SECTION 1: A PRIMER ON MAINE TIDAL WETLANDS[1]

If present and future generations are to use and enjoy the bounty and beauty of healthy tidal marshes, then understanding how they work, protecting them from negative impact, and restoring their ecological integrity is essential. This section presents a basic overview of Maine tidal wetlands, common terms used to describe them, a summary of their ecological functions and societal values, and an argument for their preservation and restoration.

Definition of Tidal Wetlands as used in the *Return the Tides Resource Book*

Tidal **wetlands**[2] can be divided into three broad categories: marine wetlands, estuarine wetlands, and tidal riverine wetlands. **Marine wetlands** are adjacent to or in the open ocean, and include **habitats** such as beaches, mud flats, rocky shores, and headlands. **Estuarine wetlands** include habitats protected from the open ocean but in contact with it, where saltwater from the ocean mixes with freshwater from upland rivers and surface runoff. Salt marshes and mud flats are common estuarine wetlands. **Intertidal riverine wetlands** are vegetated wetlands within a river channel that, while influenced by tides, are beyond the normal reach of saltwater. These are commonly referred to as **freshwater tidal marshes**.

The *Return the Tides Resource Book* focuses on vegetated tidal **marshes** which occur in both estuarine and intertidal riverine wetland habitats, and include salt marshes, brackish marshes and freshwater tidal marshes. The US Fish and Wildlife Service Wetland Classification System (See Appendix C) uses water **salinity** levels to differentiate among these three types of marshes. In the Gulf of Maine, **salt marshes** occur in a range of salinities from that of seawater, about 34 parts per thousand (ppt) of salt, to approximately 18 ppt. **Brackish marshes** are characterized by salinities

[1] This section is adapted from Bryan & Dionne, *Maine Citizens Guide to Evaluating, Restoring and Managing Salt Marshes*. Their permission is gratefully acknowledged.
[1] Terms in **bold face** are defined in the Glossary, Appendix A

ranging from 18 to 0.5 ppt. Freshwater tidal marshes are located where the salinities average less than 0.5 ppt, yet tides still affect water level.

Because wetland plant species vary in tolerance to salinity, marsh salinity is generally identified by the plant species present. In marsh systems with a strong marine influence and limited freshwater input, true salt marsh flora dominate. The flora associated with brackish and freshwater tidal marshes is more common in larger river systems. By learning several of the basic marsh plant species, you will be well on your way to an ability to identify any tidal wetland you encounter.

[[Insert Figure 1- Coastal marsh types (after Mitsch & Gosselink, 1993)]]

Tidal Marsh Formation

Tidal marshes form in low-lying coastal areas that are protected from excessive winds, waves, and currents. Such low energy environments allow for the deposit of sediments suspended in tidal waters. Over time, marsh plant communities develop on this sediment base. Sediment deposition and establishment of tidal marsh plants reinforce one another. Once plants are established, they trap additional sediments, and increased deposits of sediments raise the marsh elevation and expand it. These combined processes lead to the formation of marsh soil or peat made up of mineral sediments (trapped from the water column) and organic matter (derived from partly decayed plant material). This substrate of marsh soils and peat evolves over thousands of years and provides a foundation without which marsh plant communities could not survive. This substrate cannot be artificially re-created, therefore, it is an irreplaceable and unique resource.

[[Insert figure 2 — Tidal Marsh Development Diagram after Dreyer & Niering]]

Sea level has risen along the Maine coast over the past 4,000 to 5,000 years. Throughout this period, salt marshes have maintained themselves at the elevation necessary for plant growth through the accretion of sediments filtered from tidal waters and the slow formation of peat substrates. The two common salt marsh species in Maine are smooth cordgrass (*Spartina alterniflora*)[3], which grows in areas flooded by daily tides, and salt-hay grass (*Spartina patens*), which grows at a slightly higher elevation in less frequently flooded areas. A salt marsh responds to increases in sea level elevations by expanding over adjacent freshwater wetlands and gently sloping uplands, while at the same time it may erode or submerge below the rising low tide line at its seaward edge. This process is known as **transgression**. Thus, marsh areas may grow or shrink depending on rates of sea-level change, sediment input, sheltering, and degree of human interference.

[[Figure 3 - Growth of Wells Marshes (after Kelley et al., 1995)]]

A Note about Tides

Any discussion of tidal marshes necessarily requires reference to the tides. Anyone who has spent time on the coast of Maine is aware of the tides. We present a brief discussion of basic tide terms and concepts.

Tides are caused primarily by the gravitational influence of the moon and sun on the waters of the oceans (Because it is much closer, the moon has about 2.5 times more influence than the sun). In Maine, we have **semi-diurnal** tides: there are two high tides and two low tides each lunar day of about 24 hours and 50 minutes. Usually there is a **diurnal inequality**: one high each day is higher than the other and one low is lower than the other. Because the lunar day is almost one hour longer than the calendar day, the times of high and low tides are later each day.

The tides vary during the **lunar month** as the relative positions of the sun and moon change. Around the time of full and new moon, the **tidal range** is greatest because the sun and moon are aligned. These tides are called **spring tides** which are both higher and lower than average. About a week after full and new moon, when the moon is in its first or last quarter, the tidal range is at its monthly minimum and the tides are called

[3] For convenience we will cite the scientific (Latin) name of a plant when it is first mentioned, but use the common name thereafter. Common names are from Tiner, *Maine Wetlands and their Boundaries*, available

neap tides. The landward boundary of a tidal marsh is largely determined by the elevations reached by the extreme high tide levels associated with spring tides.

[[Figure 4- Spring And Neap Tide Forces (adapted from*, NOAA, 1999)]]*
[[Figure 5- Spring and Neap Tide Curves]]

Many other factors, such as the inclination of the moon's orbit to the earth's orbit, the distance of the moon from the earth, hydrographic, meteorological and oceanographic factors affect the height of any given tide at any given place.

Working with maps and nautical charts requires an understanding of tidal **datums**. United States nautical charts use **mean lower low water** as the reference level or datums for all soundings. To complicate matters, US Geological Survey topographic maps use **mean low water** as their sounding datum, but show the shoreline at **mean high water**. Surveyors and other government agencies such as the Army Corps of Engineers may use other tidal datums. Similar complexities arise when mapping precise horizontal locations because different charts, maps and GIS systems are referenced to different horizontal reference systems.

[[Insert figure 6- Tide Levels and Datums (adapted from HO chart 1)]]

Tidal **currents** are associated with tide changes. A **flood current** runs as the tide rises or **floods** and an **ebb current** runs as the tide falls or **ebbs**. The current is said to be **slack** during the time it changes direction and runs slowly, if at all.

In the complex channels of tidal marshes, both times and heights of the tide, as well as current speed and direction, are drastically affected by local conditions and may vary significantly from the times, height and speeds at the locations or "**stations**" for which predictions are published. Published predictions are based on typical conditions at the station and can also be significantly affected by local meteorologic, oceanographic and hydrologic conditions.[4]

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from the State Planning Office. See the appendix for more information about plant names, habitat and identification.

[4] Additional information about tides, tidal currents and tidal terms is available from the US National Oceanographic and atmospheric Administration (NOAA) on the Internet at

Important Tidal Marsh Habitats

Tidal marshes are complex systems. Within each marsh there may be a variety of habitats that support different plants and animals. Some of the more important habitat types are described below.

[[Insert figure 7- Marsh Zonation and Marsh Plant Communities after Tiner]]

Low marsh, lying between mean low tide and mean high tide, is flooded twice daily by tidal action. Low marsh typically occurs as a sloping fringe between the high marsh and a tidal creek or mud flat. Smooth cordgrass (*Spartina alterniflora*) is the dominant plant in salt and brackish low marshes.

High marsh is flooded only by above-average tides, usually over a 4-5 day period twice a month by spring tides, and irregularly by storm tides. It is at or just above mean high tide level. Salt-hay grass (*Spartina patens*), and black grass (*Juncus gerardii*) are the dominant plants in most high marshes. In brackish marshes with a strong freshwater influence, plants such as prairie cordgrass (*Spartina pectinata*), narrow-leaved cattail (*Typha angustifolia*) or rushes (*Scirpus sp.*) may dominate. The high marsh is usually substantially level and occurs between the low marsh and uplands.

Pannes are shallow "ponds" that form in the high marsh peat. Flooded periodically by spring tides, pannes provide an abundance of food for waterfowl and migrating shorebirds. . A short form of smooth cordgrass frequently occurs in these areas. Common glasswort, (*Salicornia europaea*) and other non-grassy plants or **forbs** often colonize shallow pannes that dry out. Much of the plant diversity on the salt marsh is associated with these shallow pannes. Deeper pannes that remain water filled may support widgeon grass (*Ruppia maritima*), which is valuable forage for waterfowl.

Tidal creeks, open water, and tidal flats are all-important components of the marsh ecosystem. For the purposes of this book, open water is defined as a permanently

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http://www.opsd.nos.noaa.gov/pub.html, where you can find their publication "Our Restless Tides" and an extensive glossary of terms.

flooded (i.e., below mean low water) water body greater than 100 meters (330 feet) wide. Tidal creeks are less than 100 meters wide at mean low water. Tidal flats are nearly level to gently sloping unvegetated areas located within the intertidal zone. Tidal flats may support commercially significant worm and clam populations.

Classification of Tidal Marsh Systems

Variation in topography, geology, tides, sediment supply, wave exposure, and rate of sea-level rise along the Maine coast lead to the development of different marsh types. The three basic **geomorphologic** types of tidal marshes used in this book are **coastal/back barrier marshes, finger marshes,** and **fringe marshes**. The three marsh types can be determined visually from maps and are described and illustrated below.

[[Insert Figure 8- Marsh Geomorphology (after Bryan & Dionne, 1997)]]

<u>Coastal/Back Barrier Marshes</u>

- associated with barrier beaches
- most common west of Sheepscot Bay
- marshes are located adjacent to the Atlantic coast and have direct access to the ocean
- dominated by high marsh
- marshes in Scarborough and Wells are notable examples of coastal/back barrier marshes

<u>Finger Marshes</u>

- area of high marsh is large compared to size of channel
- elongated marsh follows long axis of channel
- The Back River tidal marsh being restored on the north side of Route 1 in Woolwich is a noteworthy example of a finger marsh.

<u>Fringe Marshes</u>

- found along protected shoreline in estuarine reaches and rivers (coves, indentations, small tributaries, meanders) or at the toe of eroding bluffs

- limited development of high marsh
- strongly influenced by ice erosion; also affected by erosion from river flow and waves
- often bordered by mud flats
- The shorelines of the York River that can be seen from the Maine Turnpike are good examples of fringe marshes.

Depending on salinity levels, a range of plant communities may be found within each geomorphologic type. Moving along the main marsh channel from the inlet to the **head of tide**, salinities decline, and tidal salt marsh grades to tidal brackish marsh, and freshwater tidal marsh. Freshwater tidal marshes experience daily tidal flushing, as do salt marshes, but are dominated by freshwater plants.

Distribution of Tidal Marshes on the Maine Coast

Researchers at the University of Maine and the Maine Geological Survey have determined that Maine's convoluted shoreline, approximately 5,970 km (3,700 miles)[5] in length, contains over 79 km^2 (19,500 acres) of salt marsh, far more than any other New England state, New York, or Canadian province on the Gulf of Maine (Jacobson et al. 1987). In reviewing the distribution of tidal marshes, these researchers found the geologic setting and abundance of marshes varied among four broad coastal regions. The following descriptions are based on the work of Jacobson et al. (1987):

Sandy barrier beaches behind which extensive coastal/back barrier marshes have developed characterize the southwest coast (the Arcuate Embayment Complex) from Kittery to Cape Elizabeth. Although comprising a relatively short segment of the Maine coast, approximately 34% of the state's salt marshes are found in this area.

The peninsulas and islands from Cape Elizabeth to Spruce Head (the Indented Shoreline Complex) provide protection from wind and waves, thus allowing extensive salt marsh development. Approximately 35% of the state's tidal marshes are found in this region. The shoreline is highly convoluted and is dominated by narrow indented embayments and tidal rivers, with many fringe marshes and finger marshes. There are

[5] More recent, GIS analysis has yielded a coastal shoreline length of 4,568 miles. When the shorelines of 4,617 islands are included, the coastal shoreline is 7,039 miles. (Conkling, 1999)

also notable barrier beaches and back barrier marshes near the mouth of the Kennebec River in Phippsburg and Georgetown. Extensive brackish marshes occur in the Kennebec River estuary, and the majority of the state's freshwater tidal marshes are found in Merrymeeting Bay and its tributaries.

The Island-Bay Complex extends from Spruce Head to Cross Island, including Machias Bay. This region is more exposed to wind and waves, and there are fewer rivers to provide the sediment needed for marsh accretion. Thus, only 26% of the state's marshes are found in this extensive region. Most of them, approximately 16.5 km^2 (4,000 acres) are found in the estuaries associated with the Penobscot, Pleasant, and Narraguagus Rivers. Fringe and finger marshes predominate; coastal back barrier marshes are limited to occasional small pockets behind a few sandy beaches.

The area from Cross Island to the Canadian border is known as the Eastern Cliff Shoreline. Erosion-resistant bedrock and few rivers offer limited protection and sediment supply for marsh development. Only 5% of the state's tidal marshes are found in this region, with most of these in Cobscook Bay.

[[Insert Figure 9- Maine Coastal Marsh Distribution (after Bryan & Dionne, 1997)]]

Maine salt marshes can also be divided into two categories based on differences in their plant communities. Marshes south and west of Penobscot Bay, including Scarborough Marsh in Cumberland County and the York County marshes near Wells are similar to marshes in Southern New England. Well-defined high and low marsh zones that are dominated by smooth cordgrass and salt-hay grass, respectively, distinguish these marshes.

The marshes in Penobscot Bay and eastward are affected by the larger tidal range and shorter growing season of the area and are similar to the Fundy type of marsh found in New Brunswick and Nova Scotia. Although less than a third of the State's marsh is along this shoreline, there are more individual marsh units here than in the rest of the state. Eastern Maine marshes have a less distinct high/low marsh zonation. Smooth cordgrass is found in patchy stands along creeks on tidal channels, interspersed with a mixed community which includes black grass, red fescue (*Festuca rubra* L.), Baltic Rush

(*Juncus balticus*) and creeping bentgrass (*Agrostis gigantea Roth.*). The transition between low and high marsh is indistinct. The high marsh is flat overall, but has many slight rises, depressions and pannes. Principal high marsh plants in this area are salt-hay grass, quackgrass (*Agropyron repens*), red top (*Agrostis alba*), black grass, seaside arrow grass (*Triglochin maritima*) and Baltic rush. Uniform stands of black grass and Baltic rush are common, often in slight depressions. Fundy type high marshes have much more diverse vegetation than Southern New England type high marshes that typically are dominated by salt-hay grass.

Studies of southeast coastal Nova Scotia marshes have identified four distinct plant zones dominated by smooth cordgrass, salt-hay grass, chaffy sedge (*Carex paleacea*) and Baltic rush, between tidewater and upland. Although marshes on Mount Desert Island do not show such distinct zonation, these species are all present there as well. (Calhoun, 1994)

Ecological Functions and Societal Benefits of Tidal Marshes

Tidal marshes can be described in terms of the ecological functions they perform and the societal benefits they offer. Some functions and benefits, such as wildlife habitat and recreation/tourism, are closely related.

Ecological Functions of Tidal Marshes

Tidal marsh ecosystems are formed and persist through a combination of geological, hydrological and biological processes or functions. Several of these functions can be described in light of the tangible benefits they provide to the human community, directly or indirectly. These functions include:

- **Shoreline Anchoring** - The accretion of peat and sediment in the marsh maintains marsh elevation as sea level rises, and buffers the upland shoreline against the erosive action of open water waves and currents.
- **Storm Surge Protection** - The resistance to water flow presented by marsh vegetation slows the movement of water over the marsh and reduces erosion from storms. The marsh vegetation also encourages the deposit of sediments suspended in the water column onto the surface of the marsh.

- **Water Quality Maintenance** - Pollutants often enter aquatic systems attached to sediment particles. Many of these particles are deposited on the marsh, limiting their movement to other ecosystems. Nutrients in the water are taken up by the vegetation, buffering the discharges of these nutrients into shallow coastal waters where they might encourage blooms of nuisance algae. Other pollutants may bind with marsh soil particles and become unavailable for uptake by plants or animals.
- **Wildlife, Finfish, and Shellfish Habitat** - The rapid growth rates of salt marsh grasses form the base of a highly productive food web. A diverse animal community, including many species of birds, finfish, shellfish and other invertebrates, uses salt marshes for food and shelter, spawning and nursery areas, and sanctuary from ever-present predators. The link between salt marsh productivity and the health of the Gulf of Maine remains to be studied, but in some parts of the United States well over 50% of the productivity of the near shore marine system is tied to the adjacent estuary systems. It is likely that coastal marshes are important contributors to the productivity of the greater Gulf of Maine ecosystem.

[[Insert figure 10- Maine Marsh Bird List }}

These ecological functions have a tremendous economic value. Two-thirds of commercial shellfish and finfish landed in the US depend on coastal wetlands for nursery and breeding habitat or on forage fish that breed in our coastal wetlands (Gosselink et al. 1974). The estimated total income for the harvest and processing of finfish and shellfish in Maine in 1997 was $653 million, resulting in twenty-two thousand jobs (Sheehan 1999). Recreational fishing, hunting, wildlife watching, and boating in coastal wetlands also contribute significant economic value.

[[insert Figure 11- Marsh and Estuary Food Pathways (after Dreyer & Niering, 1995)]]

Societal Benefits of Tidal Marshes

Humans have depended on Maine tidal marshes for millennia. Native Americans harvested birds, fish and shellfish from tidal marshes for thousands of years. In historical times, uplands adjacent to salt marshes were preferred sites for European settlement. The early colonists harvested the animals of the marshes, and, in a region dominated by extensive forest, used marsh grasses as fodder for their livestock. By 1650, 34 communities had been established near marshes in Massachusetts and Maine (Nixon 1982), including most of the present day coastal towns from the south shore of Boston north to Portland.

During the late 19th century period of industrialization and urbanization, people ceased to value tidal marshes as a natural resource. Coastal marshes were filled, restricted or blocked from the tides when railroads and highways were developed to satisfy society's desire for high-speed travel. Concurrently, development of harbors, wharves and other shoreside projects often led to dredging or filling to create land or to use as dumps.

Before mosquitoes were identified as disease carriers, the marshes themselves were often viewed as unhealthy places that caused "damps" and "miasmas". When mosquitoes were recognized as the disease-bearing vectors, marshes became feared as their breeding and were destroyed in the name of public health by being filled or drained by "mosquito ditches"[6].

Many tidal marshes were damaged or destroyed by development projects after World War II as people moved to the coastline for commerce and recreation. Only in the 1960's, as the new discipline of ecology produced detailed studies of marsh functions, did society come to a renewed awareness of the value and productivity of salt marshes. With this new knowledge, people began to appreciate salt marshes and to preserve and restore the marshes that had not been destroyed.

Today, the ecological and societal benefits of healthy tidal marshes are recognized. Tidal marshes offer opportunities for bird watching, canoeing, sport fishing, hunting and other kinds of recreation. Salt marshes are the principle native grasslands of coastal New England. Open, verdant expanses and coastal vistas also provide aesthetic pleasure. As ecosystems that have maintained themselves for thousands of years, they provide excellent outdoor classrooms for the teaching of basic ecological concepts. Many salt marsh sites are noteworthy for their importance in the history and pre-history of New England human culture.

Societal benefit include:

- **Recreational and Commercial Potential** - The use of tidal marshes for hunting, fishing, boating, birdwatching, clamming or similar activities;
- **Aesthetic Qualities** - The appearance of the tidal marsh and its contribution to the visual landscape of a community as green space or open space in a developed area;
- **Educational Potential** - The use of tidal marshes as a field trip sites or outdoor science laboratories for schools and other groups, such as research sites for endangered species habitat.

Threats to Tidal Marshes

Many of Maine's salt marshes have persisted in approximately the same sites for up to 4,500 years, demonstrating remarkable resilience throughout their geologic history. However, in the 300 to 400 years since European colonization, humans have used tidal marsh ecosystems in ways that have altered the basic geological, hydrological and biological processes that sustain their ecological integrity.

The bounty that once was harvested from Maine coastal marshes has declined significantly. Many of the tidal marsh shellfish beds in the state are closed due to poor water quality. Road and dam construction along the coast has severely altered many marshes. Over-fishing in the near coastal waters has depleted stocks of nursery fish. The numbers of ducks and shorebirds that frequent tidal marshes are a small fraction of the tremendous flocks of migrating birds that European colonists found when they

[6] One of the great ironies of marsh management is that the mosquito control measures of ditching often aggravated the abundance of mosquitoes by insulating their water-borne larvae from fish predators. Reflooding of formerly ditched marsh has often been accompanied by a decline in mosquito populations.

arrived in North America. Marshes and inlets that were dammed for ice ponds and for tide mills no longer contribute to the marine environment

Human activities can affect the functions, values and ecological integrity of tidal marshes negatively. Freshwater tributaries can be diverted, dammed, or channeled, greatly altering the seasonal flow of fresh water and sediments to the marsh. This can affect salinity levels and alter habitat sustainability of saline-sensitive species of plants, fish, and other animals. Shorelines of tributaries and marshes may be extensively developed, as buildings, parking areas, roads and lawns replace forest and pasture. This leads to dramatic changes in the pattern and quality of freshwater runoff, including increased sediment and pollutant loads, and larger "pulses" that follow rains or snow melts. Bluffs, beaches and inlets may be stabilized with sea walls and jetties that reduce the amount of sediment available for marsh accretion. Filling and dredging have reduced salt marsh area, while ditching has altered tidal marsh hydrology and ecological function. Fill for roads and railroads, culverts, tide gates and dams fragment tidal marshes, interfere with normal tidal flow, and adversely affect water and soil quality. Bridge openings may not be wide enough to allow full flow of the tide, culverts may be undersized or perched too high to allow flow at low tide levels.

Like tourniquets on a leg or arm that cut off the flow of vital blood to the limb, these restrictions limit or prevent vital salt water from reaching portions of the marsh. The more tidal restrictions in an estuary, the more the hydrology of the marsh is altered, until marsh grasses die back, marsh water and soil chemistry changes, marsh peat degrades, and marsh elevation subsides. Areas of healthy high and low salt marsh affected by tidal restrictions are often invaded by pest plants such as purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis),* and narrow-leafed cattail *(Typha angustifolia)* or may be transformed into mudflat, salt panne, fresh marsh or upland. These changes in vegetation or marsh type have profound effects on the original ecological function and societal benefits of the salt marsh. In addition to reducing the tidal range, crossings can reduce access to tidal marshes by estuarine and marine organisms. Reduced access prevents use of the affected marshes by important bottom-tier food chain fish species, such as mummichogs (*Fundulus heteroclitus).* Culverts that are too long can be a problem for some migratory fish and other aquatic species that need light for passage. Some culverts are poorly designed and sit well above the level of the low tide line, which prevent full draining of the marsh and act as barriers to passage of organisms during much of the tidal cycle.

A vital life-support function for the food web of estuarine and marine environments, the exchange of organic matter and nutrients between salt marsh and estuary, is reduced or eliminated where tidal exchange is restricted or cut off by a culvert, tide gate, or dike. In New Hampshire, 20% of existing coastal marshes have been degraded by tidal restrictions (USDA SCS, 1994), and this figure is probably similar for large sections of the Maine coast, especially west of the Kennebec River.

High marsh habitats have been ditched for mosquito control, or more commonly, in Maine, for salt hay production. Extensive ditching can alter a marsh's natural hydrology, in some cases causing excess drainage and in others trapping water behind ditch spoils. These alterations encourage spread of invasive plants and reduce the high marsh's water exchange with tidal creeks and with the larger marine environment.

Finally, sea levels are rising worldwide.[7] Rising sea levels and the engineered armor of concrete seawalls or boulder fields created by residential and commercial developments that extend into the intertidal zone to prevent erosion, pose threats to the future of tidal marshes. Daily tidal cycles are critical to the maintenance of natural tidal marshes because flooding waters bring salt, sediment, and nutrients, and ebbing waters flush the marsh and allow marsh grasses to thrive. Through these processes, peat accumulates and marsh elevations keep pace with rising sea levels. Our oldest marshes, approximately 4,500 years old, have built a layer of peat up to 6 meters thick (about 20 feet) in response to an equivalent rise in sea level. During past periods of rising sea levels, marshes have kept pace by expanding into newly flooded areas. Today, extensive commercial and residential development along our coast makes the natural landward expansion of tidal marshes into adjacent, low-lying, developed areas problematic. Decisions will have to be made that weigh the benefits of tidal marshes against the loss of private property. As sea levels continue to rise, large areas of tidal marsh could be lost if development impedes landward movement of marshes. Marshes need sufficient sediment to grow vertically and horizontally. If adequate sediment is not

[7] For more information on the effects on Maine of global warming, a primary cause of sea level rise, see Habitat, the Journal of the Maine Audubon Society, Fall 1999, v. 16 no. 4.

available, the increased duration of flooding that accompanies sea level rise could result in the loss or dieback of tidal marshes, with dramatic changes in ecosystem functions and benefits.

Tidal marshes that have been completely lost because of dredging, draining or filling may never be replaced. However, many remaining acres of marsh in Maine, which have been degraded as the result of human activities, can be restored. Tide gates and dams can be removed, existing culverts can be added, enlarged or re-engineered to restore tidal flushing. Buffers and catch basins along highways and large paved areas that are adjacent to marshes can be installed to help restore natural runoff patterns. Tidal ditches that once drained the marsh can be plugged to restore natural hydrology. These measures help reverse the process of marsh degradation, allow the recovery of salt marsh plants and formation of peat substrate.

Although outright destruction, filling and dredging of tidal wetlands are now virtually prohibited by law, incremental and unauthorized activities need to be prevented. Vigilant and thoughtful defense of existing marshes is critical to their preservation, but prevention alone is not enough. With creative and effective restoration and management, marshes can recover their important role in the functioning of the larger ecosystem. The purpose of this book is to help local groups and individuals evaluate threatened and degraded marsh systems in their areas, establish priorities for restoration, and learn about funds and in-kind services that are available from federal and state agencies for this important work.