RH
Phrag	Terry Creek	technol	RH

HIGHEST TO LOWEST BY TOWN

Habitat Type	Site Name	Keywords	Town
Beach	Sammi's Beach	grade, plant	**EH**
Shorebird	Hicks Island Plover/Tern	veg_rmv	
Alewife	Alewife Brook Alewife Access	dbrs_rmv, inv_rmv	
Wetland	Accabonac Harbor Wetlands	dbrs_rmv, grade, plant	
Wetland	Fort Pond Wetlands	excav, grade, plant	
Alewife	Lake Montauk Alewife Access	dredge, dbr_rmv, inv_rmv	
Eelgrass*	Northwest Creek Eelgrass	transpl	
Grassland	Culloden Grassland	inv_rmv, burn, plant	
WQ	Lake Montauk Water Quality	technol	
Phrag	Alewife Brook Phragmites	inv_rmv	
WQ	Accabonac Harbor Road End	excav, grade, inv_rmv, plant	
Phrag	Accabonac Harbor Phragmites	inv_rmv	
Eelgrass*	Napeauge Eelgrass	transpl	
Phrag	Northwest Creek Phragmites	inv_rmv	
WQ	Oyster Pond Water Quality	omwm	
Eelgrass*	Lake Montauk Eelgrass	transpl	
WQ	Accabonac Harbor Flushing	technol, dredge	
Eelgrass*	Accabonac Harbor Eelgrass	transpl	
Wetland	Three Mile Harbor Wetlands	grade, plant	
Grassland	Fort Hill Cemetery Grassland	inv_rmv, burn	
WQ	Fresh Pond Flow	dredge	
Phrag	Little NW Creek Phragmites	inv_rmv	
Phrag	Fresh Pond Phragmites	inv_rmv, plant, dredge	
Phrag	Napeague Phragmites	inv_rmv	
Phrag	Barnes Meadow Phragmites	inv_rmv, plant	
Phrag	Fort Pond Phragmites	inv_rmv	
Wetland	Lake Montauk Wetlands	excav, grade, plant	
Eelgrass*	Three Mile Harbor Eelgrass	transpl	
Phrag	Three Mile Harbor Phragmites	inv_rmv	
Phrag	Lake Montauk Phragmites	inv_rmv	
Phrag	Hog Creek Phragmites	inv_rmv	
Phrag	Tidal Sawmill Creek	inv_rmv, excav, plant, technol	**RH**
Phrag	East Creek	technol, inv_rmv	
Phrag	Peconic Edwards	inv_rmv, plant	
Phrag	Gravel Pit (Dog Ponds)	inv_rmv, technol, plant	
Phrag	Browns Point	inv_rmv, technol, dbrs_rmv	
Phrag	Tidal Peconic	inv_rmv, plant, technol	
Phrag	Linns Pond	inv_rmv, plant	
Riverine	Peconic Upper Mills	inv_rmv, plant	
Phrag	Broad Cove	technol, inv_rmv	
Phrag	Bay Woods	dredge, inv_rmv	

Highest to Lowest by Town, Continued

Phrag	Warner Duck Farm	inv_rmv, excav, plant, dbrs_rmv	
Phrag	Reeves Creek	inv_rmv, technol	
Phrag	Peconic Seep	inv_rmv, excav, technol	
Phrag	Grumman	inv_rmv, technol	
Phrag	Upper Sawmill Creek	inv_rmv, excav	
Phrag	Terry Creek	technol	
Wetland	Nassau Point	excav, grade, plant	**SD**
Wetland	Fleets Neck	excav, grade, plant	
Phrag	Cedar Beach Phragmites	excav, inv_rmv, plant	
Eelgrass*	Cutchogue	other	
Wetland	TGA Easement	omwm, inv_rmv	
Phrag	Lake Marion	dredge, inv_rmv, plant	
Wetland	Davis Creek Wetlands	grade, omwm, plant	**SH**
Wetland	Noyack Creek Wetlands	excav, grade	
Wetland	Sag Harbor Cove/Paynes Creek	grade, fill, plant	
Grassland	Shinnecock Grassland	inv_rmv, burn	
Shorebird	Mill Creek Enhancement Project	fill, veg_rmv, plant	
Eelgrass*	Noyack Creek Eelgrass	transpl	
Wetland	Cold Spring Pond Wetlands	excav, dbrs_rmv	
Wetland	Upper Sag Harbor Cove Wetlands	fill	
Eelgrass*	Paynes Creek Eelgrass	transpl	
Eelgrass*	Upper Sag Harbor Cove Eelgrass	transpl	
Eelgrass*	Bullhead Bay Eelgrass	transpl	
Eelgrass*	Sag Harbor Cove Eelgrass	transpl	
Wetland	Paynes Creek Enhancement Project	plant	
Wetland	North Sea Wetlands	grade, plant	
Wetland	Fish Cove Wetland Enhancement	dbrs_rmv	
Wetland	North Sea/Alewife Creek Wetlands	omwm	
Wetland	Cedar/Taylor Island Revegetation	hrd_rmv, plant	**SI**
Beach	Reel Point	other	
Beach	Wades Beach	fill, plant, excav, dredge	

BY TOWN AND HABITAT TYPE

Habitat Type	Site Name	Keywords	Town
Alewife	Alewife Brook Alewife Access	dbrs_rmv, inv_rmv	**EH**
	Lake Montauk Alewife Access	dredge, dbr_rmv, inv_rmv	
Beach	Sammi's Beach	grade, plant	
Eelgrass*	Northwest Creek Eelgrass	transpl	
	Accabonac Harbor Eelgrass	transpl	
	Napeauge Eelgrass	transpl	
	Lake Montauk Eelgrass	transpl	
	Three Mile Harbor Eelgrass	transpl	
Grassland	Fort Hill Cemetery Grassland	inv_rmv, burn	
	Culloden Grassland	inv_rmv, burn, plant	
Phrag	Three Mile Harbor Phragmites	inv_rmv	
	Alewife Brook Phragmites	inv_rmv	
	Accabonac Harbor Phragmites	inv_rmv	
	Northwest Creek Phragmites	inv_rmv	
	Lake Montauk Phragmites	inv_rmv	
	Fort Pond Phragmites	inv_rmv	
	Little NW Creek Phragmites	inv_rmv	
	Barnes Meadow Phragmites	inv_rmv, plant	
	Napeague Phragmites	inv_rmv	
	Hog Creek Phragmites	inv_rmv	
	Fresh Pond Phragmites	inv_rmv, plant, dredge	
Shorebird	Hicks Island Plover/Tern	veg_rmv	
WQ	Accabonac Harbor Flushing	technol, dredge	
	Fresh Pond Flow	dredge	
	Oyster Pond Water Quality	omwm	
	Accabonac Harbor Road End	excav, grade, inv_rmv, plant	
	Lake Montauk Water Quality	technol	
Wetland	Accabonac Harbor Wetlands	dbrs_rmv, grade, plant	
	Fort Pond Wetlands	excav, grade, plant	
	Three Mile Harbor Wetlands	grade, plant	
	Lake Montauk Wetlands	excav, grade, plant	
Phrag	Upper Sawmill Creek	inv_rmv, excav	**RH**
	East Creek	technol, inv_rmv	
	Bay Woods	dredge, inv_rmv	
	Broad Cove	technol, inv_rmv	
	Peconic Edwards	inv_rmv, plant	
	Linns Pond	inv_rmv, plant	
	Tidal Sawmill Creek	inv_rmv, excav, plant, technol	
	Reeves Creek	inv_rmv, technol	
	Grumman	inv_rmv, technol	
	Peconic Seep	inv_rmv, excav, technol	

By Town and Habitat Type, Continued

	Tidal Peconic	inv_rmv, plant, technol	
	Warner Duck Farm	inv_rmv, excav, plant, dbrs_rmv	
	Terry Creek	technol	
	Browns Point	inv_rmv, technol, dbrs_rmv	
	Gravel Pit (Dog Ponds)	inv_rmv, technol, plant	
Riverine	Peconic Upper Mills	inv_rmv, plant	
Eelgrass*	Cutchogue Harbor	other	**SD**
Phrag	Lake Marion	dredge, inv_rmv, plant	
	Cedar Beach Phragmites	excav, inv_rmv, plant	
Wetland	Fleets Neck	excav, grade, plant	
	Nassau Point	excav, grade, plant	
	TGA Easement	omwm, inv_rmv	
Eelgrass*	Upper Sag Harbor Cove Eelgrass	transpl	**SH**
	Paynes Creek Eelgrass	transpl	
	Sag Harbor Cove Eelgrass	transpl	
	Noyack Creek Eelgrass	transpl	
	Bullhead Bay Eelgrass	transpl	
Grassland	Shinnecock Grassland	inv_rmv, burn	
Shorebird	Mill Creek Enhancement Project	fill, veg_rmv, plant	
Wetland	Cold Spring Pond Wetlands	excav, dbrs_rmv	
	Upper Sag Harbor Cove Wetlands	fill	
	Noyack Creek Wetlands	excav, grade	
	Davis Creek Wetlands	grade, omwm, plant	
	Sag Harbor Cove/Paynes Creek Wetlands	grade, fill, plant	
	Paynes Creek Enhancement Project	plant	
	Fish Cove Wetland Enhancement Project	dbrs_rmv	
	North Sea Wetlands	grade, plant	
	North Sea/Alewife Creek Wetlands	omwm	
Beach	Wades Beach	fill, plant, excav, dredge	**SI**
	Reel Point	other	
Wetland	Cedar/Taylor Island Revegetation	hrd_rmv, plant	

ALPHABETICAL BY SITE NAME

Habitat Type	Site Name	Keywords	Town
Eelgrass*	**Accabonac Harbor Eelgrass**	transpl	EH
WQ	**Accabonac Harbor Flushing**	technol, dredge	EH
Phrag	**Accabonac Harbor Phragmites**	inv_rmv	EH
WQ	**Accabonac Harbor Road End**	excav, grade, inv_rmv, plant	EH
Wetland	**Accabonac Harbor Wetlands**	dbrs_rmv, grade, plant	EH
Alewife	**Alewife Brook Alewife Access**	dbrs_rmv, inv_rmv	EH
Phrag	**Alewife Brook Phragmites**	inv_rmv	EH
Phrag	**Barnes Meadow Phragmites**	inv_rmv, plant	EH
Phrag	**Bay Woods**	dredge, inv_rmv	RH
Phrag	**Broad Cove**	technol, inv_rmv	RH
Phrag	**Browns Point**	inv_rmv, technol, dbrs_rmv	RH
Eelgrass*	**Bullhead Bay Eelgrass**	transpl	SH
Phrag	**Cedar Beach Phragmites**	excav, inv_rmv, plant	SD
Wetland	**Cedar/Taylor Island Revegetation**	hrd_rmv, plant	SI
Wetland	**Cold Spring Pond Wetlands**	excav, dbrs_rmv	SH
Grassland	**Culloden Grassland**	inv_rmv, burn, plant	EH
Eelgrass*	**Cutchogue Harbor**	other	SD
Wetland	**Davis Creek Wetlands**	grade, omwm, plant	SH
Phrag	**East Creek**	technol, inv_rmv	RH
Wetland	**Fish Cove Wetland Enhancement**	dbrs_rmv	SH
Wetland	**Fleets Neck**	excav, grade, plant	SD
Grassland	**Fort Hill Cemetery Grassland**	inv_rmv, burn	EH
Phrag	**Fort Pond Phragmites**	inv_rmv	EH
Wetland	**Fort Pond Wetlands**	excav, grade, plant	EH
WQ	**Fresh Pond Flow**	dredge	EH
Phrag	**Fresh Pond Phragmites**	inv_rmv, plant, dredge	EH
Phrag	**Gravel Pit (Dog Ponds)**	inv_rmv, technol, plant	RH
Phrag	**Grumman**	inv_rmv, technol	RH
Shorebird	**Hicks Island Plover/Tern**	veg_rmv	EH
Phrag	**Hog Creek Phragmites**	inv_rmv	EH
Phrag	**Lake Marion**	dredge, inv_rmv, plant	SD
Alewife	**Lake Montauk Alewife Access**	dredge, dbr_rmv, inv_rmv	EH
Eelgrass*	**Lake Montauk Eelgrass**	transpl	EH
Phrag	**Lake Montauk Phragmites**	inv_rmv	EH
WQ	**Lake Montauk Water Quality**	technol	EH
Wetland	**Lake Montauk Wetlands**	excav, grade, plant	EH
Phrag	**Linns Pond**	inv_rmv, plant	RH
Phrag	**Little NW Creek Phragmites**	inv_rmv	EH
Shorebird	**Mill Creek Enhancement Project**	fill, veg_rmv, plant	SH
Phrag	**Napeague Phragmites**	inv_rmv	EH
Eelgrass*	**Napeauge Eelgrass**	transpl	EH
Wetland	**Nassau Point**	excav, grade, plant	SD

Alphabetical by Site Name, Continued

Wetland	**North Sea Wetlands**	grade, plant	SH
Wetland	**North Sea/Alewife Creek Wetlands**	omwm	SH
Eelgrass*	**Northwest Creek Eelgrass**	transpl	EH
Phrag	**Northwest Creek Phragmites**	inv_rmv	EH
Eelgrass*	**Noyack Creek Eelgrass**	transpl	SH
Wetland	**Noyack Creek Wetlands**	excav, grade	SH
WQ	**Oyster Pond Water Quality**	omwm	EH
Eelgrass*	**Paynes Creek Eelgrass**	transpl	SH
Wetland	**Paynes Creek Enhancement Project**	plant	SH
Phrag	**Peconic Edwards**	inv_rmv, plant	RH
Phrag	**Peconic Seep**	inv_rmv, excav, technol	RH
Riverine	**Peconic Upper Mills**	inv_rmv, plant	RH
Beach	**Reel Point**	other	SI
Phrag	**Reeves Creek**	inv_rmv, technol	RH
Eelgrass*	**Sag Harbor Cove Eelgrass**	transpl	SH
Wetland	**Sag Harbor Cove/Paynes Creek Wetlands**	grade, fill, plant	SH
Beach	**Sammi's Beach**	grade, plant	EH
Grassland	**Shinnecock Grassland**	inv_rmv, burn	SH
Wetland	**TGA Easement**	omwm, inv_rmv	SD
Phrag	**Terry Creek**	technol	RH
Eelgrass*	**Three Mile Harbor Eelgrass**	transpl	EH
Phrag	**Three Mile Harbor Phragmites**	inv_rmv	EH
Wetland	**Three Mile Harbor Wetlands**	grade, plant	EH
Phrag	**Tidal Peconic**	inv_rmv, plant, technol	RH
Phrag	**Tidal Sawmill Creek**	inv_rmv, excav, plant, technol	RH
Eelgrass*	**Upper Sag Harbor Cove Eelgrass**	transpl	SH
Wetland	**Upper Sag Harbor Cove Wetlands**	fill	SH
Phrag	**Upper Sawmill Creek**	inv_rmv, excav	RH
Beach	**Wades Beach**	fill, plant, excav, dredge	SI
Phrag	**Warner Duck Farm**	inv_rmv, excav, plant, dbrs_rmv	RH

KEYS TO TABLES

Keyword	Definition
burn	controlled burning, designed to enhance ecological conditions, *e.g,* in fire-dependent communities
dbrs_rmv	debris removal
dredge	removal of material from the aquatic environment, usually to enhance water circulation
excav	fill, stands of Phragmites, or other material will be removed from the area
fill	material will be added to area, usually to achieve appropriate elevations and grades
grade	grading of area to appropriate elevations, usually designed to enhance tidal flushing
hrd_rmv	removal of shoreline hardening structures
inv_rmv	invasive species removal, usually manual (*i.e.*, cutting or mowing)
omwm	manipulations of existing ditches to enhance site hydrology
other	non-restoration activities, including public education, land acquisition, and research
plant	restoration site will be planted rather than revegetated naturally
technol	application of water quality improvement technology, such as catchment basins or culverts
transpl	transplantation; taking vegetation from one site for use in restoration of another site
veg_rmv	vegetation removal; usually to enhance shorebird nesting habitat by setting back succession

Code	Town
BR	Brookhaven
EH	East Hampton
RD	Riverhead
SI	Shelter Island
SH	Southampton
SD	Southold
SCo	Suffolk County

* The Habitat Restoration Workgroup (HRWG) believes that the ranks developed for the nominated eelgrass restoration sites using the ranking methodology do not accurately predict the best sites for eelgrass transplantation. Field reconnaissance, conducted to gather additional data on sediment type at the nominated eelgrass sites, confirms this belief. Eelgrass restoration is highly uncertain, and many aspects of the relationship between site conditions and transplant success are not well understood. For the sake of consistency, nominated eelgrass sites are presented as ranked throughout this plan. However, the high uncertainty associated with eelgrass restoration precludes the Workgroup from advocating any of the eelgrass restoration sites at this time. Case-by-case analysis of specific site conditions, selected methods, and project timing must be conducted to accurately assess the potential for success.

APPENDIX C

COST ESTIMATES

1. COST ESTIMATES FOR RESTORATION OF PRIORITY HABITAT TYPES

The following estimates **do not** include planning and design costs.
All costs are **wholesale prices** quoted in 2000 dollars.
See references for sources of existing and lost acreage numbers.

TIDAL WETLANDS

Current Tidal Wetland (TW) acreage:	5,600 acres
TW acreage lost since 1972:	115 acres
Number of TW projects in HRP:	17 projects

Assumptions:
Using 1 planting unit (PU) per 1 ft^2
Labor cost for planting equals plant materials cost
Each project is a 1 acre restoration
Equipment and labor will be required for 5 days
Post-project monitoring will be conducted for 5 years

Costs:

Spartina alterniflora (PU = 2" peat pot)	$0.70/PU
Excavation equipment:	$1,500.00/day
Monitoring:	$1,000.00/year
Exclosure fencing:	$1,000.00

Per project cost estimate:

44,000 PU/acre x $0.70/PU =	$30,800/acre for plant materials
$30,800 x 1 =	$30,800 for labor
$1,500/day x 5 days =	$7,500 for excavation
$1,000/year x 5 years =	$5,000 for monitoring
$1,000 =	$1,000 for fencing
Cost =	**$75,100 per project acre**

FRESHWATER WETLANDS

Current Freshwater Wetland (FW) acreage:	3,400 acres
FW acreage lost since 1972:	44 acres
Number FW projects in HRP:	1 project

Assumptions:
Using 1 planting unit (PU) per 1 ft^2
Common freshwater emergent plant species are similarly priced
Labor cost for planting equals plant materials cost
Use of geotextiles doubles total project costs
Each project is a 1 acre restoration
Equipment and labor will be required for 5 days

Post-project monitoring will be conducted for 5 years

Costs:

Plant materials (PU = 2" plug)	$0.70/PU
Excavation equipment:	$1,500.00/day
Monitoring:	$1,000.00/year
Exclosure fencing:	$1,000.00

Per project cost estimate:

44,000 PU/acre x $0.70/PU =	$30,800/acre for plant materials
$30,800 x 1 =	$30,800 for labor
$1,500/day x 5 days =	$7,500 for excavation
$1,000/year x 5 years =	$5,000 for monitoring
$1,000 =	$1,000 for fencing
Cost =	**$75,100 per project acre**
Add geotextile use	x 2
Cost =	**$150,200 per project acre**

COMMON REED CONTROL

Current *Phragmites*-dominated acreage:	1,366 acres
Phragmites acreage lost since 1972:	N/A
Number Phrag projects in HRP:	28 projects

Assumptions:
Using 1 planting unit (PU) per 1 ft^2
Labor cost for planting equals plant materials cost
Each project is a 1 acre restoration
Equipment and labor will be required for 5 days
Post-project monitoring will be conducted for 5 years

Costs:

Plant materials (PU = 2" peat pot)	$0.70/PU
Excavation equipment:	$1,500.00/day
Removal equipment:	$1,200/day
Monitoring:	$1,000.00/year
Exclosure fencing:	$1,000.00

Per project cost estimate:

44,000 PU/acre x $0.70/PU =	$30,800/acre for plant materials
$30,800 x 1 =	$30,800 for labor
$1,500/day x 5 days =	$7,500 for excavation
$1,200/day x 5 days =	$6,000 for removal
$1,000/year x 5 years =	$5,000 for monitoring
$1,000 =	$1,000 for fencing
Cost =	**$81,100 per project acre**

GRASSLAND

Current Grassland (GL) acreage:	? acres
GL acreage lost since 1972:	250 acres
Number GL projects in HRP:	3 projects

Assumptions:
Pure live seed (pls) required is 20 lbs/acre
Labor cost for planting equals plant materials cost
Each project is a 1 acre restoration
Equipment and labor will be required for 2 days
Post-project monitoring will be conducted for 5 years
Mowing costs required in perpetuity = 30 years

Costs:

Panicum virgatum (10 lbs pls)	$20.00/lb
Schizachyrium scoparium (10 lbs pls)	$35.00/lb
Tractor and seed drill:	$500.00/day
Monitoring:	$1,000.00/year
Mowing tractor:	$250/year

Per project cost estimate:

$20.00/lb x 10 lbs =	$200/acre for *Panicum virgatum*
$35.00/lb x 10 lbs =	$350/acre for *Schizachyrium scoparium*
$200/acre + $350/acre =	$550/acre for labor
$500/day x 2 days =	$1,000 for equipment
$1,000/year x 5 years =	$5,000 for monitoring
$250/year x 30 years =	$7,500 for mowing
Cost =	**$14,600 per project acre**

SUBMERGED AQUATIC VEGETATION

Current SAV (all species) acreage:	24,000 acres
SAV acreage lost since 1972:	? acres
Number SAV projects in HRP:	11 projects

Assumptions:
Using *Zostera marina* transplants from existing beds
Each project is a 1 acre restoration
Equipment and labor will be required for 5 days
Monitoring requires ½ day time monthly from boat/operator, technician, divers
Post-project monitoring will be conducted 6 months/year for 5 years

Costs:

Boat time and operator:	$275/day
Technician time:	$100/day

Diver time (2 divers):	$400/day

Per project cost estimate:

$275/day x 5 days =	$1,375 for boat/operator
$100/day x 5 days =	$500 for technician
$400/day x 5 days =	$2,000 for divers
$775 x 0.5 day/mo x 6 mo/yr x 5 years =	$11,625 for monitoring
Cost =	**$15,500 per project acre**

BEACHES AND DUNES

Current Beach and Dune (BD) acreage:	1,500 acres
BD acreage lost since 1972:	6 acres
Number BD projects in HRP:	5 projects

Assumptions:

All projects are planting projects only
Using 1 planting unit (PU) per 1 ft^2
Each project is a 1 acre restoration
Equipment and labor will be required for 2 days
Post-project monitoring will be conducted for 5 years

Costs:

Ammophila breviligulata (1 PU = 2 stems)	$0.14/PU
Labor (2 people @ $10.00/hr):	$160/day
Monitoring:	$500/year
Snow fencing:	$1,000

Per project cost estimate:

44,000 PU/acre x $0.14/PU =	$6,160/acre for plant materials
$160/day x 2 days =	$320 for labor
$500/year x 5 years =	$2,500 for monitoring
$1,000 =	$1,000 for fencing
Cost =	**$9,980 per project acre**

COASTAL FORESTS

Current Coastal Forest (CF) acreage:	? acres
CF acreage lost since 1972:	2,943 acres
Number CF projects in HRP:	0 projects

Assumptions:

All projects are planting projects only
Using 1,000 planting unit (PU) per acre
Each project is a 1 acre restoration

Equipment and labor will be required for 3 days
Post-project monitoring will be conducted for 5 years

Costs:

Pinus rigida, Myrica pensylvanica, Vaccinium spp., *Ilex* spp., *Arctostaphylos uva-ursi* (PU = 18"/24" container)	$5.00/PU
Quercus spp., *Prunus serotina*, *Nyssa sylvatica* (PU = 18"/24" container)	$8.00/PU
Labor (2 foresters):	$720/day (8 hours @ $45.00/hr)
Monitoring:	$1,000/year

Per project cost estimate:

500 PU/acre x $8.00/PU =	$4,000/acre for *Quercus* spp. etc.
500 PU/acre x $5.00/PU =	$2,500/acre for *Pinus rigida* etc.
$720/day x3 days =	$2160 for labor
$1,000/year x 5 years =	$5,000 for monitoring
Cost =	**$13,660 per project acre**

RIVERINE MIGRATORY CORRIDORS

Current Riverine (RMC) acreage:	? acres
RMC acreage lost since 1972:	? acres
Number RMC projects in HRP:	2 projects

Assumptions:
All projects are fish access improvement projects
Post-project monitoring will be conducted for 5 years

Costs:

Fish ladder:	$100,000
Labor:	$20,000
Monitoring:	$1,000.00/year

Per project cost estimate:

$1,000/year x 5 years =	$5,000 for monitoring
$20,000 =	$20,000 for labor
$100,000 =	$100,000 for fish ladder
Cost =	**$125,000 per project acre**

INTERTIDAL MUDFLATS

Current Intertidal Mudflats (IM) acreage:	100 acres

IM acreage lost since 1972: ? acres
Number IM projects in HRP: 0 projects

The cost of Intertidal Mudflat restoration is encompassed by Tidal Wetland restoration costs. There are no extensive mudflat areas in the Peconic Estuary requiring individual attention. Rather, this habitat occurs as a narrow fringe adjacent to estuarine wetlands. This habitat is considered to be a part of the overall Tidal Wetland ecosystem. Therefore, Tidal Wetland restoration projects will include benefits to Intertidal Mudflats.

ESTUARIES AND EMBAYMENTS

Current Estuarine (EE) acreage: 100,000 acres
EE acreage lost since 1972: N/A
Number EE projects in HRP: 5 projects

Estuaries and Embayments restoration projects are primarily water quality improvement projects. The cost of such projects will be highly variable, depending upon technology selected. For example, culvert installation may be required to improve flushing. Alternatively, stormwater retention basins may be needed in certain embayments. Some projects may be associated with dredging. Such technologies have significantly different costs, therefore, no generic cost estimate has been made.

2. ESTIMATED COSTS FOR RESTORATION PLAN IMPLEMENTATION

Table F-1. Estimated cost for implementation of Habitat Restoration Plan high priority projects.

	#Projects/Category					**Cost/Acreage Category**				
	0-3	**4-10**	**11-50**	**>50**	**Cost/ac***	**0-3**	**4-10**	**11-50**	**>50**	**TOTAL**
Calc #	*(1.5)*	*(7)*	*(30)*	*(50)*		*(1.5)*	*(7)*	*(30)*	*(50)*	
SAV	2	0	1	0	$15,500	$46,500	$0	$465,000	$0	**$511,500**
TW	4	0	0	0	$75,100	$450,600	$0	$0	$0	**$450,600**
BD	0	1	2	0	$9,980	$0	$69,860	$598,800	$0	**$668,660**
FW	1	0	0	0	$150,200	$225,300	$0	$0	$0	**$225,300**
CG	1	0	1	0	$14,600	$21,900	$0	$438,000	$0	**$459,900**
EE	0	0	0	1	N/A	$0	$0	$0	$0	**N/A**
RMC	1	0	0	0	$125,000	$187,500	$0	$0	$0	**$187,500**
IF	0	0	0	0	N/A	$0	$0	$0	$0	**N/A**
CF	0	0	0	0	$13,660	$0	$0	$0	$0	**$0**
Phrag	1	2	0	0	$81,100	$121,650	$1,135,400	$0	$0	**$1,257,050**
#proj	10	3	4	1	**= 18 projects total**			**Total Cost =**		**$3,760,510**
#ac	15	21	120	50	**= 206 acres total**					

Table F-2. Estimated acreage accounted for by all Habitat Restoration Plan projects.

Habitat type	**Number of projects/acreage category**				**Projects/habitat type**
	0-3 ac	**4-10 ac**	**11-50 ac**	**>50 ac**	
Calculation #	*1.5 ac*	*7 ac*	*30 ac*	*50 ac*	
SAV	6	3	2	0	11
TW	9	6	2	0	17
BD	0	2	3	0	5
FW	1	0	0	0	1
GL	1	1	1	0	3
EE	0	2	2	1	5
RMC	1	1	0	0	2
IM	0	0	0	0	0
CF	0	0	0	0	0
Phrag	7	13	7	1	28
Total #	**25**	**28**	**17**	**2**	**72 projects**
(Total acres)	**(37.5 ac)**	**(189 ac)**	**(510 ac)**	**(100 ac)**	**(836.5 acres)**

Table F-3. Estimated cost for implementation of all Habitat Restoration Plan projects.

		Acreage Category (# Projects per Category)				
Habitat	**Cost/ac***	**0-3 (# proj)**	**4-10 (# proj)**	**11-50 (# proj)**	**>50 (# proj)**	**Total**
Calculation #		*1.5 acres*	*7 acres*	*30 acres*	*50 acres*	
SAV	$15,500	$139,500 (6)	$325,500 (3)	$930,000 (2)	$0 (0)	**$1,395,000**
TW	$75,100	$1,013,850 (9)	$3,154,200 (6)	$4,506,000 (2)	$0 (0)	**$8,674,050**
BD	$9,980	$0 (0)	$139,720 (2)	$898,200 (3)	$0 (0)	**$1,037,920**
FW	$150,200	$225,300 (1)	$0 (0)	$0 (0)	$0 (0)	**$225,300**
CG	$14,600	$21,900 (1)	$102,200 (1)	$438,000 (1)	$0 (0)	**$562,100**
EE	N/A	$0 (0)	$0 (1)	$0 (2)	$0 (1)	**N/A**
RMC	$125,000	$187,500 (1)	$875,000 (1)	$0 (0)	$0 (0)	**$1,062,500**
IF	N/A	$0 (0)	$0 (0)	$0 (0)	$0 (0)	**N/A**
CF	$13,660	$0 (0)	$0 (0)	$0 (0)	$0 (0)	**$0**
Phrag	$81,100	$851,550 (7)	$7,380,100 (13)	$17,031,000 (7)	$4,055,000 (1)	**$29,317,650**
					Total cost =	**$42,274,520**

Table F-4. Estimated cost for restoration of acreage lost in Peconic Estuary since 1972.

Habitat type	Acres lost	Cost/acre*	Cost to restore acres lost
SAV	?	$15,500	?
TW	115	$75,100	$8,636,500
BD	6	$9,980	$59,880
FW	44	$150,200	$6,608,800
GL	250	$14,600	$3,650,000
EE	?	N/A	?
RMC	?	$125,000	?
IM	?	N/A	N/A
CF	2943	$13,660	$40,201,380
Phrag	N/A	$81,100	?
Total acres =	**3358**	**Total cost =**	**$59,156,560**

* see assumptions in section F-I "Cost Estimates for Restoration of Priority Habitat Types"

3. LONGTERM GOAL SETTING FOR HABITAT RESTORATION

10-Year Restoration Goal:	**All Priority Projects**
Number of priority HRP projects:	18 projects
Habitat acreage accounted for by priority HRP projects:	206 acres
Estimated cost* for priority projects implementation:	$3,760,510
Estimated annual cost for 10-year goal:	$376,051 per year
Annual habitat acreage restored to achieve 10-year goal:	21 acres per year
Total number of HRP projects:	72 projects
Habitat acreage accounted for by HRP projects:	836.5 acres
Estimated cost* for HRP implementation:	$42,274,520
Total acreage lost in the Peconic Estuary since 1972:	3,358 acres
Estimated cost* for restoration of acreage lost:	$59,156,560

References

Cashin Associates. 1996. Peconic Estuary Program final submerged aquatic vegetation study. Prepared for the Peconic Estuary Program. 374 pp.

Long Island Planning Regional Board. 1990. BTCAMP contract work completion, Task 2B6--Changes in environmental resources from 1976 to 1987/88.

Peconic Estuary Program Comprehensive Conservation and Management Plan. In press. Peconic Estuary Program Office, Office of Ecology, Suffolk County Department of Health Services, County Center, Riverhead, NY. Draft-September 1999.

Tiner, R.W., D.B. Foulis, G.S. Smith, J. Swords, S. Schaller, & D. Peterson. 1998. The Peconic watershed-recent trends in wetlands and their buffers. Prepared for the Peconic Estuary Program by the U.S. Fish and Wildlife Service, Ecological Services Unit, National Wetlands Inventory Program, Hadley, MA. July, 1998.

4. GENERIC ESTIMATED COST INFORMATION FOR LISTED PROJECTS

Habitat Type	Site Name	Size (acres)	Estimated Cost/Acre▪
Wetland	Accabonac Harbor Wetlands	0-3	$75,100.00
WQ	Accabonac Harbor Flushing	11-50	n/a
Eelgrass*	Accabonac Harbor Eelgrass	4-10	$15,500.00
Phrag	Accabonac Harbor Phragmites	11-50	$81,100.00
WQ	Accabonac Harbor Road End	0-3	n/a
Alewife	Alewife Brook Alewife Access	0-3	$125,000.00
Phrag	Alewife Brook Phragmites	4-10	$81,100.00
Phrag	Barnes Meadow Phragmites	4-10	$81,100.00
Phrag	Bay Woods	0-3	$81,100.00
Phrag	Broad Cove	4-10	$81,100.00
Phrag	Browns Point	11-50	$81,100.00
Eelgrass*	Bullhead Bay Eelgrass	0-3	$15,500.00
Phrag	Cedar Beach Phragmites	0-3	$81,100.00
Wetland	Cedar/Taylor Island Revegetation	0-3	$75,100.00
Wetland	Cold Spring Pond Wetlands	0-3	$75,100.00
Grassland	Culloden Grassland	0-3	$14,600.00
Eelgrass*	Cutchogue Harbor	0-3	$15,500.00
Wetland	Davis Creek Wetlands	4-10	$75,100.00
Phrag	East Creek	11-50	$81,100.00
Wetland	Fish Cove Wetland Enhancement	0-3	$75,100.00
Wetland	Fleets Neck	0-3	$75,100.00
Wetland	Fort Pond Wetlands	4-10	$75,100.00
Phrag	Fort Pond Phragmites	4-10	$81,100.00
Grassland	Fort Hill Cemetery Grassland	4-10	$14,600.00
WQ	Fresh Pond Flow	4-10	n/a
Phrag	Fresh Pond Phragmites	4-10	$81,100.00
Phrag	Gravel Pit (Dog Ponds)	4-10	$81,100.00
Phrag	Grumman	0-3	$81,100.00
Shorebird	Hicks Island Plover/Tern	4-10	$9,980.00
Phrag	Hog Creek Phragmites	0-3	$81,100.00
Eelgrass*	Lake Montauk Eelgrass	11-50	$15,500.00
Phrag	Lake Montauk Phragmites	0-3	$81,100.00
Phrag	Lake Marion	11-50	$81,100.00
Alewife	Lake Montauk Alewife Access	4-10	$125,000.00
WQ	Lake Montauk Water Quality	>50	n/a
Wetland	Lake Montauk Wetlands	4-10	$75,100.00
Phrag	Linns Pond	4-10	$81,100.00
Phrag	Little NW Creek Phragmites	11-50	$81,100.00
Shorebird	Mill Creek Enhancement Project	11-50	$9,980.00
Phrag	Napeague Phragmites	0-3	$81,100.00
Eelgrass*	Napeauge Eelgrass	4-10	$15,500.00
Wetland	Nassau Point	0-3	$75,100.00

Generic Cost Information Continued…

Wetland	North Sea Wetlands	4-10	$75,100.00
Wetland	North Sea/Alewife Creek Wetlands	0-3	$75,100.00
Phrag	Northwest Creek Phragmites	4-10	$81,100.00
Eelgrass*	Northwest Creek Eelgrass	11-50	$15,500.00
Wetland	Noyack Creek Wetlands	11-50	$75,100.00
Eelgrass*	Noyack Creek Eelgrass	0-3	$15,500.00
WQ	Oyster Pond Water Quality	11-50	n/a
Wetland	Paynes Creek Enhancement Project	0-3	$75,100.00
Eelgrass*	Paynes Creek Eelgrass	0-3	$15,500.00
Phrag	Peconic Seep	11-50	$81,100.00
Phrag	Peconic Edwards	4-10	$81,100.00
Riverine	Peconic Upper Mills	0-3	$150,200.00
Beach	Reel Point	4-10	$9,980.00
Phrag	Reeves Creek	0-3	$81,100.00
Wetland	Sag Harbor Cove/Paynes Creek Wetlands	11-50	$75,100.00
Eelgrass*	Sag Harbor Cove Eelgrass	0-3	$15,500.00
Beach	Sammi's Beach	11-50	$9,980.00
Grassland	Shinnecock Grassland	11-50	$14,600.00
Phrag	Terry Creek	11-50	$81,100.00
Wetland	TGA Easement	4-10	$75,100.00
Eelgrass*	Three Mile Harbor Eelgrass	4-10	$15,500.00
Phrag	Three Mile Harbor Phragmites	4-10	$81,100.00
Wetland	Three Mile Harbor Wetlands	4-10	$75,100.00
Phrag	Tidal Peconic	4-10	$81,100.00
Phrag	Tidal Sawmill Creek	4-10	$81,100.00
Eelgrass*	Upper Sag Harbor Cove Eelgrass	0-3	$15,500.00
Wetland	Upper Sag Harbor Cove Wetlands	0-3	$75,100.00
Phrag	Upper Sawmill Creek	>50	$81,100.00
Beach	Wades Beach	11-50	$9,980.00
Phrag	Warner Duck Farm	4-10	$81,100.00

■ see assumptions in section F-I "Cost Estimates for Restoration of Priority Habitat Types"

* The Habitat Restoration Workgroup (HRWG) believes that the ranks developed for the nominated eelgrass restoration sites using the standard ranking methodology do not accurately predict the best sites for eelgrass transplantation. Field reconnaissance, conducted to gather additional data on sediment type at the nominated eelgrass sites, confirmed this belief. Eelgrass restoration remains a highly uncertain activity, and many aspects of the relationship between site conditions and transplant success are not completely understood. The HRWG presents, for the sake of consistency, nominated eelgrass sites as ranked throughout this plan. However, the high uncertainty associated with eelgrass restoration precludes the Workgroup from advocating a rank order for these sites. Case-by-case analysis of site conditions, selected methods, and project timing must be conducted to accurately assess the potential for success.

APPENDIX D

RESTORATION SITE NOMINATION SOLICITATIONS

APPENDIX E

NOMINATED RESTORATION SITE RANKING WORKSHEET

Site Name: ____

Target Habitat Type:________________________________

Estimated Cost of Restoration:

Site Accessible?

****

Ecological Considerations	**100 points**	**_______/100**

Lost Habitat Value	-30
Endangered Species	-30
The project will negatively impact or eliminate the habitat of an endangered species.	
Threatened Species	-20
The project will negatively impact or eliminate the habitat of a threatened species.	
Special Concern Species	-10
The project will negatively impact or elimiate the habitat of a special concern species.	
Level of Degradation	30
Severe	30
There is little or no ecological function at the site for the habitat to be restored (e.g., 3 feet or more of dredge spoil on a former salt marsh).	
Medium	15
There is limited ecological function at the site for the habitat to be restored (e.g., formerly connected salt marsh).	
Low	5
The ecological functions of the site are present, but the habitat could be enhanced (e.g., parallel grid ditching in a salt marsh).	
Historical Justification	8
Well-documented	8
Photographic, written, and/or field evidence of habitat prior to disturbance or loss.	
Some documentation	4
Anecdotal reports describing the habitat prior to distrubance or loss.	
No information	0
Proposed project size	10
0 to 3 acres	4
3 to 10 acres	5
10 to 50 acres	7
>50 acres	10
Habitat contiguity/Adjacent land use	20

complete contiguity with protected areas	20
partial contiguity with protected areas	15
complete contiguity with undevel. areas	8
partial contiguity with undevel. areas	4
no contiguous habitat	0
unabated impacts from adj. land uses	-10

<u>Target restoration functions (additive) 5</u>

nutrient retention 1

Proposed restoration will contribute to a reduction in or assimilation of nutrients.

species diversity 1

Proposed restoration will increase species diversity.

groundwater protection 1

Proposed restoration will aid in groundwater recharge or contaminant abatement.

food chain support 1

Proposed restoration will contribute or enable the transfer of energy into a food chain.

fish/wildlife corridor 1

Proposed restoration will facilitate the movement of fish/wildlife through the site.

<u>Promotes habitat diversity in the landscape 6</u>

yes 6

The proposed restoration will increase or maintain habitat types that are being degraded or lost in the region.

<u>Provides benefit to state-listed species 16</u>

Endangered species 16

The proposed restoration is of a type required in some way by an endangered species.

Threatened species 12

The proposed restoration is of a type required in some way by a threatened species.

Special concern species 8

The proposed restoration is of a type required in some way by a species of special concern.

<u>In/adjacent to State or locally designated areas 5</u>

yes 5

Such designations include NYS DOS SCFWH and LWRPs

Logistical Considerations	**100 points**	**____/100**

<u>Ownership</u>	<u>18</u>
Public	18
Private/acquired	12
Private/easement	12
Private/no protection	Put in separate pile
<u>Relationship to larger planning efforts</u>	<u>10</u>
yes	10
The proposed restoration has been identified by some local, regional or Federal planning effort.	
<u>Current stage of planning</u>	<u>17</u>
Permits obtained or pending	17
Planning completed	12
A survey and plan have been completed, no permits have been obtained	
Planning underway	6
No surveys or written plan have been accomplished.	
<u>Funding process</u>	<u>10</u>
Some funding committed/leveraged	10
<u>Probability of success</u>	<u>25</u>
Knowledge & technology high	25
Proposed restoration methods are of a type commonly undertaken and normally successful.	
Knowledge & technology medium	13
Proposed restoration methods are of a type occasionally undertaken and sometimes successful.	
Knowledge & technology low	0
Proposed restoration methods are of a type rarely undertaken and rarely successful.	
<u>Community & User group support</u>	<u>5</u>
Significant support	5
One or more groups (other than that nominating the site) have voiced support or endorsed the proposed restoration project.	
No opposition	0
No support or opposition evident regarding the proposed restoration.	
Significant opposition	-5
Strong opposition by one or more groups or individuals which could likely delay or prevent the proposed project from being initiated or completed.	
<u>Post-restoration maintenance</u>	<u>15</u>

No maintenance required *The proposed project would not require any regular maintenance to succeed.*	15
Minor maintenance required *The proposed project would require at least periodic maintenance during the first year to succeed (e.g., maintenance of exclosure fencing around plantings during the first growing season, or fish ladder maintenance).*	10
Major maintenance required *The proposed project would require regular maintenance to be successful (e.g., regular mowing, burning, or removal of invasive species).*	0

Public/Economic Benefit Considerations 50 points ____/50

Enhances public access & awareness (additive)	10
Enhances appropriate public access *The proposed restoration improves access to a habitat or site which can support the presence of the public on a regular basis.*	5
Enhances public awareness of the resource *The proposed restoration includes specific provisions for education and public outreach about the habitat.*	5
Enhances commercial & recreational uses	20
Historical, low impact uses *The proposed restoration would help to support or enhance resources which have historically been harvested or utilized in a low impact way (e.g., small scale shellfishing, herring runs).*	20
New, low impact uses *The proposed restoration would help to support or enhance resources which have not historically been harvested or utilized and will not result in significant impact to the environment (e.g., kayaking, birding).*	15
Medium impact uses *The proposed restoration would help to support or enhance resources which an be harvested or utilized in a way that has some impact to the environment (e.g., cumulative impacts of multiple uses).*	5
New, minor infrastructure required *The proposed restoration would help to support or enhance a previously unused resource which would require the construction of minor infrastructure which will have some impact on the site (e.g., boardwalk, observation platform).*	1
New, major infrastructure required *The proposed restoration would help to support or enhance a previously unused resource which would require the construction of major infrastructure which will have a significant impact on the site (e.g., parking lot, boat ramp, bathrooms).*	-10
Benefit to recreational & commercial species	20
Direct benefit to 2 or more species	20
Direct benefit to 1 species	10
Indirect benefit to any species of this type	2

APPENDIX F

RESPONSE TO COMMENTS RECEIVED ON DRAFT PLAN

HABITAT RESTORATION WORKGROUP RESPONSES TO COMMENTS RECEIVED ON THE JULY 15, 2000 DRAFT HABITAT RESTORATION PLAN

Comment 1: *Phragmites australis* is much more valuable to the estuarine ecosystem than was previously thought.

Response 1: Agreed. The HRP notes new research findings to this effect in Section Nine. The HRWG has also supplemented this section with additional references.

Comment 2: Restored marshes may take many years to approach the level of function and biotic diversity associated with natural marshes. Given this, and assuming reasonably comparable function and biotic use of *Phragmites australis*, should we still embark on "restoration" of *Phragmites* sites?

Response 2: The HRWG supports evaluating *Phragmites australis* control projects on a case-by-case basis. In evaluating the nominated *Phragmites australis* control sites listed in this plan, the HRWG took into account a variety of factors. Of primary concern to the Workgroup was the likelihood of success of the control effort and the degree of maintenance required post-project. *Phragmites* control projects in brackish or freshwater environments were rated as having a low likelihood of success. All *Phragmites* control projects were rated as requiring high post-project maintenance. In addition, the HRWG took into account adjacent land uses and unmitigated impacts to nominated sites, both factors affecting the likelihood of success. At highly disturbed sites without the possibility of regular, saline inundation, leaving *Phragmites* stands alone was generally considered preferable to attempting restoration.

Comment 3: The responsible party for each of the 16 restoration actions outlined in the HRP is unclear.

Response 3: The 16 restoration actions covered by the HRP and outlined in Section Two were provided to the HRWG by the PEP Management Conference through its Comprehensive Conservation Management Plan (CCMP). Additional information, including responsible parties, on each and every action is provided in that document.

Comment 4: The HRP seems to suggest that each municipality is responsible for implementing its own projects.

Response 4: Agreed. Each municipality is responsible for implementing its own restoration projects.

Comment 5: The HRP does not specify the dollar amount per project for listed projects.

Response 5: Most of the projects nominated to the HRWG have not completed planning and design work. It is not possible to make accurate cost determinations without this information. It would be inadvisable to make project-specific cost estimates prior to project readiness and fix them in print in the HRP. If specifications of a project change during planning or design, or if market values of project elements change, the printed estimate will no longer be accurate and may hinder municipal applications for funding.

The HRWG has provided estimated costs for a generic habitat restoration project in each priority habitat type in the Peconic Estuary in Appendix C. The estimated cost for implementation of high-priority HRP projects is also provided in Appendix C.

Comment 6: The HRP outlines a series of restoration methods for each habitat type, and it is difficult to determine which approach is best for each restoration project. The HRWG should recommend the specific method or methods most feasible and least disruptive to the Peconic Estuary for each restoration site.

Response 6: It is not possible or advisable to specify methods to the degree requested for each project site listed in the HRP. First, since each municipality is responsible for implementing its own restoration projects, it therefore has the right to determine the restoration methodology that is most efficient, effective, and economical for its project and its municipal goals. Second, many of the projects nominated to the HRWG have not initiated site investigation and planning and the requested degree of specificity regarding methodology is therefore not possible. For listing in the HRP, sites were evaluated largely on their potential for restoration using best professional judgement and knowledge of site conditions, project goals, and acceptable restoration methods. The HRP outlines the most feasible and least disruptive restoration techniques for each priority habitat type in the Peconic Estuary. This information should assist municipalities in selecting site-specific methods once site investigations and project planning are complete.

Comment 7: For eelgrass restoration projects, a case-by-case analysis of site conditions, selected methods, and project timing should be conducted to assess their potential for success.

Response 7: Agreed. Please refer to Section Five of the HRP for the Workgroup's position on eelgrass restoration. Conducting the case-by-case analysis as suggested requires substantial field work and is outside the purview of the HRWG. Municipalities are encouraged to conduct such an analysis and consult the information in the HRP prior to undertaking any eelgrass restoration planning.

Comment 8: It would be useful to map existing eelgrass beds as a baseline to provide target acreage for eelgrass restoration.

Response 8: Agreed. This is an ongoing initiative of the PEP. Please refer to the CCMP for additional information.

Comment 9: It is not clear in the HRP how municipalities will obtain the necessary funding to conduct their habitat restoration projects.

Response 9: Section Thirteen of the HRP provides a table of potential sources of habitat restoration funding. The HRWG verified all information in the table prior to inclusion in the document. Each municipality is responsible for implementing its own restoration projects. The HRWG, or an analagous group within the PEP, will continue to assist municipalities in locating appropriate sources of funding for habitat restoration projects.

Comment 10: Habitat restoration projects that are appropriate for large scale use of volunteer labor should be promoted.

Response 10: Section Twelve of the HRP is devoted to volunteer-based restoration and monitoring projects.

Comment 11: A comprehensive, integrated monitoring plan for the HRP to assist in reporting on progress and identifying whether the program has achieved measurable environmental results needs to be developed. The monitoring plan must also articulate a data management system for monitoring information.

Response 11: The HRWG strongly recommends that monitoring programs be developed in conjunction with each restoration project. Please refer to Section Fifteen of the HRP for recommendations on project monitoring. This section also proposes a GIS restoration project database to be housed in the PEP Program Office. Development of the HRP itself is an action specified by the PEP CCMP, and information on tracking progress and effectiveness of all CCMP actions may be found in that document.

Comment 12: There should be standardized monitoring protocols for each habitat type.

Response 12: Agreed. Such protocols are not currently available. Appropriate, standardized protocols that exist at the time of publication are referenced in Section Fifteen.

Comment 13: How is the Section Sixteen: Completed Restoration Project Inventory and Abstracts related to the identified restoration sites presented in Tables One and Two?

Response 13: The HRWG wanted to document habitat restoration work already underway in the Peconic Estuary to assist others in planning, designing, and implementing their own projects. Information about discrete completed or ongoing projects is presented in Section Sixteen. The projects listed in Section Sixteen are different than projects listed in Tables One and Two. Some waterbodies or sites proposed for work in Tables One and Two have already had restoration work done and are also listed in Section Sixteen. When a waterbody or site location is listed in Section Sixteen, this does not mean all possible restoration work has been accomplished. The Section Sixteen inventory documents discrete projects and is not meant to suggest that additional restoration work is unnecessary.

Comment 14: The map showing PEP potential restoration sites is unclear. The map should be coded by habitat type.

Response 14: This map is not meant to convey the information requested. It is included to show the geographic spread of potential restoration sites throughout the Peconic Estuary. Information on the habitat types to be restored at each project site is available in Section Five.

APPENDIX G

NATURAL RESOURCES SUBCOMMITTEE MEMBERSHIP

Natural Resources Subcommittee

Susan Antenen, The Nature Conservancy, *Chair*
Matthew Sclafani, New York State Department of Environmental Conservation, *Coordinator*

Rick Balla, United States Environmental Protection Agency, Region Two
Marci Bortman, The Nature Conservancy
Robert Cerrato, SUNY Stony Brook, Marine Science Research Center
DeWitt Davies, Suffolk County Planning Department
Walter Dawydiak, Suffolk County Department of Health Services, Office of Ecology
Tom Halavik, United States Fish and Wildlife Service, Coastal Ecosystems Program
Jeff Kassner, Town of Brookhaven, Department of Environmental Protection
Chris LaPorta, New York State Department of Environmental Conservation
Jack Mattice, New York Sea Grant
Kevin McAllister, Peconic Baykeeper
Lynn Mendelman, Peconic Estuary Program Citizens' Advisory Committee
Nancy Niedowski, New York State Department of State Coastal Program
Robert Parris, United States Fish and Wildlife Service
Larry Penny, Town of East Hampton Natural Resources Department
Greg Rivara, Cornell Cooperative Extension Marine Program
Sam Sadove, Tradewinds Environmental, Inc.
Chris Smith, Cornell Cooperative Extension Marine Program
Alice Weber, New York State Department of Environmental Conservation
Judith Weis, Rutgers University, Department of Biology