CHARTING THE COURSE:

A Blueprint for the Future of Aquatic Habitat Restoration in Massachusetts

Report of the
Aquatic Habitat Restoration Task Force

January 2008

AQUATIC HABITAT RESTORATION TASK FORCE

Members

Bruce Carlisle (Chair), Assistant Director, Office of Coastal Zone Management

Mike Armstrong, Program Manager, Recreational and Anadromous Fisheries, Division of Marine Fisheries, Department of Fish and Game

Kathy Baskin, Water Policy Director, Executive Office of Energy and Environmental Affairs

Alison Bowden, Freshwater Program Director, Massachusetts Field Office, The Nature Conservancy

Hunt Durey, Manager, Wetlands Restoration Program, Office of Coastal Zone Management

Brian Graber, Associate Director, Restoring Rivers Initiative, Northeast Region, American Rivers

Bill Hubbard, Chief, Evaluation Branch, U.S. Army Corps of Engineers; Representing Coastal America and federal agencies

Joan Kimball, Director, Riverways Program, Department of Fish and Game

Lealdon Langley, Director, Wetlands and Waterways Program, Department of Environmental Protection

Dennis Lowry, Wetlands Ecologist, ENSR International; Representing the Massachusetts Corporate Wetlands Restoration Partnership

Kerry Mackin, Executive Director, Ipswich River Watershed Association

E. Heidi Ricci, Senior Policy Analyst, Mass Audubon

Alternates

Priscilla Chapman, Watershed Advocate, Mass Audubon (for Heidi Ricci)

Jessica Darling, Program Coordinator, Ipswich River Watershed Association (for Kerry Mackin)

John Kick, Resource Conservationist, Massachusetts Office, Natural Resources Conservation Service; Representing Coastal America and federal agencies (for Bill Hubbard)

Beth Schreier, Resource Conservationist, Massachusetts Office, Natural Resources Conservation Service; Representing Coastal America and federal agencies (for Bill Hubbard)

Matt Schweisberg, Manager, Wetlands Protection Unit, Region 1, U.S. Environmental Protection Agency; Representing Coastal America and federal agencies (for Bill Hubbard)

Mike Stroman, Program Chief, Wetlands Program, Department of Environmental Protection (for Lealdon Langley)

Michael Toohill, Restoration Ecologist, ENSR International; Representing the Massachusetts Corporate Wetlands Restoration Partnership (for Dennis Lowry)

Laura Wildman, Director of River Science, American Rivers (for Brian Graber)

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A number of people shared their insights and experiences in aquatic habitat restoration, provided suggestions to the group, and pledged future assistance. These individuals were Henry Barbaro (Environmental Division, Massachusetts Highways Department), Todd Fontanella (Executive Office of Transportation, Public Works), Bob O'Conner (Land and Forest Conservation, Executive Office of Energy and Environmental Affairs), Bill Salomaa (Office of Dam Safety, Department of Conservation and Recreation), Liz Sorenson (Area of Critical Environmental Concern Program, Department of Conservation and Recreation), Emily Sullivan (Northeast Massachusetts Mosquito Control and Wetlands Management District), and Dale Young (Natural Resources Damages Program, Executive Office of Energy and Environmental Affairs).

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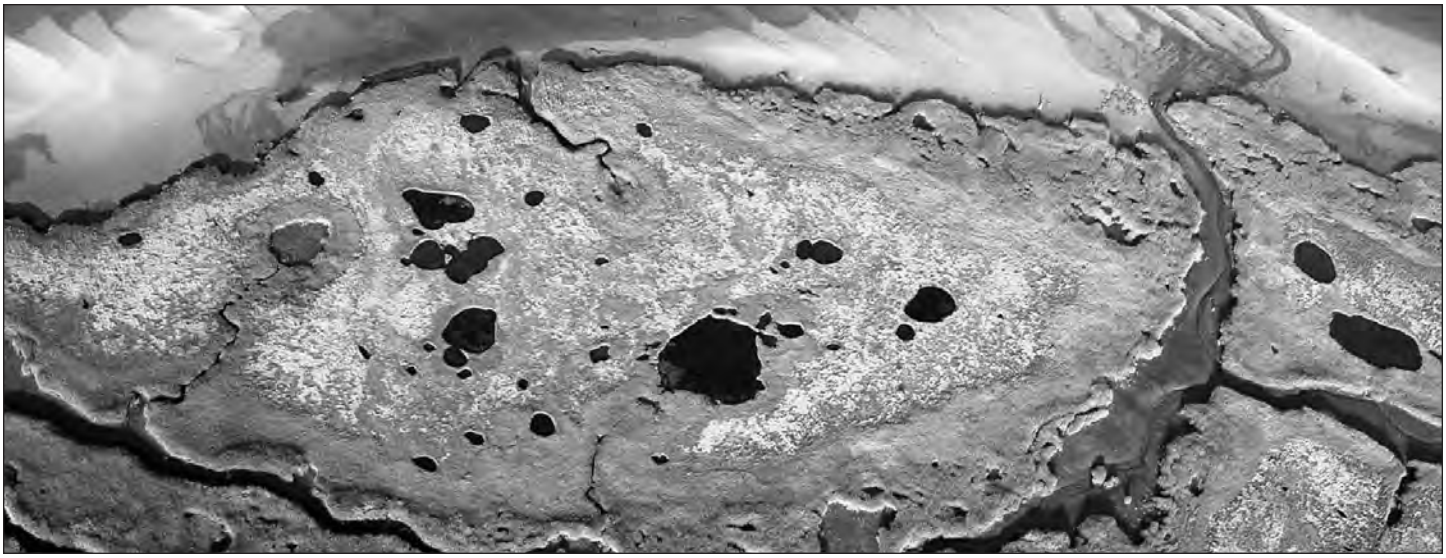


Photo: Stephen Gersh

Massachusetts is a leader in aquatic habitat restoration—but while significant success has been achieved, tremendous opportunities remain.

SECTION 1 - INTRODUCTION

MASSACHUSETTS HAS ALWAYS BEEN A LEADER. The image of our early patriots helping to create a new nation is part of the character of the Commonwealth. That leadership has created great prosperity and quality of life—but at a price. The industrial, commercial, and residential development that both supported and resulted from Massachusetts's growth also had the unintended consequence of widespread habitat alteration, degradation, and loss.

Massachusetts is also an environmental leader—consistently demonstrating this leadership through deliberate policies and actions that protect and conserve our natural heritage. Recognizing the great value of aquatic resources, such as wetlands, rivers, lakes, and ponds, Massachusetts was the first state in the country to develop laws protecting these areas and the public interests they provide.

Massachusetts leads in land conservation as well. From the early acquisition and planning efforts of Charles Eliot, Frederick Olmsted, and the Trustees of Public Reservations (now the Trustees of Reservations) to Governor Patrick's recent announcement of $50 million annually over five years, large land areas throughout the state are set aside to remain as undeveloped landscapes for generations to come.

While existing laws and programs conserve and protect many natural resources and landscapes, there is now a clear need to go beyond these measures—to restore our damaged aquatic habitats. Restoration is the logical third element of an integrated approach to environmental management—protect, preserve, and restore. Over the past two decades, the Commonwealth has made great strides in this area, reversing the damage of the past. But while considerable successes have been achieved, significant needs and opportunities remain. To effectively move forward, leadership and strategic investment are required.

Our growing awareness of global climate change adds even greater urgency to the need to undo past damage through habitat restoration and to develop proactive adaptation strategies. Potential climate change impacts include: flooding as aging dams and other infrastructure are stressed by increased precipitation; rising ocean levels leading to shoreline erosion and the inundation of fragile estuaries and marshes; increasing salinity levels of freshwater habitat and drinking water supplies; and the loss of critical nursery habitats for fish. Aquatic habitat restoration is a key component to increasing ecosystem resilience—reducing the vulnerability of humans, ecosystems, infrastructure, and the economy to climate change impacts.

In recognition of these challenges, the Aquatic Habitat Restoration Task Force was formed to create a blueprint for the future of restoration in Massachusetts. On May 30, 2007, Executive Office of Energy and Environmental Affairs (EOEEA) Secretary Ian Bowles announced the formation of the Task Force while overlooking the North Shore's Great Marsh during an event at The Trustees of Reservations' Crane Estate. He charged the Task Force to chart a course in aquatic habitat restoration for the next four years and beyond.

To obtain a broad and balanced assessment, the Task Force was formed with equal representation from government agencies and non-government organizations. (See the inside front cover of this report for a list of the Task Force members and their alternates.) Starting on August 2, 2007, the Task Force met six times over a four-month period. At these meetings, a number of guests came to share specific experiences, insights, and ideas.

At the first meeting, Task Force members identified the highest priority opportunities and challenges for aquatic habitat restoration in the Commonwealth. The themes that emerged from that meeting were: restoration policy, restoration capacity, inter-agency coordination, regulatory streamlining, new partnerships and funding opportunities, and collaboration with infrastructure agencies. At the next four meetings, the Task Force engaged in extensive deliberations on these themes and developed specific recommendations. The Task Force agreed to define aquatic habitat restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed," as defined in the Society

Photo: Tim Watts

for Ecological Restoration International Science and Policy's 2004 publication, *The SER International Primer on Ecological Restoration*. (See Appendix A for the definition and attributes of aquatic habitat restoration.)

At the last meeting, and through additional conversations and correspondence, the Task Force reviewed the draft recommendations, revised and refined them, and acknowledged consensus. The report presented here is intended to guide the efforts of EOEEA and its partners to achieve greater restoration results for our communities and to ensure the Commonwealth's position as a national leader for habitat restoration in the decades ahead.

THIS REPORT IS ORGANIZED AS FOLLOWS:

• Section 2 provides an overview of the history of aquatic habitat degradation and destruction, discusses the overall value of these habitats, and describes the aquatic habitats that have been the focus of restoration efforts in Massachusetts (salt marshes, eelgrass beds, rivers and streams, lakes and ponds, and freshwater wetlands).

• Section 3 discusses the partnership approach to restoration used in Massachusetts, which has a proven track record of success.

• Section 4 highlights the future potential of aquatic habitat restoration in the Commonwealth to: undo past damage, leverage federal and private funds, empower local efforts, undertake proactive efforts to adapt to climate change, and continue to maintain our position as a national leader.

• Section 5 presents the Task Force's six recommendations, along with specific action items.

• Section 6 concludes the report, laying the foundation for future efforts.

• Appendix A provides the definition of aquatic habitat restoration.

• Appendix B summarizes the aquatic habitat restoration programs in the Executive Office of Energy and Environmental Affairs.

• Appendix C includes the references used in the report.

• Appendix D provides the list of recommendations from the Aquatic Habitat Restoration Task Force.

SECTION 2 - THE HABITATS

The Aquatic Habitat Restoration Task Force focused on aquatic habitats—defined as areas or environments consisting of, or strongly affected by water, where an organism, species, or ecological community normally occurs. Natural aquatic habitats generally include rivers, streams, lakes, ponds, estuaries, and wetlands. This section provides an overview of the history of aquatic habitat destruction and degradation in Massachusetts, discusses the overall value of aquatic habitat resources to the Commonwealth, and describes aquatic habitats that have been the focus of restoration efforts throughout the state.

History of Degradation and Destruction of Aquatic Habitats in Massachusetts

The Commonwealth of Massachusetts has a long history of habitat alteration and—to some extent—destruction. Though Native Americans, early settlers, and the Colonists made their mark on the landscape, it was not until the 19th and 20th centuries that humans began to dramatically alter aquatic habitats. From the mid-1800s to the early 1900s, Massachusetts led in the industrialization of the United States, focusing on textiles, paper, machinery, and transportation. As textile mills proliferated, rivers and streams throughout the state were dammed for millworks and channelized for canals. During this time, new railroad systems were built—including the Boston and Lowell, the Boston and Providence, and the Boston and Worcester—filling corridors through freshwater wetlands and floodplains, crossing rivers and streams, and fragmenting natural systems. Conversion of wetlands to agricultural fields and cranberry bogs also resulted in significant wetland losses, particularly along river corridors and in southeastern Massachusetts. In addition, demand for urban land in the Boston area led to massive filling of salt marshes and tidal flats in the Back Bay, South Boston, East Boston, Cambridge, and Charlestown.

In the mid-1900s, post-war Massachusetts experienced economic and social changes, including declines in its major industries and an influx of government spending and private investment. These changes led to a new generation of middle-class workers, and a resulting trend toward suburbanization. Demand for commercial and residential real estate outside of urban centers increased dramatically, along with the network of roads and highways necessary to support this development. Extensive filling, diking, draining, channelization, and pollution of aquatic habitats continued largely unchecked throughout this period.

Regulatory protections were put in place and land conservation efforts accelerated in the late 1900s, and continue today. However, the effects of poorly planned development and "sprawl"—including increased habitat fragmentation, pollution, and water demand—continue to impact the Commonwealth's aquatic habitats. In addition, according to recent analysis by the Massachusetts Department of Environmental Protection (MassDEP), "from 1991 to 2001, 800 acres of wetlands were lost or altered in the state. An additional 450 acres were either lost or altered in the state from 2001 to 2005" (www.mass.gov/dep/service/compliance/wlossmap.htm). The 2003 report, *Living Waters*, concluded that "the state of our freshwater biodiversity has reached a critical junction" and outlined a protection and conservation strategy that includes not only restoring habitat for rare and endangered species but also habitat for native species (NHESP, 2003).

Value of Massachusetts Aquatic Habitats

Aquatic habitats provide very real environmental, social, and economic benefits to Massachusetts. Such benefits are called "ecosystem services"—the wide range of conditions and processes through which natural systems help sustain and fulfill human life (Daily et. al, 1997). In its 2003 report *Losing Ground: At What Cost*, Mass Audubon lists the ecosystem services provided by the Commonwealth's natural environments, including the:

- Capture and storage of carbon dioxide by forest and other plant cover, reducing global warming.
- Storage, control, and release of water by forests and wetlands, providing local supply of water.

- Filtering of pathogens and nutrients by forests and wetlands, reducing the need for water-treatment systems.
- Cycling of nutrients through ecosystems, reducing the need to apply fertilizers.
- Support of a diversity of plant and animal life through contiguous patches of forest and wetland habitat.
- Creation of new soils and prevention of erosion, reducing the need for dredging and reducing the damage from siltation of rivers and streams.
- Protection from flooding and coastal damage by natural wetlands and floodplains.
- Recreational value of natural places, as well as positive impact on nearby property values.

Putting a dollar value on the ecosystem services sustained by aquatic habitats is difficult because most of these services are not part of the market economy. Some services—such as support for commercial and recreational fisheries and flood control functions—have been the focus of economic analysis, and when they are quantified, the value is substantial. The National Marine Fisheries Service states that 32% of the commercial fish and shellfish collected in New England are directly dependent on estuaries and salt marshes (Stedman and Hanson, 1997). When applied to the dockside worth of commercial fish and shellfish landings from New Bedford and Gloucester in 2001 alone, the annual economic value of these habitats for commercial fisheries is more than $57.5 million (Holliday and O'Bannon, 2002). Rivers and streams, when not blocked by dams and other barriers, also provide significant spawning grounds for commercial fisheries.

In another example, the U.S. Army Corps of Engineers assessed historical flooding issues in Boston and its western suburbs along the Charles River, and concluded that conserving wetlands was a natural, less expensive solution than attempting to control flooding with the construction of dikes and dams. The economic flood control benefits derived from wetlands in the Charles River basin alone are estimated to be nearly $40 million per year in 2003 dollars (Schuyt and Brander, 2004).

In *Losing Ground*, investigators conservatively estimate that freshwater and salt marsh wetlands in Massachusetts provide a combined total value of more than $2.3 billion per year. While recent efforts in "green accounting" have made tremendous inroads into describing and calculating these services at various scales, they are bound to fall short—these habitats generate so many diverse functions, services, and products that the magnitude of effort to trace and measure all of them to derive economic value is prohibitive (King, 1998).

Aquatic Habitats: Focus of Restoration in Massachusetts

The following aquatic habitats—salt marshes, eelgrass beds, rivers and streams, lakes and ponds, and freshwater wetlands—are discussed in this report because they have been subject to considerable loss and alteration, and have been the focus of significant restoration efforts. However, other aquatic habitats (such as inter-tidal flats and shellfish beds), and other aquatic-influenced areas (such as barrier beaches and dunes), can and should be the focus of successful restoration efforts. All of these habitats—and the flora and fauna, native fish and wildlife, and rare and endangered species that inhabit them—are crucial resources for the Commonwealth.

Salt Marshes

With a diverse 1,500-mile coastline, the Bay State has a rich array of coastal aquatic habitats, particularly in estuaries, where rivers meet the sea. Estuaries and salt marshes provide key habitats for many of the commercial fish and shellfish in the Commonwealth. Agricultural activities in estuaries, such as salt marsh grass haying and aquaculture, are also economically important. In addition, these areas provide tremendous recreational opportunities—such as shellfishing, kayaking, wildlife observation—and vast educational opportunities and aesthetic value.

Description: Salt marshes—important estuarine habitats—have been, and continue to be, a focus of restoration efforts in Massachusetts. Salt marshes are grass-dominated habitats that are exposed to a regular pattern of tidal flooding and inundation. They are found in sheltered marine and brackish environments—behind barrier spits and islands, on the shorelines of estuarine rivers and salt ponds, and tucked along protected coves and bay shores. According to data developed by MassDEP and provided by the Massachusetts Office of Geographic and Environmental Information (MassGIS), there are more than 45,400 acres of salt marsh in Massachusetts (MassDEP and MassGIS, 2006). Although these data were developed from different sources and scales of aerial photography, they provide the best available statewide coverage of these resources. These data do not, however, indicate the past extent of salt marsh, or explain the current health and quality of these habitats.

Importance: Salt marshes are one of the most productive ecosystems in the world. Plant material, microscopic organisms, algae, and decaying matter support not only resident and transitory animals in the marsh, but the larger marine system as nutrients are carried out with the tides. This rich food base combined with the protective shelter provided by the marsh plants make salt marshes a critical feeding and breeding area for migratory birds, fish, crabs, and shrimp, including commercially important species, such as

softshell clams, striped bass, flounder, menhaden, tomcod, and tautog. Salt marshes help maintain water quality by filtering and settling sediments and trapping nutrients. They also help protect the shoreline from erosion by absorbing wave energy and stabilizing sediments with extensive root systems. Salt marshes also provide flood protection by storing water from rainfall, runoff, and tidal surges.

Historical Impacts: The legacy of urban development and human activities in coastal areas has resulted in the direct loss and degradation of Massachusetts salt marshes. During Colonial times, marshes were diked or filled to allow for farmers to plant upland crops on these fertile soils. During the Industrial Revolution, salt marshes were viewed as new areas for waterfront development to accommodate an increasing population and expand port infrastructure. Through the 1900s demand for real estate for development increased, and filling, diking, and draining of salt marshes continued largely unchecked until the mid-1960s, when Massachusetts became the first state in the nation to adopt wetland protection legislation and regulations. A recent study by the Office of Coastal Zone Management, the U.S. Fish and Wildlife Service, and the University of Massachusetts found that from 1893 to 1995, salt marsh losses totaled more than 8,200 acres, or 81 acres per year, in Boston Harbor, Cape Cod, Nantucket, Martha's Vineyard, and the Elizabeth Islands (Carlisle et al., 2005). For some areas, especially the metro-Boston region, considerable wetland loss and degradation occurred prior to 1893, so actual marsh losses would be even higher. Salt marsh degradation is also a serious issue. Transportation infrastructure has bisected salt marshes, fragmenting systems into smaller parts, and reducing the natural tidal flushing. Culverts placed under roadways to allow tidal passage may not be properly sized, creating tide restrictions. Reduced tidal flow from these and other causes lowers marsh salinity, altering the plant community and facilitating the spread of the invasive reed, *Phragmites australis* (*Phragmites*). The *Phragmites* out-competes other salt marsh vegetation, and because of its lower habitat value for many species, biodiversity is reduced in areas where this plant becomes dominant. Other issues include direct impacts from fill, dock and pier construction, placements of moorings, and boat operation, as well as the shading that occurs from docks and piers, causing reduced growth rates or death of plants.

Eelgrass Beds

Seagrass beds are areas where rooted, flowering plants grow in near-shore marine and estuarine systems. In Massachusetts, eelgrass and widgeon grass are the primary seagrass species. Since eelgrass is more abundant and widespread than widgeon grass, its decline has been the subject of greater concern and the focus of specific management efforts.

Description: Eelgrass forms a complex underwater landscape, with long, narrow leaves floating and swaying in the water column. Tangled roots anchor the plant to the seafloor, and rhizomes connect one plant to the next. Eelgrass grows in a fairly wide range of salinities and temperatures, and the depth of eelgrass growth is limited primarily by light penetration. Eelgrass beds thrive in areas with soft sediments (e.g., sands and mud), low wave energy, and clear water. Natural factors, such as disease, deposition of sediments, storm events, and ice scour, affect the density and extent of eelgrass beds. MassDEP and MassGIS data indicate that there are 39,200 acres of eelgrass beds in Commonwealth coastal waters (MassDEP and MassGIS, 2007).

Importance: Eelgrass beds are one of the most valuable shallow-water coastal habitats in Massachusetts, providing critical refuge and breeding habitat for fish, crabs, clams, and other invertebrates. Bay scallops and American lobster, for example, are two economically important species that depend on habitat. Eelgrass beds also produce significant amounts of organic matter that support components of marine food webs—with waterfowl, crabs, and fish feeding directly on eelgrass. Finally, like salt marsh, eelgrass helps maintain coastal water quality and protect shorelines from storm damage. The "wasting disease" outbreak along the Atlantic coast in the 1930s, which killed an estimated 90% of the eelgrass in the region, underscores the importance of eelgrass beds. Massive erosion of sediments and changes in water quality followed the eelgrass die-off, with animals (including waterfowl and shellfish) that depend on eelgrass beds for both food and shelter suffering large mortalities.

Historical Impacts: Like salt marsh, eelgrass has suffered from human activity. Shading from docks and other structures and physical disturbance from fishing and boating impact eelgrass, but eutrophication—or the over-enrichment of a system with nutrients—is currently the biggest threat. Runoff from agricultural lands, fertilized lawns, septic systems, and other sources carries nutrients to eelgrass beds, stimulating the growth of phytoplankton and other vegetation that cloud the water and shade out the seagrass. Starting in the 1990s, MassDEP developed the first statewide mapping coverage of eelgrass. Consequently, trend analyses are only available for the recent past, where changes in abundance have been observed on regional and local scales. Historically, substantial losses of eelgrass habitat occurred in Massachusetts Bay, and more recently, large-scale losses were noted in Buzzards Bay and Cape Cod where estuaries tend to be shallow, semi-enclosed systems, with relatively warmer water temperature. Substantial development in coastal watersheds in the past several decades has resulted in increased levels of nutrients

and the widespread occurrence of algae in coastal waters, raising the concern of further degradation of eelgrass habitat. The most detailed data available to assess eelgrass abundance are in Buzzards Bay, where eelgrass was widespread prior to 1930, but populations were devastated by the outbreak of wasting disease. By the 1960s and 1970s, eelgrass had mostly recovered from the wasting disease, and in 1988, eelgrass covered 11,120 acres. By 1994, however, eelgrass extent was down to 6,721 acres (a loss of 60%) (Costa 1988; MassDEP and MassGIS, 2006). This scenario is representative of declines in other regions.

The recently installed chute on the spillway at Woolen Dam in Newbury enables fish migration.

Rivers and Streams

There are approximately 10,000 miles of rivers and streams within Massachusetts, ranging from small intermittent streams to headwater tributaries to large mainstem rivers. These are the drainage pathways of the landscape, transporting and transforming water, sediment, nutrients, organic matter, and pollutants en route from ridgeline to ocean. As open and dynamic systems, rivers and streams host diverse habitat and associated biota. They provide invaluable ecological services and are linked closely with other aquatic and terrestrial habitats. They are the site of important chemical transformations, responsible for the movement of energy and nutrients, and home to incredibly diverse collections of organisms.

Description: Massachusetts is known for its clear, cold trout streams; its bedrock waterfalls; and its coastal herring streams. The Commonwealth has a diverse range of river habitats, from the low-lying meandering tidal streams of the coast to the steep bolder-laden streams of the Berkshires. Rivers are dynamic systems that change and fluctuate with the seasons and the weather. In addition to shaping the landscapes we see today, rivers create habitat for flora and fauna. The habitat along rivers and streams is as diverse as the watercourses themselves, ranging from cobble-strewn brooks to tidal creeks and wide floodplain rivers. Natural vegetation along higher gradient rivers and streams provides large woody debris to the channel that helps form "pool-riffle" habitat critical to many aquatic species and the terrestrial species dependent upon them. Many low-gradient rivers and streams are sinuous by nature; that is, they tend to move about naturally, creating new channels and abandoning old ones. Natural features such as

Chutes and Ladders: Helping Fish Pass to and from the Sea in Newbury

How do you know if your fish passage project is a success? In this case, an American eel swims right up the new chute you've installed just minutes after construction is complete.

The Woolen Dam in Newbury poses a major obstacle for fish migrating between the Parker River and the sea, including alewife, sea-run trout, blueback herring, sea lamprey, and American eel. For fish running upstream, the dam's fish ladder offers safe passage—but for those making their way to the sea (or the unfortunate freshwater fish that happen to spill over the dam crest), the boulder face of the dam's spillway poses a problem. Low flows of the river present the biggest threat, with fish being trapped in the craggy crevices of the spillway.

The solution? A chute on the spillway to help channel the fish safely over the dam—the first of its kind on a Massachusetts coastal river. The Division of Marine Fisheries led this restoration project in the summer of 2007, working with the Town of Newbury, the Parker River Clean Water Association, and the Byfield Water District, and supported by grants from the Gulf of Maine Council, the National Oceanic and Atmospheric Administration Restoration Partnership, and the U.S. Fish and Wildlife Service. The chute was molded into the existing spillway, with a system to adjust water levels in relation to river conditions and fish ladder performance.

The goal was to significantly aid in the recovery of fish populations that migrate along 17 miles of river to and from the 84 acres of spawning habitat in Pentucket Pond in Georgetown. In particular, the hope was that American eel and sea lamprey would benefit from the chute as an alternative passageway for migrating upstream. And since the initial success with that first adventurous specimen—young eels have consistently been seen using the chute during very low flows—including two reports of hundreds of tiny eels moving up the chute in October 2007.

sandbars, undercut banks, oxbows, and floodplain pools resulting from a stream or river's interaction with adjacent lands are created, undergo change through time, and eventually disappear, while the overall pattern (e.g., meandering, braiding) remains constant, at least on some larger spatial scale and longer time scale. This form of dynamic equilibrium is a singular property of rivers and accounts for much of the high biological diversity and productivity of riverine systems.

Importance: Streams and rivers support unique assemblages of aquatic plants, insects, micro-organisms, mussels, and fish. According to the Natural Heritage and Endangered Species Program, 34% of Massachusetts river and stream miles support rare or endangered species (NHESP, 2003). Rivers transport and transform nutrients, sediment, and organic debris through complex processes based upon the interactions of biological, chemical, and physical ecosystem components. River corridors and the vegetation bordering them are habitat for wildlife as well. Rivers are the link between terrestrial and other aquatic ecosystems, and form an important part of our ecological infrastructure. In addition to the obvious "quality of life" benefits of healthy rivers for fishing, boating, and swimming, rivers provide less obvious "necessities for life" benefits—water purification, flood control, decomposition of organic matter, and storage and regeneration of essential elements. Economic benefits are also significant—rivers support commercial fishing, ecotourism, and navigation. In addition, rivers supply substantial ecological benefits, providing migratory pathways for terrestrial and aquatic species, promoting biodiversity, and supporting a wide assortment of threatened and endangered species.

Historical Impacts: Rivers and streams have played a central role in the history of the Commonwealth. Prior to European settlement, rivers provided food and a transportation network for Native Americans. In the Colonial period, rivers were first harnessed on a wide-scale to provide power for the mills of the Industrial Revolution. Cities and towns developed along these lifelines of industry and commerce. Throughout all of these historical periods, rivers have supported fisheries and provided important recreational and aesthetic benefits. Centuries of human alteration and use have significantly degraded the condition of rivers and streams within Massachusetts. The legacy of historical impacts is compounded by modern impacts as well. Today for example, water withdrawal by municipalities and industry at unsustainable rates leads to stressed and unnaturally dry streams. Biological diversity (fish, insects, mussels, algae, etc.) is being reduced from pollution and habitat fragmentation. Massachusetts rivers must pass through more than 3,000 dams and impoundments and an estimated 30,000 culverts and bridges—presenting significant barriers to the passage of fish and other aquatic life and degrading habitat by altering flows, temperature, and water quality. In addition, changes to river systems are occurring so quickly that science is struggling to keep up to understand the ramifications, and predict future conditions. The impacts are visible in drastically reduced populations of fish species that migrate to and from the sea, a decline of commercial fisheries, and an increase in invasive species introductions, which can cost the state millions of dollars to control. These changes are likely to become more unpredictable and uncontrollable in the face of predicted climate change. Other predicted climate change impacts that will affect rivers include "changes in precipitation patterns, including more frequent intense storms and flooding as well as more frequent summer droughts. Combined with increasing temperatures, these changes will add to the stresses our rivers and the aquatic life in them are already experiencing" (NECIA, 2007).

Lakes and Ponds

Massachusetts has approximately 3,530 lakes and ponds, ranging in size from less than one acre to more than 24,000 acres. Assawompsett Pond in Lakeville and Middleborough is the largest natural waterbody at 2,656 acres, and Quabbin Reservoir (24,704 acres) is the largest manmade lake. Only 29 lakes and ponds in the state, either natural or manmade, are more than 500 acres.

Description: Lakes and ponds are surface water bodies. These generally non-flowing aquatic ecosystems store water on the landscape, serving as a source of open water. Many Massachusetts lakes were formed 10,000 to 20,000 years ago at the end of the last ice age. The retreating glaciers carved deep holes and gouges in the surface of the earth, and some of the remaining glacial materials dammed the rivers and streams to create lakes. Kettle ponds, commonly found in the southeastern part of the state (including Cape Cod), were created when ice chunks from glaciers were buried and later melted. In the last few hundred years, human activity has resulted in the creation of new lakes and ponds. Dams have been constructed to produce mill ponds and reservoirs, create roads, produce hydro-electric power, and supply irrigation water for crops. The American beaver also creates dams across streams, forming temporary ponds.

Importance: The Commonwealth's lakes and ponds provide substantial quality of life benefits. These aquatic systems provide habitat for fish and wildlife (including numerous rare and endangered plant and animal species); recreational opportunities for swimming, fishing, and boating; drinking water; flood control; irrigation; and electricity generation. In a healthy lake, a native plant community is desirable and will grow where sediments are suitable and light penetrates the water. The plants then provide habitat and food for many forms of animal life—from microscopic algal filters to insects, fish, birds, amphibians, reptiles, and aquatic mammals.

Army Reserves assisted with the removal of the Billington Street Dam (right). Dam removal restored fish passage to Town Brook, allowing herring to reach historical spawning grounds (below).

Photo: Army Corps of Engineers

Photo: David Gould

Historical Impacts: Recent reports have demonstrated that Massachusetts lakes and ponds continue to face ecological degradation, and the current problems are likely to increase in the future. One common problem is eutrophication (as discussed previously in the eelgrass section). Eutrophication in lakes and ponds promotes excessive plant growth and decay, favors certain weedy species over others, and is likely to cause severe reductions in water quality—resulting in changes in species composition, fish kills, and overall loss of ecosystem and aesthetic value. Many of the lakes in the state have not been assessed for water quality, but for those that have, some worrisome trends include:

- Of the 2,000 assessed lakes, approximately 80% are not meeting state and federal water quality standards (ELM, 2006).
- Of the more than 800 lakes that have been assessed for aquatic invasive species, only 5% were found to be free of invasives. In addition, the majority of Massachusetts lakes remain un-assessed and at risk for new invasions (DCR, 2006).
- Statewide, many municipalities and lake groups are unable to fund needed restoration and protection activities to address stormwater runoff impacts, and lakes and ponds have experienced: complete loss of open water in some cases due to eutrophication, excessive plant growth, and sedimentation; toxic algae blooms; and loss of biodiversity and habitat to aquatic invasive species.

The degraded conditions of our lakes and ponds affect human, environmental, and animal health. Impacts include: overall loss of biodiversity, loss of recreation opportunities due to contamination (beach closures) and invasive plant infestations, increasing occurrence of toxic blue-green algae (cyanobacteria) affecting human and wildlife health, and significant decline in property and tourism value due to increased invasive plant growth and eutrophication.

Dam Removal: One Big Step Leads to Ongoing Partnerships in Plymouth

By David Gould, Environmental Resources Manager, Town of Plymouth

It started in 2002 when the Town Brook Partners (made up of federal, state, and local participants) successfully removed the Billington Street Dam—the first proactive dam removal project in the Commonwealth. The positive impacts for the fish and river system were immediately evident. But it was just the beginning...

After the Billington Street Dam removal project, the Town of Plymouth committed to a long-term restoration program. Together with state and federal partners, who provided technical support and funding, Plymouth has made remarkable strides in environmental protection and river restoration.

Plymouth is pursuing an integrated approach, combining restoration projects with public space and infrastructure improvements. Take the Brewster Gardens project, for example. While rehabilitating the oldest and most historically significant municipal park in Plymouth, this project also partially breached a dam for better fish passage and restored river and wetland resources through the construction of a pool and riffle complex in the stream and the planting of a riparian wetland within the park. Similarly, the recent reconstruction of the Jenney Grist Mill fishway not only improved fish passage, but enhanced the public park through the construction of a stone masonry viewing area with landscaping next to a public trail. Additionally, stormwater projects upgraded roadways while reducing water pollution through the implementation of best management practices to treat pollutants like oil and grease, total suspended solids, and bacteria commonly found in road runoff. Finally, the proposed restoration of the Eel River Headwaters includes the acquisition of more than 90 acres of protected open space.

Freshwater Wetlands

Freshwater wetlands are areas where non-tidal water covers the soil, or is present either at or near the surface of the soil for at least part of the growing season. The occurrence and flow of water (hydrology) largely determine how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands vary widely because of regional and local differences in soils,

topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance.

Description: Freshwater wetlands are located on floodplains along rivers and streams (riparian wetlands), in isolated depressions surrounded by dry land, along the margins of lakes and ponds, and in other low-lying areas where the groundwater intercepts the soil surface or where precipitation sufficiently saturates the soil (vernal pools and bogs). Freshwater wetlands include marshes and wet meadows dominated by herbaceous plants, swamps dominated by shrubs, and wooded swamps dominated by trees. Many of these wetlands are seasonal—the quantity of water present and the timing of its presence in part determine the functions of a wetland and its role in the environment. Even wetlands that appear seasonally dry, such as vernal pools, often provide critical habitat for wildlife adapted to breeding exclusively in these areas. MassDEP's Wetlands Conservancy Program is mapping the state's wetlands using aerial photography and photointerpretation to delineate wetland boundaries. Through these efforts, MassDEP estimates that there currently are more than 48,000 acres of freshwater wetlands in Massachusetts (MassDEP, 2006).

Importance: Historically, wetlands were regarded as "wastelands" and obstacles to economic development. However, scientific studies have shown that wetlands protect public health, safety, and property, as well as provide habitat for a variety of wildlife. Wetlands are some of the most biologically productive natural ecosystems in the world. Abundant vegetation and shallow water provide diverse habitats for fish and wildlife. Aquatic plant life flourishes in the nutrient-rich environment, and energy converted by the plants is passed up the food chain to fish, waterfowl, and other wildlife, as well as to humans. In addition to valuable habitat (including habitat for numerous rare and endangered species), wetlands provide: improved water quality by breaking down, removing, using, or retaining nutrients, organic waste, and sediment carried to the wetland in runoff; flood storage and reduced severity of floods by retaining water and releasing it during drier periods; erosion protection for stream banks and shorelines; groundwater recharge, protecting water supplies during dry spells; fish and other products for human use; and recreational opportunities—bird watching, fishing, waterfowl hunting, photography, ecotourism, and outdoor education.

Historical Impacts: While we now recognize the benefits of wetlands, that recognition has come late. Since Colonial times, almost one third of Massachusetts wetlands have been destroyed (Dahl, 1990). Concerned about the loss of wetlands, Massachusetts adopted the nation's first wetlands protection laws in the early 1960s—and today, wetlands are protected by state and federal laws, and sometimes local bylaws. Many remaining wetlands are in poor condition, however, and degraded wetlands are less capable of effectively performing key functions. Human activities have and continue to cause wetland degradation and loss by changing water quality, quantity, and flow rates; increasing pollutant inputs; and changing species composition as a result of disturbance and the introduction of non-native species. In addition to degradation, wetland loss continues in Massachusetts. According to MassDEP, from 1991 to 2001, 800 acres of wetlands were lost or altered, and an additional 450 acres were either lost or altered from 2001 to 2005 (MassDEP, 2006).

Photo: Paul Shoal

Students lend a hand, stocking salmon at Yokum Brook in Becket.

Photo: Stephen Gersh

Aerial view of the Great Marsh on the North Shore of Massachusetts.

SECTION 3 - THE TEAM APPROACH

Habitat restoration efforts are often complex and long-term undertakings that typically require the resources and expertise of many partners.

In Massachusetts, restoration programs and projects operate according to a proven partnership model that draws support and participation from all sectors of society: government, corporate, non-profit, and citizen. Experience has shown time and again that "partnerships get projects done."

In Massachusetts, state programs provide numerous services that help restoration teams achieve their goals. For example, they develop regional restoration plans to identify opportunities, facilitate public outreach, leverage funding from multiple sources, develop project plans, provide technical services, coordinate with regulatory agencies, provide restoration grants, monitor restoration sites, and help manage projects from concept to completion. The Executive Office of Energy and Environmental Affairs (EOEEA) maintains a range of programs within the Secretary's office and in each of the departments (see Appendix B for descriptions of some state programs). These programs are currently coordinated through an informal network—sharing information, experiences, and expertise.

At the federal level, agencies belonging to the Coastal America partnership provide technical assistance and millions of dollars in grants each year to support restoration projects in Massachusetts. Several federal partners play very active roles, directly advancing projects and leading regional planning efforts that set the stage for future project development. Other federal partners provide crucial financial, coordination, and technical assistance. Agencies include the National Oceanic and Atmospheric Administration's Restoration Center and National Marine Fisheries Service, the National Park Service, the Natural Resources Conservation Service, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish & Wildlife Service, and the U.S. Geologic Survey. (For more on Coastal America, see www.coastalamerica.gov/.)

Non-government groups also actively support habitat restoration efforts in the Commonwealth, and many have taken leadership roles to complete projects. These groups include, for example, American Rivers, Coastal America Foundation, Conservation Law Foundation, the Corporate Wetlands Restoration Partnership, Ducks Unlimited, Fish American Foundation, Mass Audubon, Massachusetts Association of Conservation Commissions, The Nature Conservancy, Trout Unlimited, The Trustees of Reservations, and watershed organizations like the Charles River Watershed Association, the Connecticut River Watershed Council, the Ipswich River

Bridge Creek salt marsh following railroad culvert replacement in 2003.

Photo: Andrew Eldredge

Photo (top): Association to Preserve Cape Cod

Bringing Back Yokum Brook in Becket: A Team Approach to Restoration

The Goal: Remove two dams to restore a cold-water stream, provide habitat for fish and wildlife, and restore a salmon run—a sensitive operation in the middle of an historic town.

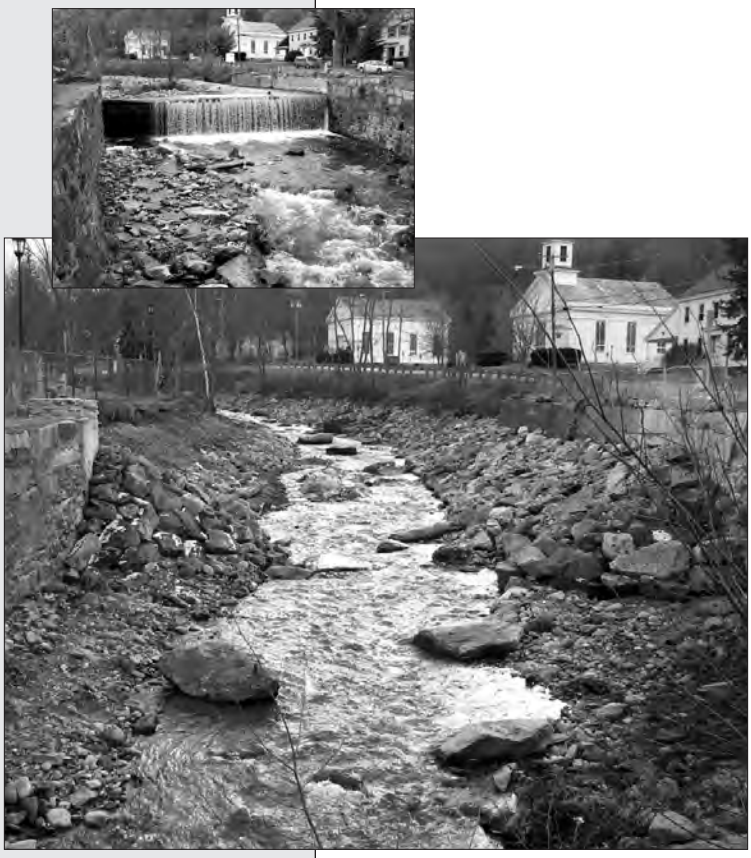
The Solution: Bring together a team of 27 partners and get the job done.

For Yokum Brook—a high-quality, cold-water, Atlantic salmon stream in Becket—restoration costs were more than $600,000, greater than one entity could come up with alone. So, the project leads, the Massachusetts Riverways Program with the Town of Becket, secured donations and grants from 12 sources, from corporations and small foundations to government agencies. This widespread commitment, in turn, helped Riverways and the Town justify contributing the remaining cash match.

Of course, the funding is just one part of the story. The project could not have been completed without the expertise and efforts of dozens of committed staff at the local, state, and federal levels, and citizen volunteers, as well as experienced engineering and contracting firms. The project also hinged on an agreement by the Town of Becket to remove the municipally owned dams. In the process, many volunteers got their hands wet—including the elementary students from the Becket-Washington School, who raised salmon fry in science class and released the fry into the brook.

In all, two dams were removed and dead trees and roots were placed in the stream to improve fish habitat. A fire pond behind one of the dams was also replaced with a state-of-the-art cistern and dry hydrant system.

The Results: More than five miles of stream were restored—providing quality habitat, easier passage for migrating salmon and brook trout, improved navigation and public access along the stream, greater public safety through the new fire suppression system for the town, and reduced liability and maintenance costs.



Yokum Brook in Becket before (top) and after (bottom) dam removal.

Thanks in part to the success of Yokum Brook, the state, led by the Riverways Program, is in the process of removing a dozen dams and is examining the feasibility of removing a dozen more for habitat restoration and fish passage. The project, nationally recognized as the recipient of a Coastal America Partnership Award, shows that dam removals can be completed safely in areas with adjacent infrastructure (e.g., roads and retaining walls). It also demonstrates that dams serving a primary municipal purpose, such as water impoundment for fire suppression, can be successfully removed when community concerns are addressed through a team approach.

Project Partners: *American Rivers; Becket-Washington School; Connecticut River Watershed Council; FishAmerica Foundation and Pro-line Manufacturing; 4Winns Productions; local citizens and volunteers; Lowe's Charitable and Educational Foundation; Massachusetts Corporate Wetlands Restoration Partnership; Massachusetts Department of Environmental Protection; Massachusetts Division of Fisheries and Wildlife; Massachusetts Office of Dam Safety; Massachusetts Office of Fishing and Boating Access; Massachusetts Riverways Program; National Fish and Wildlife Foundation; National Oceanic and Atmospheric Administration; National Park Service; The Nature Conservancy; Natural Resources Conservation Service; Northeast Utilities System; Sweetwater Trust; Taconic Chapter of Trout Unlimited; Town of Becket; U.S. Environmental Protection Agency; U.S. Fish and Wildlife Service; U.S. Geological Survey; Westfield River Watershed Association; Westfield River Wild and Scenic Advisory Committee.*

Watershed Association, the Neponset River Watershed Association, and the Taunton River Watershed Alliance.

At the heart of the team approach are Massachusetts communities, citizens, and landowners—the driving force behind all successful restoration projects. Local participation and support are crucial elements, regardless of size or type of restoration project. The partnership model ensures that local interests are engaged early in project development and are encouraged to provide as much support as possible to help achieve project goals.

To bring all of these participants together, the Partnership to Restore Massachusetts Aquatic Habitats was founded in the mid-1990s to enhance the coordination and collaboration of organizations involved in aquatic habitat restoration across Massachusetts. Partners meet biannually and communicate regularly to discuss all aspects of habitat restoration, including science, policy, planning, permitting, funding, monitoring, and project implementation. Benefits of this active collaboration range from efficient matching of funding opportunities with project needs, to addressing common issues that affect different types of restoration projects and require a coordinated approach.

The successes achieved by restoration partners in Massachusetts are impressive, and underlie the Commonwealth's well-deserved reputation as a national leader in habitat restoration.

The undersized culvert (top) below the railroad track was replaced to increase tidal flow to the degraded upstream salt marsh.

Never Say Never: Seizing an Opportunity to Restore a Salt Marsh

What does it take to restore a freely flowing tidal creek choked off by both a major roadway and an active railroad track? More than $1.5 million, a strong group of partners, and a little luck.

Bridge Creek flows from Barnstable Harbor up through two major transportation crossings. At the first crossing, created by the Old Bay Colony Railroad, the 15-foot creek was forced to flow through a 3-foot diameter culvert. At the second crossing, the creek was channeled through a 4x5-foot box culvert beneath Route 6A. Removing these two restrictions would restore tidal waters to more than 40 acres of degraded marsh. But how could this be done, given the costs and the logistics?

Luck struck in the fall of 2001, when the Town of Barnstable was informed of a one-time shutdown of the railroad, providing the opportunity to replace the railroad culvert at significant savings. Working with the Massachusetts Office of Coastal Zone Management's Wetlands Restoration Program, they brought together a team of more than 35 partners to tackle the project—enhanced by pre-existing relationships, particularly with the federal partners.

Today, with new culverts in place, the short-term goal of restoring tidal flow to the marsh has been achieved. Over the longer term, the project will be monitored with assistance from volunteer groups to gauge future success. Expected results include: an increase in the presence of native vegetation, a decrease in non-native invasive species (such as *Phragmites*), and an increase in salinity as a direct result of restored tidal flow—promoting a healthier tidal marsh.

The Town alone would have been hard pressed to come up with the cash match to secure the grants needed for the project. However, the team secured a combined $500,000 (in cash and in-kind donations from local organizations and private business through the Corporate Wetlands Restoration Partnership and state assistance in the initial project phases of planning, design, and permitting). These contributions provided the necessary matching funds to leverage more than $1 million in federal grants for implementation and construction. For each state dollar invested, more than three dollars of non-state funding was leveraged—a model for successfully leveraging substantial funding when fiscal and technical needs are beyond the capabilities of any single project partner.

Project Partners: *Association to Preserve Cape Cod; Barnstable Land Trust; Battelle; Bay Colony Railroad; Capaccio Environmental Engineering, Inc.; Cape Cod Central Railroad; Cape Cod Commission; Cape Cod Cooperative Bank; Comcast Cable Communications; Conservation Law Foundation; Ducks Unlimited; Duke Energy; Earth Tech, Inc.; The Gillette Company; Gulf of Maine Council; Lawrence Lynch Corporation; local citizens and volunteers; The Louis Berger Group, Inc.; Massachusetts Bays Program; Massachusetts Corporate Wetlands Restoration Partnership; Massachusetts Department of Conservation and Recreation; Massachusetts Department of Environmental Protection; Massachusetts Division of Marine Fisheries; Massachusetts Highway Department; Massachusetts Office of Coastal Zone Management's Wetlands Restoration Program; N-Star; National Oceanic and Atmospheric Administration; Natural Resources Conservation Service; The Nature Conservancy; Northern Construction Service, LLC; Town of Barnstable; U.S. Army Corps of Engineers; U.S. Environmental Protection Agency; U.S. Fish and Wildlife Service; Verizon; Weston and Sampson Engineers.*

SECTION 4 - THE POTENTIAL

While Massachusetts has made important strides in aquatic habitat restoration, tremendous opportunities remain. These opportunities provide the unparalleled potential to: undo past harm to aquatic environments, leverage available sources of funding, empower local involvement in restoration, undertake proactive efforts to adapt to climate change, and demonstrate leadership on this important national issue.

Undoing Past Damage

Through restoration, the Commonwealth has the potential to reverse the legacy of aquatic habitat alteration and destruction. Even though development and other changes to the landscape (including natural alterations) preclude the restoration of some systems, existing restoration opportunities eclipse our current capacities. The Great Marsh Coastal Wetlands Restoration Plan, for example, used remote sensing and onsite surveys to identify more than 100 degraded and former coastal wetland habitats in the North Shore region alone. In another example, a recent survey completed by the Division of Marine Fisheries in southeastern Massachusetts identified 380 obstructions to migratory fish passage on 215 coastal streams, and concluded that "the majority of the [identified] obstructions are manmade dams that in many cases have long ceased to perform the functions for which they were originally constructed" (Reback et al., 2004). While the Riverways Program and the Wetlands Restoration Program are both working on more than 60 priority projects located throughout the Commonwealth, this clearly only scratches the surface of the restoration potential.

Practices for aquatic habitat restoration have evolved over time, contributing to the number of restoration options available and the overall success of restoration efforts. Examples of current restoration approaches include:

- **Salt marsh** - Tidal flow is often re-established by removing or re-sizing water passage structures, such as culverts and bridges. These efforts increase natural salinity levels and improve tidal flushing, allowing a diverse natural habitat to reestablish. To address flooding concerns to low-lying development, self-regulating tide-gates can be used to prevent higher storm tides while allowing normal tides to pass to and from the marsh. Other practices include removing fill material, regrading, and replanting.
- **Eelgrass beds** - Addressing water quality issues through nutrient management and stormwater controls are important elements of eelgrass restoration. In recent years, advances in methods to transplant eelgrass have been made, giving hope to the prospect of reestablishing eelgrass at former sites.
- **Rivers and streams** - Dam removal and culvert replace ments are major components of river and stream restoration, enabling stream continuity and fish passage. Additional stream restoration activities include: aquatic habitat improvement, stream daylighting and naturalization, and urban stream revitalization, as well as providing sustainable instream flows.
- **Lakes and ponds** - Methods of restoring water quality and habitat include point and non-point source pollution management, along with physical, chemical, and biological controls to manage aquatic invasive plants. The Generic Environmental Impact Report on Eutrophication and Aquatic Plant Management (Mattson et al., 2004) provides comprehensive guidance on preventing and controlling eutrophication and aquatic invasive plants in Massachusetts lakes and ponds. The Massachusetts Lake and Pond Guide (DCR, 2004) also includes management practices to help reduce the harmful effects of stormwater, including structural and non-structural approaches for both in-lake and watershed work.
- **Freshwater wetlands** - For freshwater wetlands, habitat restoration activities include: restoring continuity of aquatic habitats (e.g., through culvert replacement), addressing pollution sources, controlling invasive species, and removing fill materials and regrading wetland surfaces.

The restoration of aquatic habitats can be achieved in stages and, in some cases, adaptive and iterative approaches may be the most efficient and cost-effective. Also, while restoration projects attempt to return a system to an historical and self-sustaining condition, in some cases, contemporary constraints may make this impossible. But even when only partial ecological restoration can

be achieved, significant benefits can be attained. And with human activities continuing to cause aquatic habitat degradation and destruction, restoration offers an important way to return some of these ecosystems to a healthier condition.

Big Picture Connections: Using River Restoration to Improve Environmental Health AND Public Safety

From 1995 through 1998 alone, flash-flooding damage in Vermont approached $60 million. Much of this damage occurred where rivers have been separated from their floodplains by development, or where rivers have been adjusting their length, depth, or width because nearby activities have caused the river systems to become unbalanced and destabilized.

A river is not an isolated landscape feature, and consequently, river protection and restoration efforts must consider all areas that contribute to habitat and habitat-forming processes—the river channel, banks, low floodplain, riparian wetlands, high floodplain terraces, and adjacent uplands. Clearly, river systems consist of much more than the river channel. Similarly, river restoration does more than simply improve river habitat—it helps to stabilize the entire system, providing substantial public safety and infrastructure protection benefits by reducing flooding.

Recognizing these big picture connections, the state of Vermont has launched a comprehensive river protection program. As part of this effort, the state is helping communities to perform physical assessments at the watershed scale to accommodate and maintain river channel stability. These watershed-level assessments enable scientific data to guide the protection, management, and restoration of stable river corridors—and the assessments are being used to guide land use, development, and infrastructure planning and design decisions.

Massachusetts can learn much from the Vermont experience, better linking river habitat restoration efforts with measures to improve public safety and reduce infrastructure damage. Adoption of this approach would allow Massachusetts to leverage new sources of funding, such as transportation and emergency management grants, to meet both environmental and public safety goals.

For more on the Vermont program, see www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassess.htm.

Leveraging Restoration Funds

The level of habitat restoration that can be achieved in Massachusetts is strongly correlated with the capacity of state programs to attract and leverage non-state funds, and to provide overall project planning, coordination, and technical support. Investments in state program staff, grants, and other assistance typically leverage a minimum of three non-state dollars for every state dollar invested—and often that ratio is much higher. When restoration benefits (such as water supply protection, flood control, and fisheries enhancement) are taken into account, the return on investment of public dollars is substantial.

Non-state investments in Massachusetts restoration projects are often made because investors (e.g., federal agencies and corporate donors) have a high level of confidence in the success of restoration projects when their investments are matched by state program staff and resources. While the Commonwealth has successfully attracted significant restoration investments over the past decade, millions of dollars in federal funding remain unmatched and therefore unused. The following examples highlight the unrealized potential for increasing restoration capacity:

- **$24 million in NRCS Funding** - In 2006, the Natural Resources Conservation Service (NRCS) completed the Final Watershed Plan and Areawide Environmental Impact Statement for the Cape Cod Water Resources Restoration Project. Developed in partnership with the state, regional groups, and Cape Cod municipalities, this plan proposes to fund 26 salt marsh restorations projects, 24 fish passage projects, and 26 stormwater/shellfish remediation projects over a 10-year period. The plan calls for expenditure of $24 million in federal funds to be combined with $6 million in non-federal match. This tremendous opportunity to produce on-the-ground restoration results provides a compelling example of the need for greater state and local resources to leverage federal funds.
- **$20 million in Army Corps Restoration Funds** - The Coastal Massachusetts Ecosystem Restoration General Investigation study was authorized by the U.S. Congress in 1997—giving the U.S. Army Corps of Engineers and Massachusetts the ability to cost share (65% federal, 35% state) on projects that are "in the interest of environmental restoration . . . along the Massachusetts and Cape Cod Bays' coastal shoreline and associated waters." The 2001 Reconnaissance Report identifies nearly 2,000 acres of wetlands, hundreds of stream miles, and significant estuarine and shellfish habitats as eligible for Army Corps cost sharing at 33 different sites. The total project cost was preliminarily estimated at $30 million, of which the Army Corps would pay approximately $20 million. To date, this funding has largely been left

unmatched, with only 2 of 33 sites having sufficient cost share: Malden River and Pilgrim Lake. The remaining restoration projects could be funded if the Commonwealth and other partners could provide the non-federal match.

- **Other funds from NOAA and USFWS and Associated Partners** - The National Oceanic and Atmospheric Administration (NOAA) and U.S. Fish and Wildlife Service (USFWS) have developed strategic partnerships with regional non-profits to provide millions of dollars to habitat restoration projects; examples include NOAA- American Rivers grants for habitat restoration and USFWS-Trout Unlimited, Eastern Brook Joint Venture.

Empowering Local Involvement

State investment and involvement in habitat restoration serves as a catalyst for local action. Over the last 10 years, the restoration field has shifted—where state and federal agencies once instigated most restoration projects, today local partners are beginning to initiate more projects and request more assistance than the state can provide. This shift is largely the result of local partners witnessing the benefits of aquatic habitat restoration projects managed at the state and federal level, and wanting to realize the same kinds of success in their own communities.

Typically, when state programs become involved in a restoration projects, the first step is to form a partnership between local, state, and federal organizations. These partnerships guide the project from feasibility studies through implementation—and many last beyond the life of the restoration project. Local partners, such as municipalities, non-profit organizations, and regional planning groups, often capitalize on these lasting relationships, which provide the foundation for future restoration success.

Funding tends to be a limiting factor for local restoration efforts, and the team approach helps to address this issue. Through partnerships with state and federal agencies, local proponents learn about diverse funding sources. In addition, local partners can draw on funding and technical assistance from the state to match federal and other grants.

Restoration projects are complex and multidisciplinary—involving topics from stream ecology to hydrology—and requiring expertise in everything from contract management to engineering. It takes time and attention to learn to manage these projects. Experienced state programs mentor local partners as they gain the skills to run projects on their own. This successful team approach has its own momentum, building long-term and sustainable local capacity for future restoration. Consequently, today's state-level investments in aquatic habitat restoration translate into even greater future potential.

Adapting to Climate Change

Massachusetts air temperatures may increase by as much as 14 degrees Fahrenheit in the summer months by century's end, while rainfall is forecasted to increase. As the frequency and severity of heavy rainfall events increase seasonally, and as the severity of drought also increases, low flow events will also increase (NECIA, 2007). Scientific evidence accumulated over the last decade documents that the U.S. Northeast is already experiencing climate change impacts, such as seasonal warming patterns, advances in high spring streamflow, decreases in snow depth, extended growing seasons, and earlier bloom dates (Hayhoe, 2007). Climate change implications for aquatic systems include the following:

- Greater precipitation levels (up to 20%) will increase river and stream storm flows, stressing aged and weakened dams and undersized culverts—potentially causing catastrophic flooding.
- Rising ocean levels will cause salt water to infiltrate further inland, and coastal storm surges will erode valuable shoreline. Additionally, fragile estuaries and marshes will be inundated by higher water levels and storm surges, and may be unable to migrate inland; salinity levels of freshwater environments may increase, affecting habitat and drinking water supplies; and critical nursery habitats for fish could be lost, with some fish species being unable to migrate or otherwise adapt.
- Increasing length and severity of droughts in summer and fall will impact stream and wetland habitat beyond historical low levels. Species adapting to historical, natural low flows will face additional stress.
- Organisms will attempt to adapt to temperature changes in lakes, rivers, and oceans by migrating to suitable areas. For example, temperature-sensitive migratory fish, such as herring and salmon, will alter their patterns to the potential detriment of entire ecosystems. Freshwater fish species, like native brook trout, may find rivers too warm to sustain them. Invasive species could also expand in range and significantly affect habitats and nutrient levels. Some natural communities may be able to adapt to these changing conditions, others will not.

Our growing awareness of these threats adds urgency to the need to undo past damage through habitat restoration and develop proactive strategies to adapt to climate change impacts. As George Gann, incoming Chair of the Society for Ecological Restoration International, has indicated, "Ecological restoration offers hope in two key areas: by reconnecting fragmented ecosystems allowing animals and plants to migrate in response to such change; and, by capturing carbon through

the restoration of forests, peat-forming wetlands, and other ecosystems that act as carbon sinks."

To underscore the need for habitat protection and restoration in the face of global climate change, the Society for Ecological Restoration International issued a position statement during its recent joint conference with the Ecological Society of America. The statement calls attention to the vital role played by terrestrial and aquatic ecosystems, and the need to protect and restore these habitats to mitigate global climate change and its effects (SERI, 2007). To prepare for climate change impacts and develop adaptation strategies, policy makers and resource managers should therefore give considerable attention to aquatic habitat restoration opportunities.

A key component to adapting to global climate change will be promoting environmental resilience—the ability of a system to absorb and rebound from the impacts from weather extremes and climate variability (Moser, et al., in press). Specifically, aquatic habitat restoration initiatives will improve ecosystem resilience by:

- Protecting and restoring habitat on which already stressed species depend.
- Connecting aquatic corridors to allow species to migrate and find refuges as temperatures change, especially in fragmented landscapes that might otherwise prevent migration.
- Maintaining the integrity of natural systems to protect valuable services, such as flood control and water purification.
- Addressing specific climate change scenarios, such as:
  - Removing dams and impoundments and replacing undersized culverts to connect habitats and restore environmental health while safeguarding infrastructure and communities from severe flooding.
  - Creating upland and coastal buffers that allow for salt marsh migration with rising sea levels.

Freshwater wetlands provide many functions, including flood storage and habitat for rare species, such as Arethusa, *a threatened plant species in Massachusetts.*

Photos: Chris Buelow - NHESP

In Massachusetts, strategically coordinated aquatic habitat restoration efforts can support successful climate adaptation strategies. Through these efforts, the scientific and restoration community can identify and monitor early effects of climate change on natural systems, and integrate climate change adaptation strategies into environmental plans. Additionally, policy initiatives can make ecosystem resilience a priority, and help ensure that infrastructure is designed and maintained with climate change impacts in mind.

The Society for Ecological Restoration International closes their position paper by strongly urging "local, regional, and national governments, international development banks and non-governmental organizations as well as private institutions to help plan, finance and coordinate ecological restoration projects and programs as part of a comprehensive global strategy for mitigating climate change. Likewise, local, regional and national authorities are encouraged to aggressively enhance incentives to the private sector for restoring ecosystem services and biodiversity in order to combat global climate change and promote sustainable development" (SERI, 2007). The Aquatic Habitat Restoration Task Force supports this recommendation. Massachusetts has the opportunity to successfully mobilize aquatic habitat restoration efforts in a way that maximizes adaptation to climate change—increasing ecosystem resilience and thereby reducing the vulnerability of humans, ecosystems, infrastructure, and the economy in the face of this major global environmental issue.

Demonstrating National Leadership

Habitat restoration is an important and growing element of national and global efforts to preserve our natural heritage, restore the essential services that these habitats provide to society, and adapt to a changing climate. Massachusetts maintains a stellar reputation as a national leader in habitat restoration. In the words of Virginia Tippie, the national Director of the federal Coastal America Partnership: "Massachusetts has led the way in habitat restoration, first with the signing of an interagency [agreement] in 1994 fostering state and federal collaboration in wetlands restoration. Then, in establishing the Wetlands Restoration and Riverways Programs and their facilitation of a partnership for aquatic restoration. And finally, the creation of the Corporate Wetlands

The Virginia rail is a secretive freshwater marsh inhabitant.

Photo: Chris Buelow - NHESP

CWRP: The Public-Private Partnership Potential

In 1999, Massachusetts started the first Corporate Wetlands Restoration Partnership (CWRP) in the nation. Jointly launched by the U.S. Environmental Protection Agency Region 1, the Massachusetts Executive Office of Energy and Environmental Affairs, and The Gillette Company—Massachusetts CWRP has since contributed almost $2 million in cash and services to restoration projects across the state. And since 2000, Coastal America has helped transform the CWRP into a national effort.

The CWRP offers an opportunity for environmentally responsible companies to make voluntary donations to support non-profit coastal habitat restoration or public education projects. In addition to cash donations, companies can provide employee time, expertise, and equipment to conduct the variety of tasks required in restoration work—from field surveys to hydrologic modeling to engineering and construction. At the company's direction, these funds or services are used for projects endorsed by Coastal America Regional Implementation Teams.

Through the CWRP, companies can help their communities make the required local match to secure federal restoration funds—a win-win situation. The companies demonstrate their commitment to environmental stewardship, receive positive publicity, and promote morale by allowing employees to make a difference in their communities. The communities receive the necessary funding and expertise to make restoration a reality. Finally, the federal government maximizes the environmental benefits of each grant dollar spent.

There's no arguing with success. Since 1999, 49 CWRP companies have supported 26 projects that have restored 210 acres of wetlands and 9.5 river miles—and current commitments have the potential to restore an additional 1,876 acres of wetlands and 64 river miles. But the potential is greater still. Given its flexibility, connections, and corporate resources, the Massachusetts CWRP can play an important strategic role in restoration. When brought into projects early, the CWRP can readily identify and tap private resources necessary for project success. In addition, the value of the partnerships themselves is immense. Thanks to the CWRP, successful and lasting relationships are formed as people from companies, government, non-profits, and other organizations work together for restoration.

Restoration Partnership, which has been adopted nationally and implemented in 14 states. The Massachusetts programs are a model for the nation and are looked to for future state leadership in the field of restoration."

In addition, Bill Hubbard, Chief of the Evaluation Branch of the U.S. Army Corps of Engineers says: "The Commonwealth has an excellent reputation with the federal restoration agencies. The efficient structure and professional management of the restoration programs in Massachusetts are well recognized. The short- and long-term planning, excellent communication, and the use of the interagency steering committee (Partnership to Restore Massachusetts Aquatic Habitats) all give federal funding agencies confidence in the granting of funds to these programs. It is known that Massachusetts can deliver finished projects in reasonable time frames and with efficient use of federal, state, and corporate funds. This results in a higher percentage of federal project funding for the Commonwealth of Massachusetts."

Massachusetts has earned this reputation as a nationally recognized leader in habitat restoration by advancing innovative ideas, developing restoration capacity, and fostering partnerships that produce results. The time is right, however, to bring these efforts to a new level by increasing habitat restoration capacity and incorporating restoration as part of an integrated approach to resource management. Massachusetts is poised to further transform aquatic habitat restoration—providing not only immediate environmental, economic, and public safety benefits—but promoting our status as a national model as restoration continues to gain prominence as an essential resource management tool.

SECTION 5 - THE BLUEPRINT FOR SUCCESS: RECOMMENDATIONS OF THE AQUATIC HABITAT RESTORATION TASK FORCE

Over a four-month period from August to November 2007, the Aquatic Habitat Restoration Task Force held a series of six meetings. Through deliberations at these meetings and additional conversations and correspondence, the Task Force achieved consensus on the six recommendations presented below.

These recommendations represent a group of big-picture steps that collectively form the blueprint for success and leadership in aquatic habitat restoration for the Commonwealth for the next several years and into the next decade. They build on and expand the significant energy and attention that has been committed to aquatic habitat restoration on the part of numerous partners and interested parties. They also identify issues or areas where improvements can be made, offering suggestions to enhance the efficiency—and ultimately, the efficacy—of restoration actions in Massachusetts.

RECOMMENDATION #1 - ENHANCE STATE LEADERSHIP FOR AQUATIC HABITAT RESTORATION

Issue

Over the past decade, Massachusetts has made considerable progress restoring degraded aquatic habitats, yet the awareness and practice of restoration as a critical environmental management tool has been limited. Restoration is an important complement to resource protection and conservation efforts because it provides a mechanism to rectify past habitat damage, loss, and resulting impacts to our communities and economy. To maintain and enhance Massachusetts's national leadership role in the field of restoration, the state should increase formal coordination, address broad policy issues, and elevate restoration as a mainstream component of environmental management strategies.

While state restoration programs and other partners currently coordinate through an ad-hoc group, there is no official, unifying body or framework that guides restoration efforts and addresses high-level policy issues that cross program areas. A number of important policy issues require Secretariat-level strategic consideration, leadership, and response. Examples include the need to:

- Coordinate and integrate restoration efforts with "infrastructure" agencies—such as the Executive Office of Transportation (including MassHighways and Massachusetts Bays Transportation Authority).
- Institute policies (e.g., Memoranda of Agreement, Executive Orders, etc.) that promote habitat restoration on state-owned lands and require that restoration opportunities be considered during state agency actions.
- Address issues (i.e., roles, responsibilities, and protocols) concerning the intersection of aquatic habitat restoration and mosquito control.
- Develop strategies that utilize restoration as a key component of climate change mitigation and adaptation efforts.
- Ensure that regulatory requirements for aquatic habitat restoration projects are streamlined to reduce project costs and timeframes, but still ensure that long-term environmental benefits are maximized and adverse effects minimized.

Recommended Actions

Action #1a - Endorse and advance aquatic habitat restoration as an integral priority for environmental management in Massachusetts

The Executive Office of Energy and Environmental Affairs (EOEEA) should establish aquatic habitat restoration as a top priority environmental issue for the Patrick Administration, elevating its importance as the third component of sound environmental resource management (together with protection and conservation). Policy development and coordination

Photo (top): Stephen Gersh

should encompass a broad and inclusive definition of restoration that focuses on core activities (e.g., wetland and river habitat restoration) while integrating those efforts with other state government actions that impact aquatic habitats (e.g., stormwater and wastewater discharges, water withdrawals, and transportation infrastructure projects).

Action #1b - Establish a new EOEEA Interagency Restoration Committee

An EOEEA-chaired Interagency Restoration Committee would promote holistic, integrated approaches to restoration based on ecological, geographic, and other logical frameworks—across programs, departments, and executive offices—and serve as the policy body that would tackle issues requiring a coordinated and high-level response. The Committee would be modeled on the existing Interagency Lands Committee, which for more than a decade has served as a critical coordinating and policy body for land conservation efforts. Based on that model, the Committee would be structured to keep the expertise and capabilities within the agencies' restoration programs, while better coordinating these programs to ensure that the Commonwealth's restoration efforts are synchronized and managed to reflect the goals and direction of the Secretary and Administration. The Committee would be comprised primarily of representatives from the EOEEA restoration programs and would seek the participation of other state cabinet and agency staff and non-state representatives on an issue-specific basis. The Committee would meet once a month. The chair would determine the agenda, administer the meetings, authorize workgroups as necessary, and keep the Secretary and cabinet apprised of progress and developments.

Action #1c - Create a new staff position within EOEEA responsible for coordinating state habitat restoration efforts

To address the need for statewide leadership, policy development, and coordination, a habitat restoration policy staff position should be created within EOEEA. This position would report to the Secretary via the Assistant Secretary for Policy and would chair the Interagency Restoration Committee. Creation of this position (similar to the existing EOEEA lands and water policy directors) would help coalesce all state restoration efforts and greatly improve coordination with other Secretariats, elected officials, federal agencies, and non-governmental partners.

Recommendation #2 - Invest Strategically to Maximize Restoration Results

Issue

Since Colonial times, large areas of aquatic habitat in the Commonwealth have been lost and degraded as a direct result of human activities, and the missing or compromised services provided by these systems affect the economic and social well-being of residents and visitors. While existing land uses may preclude the restoration of some of this former habitat, substantial opportunities for restoration exist throughout the state. Over the past decade, considerable advances have been made in aquatic habitat restoration—especially for estuarine wetlands, rivers and streams, and diadromous fish habitat—but this progress has been limited by resource constraints and partner capacities.

The costs of lost and degraded aquatic resources and the many services they provide are borne by residents of the Commonwealth in a multitude of ways, such as:

- Deteriorated habitat for wildlife and reduced species diversity including rare, endangered, and commercially important species.
- Lost revenue from commercial and recreational fisheries, tourism, and property values.
- Decreased function of natural systems to protect water quality and ensure clean water for drinking and recreating.
- Reduced capacity for flood control and storm-damage protection.
- Costs of creating and maintaining artificial systems to mitigate for lost and degraded functions—including flood control systems, stormwater control measures, and fish and shellfish restocking.
- Hindered ability of natural systems to respond and adapt to the effects of global climate change.

As detailed in Section 2, the economic costs of these impacts are great. While the value of restoration has not been fully quantified in Massachusetts, it has in other areas. In the Great Lakes region, for example, a recent study by The Brookings Institution found that the monetary benefits of restoration would provide a 200% return for every dollar invested, and even greater returns when multiplier benefits are counted (Austin et al., 2007).

State investment in aquatic habitat restoration is the primary engine that generates results for communities and, on average, an investment of one state dollar will leverage more than three non-state dollars of additional investment. This tremendous return on investment—the leveraging of non-state funds combined with the benefits that restoration delivers to communities—should be enhanced through strategic efforts to expand existing resources and identify new sources of support.

Photo (top): Cape Cod National Seashore

In one of the largest restoration projects in New England, the Cape Cod National Seashore and the Towns of Wellfleet and Truro, along with other local, state, and federal partners, are working to restore tidal exchange to 1,000 acres of Herring River floodplain habitat. Strategic planning, broad partnerships, and creative fundraising will be critical to making this restoration project a reality.

Recommended Actions

Action #2a - Define restoration objectives, identify key projects, and allocate appropriate resources

Similar to the lands conservation process, the Commonwealth should establish overarching priorities for aquatic habitat restoration by identifying broad habitat goals and related health and safety benefits. With support from both the public and private sectors, project opportunities, including pilot projects, should be identified to meet these goals. These opportunities would include not only comprehensive restoration projects—but also efforts to remove or retrofit aging, deficient, or inadequate infrastructure (such as dams, impoundments, culverts, and flood control structures) to improve habitat and avoid damage and risk to health and safety from structural failure, flooding, and pollution. To fully maximize restoration potential, EOEEA should provide additional funding to ensure that state programs have the necessary capacity—in terms of project management, technical services, and grants to local projects—to successfully implement priority projects that achieve these broad habitat goals.

Action #2b - Engage in strategic planning and coordination to ensure that state, federal, local, non-profit, and private investments leverage each other's resources

The Commonwealth should seek to utilize and leverage all funding sources to the greatest extent possible. Through strategic planning with federal, local, non-profit, and private partners, resource allocation to restoration projects can be better coordinated so that each partner's funds are leveraging other funds and contributions, resulting in maximum funding efficiency and extending the reach and value of these resources.

Action #2c - Actively seek new resources and build new partnerships

New resource streams should be identified and pursued. Candidates include: improving coordination with the Natural Resources Damages Assessment and Restoration Program, as well as other supplemental environmental projects (resulting from environmental violations and settlements); expanding the membership and reach of the Corporate Wetlands Restoration Partnership (CWRP); exploring new partnerships with private foundations and individuals, including the establishment of a Massachusetts Aquatic Habitat Restoration Fund as a non-profit charitable arm of the restoration effort; and looking into innovative resources, such as carbon off-set funds.

recommendation #3 - create an informed constituency

Issue

Key decision-makers (including local, state, and federal managers, elected officials, academics, and non-profit leaders) and the public do not fully understand the severity and extent of aquatic habitat loss and degradation in the Commonwealth, and the consequences and costs that result from this problem. Awareness of the opportunities and benefits that can be achieved through restoration is also limited. The effects of lost and degraded aquatic habitats negatively impact Massachusetts communities in a number of ways. In terms of public health and safety, consequences include increased flooding, greater susceptibility to storm damage, and polluted water supplies. Economic impacts include decreased property values, lost tourism and recreational opportunities, and commercial fishery impacts. Additionally, lost and degraded habitats have reduced ability to respond and adapt to a changing climate. The restoration of lost and degraded aquatic habitats in the Commonwealth presents significant opportunities to recover damaged natural resources, stimulate the state's economy, and improve the quality of life for citizens and visitors. An outreach and education strategy that promotes the benefits of aquatic habitat restoration is essential for building a constituency that supports increased investment and builds local capacity.

Recommended Action

Action #3 - Develop and implement an outreach and education strategy targeted to specific audiences

Restoration partners should develop and implement a communication strategy to increase awareness of the magnitude of the threats and costs of degraded and lost habitat and the significant benefits that could be realized through investment in restoration. This strategy should be based on a comprehensive plan for outreach to specific audiences, and could include:

- A targeted press strategy to raise awareness of aquatic habitat loss and local restoration opportunities.
- Restoration alerts that inform decision-makers of opportunities and results of restoration.
- Case studies and information on the ecological, economic, and health and safety benefits of restoration to provide technical assistance to potential partners.
- Workshops, web sites, and printed materials to educate local officials and the public on how to become more involved with and effective in aquatic habitat restoration.
- An annual or bi-annual restoration conference to exchange information among partners.

RECOMMENDATION #4 - BUILD LOCAL AND REGIONAL CAPACITY TO SUPPORT AND IMPLEMENT RESTORATION

Issue

State and federal agencies, a few non-governmental organizations, some cities and towns, and the CWRP have demonstrated strong leadership and support for aquatic habitat restoration, but the capacity of the restoration partnership has not reached its full potential. There are numerous non-profit organizations, as well as local governments, that could provide significant contributions to local and regional restoration projects. The efforts of these potential partners are restricted by tight budgets, full agendas, and lack of technical and project management expertise.

Recommended Action

Action #4 - Increase technical and financial support directly to cities and towns, non-governmental groups, and interested landowners

Using lessons learned from the Wetlands Protection Program's Circuit Riders, the former Watershed Initiative, and other locally based technical assistance programs, such as the Massachusetts Bays and Buzzards Bay National Estuary Programs, restoration programs should work to improve the restoration capacity within communities and regions through components, such as:

- Development of guidance documents and best practices manuals.
- Technical, project management, and other hands-on training.
- Direct funding and matching incentives to foster local and regional capacity building.

By building the understanding, experience, and resources for aquatic habitat restoration at the local and regional levels, restoration results could be greatly increased.

RECOMMENDATION #5 - ENSURE EFFICIENCY IN REGULATING RESTORATION PROJECTS

Issue

Because most regulatory programs were developed without restoration projects in mind, many opportunities to reduce permitting costs and time frames, and to increase overall regulatory support and efficiency for restoration projects, are not realized. In addition, many restoration opportunities are missed every year due, in part, to regulatory requirements that act as disincentives to the pursuit of restoration as part of infrastructure repair or replacement projects. Regulatory hurdles for restoration projects are amplified by the lack of formal guidance and standards to help applicants successfully navigate the regulatory process.

Recommended Action

Action #5 - Conduct a comprehensive review of regulatory requirements for restoration projects to identify options for reducing time and cost while ensuring adequate protections

The proposed Interagency Restoration Committee, or a similar working group, should conduct a comprehensive examination of the existing regulatory structure for aquatic habitat restoration projects. The group should identify options to reduce or remove regulatory obstacles, as well as develop regulatory incentives to promote restoration elements within non-restoration projects (e.g., road and highway repair or replacement projects). Several key issues to be addressed include:

- Applying the recently updated state Programmatic General Permit Stream Crossing Standards to repair/replacement projects, and identifying other regulatory standards that may act as disincentives for incorporating restoration elements into infrastructure projects.
- More effectively using regulatory procedures for restoration projects that meet standards and further interests (e.g., clarifying the Wetlands Protection Act "limited project" at 310 CMR 10.53(4) and better utilizing the Massachusetts Environmental Policy Act process to identify applicable regulatory requirements and address issues early in the process).
- Exploring a single or merged application and review process and possibly assigning a single point-of-contact within MassDEP for restoration project permitting.
- Engaging in more advanced regulatory coordination, similar to that currently being piloted in the MassDEP southeast region for restoration projects.
- Developing regulatory and policy guidance, similar to the draft dam removal policy by EOEEA and guidance recently completed by MassDEP to steer project proponents through the various phases of restoration.

RECOMMENDATION #6 - MAXIMIZE THE ROLE OF SCIENCE AND TECHNOLOGY IN RESTORATION

Issue

Science and technology are integral parts of habitat restoration, providing the basis for many key decisions, such as assessing which habitats are degraded; identifying and measuring key species, communities, or ecological processes; setting restoration

Understanding the capacity for tidal creeks and salt marshes to accommodate sea-level rise is key for climate change adaptation.

goals and objectives; designing and engineering restoration actions; and monitoring change over time to evaluate restoration success. A major concern identified by the Task Force is the scarcity of funds and resources to enable critical restoration monitoring and evaluation. Available public resources for restoration projects typically support project planning, design, engineering, and construction—but not project identification, monitoring, and evaluation. In addition, these funds are generally accessible for durations of one to two years (or less), with few exceptions. Ecological responses to restoration vary over time, and while some changes may occur on shorter scales of one or two years, the (re)establishment of most communities and processes extend well beyond that period—requiring longer-term monitoring and evaluation that cannot be funded in these two-year cycles.

With limited resources, not every restoration decision can be informed by rigorous, peer-reviewed science or state-of-the-art technologies. Opportunities exist, however, to build on existing partnerships and develop new relationships to realize shared goals and enhance the application of science and technology for many aspects of aquatic habitat restoration.

Recommended Actions

Action #6a - Increase support for data collection and integration to facilitate restoration site identification and inventory development, as well as integrated planning, design, and engineering

Massachusetts should continue to emphasize and strengthen the roles of science and technology in the areas of project planning and implementation, monitoring, and research to advance its leadership position in the field of ecological restoration. Technological developments over the past decade have enabled great advances in the ability and capacity to inventory and survey potential restoration sites and to develop information to support restoration design. Resources are required to fund remote sensing efforts through aerial imagery, elevation data from light detection and ranging systems, and hydrologic sensors. The Commonwealth should continue to obtain statewide high-resolution ortho and oblique imagery on a three to five year frequency. These data directly support inventory and site identification work, such as the Wetlands Restoration Program's Great Marsh Coastal Wetlands Restoration Plan and UMass Amherst's Conservation Assessment and Prioritization System.

Restoration programs and other partners should enhance their ability to share and integrate data for restoration needs and opportunities. The Interagency Restoration Committee should investigate technological options to create a web- or network-based data management system—including spatial GIS data—that allows efficient distribution, querying, and reporting for information about restoration opportunities, regional planning, and project monitoring and reporting efforts. Such a system would greatly improve program coordination and collaboration to increase awareness of restoration activities across all partners, better match restoration needs with opportunities and funding sources, and strategically plan future restoration priorities that deliver the greatest social and ecological benefits.

Action #6b - Expand relationships with academic institutions and volunteer-based monitoring groups to generate more monitoring and research

The state should direct more attention to understanding and predicting achievable restoration outcomes, improving capacity for characterizing and communicating uncertainty, and integrating observations and models into adaptive management of restoration projects. With the wealth of top-caliber academic institutions in the Commonwealth, better ties should be created with faculty and students to link their research interests with active restoration projects. The role of volunteer and citizen-based monitoring should also be expanded. Existing partnerships with groups such as the Association to Preserve Cape Cod and Mass Audubon should serve as models where partner organizations' members and volunteers receive hands-on training and guidance in monitoring techniques, data management and analysis, and reporting. In addition, restoration grant programs, including state and non-state (federal and non-profit), should be expanded to directly support monitoring and assessment elements, and—because the timing of fiscal years do not correspond to the monitoring field season—mechanisms should be developed to allow grant resources for monitoring and assessment to cross fiscal years.

Finally, a few large and representative project sites should be designated as special long-term research areas, where scientists can work hand-in-hand with the project sponsors and managers to design and integrate their investigations into the restoration projects. The findings and applications of such research, in turn, should be synthesized and channeled back into restoration programs.

SECTION 6 - MOVING FORWARD

As outlined in this report, the Commonwealth's strong partnership approach to aquatic habitat restoration has generated tremendous success—with hundreds of acres of salt marshes, eelgrass beds, rivers and streams, lakes and ponds, freshwater wetlands, and other habitats effectively restored. While these achievements are truly impressive, greater levels of success are well within reach.

The Aquatic Habitat Restoration Task Force is confident that by implementing the recommendations presented in this report, Massachusetts will take the steps necessary to continue as a national leader in aquatic habitat restoration. The recommendations provide a framework for enhancing state leadership, prioritizing restoration needs, strategically building restoration capacity, and maximizing state investments through enhanced partnerships and leveraging of outside funds. They call for developing new efforts to raise awareness about aquatic habitat loss and potential local restoration opportunities, and for a comprehensive review of the regulatory requirements for restoration efforts—and they recognize that coordinated aquatic habitat restoration efforts will be an important part of climate adaptation strategies.

We realize that these recommendations are offered during a time of competing budget interests, and that the implementation of some, if not all, will require the investment of public resources. However, we also feel strongly that the return on new investment will far outweigh the cost. Restoring the health, sustainability, and resilience of these important habitats will provide tremendous environmental, economic, and public health and safety benefits to the citizens of the Commonwealth.

Opportunity awaits for restoring aquatic habitats across Massachusetts.

Today's investments are fundamental to a successful long-term strategy that establishes aquatic habitat restoration as a top priority environmental issue. While the team approach is essential for future success—continuing the proven partnerships of local, state, and federal government; not-for-profits and advocacy organizations; and private groups and individuals—state government can and should take the lead in moving forward. Following this blueprint for success, Massachusetts will strategically position itself to maximize the opportunities of today, and address the threats of tomorrow, through a coordinated and reasoned approach to aquatic habitat restoration for the next several years and into the next decade.

APPENDIX A - AQUATIC HABITAT RESTORATION DEFINED

The following definition of ecological restoration and attributes of restored ecosystems were accepted by the Aquatic Habitat Restoration Task Force as the definition and primary tenants of aquatic habitat restoration. The definition and attributes are from the Society for Ecological Restoration International Science & Policy Working Group's 2004 publication: *The SER International Primer on Ecological Restoration* (available at http://www.ser.org/content/ecological_restoration_primer.asp).

Definition of Ecological Restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

Attributes of Restored Ecosystems

The nine attributes listed below provide a basis for determining when restoration has been accomplished. The full expression of all of these attributes is not essential to demonstrate restoration. Instead, it is only necessary for these attributes to demonstrate an appropriate trajectory of ecosystem development towards the intended goals or reference. Other attributes may gain relevance and should be added to this list if they are identified as goals of the restoration project.

1. The restored ecosystem contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure.
2. The restored ecosystem consists of indigenous species to the greatest practicable extent.
3. All functional groups necessary for the continued development and/or stability of the restored ecosystem are represented or, if they are not, the missing groups have the potential to colonize by natural means.
4. The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory.
5. The restored ecosystem apparently functions normally for its ecological stage of development, and signs of dysfunction are absent.
6. The restored ecosystem is suitably integrated into a larger ecological matrix or landscape, with which it interacts through abiotic and biotic flows and exchanges.
7. Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as possible.
8. The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem.
9. The restored ecosystem is self-sustaining to the same degree as its reference ecosystem, and has the potential to persist indefinitely under existing environmental conditions. Nevertheless, aspects of its biodiversity, structure and functioning may change as part of normal ecosystem development, and may fluctuate in response to normal periodic stress and occasional disturbance events of greater consequence.

Photo: Tony Williams

APPENDIX B - AQUATIC HABITAT RESTORATION PROGRAMS IN THE EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS

The Executive Office of Energy and Environmental Affairs (EOEEA) and its agencies host a number of programs that focus directly on, or act to support, the restoration of critical aquatic habitats. The following is a brief summary of some of these efforts.

Department of Agricultural Resources (DAR)

DAR hosts the State Reclamation and Mosquito Control Board, which coordinates the mosquito control activities of nine organized mosquito control projects (or districts) located throughout Massachusetts, including the Northeast Massachusetts Mosquito Control and Wetlands Management District, which pioneered Open Marsh Water Management in the state. The Agricultural Environmental Enhancement Program supports the mitigation and prevention of negative impacts to the Commonwealth's natural resources that may result from agricultural practices.

Department of Conservation and Recreation (DCR)

DCR hosts the Lakes and Ponds Program, which works with local groups and municipalities to protect, manage, and restore valuable aquatic resources. The DCR Areas of Critical Environmental Concern Program works to preserve, restore, and enhance critical environmental resources and resource areas of the Commonwealth. The Office of Dam Safety maintains records of dams located throughout the Commonwealth and ensures compliance with acceptable practices pertaining to dam inspection, maintenance, operation, and repair. The Office of Water Resources promotes water quality and conservation through several functions, including developing water resources policy and watershed planning efforts, coordinating the review of inter-basin transfers, and administering cooperative programs with the U.S. Geological Survey.

Department of Environmental Protection (MassDEP)

Within MassDEP, the Wetlands and Waterways Program regulates activities in coastal and wetlands areas, on both coastal and inland waterways, including construction, dredging, and filling in tidelands, great ponds, and certain rivers and streams. The Massachusetts Estuaries Project is working to determine what nutrient sources and loads are and how great a nutrient load estuaries can tolerate without dramatically changing their character and usages. The Wetlands Conservancy Program maps wetland resources areas and conducts wetland change analyses. MassDEP enforcement actions may result in fines and/or Supplemental Environmental Projects that support habitat restoration activities. Enforcement actions may also force the removal of illegal fill in wetlands.

Department of Fish and Game (DFG)

DFG works to preserve the state's natural resources and people's right to the conservation of those resources, as protected by Article 97 of the Massachusetts Constitution. The Department contains several programs that address aquatic habitat restoration. The Riverways Program promotes the restoration and protection of the ecological integrity of the Commonwealth's watersheds (rivers, streams, and adjacent lands) and works to restore degraded riparian and in-stream habitats using a community-based approach. The Division of Marine Fisheries manages recreational and anadromous fish resources of the Commonwealth, including the restoration of fish habitat and passage. The Division of Fisheries and Wildlife works to protect, restore, and manage Massachusetts fauna and flora, and is responsible for the conservation, restoration, protection, and management of fish and wildlife resources for the benefit and enjoyment of the public. Housed within the Division of Fish and Wildlife is the Natural Heritage and Endangered Species Program, which is responsible for the conservation and protection of Massachusetts biodiversity and supports restoration efforts in a variety of habitat types.

Natural Resource Damages Assessment and Restoration Program

The Secretary of EOEEA is designated by the Governor as Trustee for natural resources of the Commonwealth. As Trustee, the Secretary has the authority to bring an action or claim for liability against a responsible party for natural resource damages resulting from a release

Photo: Thompson Island Outward Bound

of oil or hazardous substances. The Natural Resource Damages Program works to link damages with restoration planning and implementation to restore, replace, or acquire the equivalent of the injured resources.

Office of Coastal Zone Management (CZM)

CZM maintains several programs that address aquatic habitat restoration. The Wetlands Restoration Program helps people voluntarily restore the state's degraded and former coastal wetlands and the services they provide. The program identifies projects, organizes teams, provides technical assistance, secures project funding, and helps manage and coordinate restoration activities from start to finish. CZM hosts and chairs the state's Aquatic Invasive Species Working Group, which works to prevent new introductions and to monitor and manage the impact of aquatic invasive species already established in the Commonwealth. CZM also administers the Massachusetts Bays Program and Buzzards Bay National Estuary Program, two programs that pursue regional restoration opportunities.

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Photo: Chris Buelow - NHESP

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Bronson Brook in Worthington before (right) and after (below) successful restoration—a double-box culvert that was washed out in a 2003 storm was replaced with an arch, allowing the stream (and salmon and trout) to run freely.

APPENDIX D - LIST OF RECOMMENDATIONS FROM THE AQUATIC HABITAT RESTORATION TASK FORCE

These six recommendations represent the big-picture steps that collectively form the blueprint for success in aquatic habitat restoration for the Commonwealth. They are intended to guide the efforts of Executive Office of Energy and Environmental Affairs (EOEEA) and its partners to achieve greater restoration results for the next several years and into the next decade.

Recommendation #1 - Enhance State Leadership for Aquatic Habitat Restoration: Massachusetts should increase formal coordination, address broad policy issues, and elevate habitat restoration as the third component of sound environmental resource management (together with protection and conservation). Important policy issues requiring attention include the need to: coordinate with "infrastructure" agencies (such as MassHighways), promote habitat restoration on state land, develop strategies for climate change adaptation, and streamline regulatory requirements.

Action #1a - **Endorse and advance aquatic habitat restoration as an integral priority for environmental management in Massachusetts**

Action #1b - **Establish a new EOEEA Interagency Restoration Committee**

Action #1c - **Create a new staff position within EOEEA responsible for coordinating state habitat restoration efforts**

Recommendation #2 - Invest Strategically to Maximize Restoration Results: Large areas of aquatic habitat in the Commonwealth have been lost or degraded. Since each state dollar leverages more than three non-state dollars—expanding existing resources and identifying new sources of support will maximize results.

Action #2a - **Define restoration objectives, identify key projects, and allocate appropriate resources**

Action #2b - **Engage in strategic planning and coordination to ensure that state, federal, local, non-profit, and private investments leverage each other's resources**

Action #2c - **Actively seek new resources and build new partnerships**

Recommendation #3 - Create an Informed Constituency: The restoration of lost and degraded aquatic habitats presents significant opportunities to recover damaged natural resources, stimulate the state's economy, and improve quality of life. An outreach and education strategy that promotes the benefits of aquatic habitat restoration can build a constituency that supports increased investment and builds local capacity.

Action #3 - **Develop and implement an outreach and education strategy targeted to specific audiences**

Recommendation #4 - Build Local and Regional Capacity to Support and Implement Restoration: While a strong restoration partnership exists in Massachusetts, it has not reached its full potential. Numerous non-profit organizations and local governments could provide significant contributions—but these efforts are restricted by tight budgets, full agendas, and lack of technical and project management expertise.

Action #4 - **Increase technical and financial support directly to cities and towns, non-governmental groups, and interested landowners**

Recommendation #5 - Ensure Efficiency in Regulating Restoration Projects: Opportunities exist to reduce permitting costs and regulatory time frames, increase regulatory support and efficiency for restoration projects, and remove regulatory requirements that act as disincentives to pursuing restoration as part of infrastructure repair or replacement projects.

> Action #5 - **Conduct a comprehensive review of regulatory requirements for restoration projects to identify options for reducing time and cost while ensuring adequate protections**

Recommendation #6 - Maximize the Role of Science and Technology in Restoration: Science and technology provide the basis for key habitat restoration decisions, from identifying sites to designing successful restoration projects. With limited resources, not every decision can be informed by peer-reviewed science or state-of-the-art technologies—but opportunities exist to enhance the use of science and technology in aquatic habitat restoration, particularly with monitoring and evaluating restoration success.

> Action #6a - **Increase support for data collection and integration to facilitate restoration site identification and inventory development, as well as integrated planning, design, and engineering**

> Action #6b - **Expand relationships with academic institutions and volunteer-based monitoring groups to generate more monitoring and research**