

Hangin' in the Balance

An Urgent Call for Protecting
Cape Cod's Natural Resources



Technical Assistance provided by Horsley Witten Group



ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

*Historic development patterns on the Cape have fragmented critical habitats, eliminated key resource types, and degraded drinking and marine water quality, among other concerns. There is limited undeveloped land left on the Cape. If we, as a community, continue to develop as we have been, these problems will only get worse. **We must make better choices.***

How Cape communities choose to develop and conserve now will define the future for our region.

Protecting more of the remaining areas of critical open space is necessary to conserve and restore the land and water resources that make Cape Cod so special, both for current and future residents.

Cape Cod is blessed with globally rare coastal plain ponds, pristine beaches and shorelines, extensive salt marshes, and sprawling freshwater wetlands. These resources are some of the primary drivers for people to live and vacation on the Cape. They also provide critical habitats for the numerous rare plants and animals that live in these special areas.

The creation of the Cape Cod National Seashore in 1961 permanently preserved more than 27,000 acres (12% of the land area on Cape Cod), protecting beaches, coastal banks, salt marshes, freshwater ponds, interior forests and woodlands, and wetlands. Numerous rare and endangered species continue to thrive in the undisturbed habitat provided by the Seashore property.

Over the last 50 years, the residents of Cape Cod have recognized the need to further protect Cape Cod's fragile ecosystems and have

supported their municipalities and local land trusts in buying and preserving critical open space areas. In 1998, the passage of the Cape Cod Land Bank legislation, and then later passage of the Community Preservation Act¹ in 2000, provided a source of local funding to support town acquisitions of open space. According to the Cape Cod Commission's 2018 Regional Policy Plan, approximately 40% of the Cape is considered protected open space.

Concurrently, development pressures in the last 50 years have damaged or impacted many of Cape Cod's wetlands, ponds, and coastal estuaries. In 2022, APCC's State of the Waters: Cape Cod analysis revealed that **90%** of assessed embayments and **39%** of assessed freshwater ponds on the Cape have unacceptable water quality due to excess nutrients. A significant contributing factor to the health of these water bodies is the health of bordering lands.

¹ While the Community Preservation Act was passed by the Legislature in 2000, Cape towns used the modified CPA, enacted c. 2006 to replace the

Cape Cod Land Bank Act. Two towns, Chatham and Provincetown, used both through the Land Bank sunset in 2020.

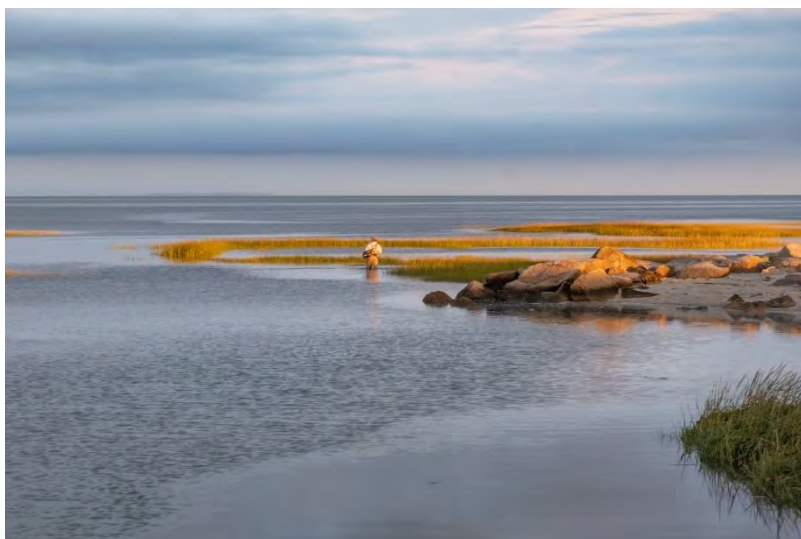


Figure 1. A fisherman casts his line in Paines Creek in Brewster (Gerald Beetham).

These important land and water resources continue to be threatened by ongoing development, exacerbated in the last two years as real estate prices and development pressure have risen substantially. See more on this below.

This report documents and maps the current status of sensitive natural resource areas on Cape Cod, estimates which of these areas have been permanently protected, and documents unprotected areas that remain at risk from development. The changes in land cover between 2001 and 2019 are also analyzed, using data from the National Land Cover Database. For example, in that timeframe, approximately **4,500 acres** of forest have been lost due in part to additional residential and commercial development on Cape Cod. This reduction in forest area and consequential fragmentation of the resource has adverse ramifications on habitat that extend beyond the actual acreage that was lost.

Since the 1980s a number of local, county, and state regulations have been adopted to restrict development in many sensitive areas, such as wetlands. Wetlands comprise approximately **30%** of the land area of the Cape, or approximately **70,000 acres**. In particular, the Massachusetts Wetlands Protection Act and local wetlands protection bylaws regulate development within 100 feet of wetland resource areas. These regulations have helped slow, but not stop, the rate of wetland loss in these areas. The result, particularly in wetland buffer areas where incursions have been allowed to occur, has been death by a thousand incremental cuts from loss of habitat, loss of flood storage capability, and less resilience to the impacts of climate change.

Development in upland areas adjacent to wetlands or in the watershed to a pond, coastal estuary, or other waterbody also directly impacts the health of these water resources. The transformation of a forested area to a residential development, even if residential areas retain portions of these forested areas, has direct impacts. Nitrogen, phosphorus, and other contaminants in septic system effluent directly impact ponds, coastal estuaries, and other waterbodies, including the Cape's drinking water supplies. Stormwater runoff transports nutrients, pathogens, and hazardous materials directly to wetlands and surface waters. Landscape practices associated with the conversion from forested areas to cultivated lawns adversely impact water resources by adding nutrients from fertilizer use and harmful contaminants in the form of pesticides and herbicides. The cost to remediate these water quality impacts is substantial. The Cape Cod Commission estimates that it will cost \$4 billion over 50 years to execute the Cape Cod 208 Plan Update, which would eliminate or reduce just the nitrogen pollution in Cape marine waters not inclusive of freshwater resources.

This report is designed to chronicle the history of land protection on Cape Cod and identify unprotected areas where additional open space acquisition and other strategies are needed to protect rare species' habitats and limit further water quality impacts. Specifically, the report documents:

Development and Preservation. This section features the extent of protected land and land development on Cape Cod. Development patterns from 2001 to 2019 seem to reflect an increase in concentrated development. “High intensity development” areas (e.g., apartment complexes, row houses, and commercial/industrial development) on the Cape saw an increase of approximately 16% between 2001 and 2019. How and if this trend continues and, if so, where it is allowed will determine if development continues to degrade the environment or is used as a tool to fix past practices. According to the Cape Cod Commission’s 2018 Regional Policy Plan, approximately 40% of the Cape is protected open space, approximately 46% is developed, and only roughly 14% remains undeveloped and unprotected. Though the Cape has roughly 91,000 acres of open space protected in perpetuity, there are nearly 50,000 acres of undeveloped land on the Cape that are not permanently protected. Of this undeveloped land, roughly 40,000 acres overlap with priority natural resource areas. What we do with these remaining acres will define our region and its future.

Priority Natural Resource Areas. This section captures the status of priority natural resource areas on Cape Cod. With a history of sprawl and unsustainable development, our natural resources on the Cape have suffered some considerable losses. The Cape has lost an estimated 36% of its salt marshes since European settlement (Association to Preserve Cape Cod, 2022). Forest cover loss amounts to approximately 4,500 acres between 2001 and 2019. Nearly 25% of forest land cover lost since 2001 appears to now be developed



Figure 2. Cape Cod wetlands (Association to Preserve Cape Cod).

landcover (e.g., single family housing, multi-family housing, commercial, and industrial development). Today, priority natural resources on the Cape comprise approximately 190,000 acres. However, development has occurred in, and consequently impacted, approximately 27% or over 50,000 acres of these remaining priority natural resource areas.

Case Studies. This section includes four case studies that document the numerous benefits that come from open space protection and resource protection strategies utilized in Brewster, Dennis, Falmouth, and Orleans. These strategies were implemented with different priorities in mind, ranging from the protection of drinking water, to planning for salt marsh migration caused by climate change, to restoring fish passage and the climate resiliency benefits

of existing resources, and restoring water quality in wetlands and coastal estuaries.

Recommendations. This section highlights 29 actions that local town governments and individuals can take to protect, preserve, restore, and enhance their natural resources. These include the following:

For Municipalities:

- Continue to advance open space acquisitions on the Cape: Continue to acquire open space parcels, especially in priority natural resource areas.
- Continue investments in nutrient reduction techniques: Expand investments in nutrient reduction techniques such as traditional sewerage, approved innovative/alternative (IA) septic systems, and shellfish propagation.
- Expand the use of innovative planning strategies to protect natural resources:
 - o Districts of Critical Planning Concern: Designate Districts of Critical Planning Concern to impose temporary moratoriums on certain types of development or activities in a specified area to plan for and adopt special rules and regulations that will protect resources or values of regional, statewide, or national significance.
 - o Natural Resource Protection Zoning: Designate Natural Resource Protection Districts to require that natural resource protection be a priority in these areas and encourage clustered development in the least impactful location.
 - o Stormwater management regulations: Develop protective stormwater management regulations that encourage enhanced infiltration.



Figure 3. Swan River Estuary (Gerald Beetham).

- Increase restoration of natural resource areas:
 - o Wetland protection regulations: Strengthen wetland protection regulations to ensure wetland resources can be fully utilized for their flood control benefits.
 - o Cranberry bogs: Support the restoration of cranberry bogs to wetlands to enhance carbon sequestration and flood storage and improve habitat restoration.
 - o Freshwater wetlands: Support the restoration of freshwater wetlands through the removal of dams or culverts to restore flows, installing stormwater treatment practices, or utilizing other water quality improvement strategies.
 - o Salt marshes: Support the restoration of salt marshes by protecting adjacent floodplains and strengthening regulatory protections.
 - o Rivers: Support the restoration of rivers through the removal of dams and culverts, installing stormwater treatment practices, or utilizing other water quality improvement strategies.

For Individuals:

- Support continued funding for open space: Encourage local decision makers to continue to support funding for the acquisition of open space in your community.
- Support restoration projects and efforts to restore migratory fish passage: Support community efforts to restore natural resources.
- Support zoning changes that direct growth to the appropriate locations: Encourage local decision makers to adopt zoning changes which ensure development occurs in areas with the appropriate infrastructure, limiting sprawl and minimizing impacts to natural resources.
- Champion stronger regulations: Encourage the adoption of regulations in your community which protect natural resources.
- Demand local investments in wastewater infrastructure: Encourage local decision makers to make investments in



Figure 4. Rain garden designed with native plants (Horsley Witten Group).

- wastewater infrastructure to reduce water pollution in your community and in the region.
- Support state and federal funding for wastewater management: Advocate for state and federal wastewater management investments for your community and the region by contacting your state legislators or federal members of Congress.
- Assist verification efforts for vernal pools: Support efforts to verify the locations of vernal pools by volunteering with local conservation organizations or reporting vernal pool observations online to MassWildlife's Natural Heritage and Endangered Species Program (NHESP).
- Support documentation for priority and estimated habitats: Support efforts to maintain accurate records for rare species by reporting rare species to the state or requesting a voluntary assessment of your property to determine whether there are any Endangered, Threatened or Species of Special Concern present on a portion of the property.
- Invasive species management: Take steps to reduce invasive plant species in your community through actions such as volunteering with local land trusts to help with invasive species removal projects, removing and controlling invasive species in your yard, and ensuring your boating equipment has been cleaned and dried before and after use in a freshwater pond.
- Native species planting: Take steps to support the cultivation of native species in your home and in your community through actions such as learning about native plantings for your yard and encouraging local decision makers to plant native plants on town-owned properties.
- Plant rain gardens to filter polluted runoff: Support the planting of rain gardens at your home and in your

community and other green infrastructure designs that encourage infiltration and treatment of stormwater runoff.

- Minimize pavement and maximize native, drought-tolerant plantings on your property: Where pavement is necessary, use permeable materials. Plant and promote the planting of native drought-tolerant plants to conserve water usage.
- Best practices to protect ponds: Support pond health through actions such as creating and maintaining a vegetated buffer of native plants between your lawn and the water, minimizing lawn area, avoiding fertilizer and pesticide use, and controlling erosion to avoid sediment entering the pond.
- Cut pesticide use: Support the reduction of pesticides used in your home and your community through actions such as employing mechanical means of weed control, avoiding the use of chemical soaps and cleaning products that contain pesticides, and encouraging local decision makers to reduce or remove pesticide usage from town-owned properties.
- Eliminate the fertilization of turf and reduce other fertilizer applications: Support the reduction of fertilizers, both organic and synthetic, on turf at home and in your community through actions such as encouraging local

decision makers to curtail the use of fertilizer application on town-owned properties.

- Proper septic system care: Ensure your septic system is up to date on maintenance and utilized appropriately through actions such as pumping your septic system at least every three years. Do not flush medications or dump hazardous fluids or paint down the drain. Avoid the use of anti-bacterial soaps and harsh cleaning chemicals.
- Take care of your gas-powered vehicles and yard equipment: Ensure proper maintenance of your gas-powered vehicles and yard equipment through actions such as fixing leaks and washing your car at a carwash with water recycling rather than washing it in your driveway.
- Manage domestic animal waste: Appropriately manage domestic animal waste through actions such as picking up after your pet and ensuring their waste ends up in the trash or supporting the proper management of manure in farm settings.
- Safely manage hazardous household products and choose non-toxic products: Limit the use of hazardous household products by choosing non-toxic products and ensuring that toxic products are disposed of properly and not down the drain.

SECTION I. PRESERVING CAPE COD

Cape Cod is home to a rich diversity of natural resources that define the region as a special place for residents and visitors. From kettle ponds and freshwater wetlands, to sloping dunes and coastal bays, the environment is in many ways the lifeblood of the Cape's economy. On the Cape, tourism generates an estimated \$1.3 billion in spending by domestic travelers, supporting 12,000 jobs and generating more than \$89 million in state and local tax receipts (The Boston Foundation, 2018). A significant number of these tourists travel to the Cape to experience the unique natural environment that defines this region. In addition to tourism, the success of the fishing industry is tied to the health of the Cape's ecosystems. Commercial fishing for six salt marsh reliant species brought in \$19 million in 2009 for the Cape, and in 2018 oyster harvesting brought in \$14.5 million and quahog harvesting brought in \$1 million for the Cape (Barnstable County Commissioners et al., 2012; Cape Cod Commission, 2020).

Part of what makes the Cape so unique are the plants and animals that inhabit this region. The Cape has the highest number and highest density of state-listed rare plant and animal species of any region in Massachusetts with a total of 132 state-listed species, including 75 threatened and endangered species (Cape Cod Commission, 2019a).

And yet, even as critical as natural resources are to the Cape, current land use practices and regulatory standards promote development patterns and practices that jeopardize the very resources that draw people to the Cape in the first place. The region faces immense challenges with degraded water quality, habitat fragmentation, the spread of invasive species, and the additional



Figure 5. Nauset Marsh in Eastham (Pixabay).

development and climate pressures that threaten its remaining natural resources. For example:

- The Cape has lost an estimated 36% of its salt marshes since European settlement (Association to Preserve Cape Cod, 2022).
- Collectively, forest cover loss amounts to approximately 4,500 acres lost between 2001 and 2019 on the Cape.
- In 2022, APCC's State of the Waters: Cape Cod assessment revealed that 90% of graded embayments and 39% of graded freshwater ponds on the Cape have unacceptable water quality due to excess nutrients (Association to Preserve Cape Cod, 2021).

These are troubling numbers considering that clean and safe waters are critical not just for recreation and fishing, but also as the underpinnings of the Cape's economy and the Cape's broader

reputation as a place of natural splendor. The destruction of the Cape's upland and wetland natural resource areas have been in large part caused by decades of planning and development decisions which encouraged sprawl and pollution without consideration for the impacts to sensitive habitats, surface waters, or groundwater. The Cape's economy will remain vibrant only as long as the waters remain clean, and the ecosystems remain healthy. Right now, the quality of the Cape's environment and our quality of life are diminished and at risk of collapse.

Having already lost a considerable amount of our natural resource areas, particularly during the 1970s-1990s, we now must contend with severely fragmented habitats, a coastline that is largely built out, and of particular concern, nutrients and other pollutants that impact water quality, one of the chief environmental threats for this region and one of the most expensive problems to address. To restore our water resources and preserve the Cape as we know it today, we will need to act comprehensively and aggressively to protect the natural resources that are remaining. While there have



Figure 7. Cape Cod Bay (Association to Preserve Cape Cod).



Figure 6. Stony Brook in Brewster (Gerald Beetham).

been conservation efforts in Cape communities to help protect open space and to restore impacted natural resources, the response has not met the scale of the problem we are facing as a region.

The almost total reliance on single family detached housing production has devastated the Cape's environment, needlessly consuming land and leading to habitat fragmentation, poor water quality, and traffic that has been exacerbated by sprawl. Based on an analysis of land cover data from 2001 to 2019, an estimated **2,399 acres** of medium density development occurred on the Cape during this time period, most commonly including single family housing development. The Cape's reliance on single family housing has also driven up the cost of housing and fueled the Cape's affordability problems. Many of the "easiest" places to develop have been developed, and future decisions regarding land use are likely to become more and more difficult. Communities throughout the Cape, more than ever, need to carefully balance the needs of residents for housing, jobs, and services with the need to maintain a strong, healthy environment.

The Cost of Preserving Open Space Versus Development

It is important to recognize that while there are upfront costs to acquire open space, these investments actually save money for a town over the long run. Two prior studies on Cape Cod looked at this issue in Brewster and Truro and documented that the cost of providing necessary services for year-round residential properties exceeds the taxes and other forms of revenue received by the town from these properties. Overall, the cost for emergency services, road maintenance, education and other town services exceed the amount paid in taxes and from other revenue by approximately 30%. The cost implications for new development are especially a challenge in Massachusetts where towns are limited to a 2.5% property tax increase each year (unless approved through a townwide referendum vote) when costs for town employee salaries and other associated expenses typically increase annually by more than the 2.5% limit. In comparison, this study revealed that open land and farms bring in more revenue than they cost the town in service expenditures. In Truro, for each dollar in revenues from open space land, the town is called on for just 41 cents in expenditures, and in Brewster, 31 cents in expenditures (Association to Preserve Cape Cod, 2001a, 2001b). Although the studies reflect a snapshot in time for both towns, the findings are consistent with similar studies conducted in other communities across the country under a model developed by the American Farmland Trust. There are clear and distinct benefits created by open space protection for water quality protection, climate change mitigation, avoided costs of additional wastewater treatment and collection capacity to mitigate incremental nutrient loading, and wildlife and endangered species habitat preservation, but there is also a potential cost savings provided to town's that make investment in additional open space acquisition particularly attractive in comparison to encouraging new development.

Part of this balance involves building smarter and more sustainably, directing new development to villages and community activity centers that have centralized wastewater infrastructure and other services; creating and expanding public sewer systems (and, where that is not practicable, using innovative wastewater treatment alternatives that are proven to be effective and permissible) to help protect groundwater and surface water resources; and embracing green building and zoning standards to lessen carbon emissions, reduce impervious surfaces, and more. Another equally vital part, however, involves continued conservation of sensitive lands and water resources. When development causes the destruction of particular natural resource areas, the loss of that habitat is magnified due to fragmentation. Preserving continuous landscapes will be critical to ensure that wildlife corridors are maintained to the greatest extent possible.

Continued growth in development must go hand in hand with natural resource protection. The purpose of this report is to make that case. We attempt to answer the following questions.

1. How has Cape Cod land cover changed over the last two decades? What natural resources have we lost? What have the impacts of this loss been?
2. What natural resources remain today and why should they be protected?
3. Where on Cape Cod have we had success in preserving, protecting, or restoring natural resources and what have been the results?

Protected Versus Developed Land on the Cape

In Massachusetts, land cover data from prior years tells a compelling story about how development has impacted our natural resources. This trend is most certainly the case for Cape Cod, which experienced explosive population growth from the 1950s through

the early 2000s (Stats Cape Cod, n.d.). Massachusetts Geographic Information System (GIS) maps from that time period illustrate a period of significant, sprawling development on the Cape, the consequences of which we are still contending with today.

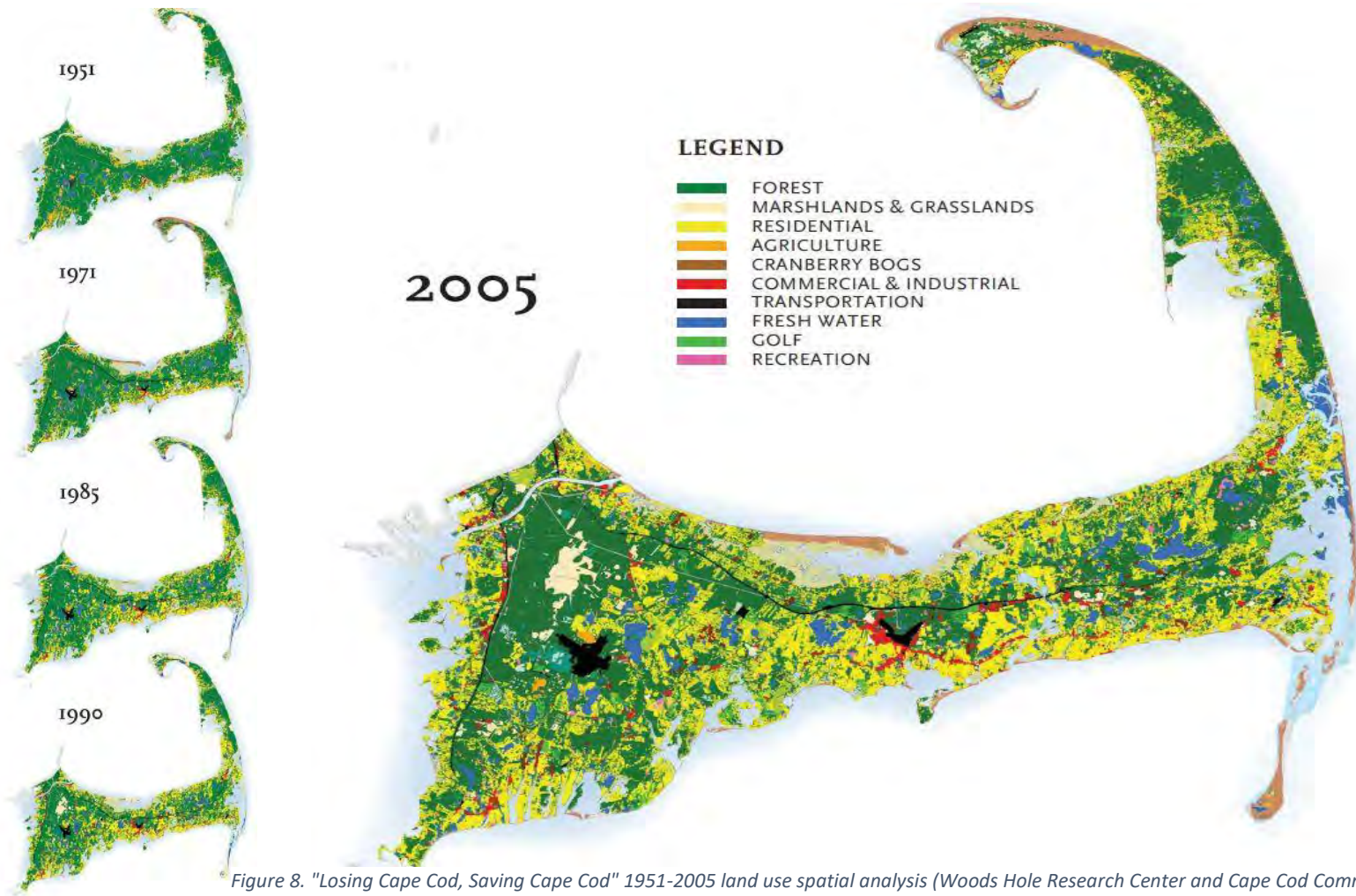
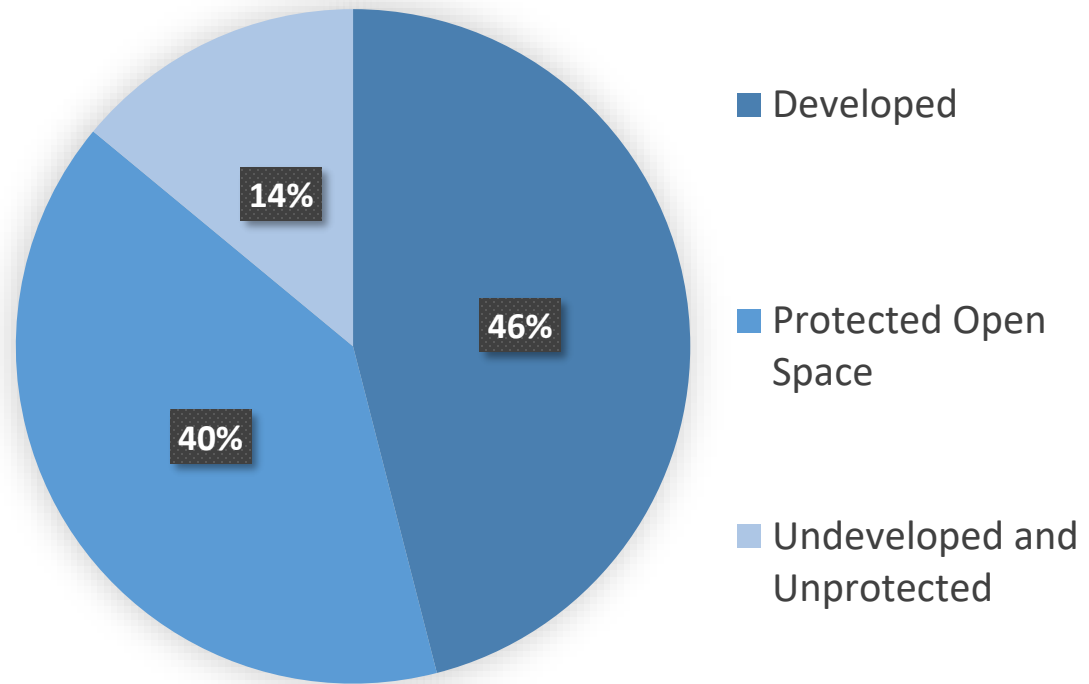


Figure 8. "Losing Cape Cod, Saving Cape Cod" 1951-2005 land use spatial analysis (Woods Hole Research Center and Cape Cod Commission).

Since the early 2000s, population growth has stabilized on the Cape and due to several contributing economic factors, including limited remaining large undeveloped parcels, development has comparatively slowed. According to the Cape Cod Commission's 2018 Regional Policy Plan, approximately 40% of the Cape is protected open space, approximately 46% is developed, and only roughly 14% remains undeveloped and unprotected.

There are nearly **50,000 acres** of remaining undeveloped land on the Cape that are not currently permanently protected. Of those acres, roughly **40,000 acres** overlap with priority natural resource areas. The choices we make for this remaining land will be a deciding factor in the future of Cape Cod.

Over these last nearly twenty years, different categories of land cover have experienced varying degrees of change, some of which were reflective of increases in development. Of note, forest loss on the Cape has been considerable over this time. Deciduous forest loss has been particularly drastic, with the estimated loss of over **2,700 acres** between 2001 and 2019, a percentage change of **28%**. As of 2019, deciduous forest cover accounts for roughly **3%** the land area of the Cape. Collectively, deciduous, evergreen, and mixed forest loss amounts to approximately **4,500 acres** lost between 2001 and 2019. As of 2019, deciduous, evergreen, and mixed forest cover accounts for approximately **37%** of the land area of the Cape. Nearly **25%** of forest land cover lost since 2001 appears to now be developed landcover (e.g., single family housing units, multi-family



housing units, commercial, and industrial development). Approximately **42%** of forest land cover lost since 2001 now appears to be herbaceous landcover (e.g., areas dominated by grasses and other plants without woody stems, such as lawns). With this loss of forest cover, the Cape has lost valuable habitat for wildlife, carbon sinks for sequestration, cooling benefits for hot summer months, enhanced recharge for drinking water areas, and more. The collective impacts of the decline of forest cover on the Cape will only put more pressure on the remaining natural resources.

The following map from the [NASA Ames Research Center](#) shows satellite-derived estimates of the fractional turf grass (lawn) area across the United States. Areas where a large fraction of the land

surface is lawn-covered are deep green, while areas where lawn cover is limited are light green or white. On this map, the Cape is depicted with darker shades of green, illustrating that lawn cover is significant in the region.

Woody wetlands (e.g., shrub swamps or other wetlands that contain at least 20% trees and shrubs) experienced a small increase (2% or 200 acres more woody wetland areas in 2019 compared to 2001) and emergent herbaceous wetlands (e.g., shallow marshes

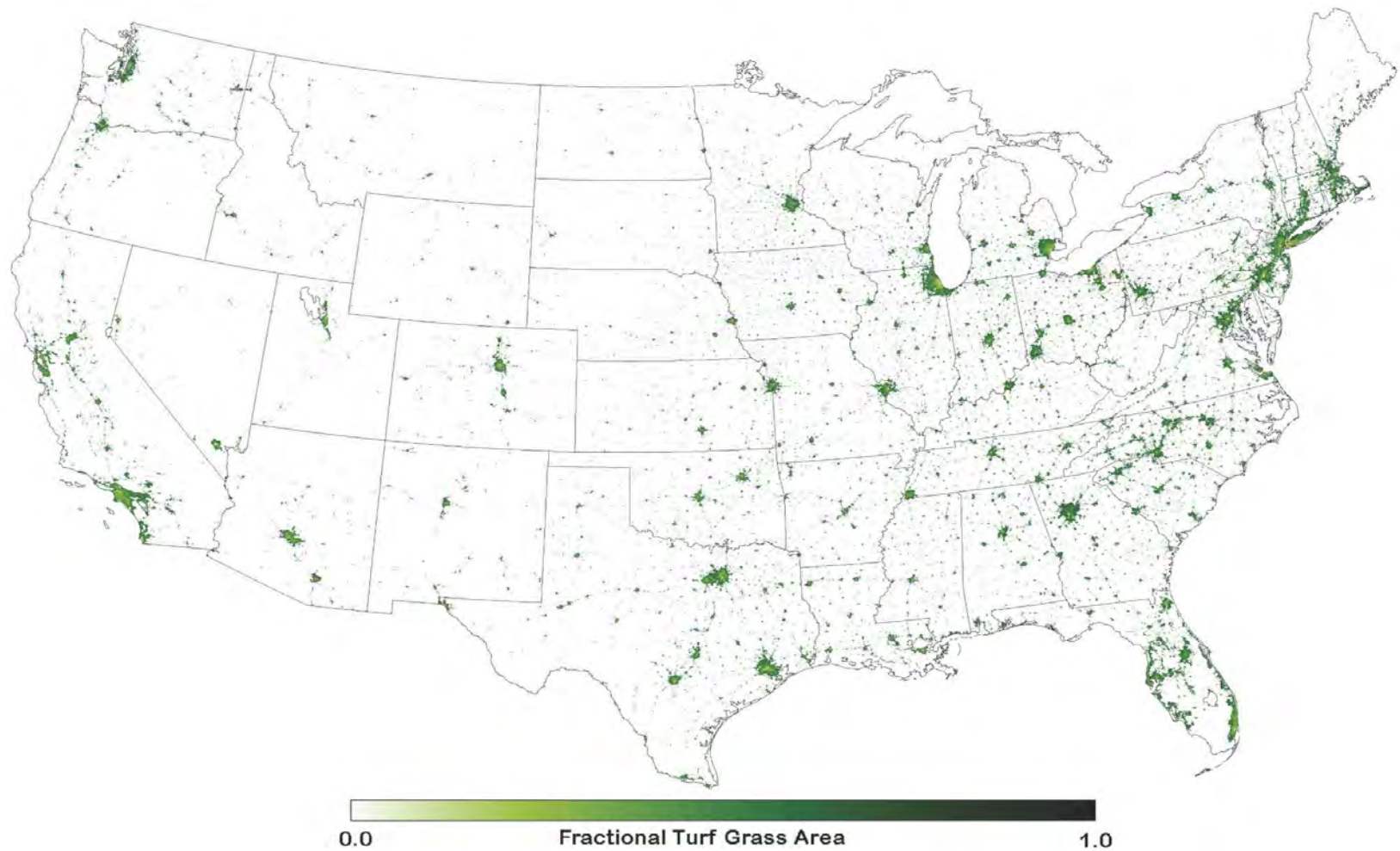


Figure 9. Satellite-derived estimates of the fractional turf grass (lawn) area in the United States (NASA Ames Research Center).

that contain short grasses, cattails, or ferns) experienced a negligible decrease (**0.1%** or **20 acres** less emergent herbaceous wetland areas in 2019 compared to 2001) over this time period. As of 2019, woody wetlands land cover accounts for **4%** of the land area of the Cape, and emergent herbaceous wetlands land cover accounts for **8%** of the land area of the Cape. The implementation of wetlands bylaws and ordinances that discourage development in these resources have likely played a factor in stemming the loss of wetlands on the Cape. Cultivated crop land cover experienced a small increase (**7%** or **80 acres** more cultivated crop areas in 2019 compared to 2001). As of 2019, cultivated crop land cover accounts for **0.5%** of the land area of the Cape.

In addition, development patterns from 2001 to 2019 seem to reflect an increase in concentrated development (see Map 1). “High intensity development” (e.g., apartment complexes, row houses, and commercial/industrial development) saw the greatest increase from 2001 to 2019, with approximately **16%** more high intensity developed areas in 2019 compared to 2001 (**700 acres**). As of 2019, high intensity development land cover accounts for **2%** of the land area of the Cape. While high intensity development can be

associated with an increase in impervious cover, which can lead to environmental degradation, this trend may indicate that the Cape is beginning to slow its historic pattern of increased sprawl. Less land available on the Cape to accommodate typical suburban development patterns may also be a factor. Higher intensity development can be environmentally beneficial when it is located properly in already disturbed areas with access to utilities and services, particularly wastewater infrastructure. Denser development in such areas can help relieve development pressure on more sensitive lands and leave more area for conservation. However, when located outside such areas, higher intensity development can be particularly harmful to the environment by converting previously undisturbed landscapes. This trend highlights the importance of strengthening zoning measures that encourage development and redevelopment in already developed areas with access to infrastructure, such as water and sewer, while also requiring or encouraging low impact development techniques (such as green roofs, rain gardens, porous pavers, rain barrels). At the same time, it is equally important to adopt protective zoning and other actions in natural resource areas to protect undeveloped areas that have significant natural resource value.

SECTION II. PRIORITY NATURAL RESOURCE AREAS

The Cape's identity and the livelihood of its residents are inextricably tied to the health of its natural resources. Without clean water for drinking and recreation, and healthy ecosystems that support the flora and fauna that have come to define this region, the Cape as we know it will be gone. In addition to development pressures, Cape Cod's natural resources are challenged by the global impacts of climate change and sea level rise reshaping coastlines, shifting the location of marshlands, and slowly altering native plant and animal habitats, among other impacts. To prepare as a region for these challenges and protect our way of life, conservation of our natural resources is essential. There are multiple benefits to strategic conservation: protecting against flood damage, preserving good drinking water quality, reducing air pollution, providing habitat, creating recreation opportunities, and



Figure 10. Eastern box turtle (Association to Preserve Cape Cod).

otherwise ensuring that we can preserve the Cape Cod we know today for generations to come. Conservation and preservation are as much about today as they are about the future.

Identifying Priority Natural Resource Areas

The Commonwealth of Massachusetts has identified many natural resource areas that are particularly important to protect.

For the purposes of this analysis, the following areas were considered “priority” for the Cape:

- BioMap2 (Core Habitat and Critical Natural Landscape)
- Zone II Wellhead Protection Areas
- Wetlands
- Certified and Potential Vernal Pools
- Priority and Estimated Habitat
- Protected Open Space (protected in perpetuity)

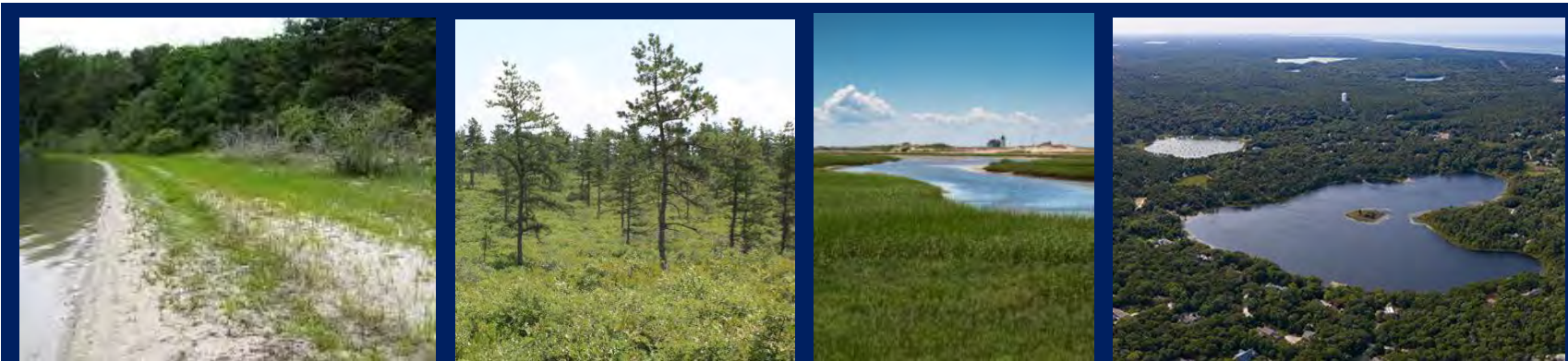
The following sections describe each of these resources and their locations on the Cape in detail, but it is important to also consider how these resources have been collectively impacted on the Cape by development. Today, priority natural resources on the Cape comprise approximately **190,000 acres**. However, development has occurred in, and consequently impacted, approximately **27%** or over **50,000 acres** of these remaining priority natural resource areas.

Protected Open Space

A common misconception is that preserved land is “unproductive.” In reality, protected open space provides value in many different ways. Protected open space can provide benefits to humans such as recreational opportunities, improved stormwater management

through the natural infiltration of water and reduction of pollutants to nearby waterbodies, improved drinking water quality through the protection of groundwater and surface water resources, carbon sequestration to mitigate climate change, and enhanced air quality from trees and understory vegetation. In addition, protected open

space adds value to existing properties and defines the rural aesthetics of the Cape, attracting non-resident visitors who inject new revenue into local economies. Every \$1 invested in land conservation in New England returns between \$4 and \$11 in economic value (Highstead, n.d.). Some may express concern that



The Cape is home to several unique ecosystems which support a diversity of plant and wildlife species. Coastal plain ponds are bodies of freshwater found in lowland coastal areas of sand and gravel which were deposited as outwash when glaciers melted. Even though these ponds are naturally nutrient-poor, human activities have increased nitrogen and phosphorous loading in many areas. Due to periodic flooding and changes in water levels, coastal plain pondshores maintain a diverse community of shoreline vegetation, which is a high priority for conservation, as well as habitat for wildlife (UMass Amherst, 2017). Pine barrens are characterized by sandy soils that are poor in nutrients and prone to drought. Pine barrens support a variety of wildlife, many of which are rare and specifically adapted to this habitat. Rapid development and suppression of fire have caused pine barrens to decline dramatically across their range (The Nature Conservancy, 2009). Salt marshes form in areas subject to oceanic tides that are mostly sheltered from wave energy, typically in estuaries and behind barrier beaches. Many species of birds forage in salt marshes and they provide essential habitat for juvenile marine creatures. Threats to salt marshes include invasive species, coastal development, sea level rise, and coastal erosion (Massachusetts Division of Fisheries and Wildlife, n.d.). Cape Cod is home to hundreds of kettle ponds, formed from depressions in glacial outwash plains 18,000 years ago. Kettle ponds are at risk from agricultural activities, stormwater runoff, invasive species, effluent from septic systems, and climate change which is gradually warming waters and leading to toxic algal blooms (National Park Service, n.d.).

From left to right: Coastal plain pond (MA Natural Heritage and Endangered Species Program); pine barren woods (MA Natural Heritage and Endangered Species Program); salt marsh (National Park Service); kettle ponds (Cape Cod XPlore).

open space purchases remove land from the tax base, but a 2014 analysis by the Brewster Assessor's Office found that even though Brewster town and non-profit open space accounted for approximately 15% of the town's land mass, protected open space amounted to a less than 1% impact on the town's tax base

("ratables") by value. When considering the substantial ecosystem services that protected open space provides to a community, the benefits clearly speak for themselves.



*One of the rare plant species supported on the Cape is the American sea-blite (*Suaeda calceoliformis*) which is a state listed species of Special Concern that is present along salt ponds, the sandy border of salt marshes and estuaries, sandy and gravelly beaches, and tidal flats. Off-road vehicles, trampling from beach users, and development are the primary threats to this species (Massachusetts Division of Fisheries and Wildlife, 2015a). Salt reedgrass (*Spartina cynosuroides*) is another state listed species that is identified as Threatened. Salt reedgrass is found at the upper margins of salt marshes and in brackish tidal marshes and estuaries. Competing invasive species and development, in particular increased runoff and siltation of wetlands, are major threats to this species (Massachusetts Division of Fisheries and Wildlife, 2015b). The slender marsh pink (*Sabatia campanulata*) is a state listed Endangered species that is found along shores of coastal plain ponds. Threats to this species include excessive water withdrawals, change in ground and surface water hydrology, and off-road vehicles (Massachusetts Division of Fisheries and Wildlife, 2015c). The Plymouth gentian is another state listed Special Concern species that is found near coastal plain ponds. Competing invasive plants, mowing of pond edge vegetation, pond eutrophication, beach raking, off-road vehicles, and changes in hydrology are the primary threats to this species (Massachusetts Division of Fisheries and Wildlife, 2022).*

From left to right: American sea-blite (Native Plant Trust); salt reedgrass (Bruce Sorrie); slender marsh pink (Bruce Sorrie); Plymouth gentian (Association to Preserve Cape Cod).

Protected open space also supports important environmental and ecological functions, such as providing habitat for plants and animals. The Cape supports [132 state-listed](#) rare plant and animal species and hundreds of additional species, including 75 threatened and endangered species

Some animal species come to the Cape for breeding or seasonal migration while others are year-round residents (Cape Cod

Commission, 2019b). Permanently protected open space is essential to ensure adequate habitat for these vulnerable species. Without protected open space to provide a variety of habitats to support so many species, the Cape as a region would lose its important ecological diversity.



Twenty-five federally protected species are present in the Cape Cod National Seashore alone, most prominently the threatened piping plover (National Park Service, 2022). Many species of migratory birds winter on the Cape or come to the Cape in the summer to breed. For example, the least tern is a state listed species of Special Concern that nests on sandy or gravelly beaches and forages in shallow-water habitats. Threats to the least tern include coastal development along the species habitat, off-road vehicles, and human encroachment on beaches where the terns nest (Massachusetts Division of Fisheries & Wildlife, 2015d). The saltmarsh sparrow is a state listed species of Special Concern that inhabits coastal salt marshes dominated by saltmeadow cordgrass and saltwater cordgrass. Sea-level rise exacerbating high tide flooding and habitat degradation from development are the primary factors reducing the reproductive success of this species (Massachusetts Division of Fisheries and Wildlife, 2020). The common tern is a state listed species of Special Concern that nests on sandy or gravelly islands or barrier beaches and forages near the shore. Threats to the common tern include increased predation and predation by gulls, exacerbated by development near tern habitat (Massachusetts Division of Fisheries and Wildlife, 2015e).

From left to right: Piping plovers (Wildlife Preservation Canada); least tern (Massachusetts Division of Fisheries and Wildlife); saltmarsh sparrow (Wikimedia Commons); common tern (Wikimedia Commons).

As of 2019, there are approximately **91,000 acres** of open space protected in perpetuity on the Cape. Cape Cod land trusts have been some of the strongest champions of open space acquisition on the Cape. A Compact of Cape Cod Conservation Trusts analysis of land protection by Cape Cod land trusts from 2000 to 2021 indicates that over this 22-year period, the land trusts have protected an average of **239 acres** per year (The Compact of Cape Cod Conservation Trusts, 2022).²

The pace of open space acquisition has been challenged by the pace of development on the Cape, however. For example, an analysis of vacant land conversion in Brewster from 2013 to 2020 indicated that over this period of time, roughly the same proportion of vacant land has been developed (**157.88 acres**) as has been conserved (**157.79 acres**) (Minis, 2022). There are nearly **50,000 acres** of remaining undeveloped land on the Cape that are not currently permanently protected. **Of those acres, roughly 40,000 acres overlap with priority natural resource areas. Our priority natural resource areas are finite and must be protected before they are gone forever.**³

Priority and Estimated Habitats

Priority Habitats of Rare Species includes the geographic extent of habitat of state-listed rare species in Massachusetts based on observations documented within the last 25 years. Priority Habitat designations are a trigger for whether a proposed project or activity

² It is important to note that in this analysis, between land trusts there may be some double counting of acreage for projects which include town partnerships.

³ It is important to note that open space acquisitions change continually and the MassGIS data layers utilized for this analysis are therefore

Joint Base Cape Cod

Of its 22,000 acres, the northern 15,000 acres of Joint Base Cape Cod were designated by Massachusetts Governor Paul Cellucci in 1999 as the Upper Cape Water Supply Reserve, and legislation officially establishing it as such was signed into law by Acting Governor Jane Swift in 2002. The Reserve is recognized by the state as the largest contiguous undeveloped area on Cape Cod and identified by the state as “permanently protected.” However, it is important to note that in the legislation establishing it, the Upper Cape Water Supply Reserve is dedicated to “(a) the natural resource purposes of water supply and wildlife habitat protection and the development and construction of public water supply systems, and (b) the use and training of the military forces of the commonwealth; provided that, such military use and training is compatible with the natural resource purposes of water supply and wildlife habitat protection.” Consequently, some proposed projects on the northern 15,000 acres represent an expansion of military activities on the Reserve, which could present new threats to the natural resources found there.

must be reviewed by the state’s Natural Heritage and Endangered Species Program (NHESP) for compliance with the Massachusetts Endangered Species Act (MESA). Areas delineated as Priority Habitat can include wetlands, uplands, and marine habitats. Although mapped areas are given a certain level of regulatory protection by

considered to be constantly under development. Additionally, due to the collaborative nature of this data collection effort, the accuracy and completeness of open space data varies across the state’s municipalities. Attributes, while comprehensive in scope, may be incomplete for many parcels.

the state, unlike permanently protected open space, these areas are not immune from development pressures. Estimated Habitats of Rare Wildlife are a subset of Priority Habitats of Rare Species. They are based on occurrences of rare wetland wildlife observed within the last 25 years and documented in the NHESP database. They do not include those areas delineated as Priority Habitat for rare plants or for rare wildlife with strictly upland habitat requirements.

Priority and estimated habitats are delineated by NHESP scientists based on documented observations of rare species and factors such as species movements and habitat requirements. Because NHESP scientists are partially reliant on third parties to recognize, identify, and report observations of rare species, these delineations are subject to change based on third party engagement. In addition, in 2012, the delineations of priority and estimated habitats were curtailed by state legislation, which restored appellate rights to priority habitat landowners whose property was subject to review and restrictions by NHESP. These changes enabled property owners to appeal in Superior Court and petition the state for compensation if land is taken or barred from future development. NHESP responded by limiting the extent of its priority and estimated habitat designations.

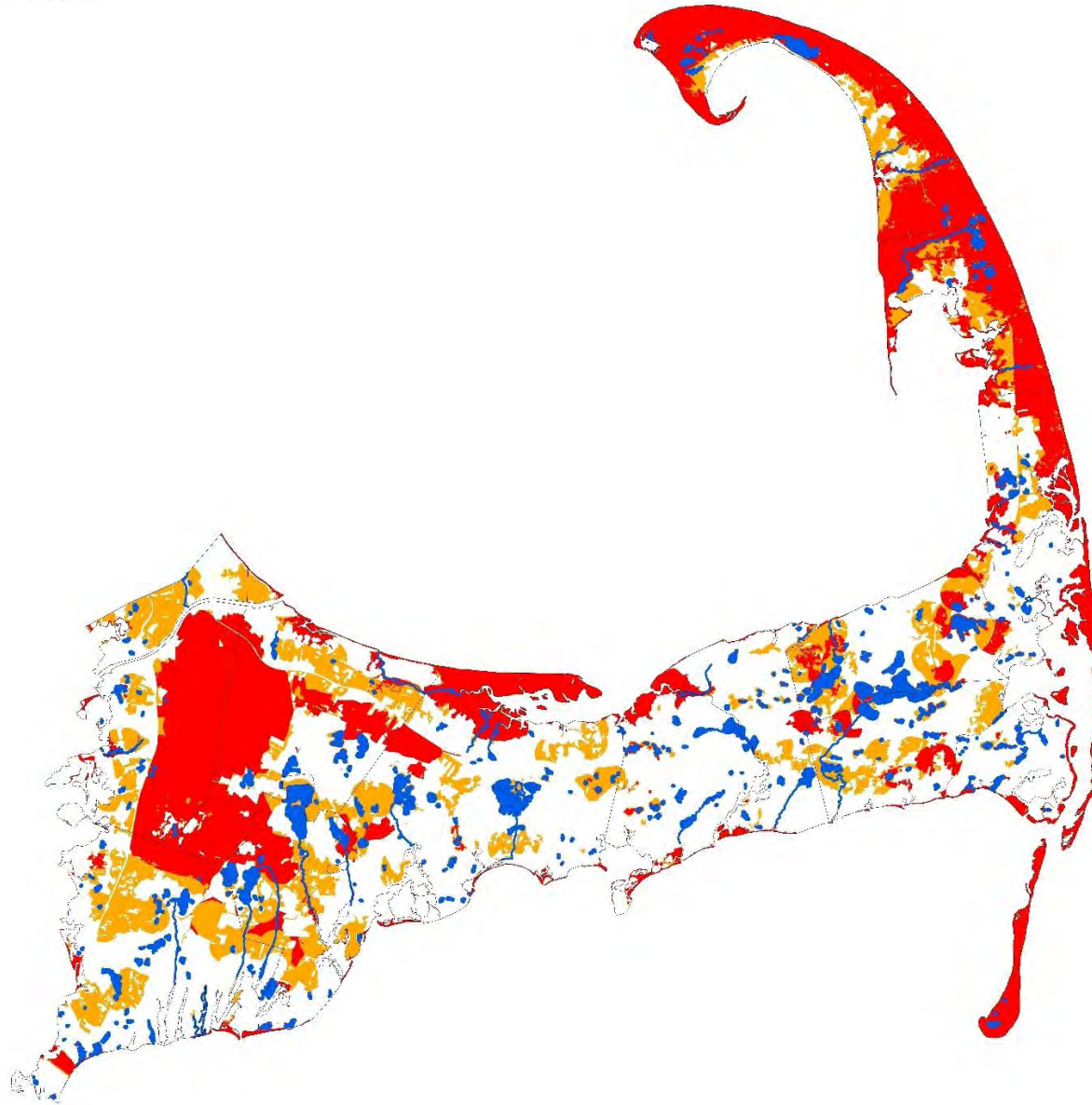
Using 2008 and 2021 NHESP delineated priority and estimated habitats, this report's spatial analysis revealed that there was a considerable loss in acres included in these state classifications between those two time periods due in part to NHESP's policy decision to curtail the extent of these habitat designations. Estimated habitat from 2008 to 2021 was reduced by **33%** or over

38,000 acres and priority habitat was reduced by **29%** from 2008 to 2021 or approximately **37,000 acres** on the Cape (see Map 2).

These reductions do not necessarily mean that habitat has been "lost." Rather, public policy decisions have changed regarding what areas are under NHESP jurisdiction. Areas no longer considered priority habitat are now more at risk than they would be otherwise. This trend underscores the importance of conservation advocacy. An important role of conservationists is volunteering time to [catalogue and report](#) on potential priority habitats as well as advocating for sound environmental policy at the state level. The protection of these now declassified lands is imperative.

Like other open space, habitat areas are particularly susceptible to the impacts of development and climate change. Development can lead to a loss of habitat that would otherwise support rare species, leading to habitat fragmentation and potential loss of wildlife as movement patterns are restricted. Often, priority and estimated habitats are home to unique ecosystems that support a variety of wildlife. As development leads to a loss in habitat, it also leads to a loss of biodiversity and other ecosystem services such as flood mitigation or water quality protection. As climate change brings changes to precipitation levels and average temperatures, native plant and animal habitats are forced to shift. In some cases, habitats may disappear altogether.

- ### MA NHESP Estimated and Priority Habitat
- Municipal Boundaries
 - USGS Major Streams and Rivers
 - USGS Major Ponds and Lakes
 - 2008 Estimated and Priority Habitat
 - 2021 Estimated and Priority Habitat



Cape Cod Open Space Analysis
Barnstable County

Map 2.0
MA NHESP priority and estimated habitats.

Map 2. MA NHESP Estimated and Priority Habitat 2008 and 2021.

BioMap2

The [BioMap2](#) project, a joint initiative between the Massachusetts Department of Fish & Game's Natural Heritage & Endangered Species Program (NHESP) and The Nature Conservancy's Massachusetts Program, is a valuable mapping tool for the Commonwealth's most sensitive land and water resources.⁴ BioMap2 integrates prior research and mapping of rare species and ecosystems and is a framework for strategic land protection and stewardship efforts. While Priority and Estimated Habitats are utilized to determine compliance with MESA, BioMap2 looks more broadly at guiding strategic biodiversity conservation efforts by focusing on areas most critical for ensuring the protection of exemplary communities, diverse ecosystems, and rare and native species. The BioMap2 resources include an [online map viewer](#) where visitors can identify areas with different types of biodiversity and conservation value. BioMap2 has no regulatory power but is a tool that every community in Massachusetts can use to identify the highest priorities for conservation.

The most significant threats to BioMap2 areas are development and climate change. Continued development within BioMap2 areas harms ecosystem functions, removing habitats that are critical to support the rare plant and animal species that call the Cape home. Loss of BioMap2 lands can also mean a loss of flood mitigation and recreational opportunities, in addition to the potential degradation of water quality. As climate change alters native plant and animal habitats with new temperatures and precipitation patterns, coupled

with sea level rise, some of these lands are in danger of being lost forever.

Core Habitat

Core Habitat is one of the main components of BioMap2. Core Habitat areas are habitat that is necessary for the long-term survival of rare and other native plants and wildlife. There are approximately **110,000 acres** of Core Habitat on the Cape (see Map 3). A local example of Core Habitat that is protected is the [Cape Cod National Seashore](#), which is known for its diverse upland, wetland, and coastal ecosystems that are home to over 450 wildlife and 800 plant species. As referenced in the Brewster Case Study in Section III, the Punkhorn Parklands have been protected to preserve drinking water in Brewster and neighboring communities. Significant portions of the Punkhorn Parklands include Core Habitat, again demonstrating the multiple benefits of open space acquisition. Unfortunately, not all Core Habitat identified areas are protected. For example, many of the Cape ponds and associated shoreline and uplands are identified as Core Habitat. These areas are especially important around coastal plain ponds which have very sensitive and globally significant plant communities. However, not all of these areas are protected, making these pondshore locations and their supporting habitats vulnerable. Protecting Core Habitat areas helps conserve wildlife habitat and also provides numerous benefits to humans, including flood mitigation, protection of drinking water quality, and recreational opportunities.

⁴ MassWildlife and The Nature Conservancy released a third, newly-updated BioMap tool in November 2022. The Core Habitat and Critical

Natural Landscapes layers for Cape Cod are largely the same as the previous BioMap2 version, which is used in this report.

Critical Natural Landscape

Critical Natural Landscape (CNL) is the other main component of BioMap2. CNL are large, minimally fragmented areas critical for ecological resilience, as they support a range of ecological processes and high biodiversity, maintain connectivity across different habitat areas, and include buffer areas upland of Core Habitat. Conserving CNL areas enhances Core Habitat and protects their associated benefits to plants, wildlife, and humans. There are approximately **94,000 acres** of Critical Natural Landscape on the Cape (see Map 3). Similarly to Core Habitat, Critical Natural Landscapes include both protected and unprotected areas. For example, one of the largest corridors of Critical Natural Landscape on the Cape extends from the Upper Cape Water Supply Reserve at Joint Base Cape Cod through Mashpee to Nantucket Sound. This corridor includes several significant habitats, but is a mixture of protected and unprotected areas.

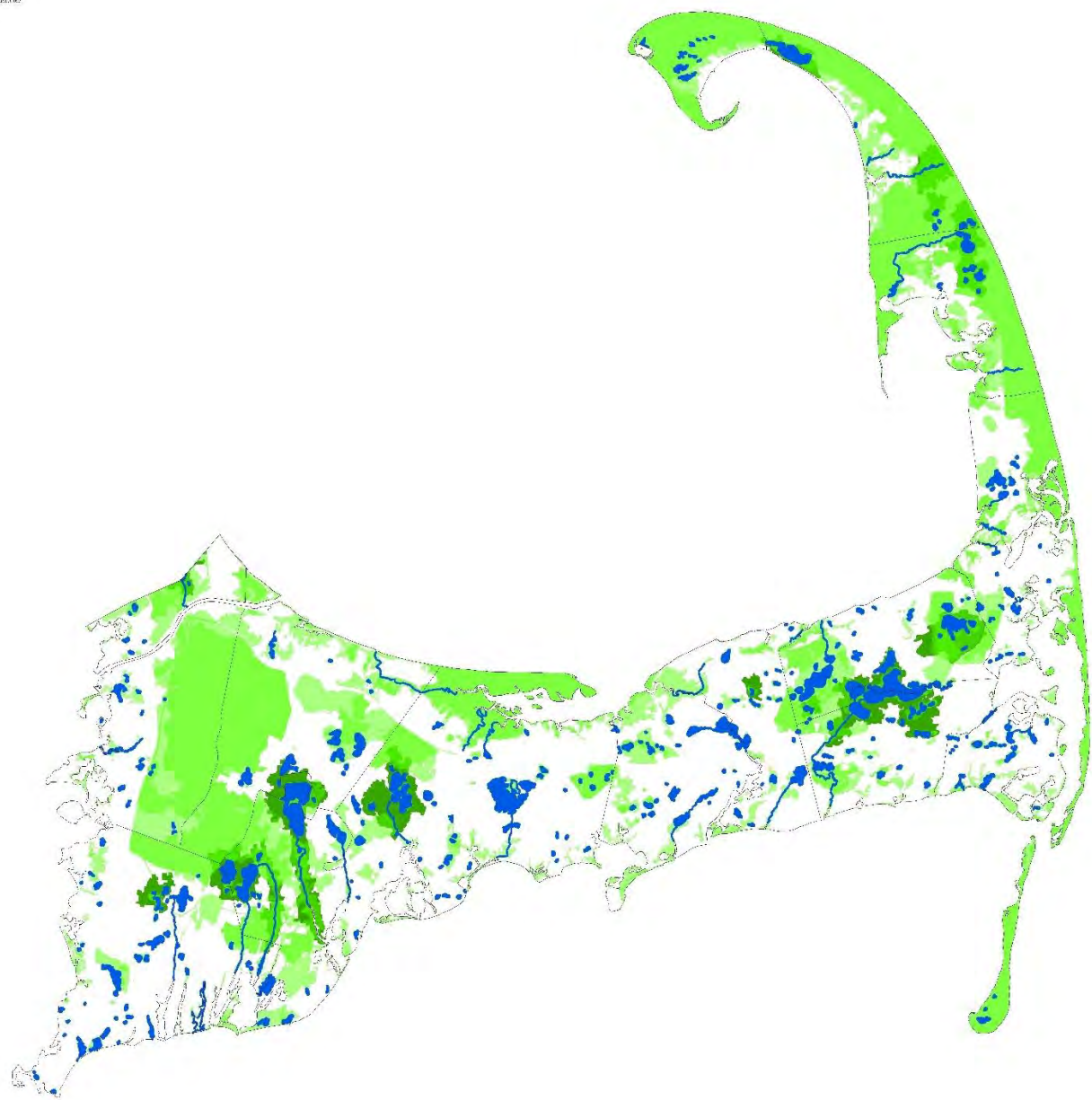
Today, BioMap2 includes considerably more land area as compared to BioMap (also known as BioMap1). It is important to note that there is some overlap of mapped CNL and Core Habitat areas in BioMap2. BioMap1 includes core habitats and supporting natural landscapes but includes considerably fewer factors than BioMap2. For example, coastal adaptation was not considered in BioMap1. In total, BioMap2 includes approximately **92,000 acres** more of land than BioMap1 (see Map 3). The following map illustrates locations of BioMap1 and BioMap2 on the Cape.



Figure 11. The saltmarsh sparrow is listed as a state species of "Greatest conservation need" (Gerald Beetham).

BioMap1 and BioMap2

- Municipal Boundary
- USGS Major Streams and Rivers
- USGS Major Ponds and Lakes
- BioMap2 (2011)
- BioMap1 (2000)



Map 3. MA BioMap1 and BioMap2.

Zone II Wellhead Protection Areas

Another important area for conservation is Zone II Wellhead Protection Areas. These areas are established by the Massachusetts Department of Environmental Protection's Drinking Water Program to protect the recharge area around public drinking water groundwater supplies. A recharge area is the area where precipitation infiltrates into the ground and replenishes the groundwater that flows into a pumping well. [All Cape Cod communities rely on the aquifer](#) for their drinking water, as even Falmouth's Long Pond reservoir is predominantly fed by groundwater. Zone II Wellhead Protection Areas are integral to maintaining high-quality and safe drinking water for the region, and communities use them to regulate land uses and activities that may



Figure 12. Drinking water protection sign in Hyannis (Association to Preserve Cape Cod).

impact drinking water quality and pose human health hazards. For example, communities can prohibit high risk uses and activities like landfills and automobile junkyards within protection areas, as contaminants may leach into underground sources of drinking water if allowed.

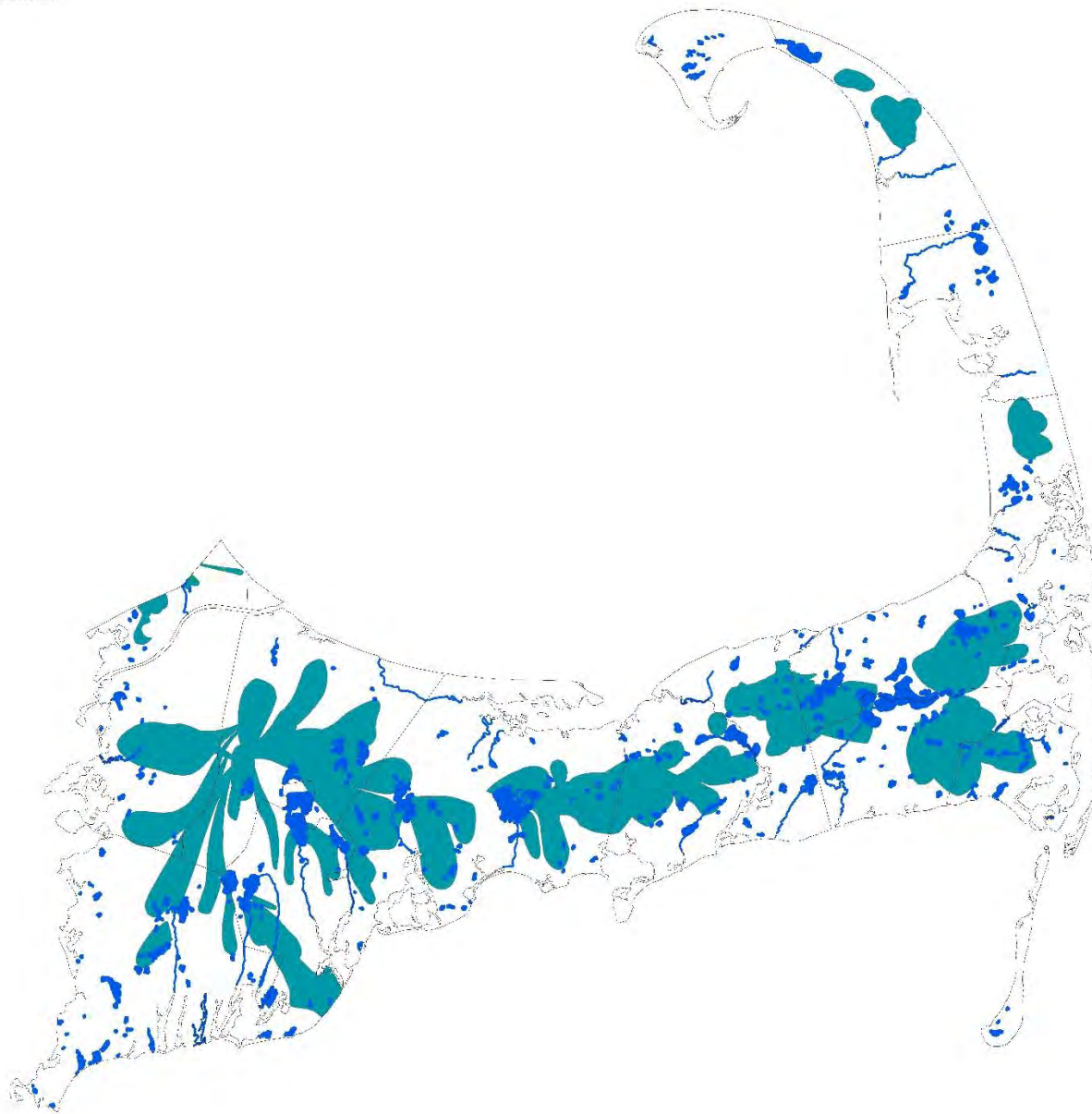
Among the most significant threats to Zone IIs is nutrient pollution from septic systems, which, counter

to intuition, are not prohibited in Zone IIs. Conventional septic systems are not designed to remove nitrogen, a nutrient which when present in drinking water supplies as nitrate can cause human health concerns. In addition to septic systems, other watershed activities taking place on top of the water supply can have direct impacts on the water supply. Emerging contaminants, such as PFAS (perfluoroalkyl and polyfluoroalkyl substances), pharmaceuticals, and other contaminants, can also seep into groundwater, polluting drinking water supplies.

The following map captures the current Zone II Wellhead Protection Areas on the Cape. Currently, Zone IIs comprise **27%** or approximately **70,000 acres** of the Cape (see Map 4). Overall, approximately 36% of the Zone II areas are protected open space. This is primarily a result of the land acquisitions in the 1980s and 1990s that focused on protecting drinking water supplies. As shown in the case study regarding Brewster, 41% of its Zone II area is protected open space. Brewster and Dennis have won quality awards for their drinking water in New England competitions, owing to the large, protected wellfields surrounding their wells.

MassDEP 2022 Zone II Wellhead Protection Areas

-  Municipal Boundaries
-  USGS Major Streams and Rivers
-  USGS Major Ponds and Lakes
-  Zone II Wellhead Protection Areas



Map 4. MassDEP designated Zone II Wellhead Protection Areas.

Wetlands, Ponds, and Coastal Estuaries

[Wetlands](#), areas where water covers or saturates the land permanently or seasonally, encompass a range of diverse and valuable habitat types that provide high biodiversity. Cape Cod is home to an extensive network of coastal and tidal wetlands, estuaries, inland and non-tidal wetlands, and freshwater ponds. Along with the Cape's ponds, freshwater wetlands include bogs, marshes, wet meadows, red maple swamps, and Atlantic white cedar swamps. Freshwater ponds and the associated wetlands that border them are particularly valuable natural resources on the Cape. They provide a diversity of habitat for the Cape's flora and fauna, including ecologically unique species, in addition to recreational value (Cape Cod Commission, 2022d). Ponds on the Cape are impacted by nutrients, including phosphorus and nitrogen, from sources such as septic systems, road runoff and lawn fertilizers. These nutrients cause eutrophication and raise the risk of harmful cyanobacteria blooms.

Coastal wetlands on the Cape include salt marshes, dunes, and intertidal areas as well as coastal estuaries and salt ponds (Cape Cod Commission, 2019c). Coastal estuaries are found along many parts of the Cape Cod shoreline and are partially enclosed coastal areas that have some level of tidal restriction. Nearly **80%** of Cape Cod's land area drains to coastal estuaries. Estuaries are a combination of fresh and salt water, providing important spawning habitat for fish, shellfish, migratory birds, and other plant and wildlife populations (Cape Cod Commission, 2022e).

With respect to protecting water quality, freshwater wetlands protect marine and freshwater bodies by removing nutrients and other pollution associated with development. Additional ecosystem benefits of wetlands for humans include drinking water quality



Figure 13. Hinkley Pond, Harwich (Gerald Beetham).

protection, flood storage and mitigation, and recreation opportunities. Separate from ponds and estuaries, the Cape's wetlands comprise approximately **30%** or roughly **70,000 acres** of land area on the Cape (see Map 5). Of those 70,000 acres, approximately **37,200 acres** of wetlands fall within permanently protected resource areas. Fresh water ponds on their own comprise approximately **5%** or roughly **5,500 acres** separately from the wetland acreage provided above. The following map illustrates the locations of wetland resources and ponds.

Historically, the Cape has a long history of wetland loss and degradation due to dredging and filling for development, roads and dikes altering freshwater or tidal flow patterns and increasing stormwater, excessive groundwater withdrawals for water supplies, and drainage ditches and salt marsh channels built for mosquito



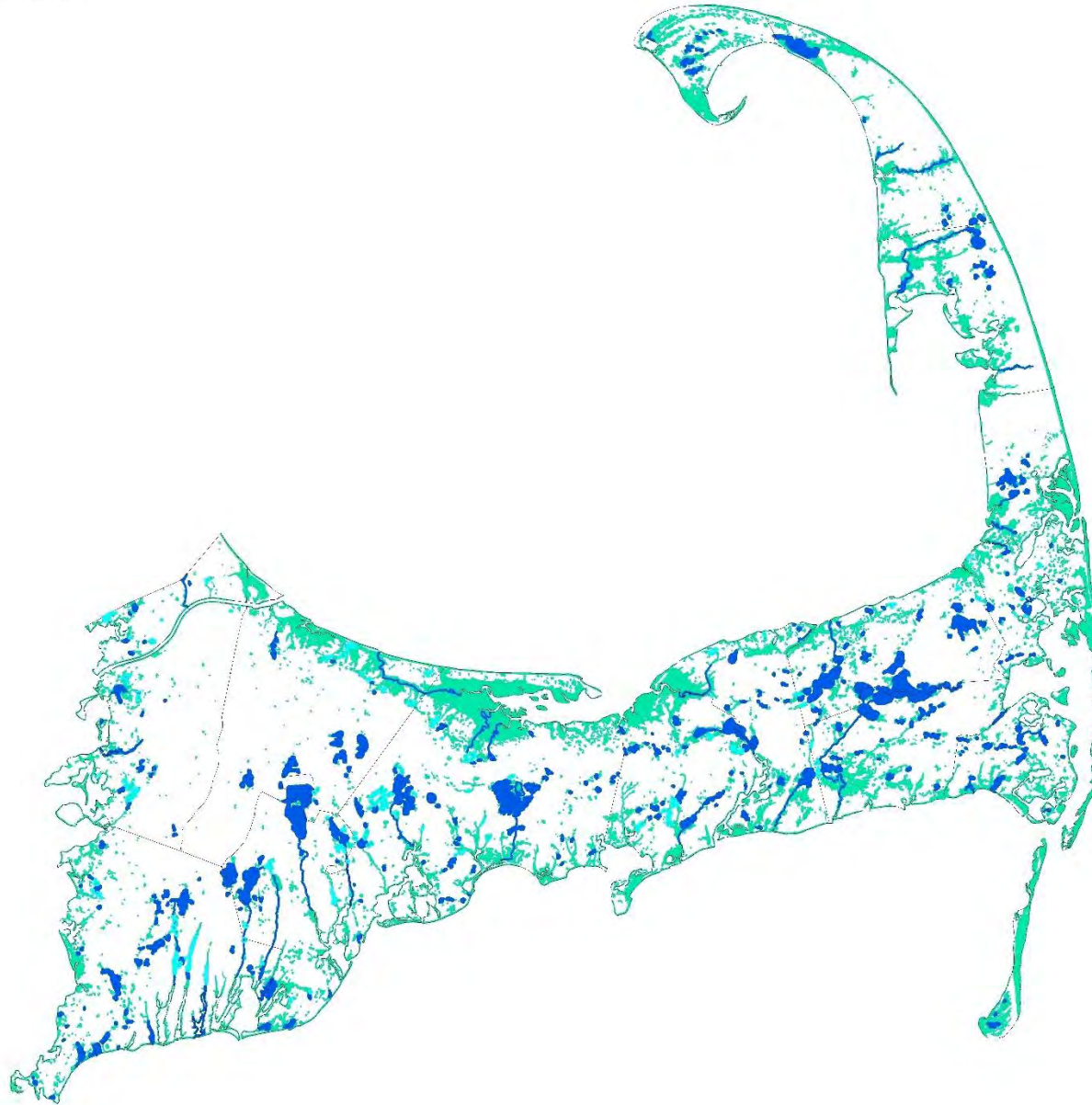
Figure 14. Olivers Pond (Gerald Beetham).

control that altered wetland hydrology.⁵ For example, a 1987 study of the Pamet River in Truro found 16 separate compartments of the estuary—diked off in the 1800s for swamp gardens and cranberry bogs (Truro Conservation Trust, 1987).

State and local wetlands protection regulations have been in place since the 1970s and have slowed the impacts on these resources. However, their health is still threatened by development pressure near the wetland border and in the upland watershed areas. The introduction of invasive species, whether intentional or by accident, has had a significant impact on the health of wetland ecosystems by putting pressure on native species and eventually pushing them out of their habitat. The water quality of wetlands has also been degraded by nutrient pollution from stormwater runoff, including from excessive fertilizer application, and septic systems. In addition, wetlands, and in particular salt marshes, are threatened by rising sea levels and increasingly intense storms, which threaten these

areas with erosion and inundation. The hardening of shorelines also inhibits salt marsh migration, and combined with sea level rise, creates a phenomenon known as “coastal squeeze” where the inland retreat pattern for marshes is entirely blocked (NOAA, 2019).

⁵ Mass Audubon reports that of the 3,000 miles of mosquito ditches in Massachusetts, most dug in the 1930s, there are 1,000 miles on Cape Cod.



National Wetlands Inventory Areas

Municipal Boundaries

USGS Major Streams and Rivers

USGS Major Ponds and Lakes

Wetlands



Map 5. National Wetlands Inventory identified wetlands.

Certified and Potential Vernal Pools

Vernal pools are temporary and often small, shallow freshwater ponds, characterized by a lack of permanent fish populations. On the Cape, due to the prevalence of kettle holes that are not connected to streams, low-lying isolated wetlands are likely to serve as vernal pool habitats. These unique wetlands support important functions for plant and wildlife species, such as breeding and feeding. Some amphibian and invertebrate species have even developed breeding strategies that are successful because of the lack of fish that would otherwise eat eggs and larvae. It is important to note that vernal pools are reliant on suitable upland habitat to sustain breeding vernal pool populations during the non-breeding times of the year, with some vernal pool-dependent amphibian species inhabiting areas 700 or more feet from the pool. For this reason, the Cape Cod Commission and APCC recommend a minimum 350-foot upland buffer around vernal pools.

[Certified vernal pools](#) are those that have been officially certified by the Massachusetts Department of Fish & Game's Natural Heritage & Endangered Species Program (NHESP) according to state guidelines. Certified vernal pools are protected under the Massachusetts Wetlands Protection Act if they meet the law's definition of "wetlands." Local regulations may provide additional protection for pools that do not meet state criteria for protection. [Potential vernal pools](#) are not protected—as they have not been officially certified by NHESP staff—and are thus more vulnerable to human impacts.

Aside from their habitat and ecosystem function value, vernal pools provide flood mitigation by capturing water and water purification by intercepting and filtering pollutants. Vernal pools and their associated plant and wildlife also enrich many passive recreational areas across Cape Cod with their beauty.



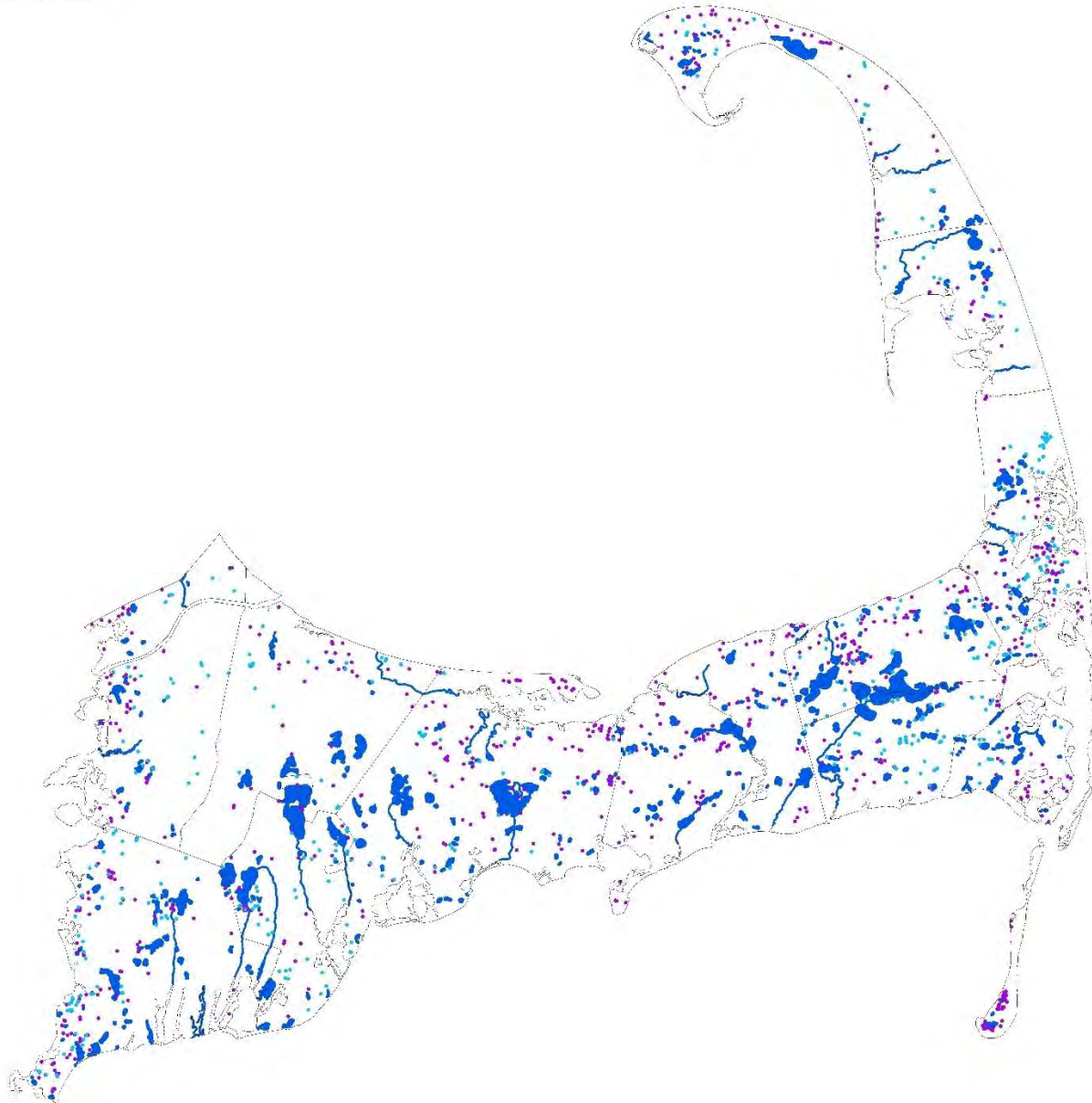
Figure 15. Vernal pool (Association to Preserve Cape Cod).

Vernal pools are particularly sensitive to the impacts of development. Development can lead to the direct loss of unregulated existing breeding pools, the clearing and conversion of adjacent habitat that supports the adult species, and a loss in landscape connectivity that restricts the movements of wildlife that rely on vernal pools. In addition, development can lead to an increase in nonpermeable surfaces (e.g., parking lots, rooftops, driveways) which exacerbate erosion and sedimentation, stormwater runoff pollution, degrading water quality for vernal pools by causing changes in water chemistry and temperature. The use of herbicides or pesticides around vernal pools can also harm vernal pool water quality and wildlife. Vernal pools may also be impacted by public well drawdown. Finally, climate change poses yet another threat to vernal pools as changes in temperatures and rainfall can disrupt the delicate environmental cues that drive the life cycle of aquatic wildlife that rely on the pools.

The following map captures the location of NHESP mapped certified and potential vernal pools on the Cape. It is important to note that many other potential vernal pools do exist beyond what is mapped by the NHESP. [Reporting of vernal pool observations](#) by the public is critical to ensure that the NHESP list is as accurate as possible. As of April 2022, there are **395** certified vernal pools and **890** potential vernal pools on the Cape (see Map 6).

NHESP Certified and Potential Vernal Pools

- Municipal Boundaries
- USGS Major Streams and Rivers
- USGS Major Ponds and Lakes
- NHESP 2022 Certified Vernal Pools
- NHESP 2013 Potential Vernal Pools



Map 6. MA NHESP Certified and Potential vernal pools.

SECTION III. NATURAL RESOURCE PROTECTION CASE STUDIES

The following case studies document land acquisition projects and important resource protection strategies on the Cape. Each of these stories illustrates how in protecting their natural resources, these communities have helped protect drinking water quality, supported salt marsh migration to facilitate adaptation to sea level rise, and reduced nutrient pollution to ponds and coastal estuaries. Each of these case studies exemplify how the protection of natural resources coupled with thoughtful planning and policy decisions can steer the Cape towards resiliency and sustainability as a region. It is important to note that the strategies employed in these case studies can be used strategically to prevent environmental degradation, restore environmental quality from previous contamination, and reduce future impacts on already challenged resources. In order to address the present and future sustainability concerns for the Cape, these tools will need to be utilized collectively by communities to ensure the resiliency of the region.

Case Study: Land Use Planning for Drinking Water Quality Protection in Brewster

Tools Utilized: Open space acquisition, Integrated Water Resource Management planning, regulatory strategies to protect water resources

When to Employ: Before environmental degradation has occurred

Intended Outcome: Protection of drinking water supplies, protection of coastal estuaries and ponds.

Brewster's decades-long commitment to the protection of its water supplies has been implemented primarily through the acquisition of open space. The community has successfully preserved

approximately 41% of the land area that contributes water to its public supply wells. The town works often and cooperatively with the local nonprofit Brewster Conservation Trust, which has expertise to arrange land purchases, married with the town's access to capital to pay for it.

One of Brewster's most significant preservation efforts was the acquisition of land that comprises the [Punkhorn Parklands](#), a major conservation area (900+ acres) in the southwestern portion of town. The town purchased most of the land, composed of many privately-owned woodlots, in the 1980s after a development moratorium. This investment was particularly notable because this event preceded the establishment of the Cape Cod Land Bank or the [Community Preservation Act](#), property tax surcharge funds that paved the way for communities to purchase conservation land. Since the 1980s acquisitions, the town has worked with the Brewster Conservation Trust to continue to purchase land adjacent to the Punkhorn to increase the amount of land protected within the Zone II wellhead protection areas in this part of town. These

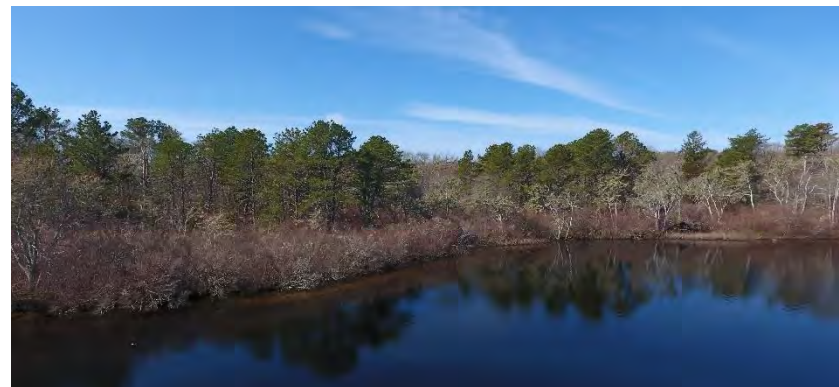


Figure 16. Slough Pond, Punkhorn Parkland (Chris Simmons).

purchases, in combination with additional acquisitions on the eastern Zone II as well as the location of [Nickerson State Park](#) over the Zone II, help to ensure that Brewster is able to maintain the high quality of its drinking water for years to come. The quality of the water provided by the town is excellent, with nitrogen concentrations below 1 mg/L. In addition to protecting drinking water, the Punkhorn property includes three kettle ponds, and prime forest ecosystems. These forests are home to red maple, black cherry, pitch pine, and black oak trees (Brewster Conservation Trust, 2022).

Brewster has also adopted a series of regulations to minimize impacts from developed areas in town as part of its [Integrated Water Resource Management Planning](#) work which

began in 2009. A District of Critical Planning Concern (DCPC) was designated in Brewster to protect the Zone II wellhead protection areas for the town wells and for wells serving the towns of Dennis, Harwich, and Orleans, on 6,538 acres in two areas of Brewster. A DCPC, adopted pursuant to authority created in the Cape Cod Commission enabling statute, is a planning tool that allows a town or group of towns to impose a temporary moratorium in a specified area on certain types of development, grandfathering, or other activities that would adversely impact the area or resource in need

of protection. The DCPC pause allows the town to plan for and adopt special rules and regulations that will protect particular resources or values of regional, statewide, or national significance (Cape Cod Commission, 2022a). The DCPC in Brewster also includes Brewster’s portion of the Pleasant Bay watershed that is impacted by nitrogen from septic system effluent, stormwater and fertilizers. In the DCPC process, Brewster adopted a [Water Quality Protection Bylaw](#) with the goal of protecting groundwater and surface water resources from phosphorus and nitrogen contamination, and

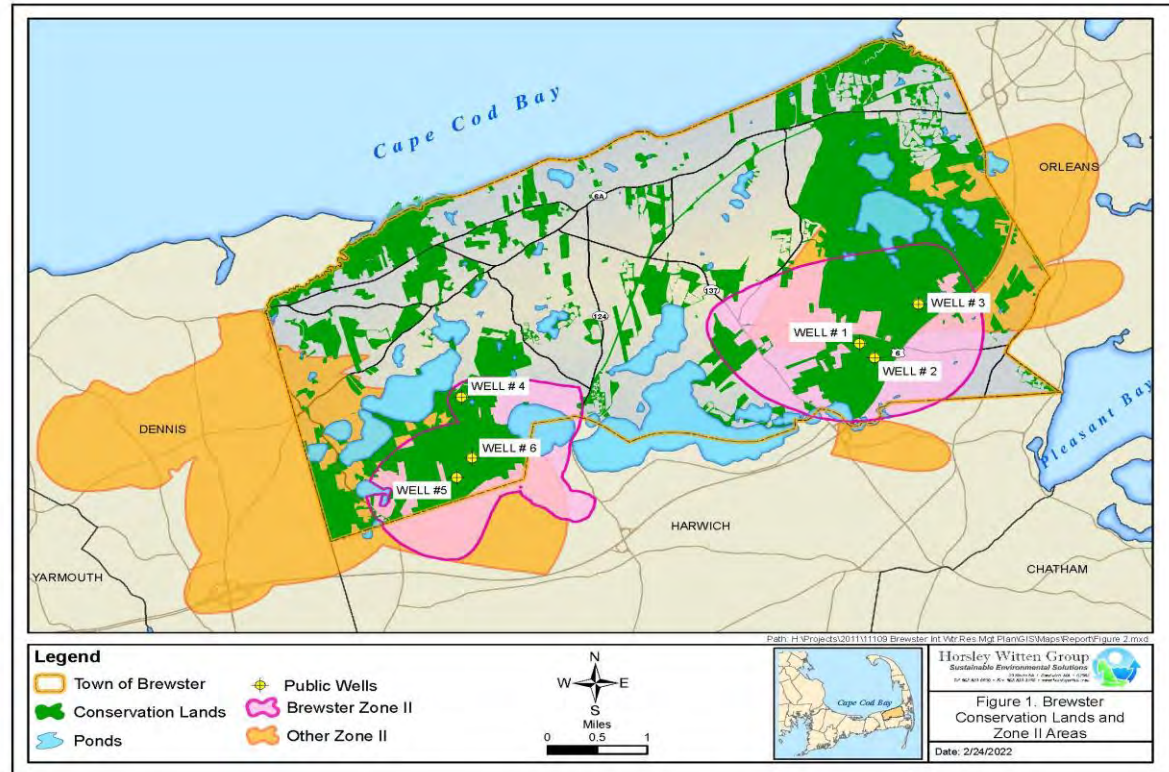


Figure 17. Brewster conservation lands and Zone II areas (Horsley Witten Group).

pollution from stormwater runoff. Specifically, the regulation limits the type of development in the regulated area to minimize threats to water quality and requires proposed projects to comply with a 5 mg/L nitrogen concentration in groundwater underneath their property. This performance standard is evaluated by the Water Quality Review Committee which works with other town boards to ensure the performance standards in the Water Quality Protection Bylaw are met. Therefore, this overlay district enables Brewster to limit phosphorous and nitrogen contamination to groundwater that impacts drinking water and coastal estuaries.

Brewster also adopted a form of natural resource protection zoning, [natural resource protection design](#) (NRPD), in the DCPC area to protect water resources and preserve open space in Brewster. This zoning tool significantly reduces development potential within the designated natural resource district, encourages compact development patterns by using flexible regulations for density and lot dimensions to promote clustered development, and requires large areas of permanently preserved open space to protect identified natural resources. NRPD reduces development impacts on surface water and groundwater by reducing impervious surface areas and also by minimizing septic loads through the reduction in development potential, particularly when compared to traditional grid subdivisions (Town of Brewster, 2022b).

Case Study: Open Space Preservation in Dennis

Tools Utilized: Open space preservation.

When to Employ: Before environmental degradation has occurred

Intended Outcome: Salt marsh migration

In 2020, the [Dennis Conservation Land Trust](#) (DCLT) preserved 14 acres of land in Dennis Village known as the “Tobey Woodlands”

that borders the north side of Route 6A. Part of Tobey Farm, the property includes seven acres of salt marsh at the head of the Chase Garden Creek estuary and nearly seven acres of pine-oak forest, maritime thicket upland habitat, and meadows (Early, 2020). The town and DLCT are in the process of acquiring the western portion of Tobey Farm (eight acres) known as “Tobey West” with support from state and local funding sources. In 2009, the Cape Cod Commission identified Tobey Farm as one of seven Priority Heritage Landscapes in Dennis. Tobey Farm includes a large BioMap2 Core Habitat and Critical Natural Landscape area and a Priority Habitat area, which includes prime tern foraging areas. The Chase Garden Creek estuary, which borders Tobey Farm, was recognized in the [UMASS CAPS Index of Ecological Integrity](#) as an important intact wildlife habitat. According to the [TNC Resilient Land Mapping Tool](#), this site is significant for terrestrial and tidal migration. Because of



Figure 18. Drone aerial photo of Tobey Woodlands (Cape Cod Times).

the shallow grade between the salt marsh and the bordering freshwater wetlands and upland forest on the site, there is strong potential for the salt marsh to migrate inland as sea level rises (Town of Dennis, 2022).

The preservation of Tobey Woodlands is a prime example of the multiple benefits that open space preservation can provide. Of particular importance, the preservation of Tobey Woodlands protected the Chase Garden Creek estuary, the largest salt marsh system in Dennis, which surrounds the property. Preserving the land surrounding the marsh is particularly valuable for climate change, as it will enable the inland migration of the salt marsh as sea level rises, allowing the marsh to maintain its natural flood mitigation capabilities during large storm events. Had the land been developed, future development at that site would have been vulnerable to flooding as sea level rise pushes the wetlands further inland.

In addition to flood mitigation and shoreline protection, salt marshes also remove carbon dioxide from the atmosphere and convert it to vegetation. Decaying matter is stored under salt marsh peat, creating what is known as “blue carbon.” Dennis has recognized the benefits of protecting parcels with salt marsh habitat for some time. For example, in Dennis’ Municipal Vulnerability Preparedness Report, the town identified the conservation of land, and in particular land which allows for salt marsh migration, as one of its top recommendations to improve climate resilience in the community (Town of Dennis, n.d.). In addition to climate adaptation and mitigation benefits, salt marshes also provide valuable habitat for plants and wildlife, as well as filtration of pollutants and sediment before they reach coastal waters and drinking water supplies. By preventing development at this parcel, Dennis will preserve these resources for years to come, even with the

challenges presented by climate change. Ultimately, by preserving the resources which surround the Chase Garden Creek estuary, the town of Dennis contributes to protecting the health of Cape Cod Bay (Young, 2019).

Case Study: Cranberry Bog, River, and Wetland Restoration in Falmouth

Tools Utilized: Open space acquisitions, dam removals, culvert removals, dredging and restoration of natural river flow, wetland restoration

When to Employ: After environmental degradation has occurred or to prevent additional stress on remaining natural resources

Intended Outcome: River restoration

The preservation of the Coonamessett River corridor in Falmouth has been a priority for Falmouth for more than 50 years. One of the longest rivers on the Cape, the Coonamessett River is a groundwater-fed river that runs through a narrow valley from



Figure 19. Coonamessett River, Falmouth (Tighe & Bond).



Figure 20. Coonamessett River post-restoration (Gerald Beetham).

Coonamessett Pond to the Great Pond estuary, which discharges into Vineyard Sound. Once home to the Lower and Middle Bog cranberry bogs, mills and cranberry operations blocked fish passage on the Coonamessett with dams and berms for decades. The river and floodplain habitats were further degraded by the removal of native vegetation and the straightening of the stream channel for cranberry operations. Floodplains and wetlands were buried by water and sand for nearly 150 years while cranberry operations were active, causing ecological damage to the river and wetland ecosystem (Tighe & Bond, 2021). This river corridor supported one of Cape Cod's most abundant river herring runs with annual populations numbering in the millions in the 1900s. In 2015, however, fewer than 75,000 river herring made the annual spring migration run (Division of Ecological Restoration, 2021).

Efforts to protect and restore the Coonamessett River and its bordering wetlands began in earnest in the early 2000s. The [300 Committee Land Trust of Falmouth](#), working with the town of Falmouth, strategically targeted land along the river for acquisition,

seeking to permanently protect the vegetated buffer alongside the riverbanks. A key component of the open space protection strategy for the area was the acquisition of Andrews Farm and Andrews Grove, which totaled 46 acres, in addition to the Romano Bog (1.68 acres) and Mars parcel (0.5 acres). Today, more than 500 acres within the river corridor are now permanently protected (The 300 Committee and Trust, 2017). Supporting these efforts was the [Coonamessett River Trust](#), which monitored the biological, chemical, and physical characteristics of the river for decades and advocated for the restoration of the river (Coonamessett River Trust, 2020).

The active restoration of the Coonamessett River took place in two phases over the course of 2018-2020. Two dams were replaced by boardwalks crossing the river; a new bridge was built to replace deteriorating culverts that restricted fish passage and water flow; lower segments of the river were dredged and re-routed to improve flow and enhance habitat for native fish; and wetlands and riverine habitat were restored. The results of the restoration were 33 acres of restored wetland, 23 acres of upland riparian habitat, a new 33% longer stream channel with enhanced biodiversity, an increase in free-flowing streams, and improved access to fish spawning areas. In addition, Falmouth also constructed the Coonamessett Greenway Heritage Trail as part of the restoration. Today, the trail network connects the conservation lands that border the river and includes 12 interpretative stations, which provide information about the cultural and natural history of the valley as well (Gladfelter, 2021).

The benefits provided by the restoration of the Coonamessett River are substantial. Falmouth discovered that since the restoration, seeds from wetland plants that had been buried for 300 years under mill ponds and cranberry bogs have sprung to life once original wetland soils were uncovered, increasing biodiversity in the area. In

addition, the removal of sand layers from the old cranberry bogs promotes better ground and surface water exchange, which helps remove nitrogen and other pollutants (Gladfelter, 2021). Insects and other wetland species populations have shown dramatic increases as well. In particular, the removal of dams and culverts on the river allowed for fish, including blueback herring, trout, and alewives to swim upriver again to their original spawning areas. This additional habitat area will help to improve the health of fisheries in the region by increasing their spawning territory and consequently their populations.

By ensuring the protection of river habitat and the mitigation of heat stress on fisheries by connecting the main river stem to strong cold-water springs, the resiliency of the Coonamessett River corridor to warming from climate change was significantly improved (Tomlinson, 2021). The removal of culverts and dams on the river improved natural flows, increasing the climate resiliency of Falmouth's coasts by reestablishing floodplain connectivity and restoring the natural flood mitigation capabilities of the existing wetlands. The restoration of the floodplain also provided space for the migration of salt marshes inland as sea level rise accelerates. With healthy, intact wetland systems, natural pollutant removal capabilities for nutrients such as nitrogen were enhanced as well.

In addition to habitat improvements and climate resilience, the restoration of the Coonamessett River and its wetlands created substantial opportunities for passive recreation for residents and visitors. Today, the restored river is enjoyed by residents and visitors from across the region. School groups participate in field trips to the river corridor and support the "Adopt-A-Herring" program organized by the Coonamessett River Trust. Walking tours of the river are organized by local and regional community organizations so visitors can explore the ecological, historical, and

cultural history of this unique river corridor (Division of Ecological Restoration, 2021).

Case Study: Nutrient Pollution Reduction Efforts in Orleans

Tools Utilized: Comprehensive Wastewater Management Plan, traditional sewerage and central wastewater treatment, permeable reactive barriers, open space acquisitions

When to Employ: In advance of degradation in nutrient sensitive areas and as a remedial tool after environmental degradation has occurred

Intended Outcome: Nutrient pollution reduction and water quality restoration

Orleans, like most of the towns on Cape Cod, continues work to implement its Comprehensive Wastewater Management Plan (CWMP). The CWMP is designed to establish the steps needed to control excess nitrogen and phosphorous pollution, which has contributed to the decline of marine and freshwater resources. Using a combination of investments in sewerage, non-traditional and adaptive management nutrient reduction strategies, along with open space preservation along the Pleasant Bay sub-embayments, ponds, and rivers to prevent additional nutrient loads, Orleans continues to make progress in improving the water quality and limiting new nutrient loads to both its marine and freshwater resources.

To address water pollution concerns and comply with the Clean Water Act, the town worked with the public and prepared an [amended CWMP](#) in 2015. This plan was developed to be consistent with the regional Cape Cod 208 Water Quality Plan, which has been approved by both the United States Environmental Protection

Agency and the Massachusetts Department of Environmental Protection. Starting in 2015, Orleans began to implement the amended CWMP with the construction of new sewerage and central wastewater treatment capacity to service its downtown area (approximately 280 parcels, 100,000 gallons per day [gpd]) and the Meetinghouse Pond Subwatershed Area (approximately 360 parcels, 50,000 gpd) (Biohabitats, 2022). These investments are anticipated to lead to a substantial reduction in nutrient pollution to Meetinghouse Pond and Pleasant Bay, protecting these resources and the aquatic ecosystems they support.

As a component of the amended CWMP, and to supplement the load reductions anticipated from collection and treatment of priority areas, the town of Orleans is also implementing non-traditional technologies, including permeable reactive barriers (PRBs). PRBs are a passive treatment technology designed to intercept and treat nitrates in groundwater before they reach downgradient surface waters. The town has already implemented PRB pilot projects in Eldredge Park and the town landfill and is planning to incorporate larger scale PRBs into wastewater implementation less suited to sewerage for other areas in the near future (Town of Orleans, 2022).

Orleans has worked effectively through enhanced coordination with neighboring communities to protect Pleasant Bay. In 1987, Orleans, Chatham, Harwich, and Brewster requested that Pleasant Bay be designated an Area of Critical Environmental Concern (ACEC) by the Commonwealth of Massachusetts. Designation of an ACEC increases environmental oversight by modifying state permitting requirements to elevate performance standards and lower thresholds for review. This ACEC designation led the four towns to develop a resource management plan for Pleasant Bay and form the Pleasant Bay Alliance to coordinate management activities.

For decades, the town of Orleans has worked strategically to acquire open space along its freshwater and marine resources to limit the introduction of new nutrient loads in the watershed. From the beginning, the focus of the Orleans Open Space Committee was the preservation of land to prevent further decline in local water quality, with a particular emphasis on the protection of Pleasant Bay. The town has acquired hundreds of acres of open space over the past several decades, ensuring the protection of local drinking water resources and surface waters as well.

In some instances, the town has worked with neighboring communities to secure land preservation opportunities across town boundaries. Brewster and Orleans have had a long history of partnering to acquire open space. For example, in 1987 Orleans and Brewster jointly protected 35.65 acres of land in the vicinity of Baker's Pond to prevent nitrogen loading of groundwater and the degradation of marine waters in Town Cove (Town of Orleans, 2013). The 2010 acquisition of the Matthews Property was also a joint venture between Brewster and Orleans. This 22.5-acre parcel



Figure 21. Henson's Cove Conservation Area (Orleans Conservation Trust).

lies within Brewster’s District of Critical Planning Concern, the Zone II wellhead protection area for Orleans, and the Pleasant Bay watershed. The property primarily contains forested uplands, which serve to protect water quality by improving the natural infiltration of water and reduction of nutrient pollution from stormwater runoff. Protection of the land within the Pleasant Bay watershed most importantly for this case study prevents additional development and associated septic systems within the watershed which would lead to increased nitrogen loading. The town of Brewster owns the land, but the town of Orleans holds a watershed preservation and conservation restriction on the land (Community Preservation Coalition, 2010).

The town of Orleans has also benefited from its partnership with the Orleans Conservation Trust (OCT), jointly acquiring over 300 acres of land across Orleans, many of which fall within the Pleasant Bay watershed. Many of these acquisitions have directly benefited protection of the water quality of surrounding marine and freshwater resources. For example, in 2021, OCT acquired the last parcel needed to complete the creation of the 23-acre Henson’s Cove Conservation Area (HCCA), a preserve that borders a small cove on Pleasant Bay, preventing the addition of 11 septic systems directly adjacent to the water. The HCCA encompasses an ecologically important area comprised of sandplain grassland, fringing marsh, freshwater wetlands, and pine-oak woodlands. The preserve provides habitat for a variety of wildlife, including nesting and feeding for the northern diamondback terrapin, a state-listed threatened species. Preservation of these parcels will ensure that the fragile ecosystems that this area supports are protected from development, all while reducing nutrient pollution into Pleasant Bay (Orleans Conservation Trust, 2022).

Through its [pollinator pathway program](#) adopted by the town, Orleans made a commitment to, among other actions, eliminate municipal use of fertilizers, and encouraged residents to do the same. This will complement other efforts to reduce nutrient impact to town water bodies. Orleans passed a ban on all fertilizer use in town and is awaiting the Legislature’s approval for the measure to take effect.



Figure 22. Diamondback terrapin found in Henson’s Cove Conservation Area (Orleans Conservation Trust).

SECTION IV. RECOMMENDATIONS

The following sections highlight actions that local officials and residents can take to protect and enhance natural resources on the Cape. While each of these individual actions focuses on a particular resource or strategy, collectively these measures can help ensure that the Cape as we know it today is protected for future generations.

Actions Local Governments Can Take to Protect, Preserve, Restore, and Enhance Natural Resources

Towns play a central role in determining which lands are protected and which are not, which habitats are restored, and which are allowed to continue to decline, and whether environmental quality is the town's priority or a secondary consideration. Towns can support or adopt measures that will improve the ability of natural resources to thrive on the Cape. Town staff and boards wield power of approval or denial of specific projects, working within the discretion allowed by law to approve or disapprove projects and to establish priorities for expenditure of public resources.

Continue to Advance Open Space Acquisitions on the Cape

Summary: Continue to acquire open space parcels, especially in priority natural resource areas.

Funding Required: Yes; potential sources include Community Preservation Act, state grants, federal grants, local taxes and funding from local land trusts.

Opportunities: Partnership among towns, land trusts, and private landowners; "undevelopment" and restoration of properties (e.g., Yarmouth, Chatham).

Benefits: Protect unique habitats and rare and endangered species; preserve public water recharge areas, maximize ecosystem benefits for resiliency to climate change; preserve community character; preserve biodiversity.

Open space protected in perpetuity comprises approximately 40% of the Cape land area. This has been done through local investments and through actions taken by the state and federal government, resulting in the preservation of large tracts such as the Cape Cod National Seashore, Nickerson State Park (Brewster), Crane Wildlife Management Area (Falmouth), and Hawksnest State Park (Harwich), among other properties.

While the extent of land preservation to date is impressive, it is not enough. The vital work to protect the Cape's unique natural resources is not done. Continuing to fund open space acquisitions is one of the best investments a town can make to ensure its quality



Figure 23. Barnstable Great Marsh (CJ Gregory/Mass Audubon).



Figure 24. Beech woods (Association to Preserve Cape Cod).

of life is protected. As discussed in the case studies, preserving open space is critical to protect drinking water, sensitive watersheds for freshwater ponds and coastal embayments, rare species' habitat, and wetlands and buffers. Preservation of open spaces is economically advantageous to the Cape. The tax revenue from development of the type historically seen on the Cape not only fails to cover the direct costs of municipal services for that development, it also fails to compensate communities for the incremental declines in

water quality, increased traffic and other stresses on the environment. In addition to economic benefits, acquisition of open space can be a critical tool to protect fragile ecosystems and ensure the longstanding protection of resources that will be critical for the mitigation of and adaptation to climate change impacts.

The Cape as we know it today would not exist without preserved open space, and it is essential that communities on the Cape continue to protect these areas and preserve the rural character of this region. Communities should particularly prioritize the acquisition of open space that contains priority natural resource areas and, ideally, parcels that connect and fill in existing open

space to establish wildlife corridors. The maps in this report, along with online mapping tools (many of which were referenced to develop this report's mapping), such as [Mass Audubon's Mapping and Prioritizing Parcels for Resilience](#), [The Nature Conservancy's Resilient Landscapes data layer](#), and the [Massachusetts Natural Heritage and Endangered Species Program BioMap2](#), all provide excellent community scale assessments that can inform local decision making for open space acquisition. For the maps in this report, communities are encouraged to identify priority natural resources that have not been permanently protected and could be acquired to connect existing open space.

Towns that don't have open space committees should establish one in order to better explore potential open space opportunities and to negotiate property acquisitions. Towns should also have up-to-date open space and recreation plans and should establish productive partnerships with the local land trust to marry the land trust's creativity and flexibility with the town's funding ability in open space acquisitions.

Communities may also think creatively about acquiring parcels that can be "undeveloped" to restore land to its original resource state. In some instances, this may be the best opportunity to create continuous open space tracts in areas where other resources may benefit. The town of Yarmouth used this strategy when acquiring the Yankee Village Motel in 2019 to preserve the land where the motel was located. The property was situated between two existing waterfront parks—also prior undevelopment projects—creating a unique opportunity for the town to create a single continuous waterfront park that would protect local coastal habitat, provide a flood buffer for a nearby road, and provide recreation opportunities for the community (Town of Yarmouth, 2022). Similarly, in 2013 the town of Chatham purchased a 1.36-acre parcel containing a recently

closed restaurant, the Pit Stop, as part of the Cackle Cove Creek Headwaters Restoration Project. The purchase enabled the town to create a continuous green corridor along Route 28, while restoring wildlife habitat and protecting water quality (Shaw, 2020).

Expand the Use of Innovative Planning Strategies to Protect Natural Resources

The following strategies offer different regulatory techniques to protect natural resource areas. It is important to note that these strategies are complementary and ideally should be utilized in combination, rather than only relying solely on one strategy.

Districts of Critical Planning Concern

Summary: Designate Districts of Critical Planning Concern to impose temporary moratoriums on certain types of development or activities in a specified area to plan for and adopt special rules and regulations that will protect resources or values of regional, statewide, or national significance.

Funding Required: No

Opportunities: Explore existing regulations in other Cape Cod communities for consideration (e.g., Brewster).

Benefits: Minimize impacts of development; protect natural resource areas; ensure sustainable growth practices.

As discussed previously in the Brewster Case Study, Districts of Critical Planning Concern (DCPC) allow for a town or group of towns to impose a temporary moratorium on certain types of development or activities in a specified area to plan for and adopt special rules and regulations that will protect resources or values of regional, statewide, or national significance. Cape Cod is unique in that the Cape Cod Commission Act enables the creation of DCPCs

within Barnstable County. To date, Barnstable County has designated 12 Districts of Critical Planning Concern. Communities that have not utilized DCPCs to date may consider adopting this planning tool to ensure they have the time needed to protect resources of particular concern, such as lands surrounding drinking water wells or fragile forest ecosystems (Cape Cod Commission, 2022a).

Natural Resource Protection Zoning

Summary: Designate Natural Resource Protection Districts to require that natural resource protection be a priority in these areas and encourage clustered development in the least impactful location.

Funding Required: No

Opportunities: Explore existing regulations in other Cape Cod communities for consideration (e.g., Brewster).

Benefits: Protect natural resources and open space; enhance watershed ecology; protect aquifers; protect wildlife corridors.



Figure 25. Mashpee River Reservation (Trustees of Reservations).

Natural Resource Protection Zoning (NRPZ) is a planning tool that can be used to support the protection of natural resources and open space. As mentioned previously in the Brewster Case Study, this tool combines low underlying densities with compact patterns of development to significantly reduce buildout in a designated district. NRPZ requires that natural resource protection be a priority for the district and that development be clustered together in the least impactful location. NRPZ can have significant regional impacts to watershed hydrology, wildlife habitat corridors, and aquifer protection when used effectively, particularly when a large open space requirement is included. In parts of Brewster, for example, the open space requirement is 80% (UMass Amherst, 2022). Cape communities which have not utilized NRPZ to date would benefit from adopting this planning tool to strategically concentrate development and ensure the protection of high value open space and natural resources.

Stormwater Management Regulations

Summary: Develop protective stormwater management regulations that encourage enhanced infiltration.

Funding Required: No

Opportunities: Explore existing regulations in other Cape Cod communities for consideration.

Benefits: Improve water quality; protect public water recharge areas; protect habitat for flora and fauna.

When it rains, water travels over impervious surfaces (driveways, roofs, roads, etc.) and picks up litter, sediment, and pollutants which can be harmful to freshwater and marine resources. While there is a significant focus on controlling water pollution via wastewater on the Cape, stormwater runoff contributes

approximately 8% of the total nitrogen load across the Cape (Cape Cod Commission, 2022b). As climate change brings more extreme storms and increases in average rainfall, the impacts of stormwater runoff pollution will become a greater challenge on the Cape.

The Clean Water Act regulates stormwater pollution through [Municipal Separate Storm Sewer System](#)

(MS4) permitting for areas designated as “urbanized.” Twelve communities on the Cape

fit that classification and are therefore required to meet the MS4 permitting requirements, including adopting local stormwater ordinances or bylaws for their areas subject to the MS4 permit. To protect water quality for both freshwater and marine resources, Cape communities can adopt protective stormwater management regulations which improve infiltration. Regulations may incorporate requirements for green infrastructure or Low Impact Development (LID) which mimic hydrologic processes by removing pollutant loads and increasing aquifer recharge, increase the infiltration requirements above MS4 standards, or apply stormwater



Figure 26. Stormwater runoff carries debris down to the storm drain (Association to Preserve Cape Cod).



Figure 27. Hatches Harbor (James Heffernan).

regulations to areas less than one acre. The town of Brewster adopted a stormwater bylaw in 2021 that requires stormwater management for all projects that create more than 500 square feet of impervious surface or disturb more than 10,000 square feet of land.

Wetland Protection Regulations

Summary: Strengthen wetland protection regulations to ensure wetland resources can be fully utilized for their flood control benefits.

Funding Required: Sufficient funding for town staff to educate citizens and enforce the regulations is critical to ensure effective implementation.

Opportunities: Explore existing regulations in other Cape Cod communities for consideration (e.g., Wellfleet).

Benefits: Improve water quality; protect habitat for flora and fauna; maximize ecosystem services to ensure resiliency to climate change.

Massachusetts already regulates wetlands through the [Wetlands Protection Act](#) (WPA), but municipalities can adopt, and most Cape towns have adopted, more protective local regulations to build on the WPA. Many Cape communities are currently using local wetland regulations creatively to ensure the protection of these resources. But can they do more? Yes. The town of Wellfleet's recently updated regulations include language specifying the protection of wetland resources for their flood control benefits. The regulations also include performance standards for Land Subject to Coastal Storm Flowage (LSCSF) and within the Wellfleet Harbor Area of Critical Environmental Concern (ACEC) relative to sea level rise and the inland migration of wetland resources (Town of Wellfleet, 2021). The town continues to explore other ways to incorporate resilience against sea level rise and other aspects of climate change in its bylaw and regulations. By improving on existing regulatory frameworks, communities on the Cape can strengthen protections for their wetlands and ensure that these resources can be utilized to their full potential in adapting to the impacts of climate change. It is important to note that having sufficient funding at the municipal level to have staff who are responsible for education and the enforcement of these regulations is essential to ensure effective implementation.

Increase Restoration of Natural Resource Areas

Cranberry Bogs

Summary: Support the restoration of cranberry bogs to wetlands to enhance carbon sequestration and flood storage.

Funding Required: Yes; potential funding sources include state grants, federal grants.



Figure 28. Cranberry bog restoration comparison (MA Division of Ecological Restoration).

Opportunities: Explore partnerships with state agencies (e.g., [Division of Ecological Restoration](#)), neighboring communities, and local conservation organizations.

Benefits: Improve water quality; maximize ecosystem services to ensure resiliency to climate change; protect and restore habitat for flora and fauna.

Approximately 13,250 acres of cranberry farms exist in Massachusetts today, and many of these farms are located on Cape Cod. Falling cranberry prices and other factors are leading some farmers in Massachusetts to consider alternatives for their land. As discussed in the Falmouth Case Study, the restoration of retired cranberry bogs to natural wetland systems on the Cape has the potential to significantly improve ecological conditions and increase the resiliency of the region to climate change. As wetlands absorb water, they can prevent flooding, which, due to climate change, is occurring more frequently with extreme storms and rising sea

levels. Wetlands also store carbon and provide habitat for fish and wildlife, supporting biodiversity on the Cape. In addition, wetlands can absorb pollutants, a key ecosystem services benefit that will help to improve water quality for marine and freshwater resources in the region (Massachusetts Division of Ecological Restoration, 2022). The continued conversion of cranberry farms to wetlands on the Cape through programs like the Massachusetts Division of Ecological Restoration’s “Green Exit Strategy”

Cranberry Program should be supported by communities to ensure that the Cape can harness the benefits of existing natural resources.

Freshwater Wetlands

Summary: Support the restoration of freshwater wetlands by removing dams or culverts to restore flows, installing stormwater treatment practices, or utilizing other water quality improvement strategies

Funding Required: Yes; potential funding sources include state grants, federal grants.

Opportunities: Explore partnerships with state agencies (e.g., [Division of Ecological Restoration](#)), neighboring communities, and local conservation organizations.

Benefits: Improve water quality; maximize ecosystem services to ensure resiliency to climate change; protect and restore habitat for flora and fauna.

In addition to restoring cranberry bogs, the ecological restoration of other wetland resources such as freshwater wetlands is also a valuable investment for Cape communities. Investments in the health of wetland resources are investments in the resiliency of the Cape. Restoration efforts may entail removing dams or culverts to restore hydrologic flows, managing invasive species to ensure biodiversity is maintained for existing habitats, installing stormwater treatment practices to reduce pollutant loading, or employing other water quality improvement strategies to restore the health of wetlands. Wetlands also capture sediment and can fortify riverbanks against erosion and flooding. Wetlands filter out impurities from upland sources and bind heavy metals in their sediments, improving downstream water quality. Healthy wetlands also sequester carbon, supporting the mitigation of climate change impacts.

Salt Marshes

Summary: Support the restoration of salt marshes by protecting adjacent floodplains and strengthening regulatory protections.

Funding Required: Yes; potential funding sources include state grants, federal grants.

Opportunities: Explore partnerships with state agencies (e.g., [Division of Ecological Restoration](#)), neighboring communities, and local conservation organizations.



Figure 29. Strong Island salt marshes (Cape Cod Chronicle).

Benefits: Improve water quality; maximize ecosystem services to ensure resiliency to climate change; protect and restore habitat for flora and fauna.

In conjunction with restoration, protecting upland areas and floodplains adjacent to salt marshes is critical to allow for these resources to migrate inland as sea level rise threatens these resources. High-functioning salt marshes support the early life stages of many marine organisms. Ensuring their longevity is essential for protecting the fishing industry on the Cape. Salt marshes also capture sediment and fortify coastal shorelines against erosion and flooding. Wetlands filter out impurities from upland sources and bind heavy metals in their sediments, improving downstream water quality. Similarly to freshwater wetlands, healthy saltmarshes also sequester carbon, supporting the

mitigation of climate change impacts. To ensure the Cape is prepared for the current and future impacts of climate change, the continued restoration of salt marsh resources will be vital.

Rivers

Summary: Support the restoration of rivers by removing dams and culverts, installing stormwater treatment practices, or utilizing other water quality improvement strategies

Funding Required: Yes; potential funding sources may include state grants, federal grants.

Opportunities: Explore partnerships with state agencies (e.g., [Division of Ecological Restoration](#)), neighboring communities, and local conservation organizations.

Benefits: Improve water quality; maximize ecosystem services to ensure resiliency to climate change; protect and restore habitat for flora and fauna.

Though perhaps known best for its marine resources, the Cape is home to several rivers that have benefitted substantially from restoration efforts, though more work remains. As discussed in the Falmouth Case Study, restored rivers support healthy aquatic ecosystems with enhanced biodiversity, ensuring that wildlife communities are resilient to the challenges posed by climate change. Rivers with healthy flows also have improved water quality and increased sediment deposition, ensuring that their flows into tidal waters contribute less pollution. Restored rivers are more likely to absorb floodwaters, reducing destructive flooding events for built infrastructure. Restored rivers also offer recreational opportunities and support healthy ecosystems for wildlife that may be harvested, such as fish. In particular, restored rivers reestablish fish passages which allows for the migration of fish like river herring.

Communities on the Cape will continue to benefit from these restoration efforts if they are expanded, helping to ensure the resiliency of the region to climate change.

Continue Investments in Nutrient Reduction Techniques

Summary: Expand investments in nutrient reduction techniques such as traditional sewerage, approved innovative/alternative (IA) septic systems, and shellfish denitrification.

Funding Required: Yes; potential funding sources may include state grants, federal grants, local taxes.

Opportunities: Explore regional strategies to share resources and minimize costs.



Figure 30. Sewer manhole cover (Pixabay).

Benefits: Improve water quality; restore degraded habitats for flora and fauna; ensure protection of resources that influence tourism and fishing revenue; protect community character; minimize public health impacts; minimize degradation of public drinking water resources.

Like the rest of Massachusetts and the nation as a whole, Cape Cod has struggled with water quality impairments. In particular, Cape Cod's reliance on individual septic systems for wastewater treatment has contributed significantly to the degradation of many freshwater ponds and almost all marine estuaries on the Cape. Septic systems, despite being designed to meet state standards (Title V, 310 CMR 15.00) are the cause of the Cape's nutrient problem. Conventional septic systems are unable to remove nitrogen, a nutrient which, in excess, leaches into the groundwater, contaminating freshwater and marine resources. Advanced septic systems designed to reduce nitrogen do a better job lowering loading, but do not reduce nitrogen to the levels needed to restore estuarine quality. The resultant nutrient loading causes water



Figure 31. Oysters and other shellfish can be utilized to improve water clarity and reduce nitrogen in marine waters (Randy Harris).

quality degradation, which can lead to environmental collapse, fish kills, and shellfish bed closures, among other impacts. Wastewater pollution is the primary source of nitrogen in the Cape coastal embayments, with septic systems identified as contributing roughly 85% of the controllable nitrogen load on Cape Cod (Cape Cod Commission, 2022c). Septic systems also contribute phosphorus to the groundwater, and by doing so, contribute to the degradation of freshwater resources. Many Cape communities have already begun the process of planning and investing in solutions to reduce nutrient pollution, but substantial additional investments will continue to be needed as the Cape addresses this widespread pollution concern.

There are a multitude of techniques that communities can utilize to reduce nutrient pollution. A mixture of approaches will be necessary to effectively manage nutrient pollution on the Cape to protect the region's water resources. Some of the options for communities include:

- **Traditional sewerage.** Conventional wastewater collection systems transport sewage from buildings by gravity flow through sewer pipes to central treatment facilities. Collection and treatment are the most effective measures to curtail nutrient pollution and contaminants of emerging concern for a specific receiving water.
- **Approved innovative/alternative (IA) septic systems.** Where sewerage is not feasible, IA septic systems can be installed to treat the effluent to reduce, but not eliminate from the watershed, nitrogen and phosphorus loading to ponds and coastal estuaries.
- **Shellfish denitrification.** Oysters and other shellfish consume phytoplankton from coastal waters, a natural measure to help improve water clarity and reduce nitrogen in marine waters. While in the water, shellfish also provide

surfaces in their guts and shells for denitrifying bacteria. The nondigested material that shellfish release also helps to remove nitrogen through denitrification. Supporting shellfish farmers and these restoration efforts supports the local economy and local water quality improvement efforts.

Actions You Can Take to Protect, Preserve, Restore, and Enhance Natural Resources

While the prior recommendations focus on tools that are utilized by municipalities, the following recommendations are catered towards actions individuals can take to advance the protection and enhancement of natural resources on the Cape.

Support Zoning Changes that Direct Growth to the Appropriate Locations

Summary: Encourage local decision makers to adopt zoning changes which ensure development occurs in areas with the appropriate infrastructure, limiting sprawl and minimizing impacts to natural resources.

Funding Required: No

Opportunities: Connect with local community organizations to identify critical moments for advocacy.

Benefits: Establish sustainable growth patterns for the long term; protect natural resource areas that might otherwise be developed.

Zoning has an immense impact on the health of our natural resources. As discussed previously, zoning tools which proactively concentrate growth around already built out areas with supporting infrastructure, especially wastewater infrastructure, will have a smaller impact on our natural resources than sprawl. Residents can support these sustainable zoning practices by advocating for their

adoption with local decision makers such as the planning board and select board. Decision makers may receive pushback on the use of these tools by stakeholders who are accustomed to the Cape's historical patterns of sprawl. It is important for residents to make evident their support for these measures in appropriate spaces, such as town meetings, to ensure the likelihood of the adoption of these measures.

Support Continued Funding for Open Space

Summary: Encourage local decision makers to continue to support funding for the acquisition of open space in your community, vote in favor of open space purchases at town meeting, and support local land conservation trusts.

Funding Required: No

Opportunities: Connect with local community organizations to identify critical moments for advocacy.



Figure 32. Provincetown Conservation Trust property (Vladimir Shuster).

Benefits: Maintain the Cape’s rural character; build climate resiliency; protect drinking water supplies; maintain diverse habitats for flora and fauna.

As discussed earlier in this chapter, the continued acquisition of open space is one of the most significant actions Cape communities can take to preserve their quality of life. However, local decision makers can receive push back from stakeholders who may question the need to spend money on acquiring additional properties. The mentality of “Haven’t we preserved enough?” can be a challenging obstacle to confront. As made evident in this report, it is critical that communities preserve open space—and in particular priority natural resource areas—to maintain the Cape’s rural character, build climate resiliency, protect drinking water supplies, and maintain diverse habitats for flora and fauna. For these reasons, it is essential that residents advocate for open space acquisitions when the opportunities are available, and publicly support decision makers and local land conservation trusts when they do pursue these acquisitions.

Champion Stronger Regulations

Summary: Encourage the adoption of regulations in your community which protect natural resources.

Funding Required: No

Opportunities: Explore existing regulations in other Cape Cod communities for consideration (e.g., Brewster).

Benefits: Improve the health of natural resources.

With nearly 1,000 freshwater or “kettle” ponds, the Cape’s freshwater ponds provide habitat for fish, invertebrates, plants, and wildlife, as well as providing recreation opportunities for residents

and visitors. However, effluent from poorly sited septic systems can seep into the groundwater that feeds these ponds, degrading water quality and harming aquatic ecosystems and wildlife. One of the most important factors for protecting pond health is limiting nutrient pollution, and residents can support the protection of these natural resources by advocating and supporting local efforts to improve wastewater and stormwater management near freshwater ponds. For example, Brewster has a regulation that prohibits septic system leaching facilities within 300 feet of



Figure 33. West Reservoir cyanobacteria bloom in Harwich (Association to Preserve Cape Cod).

a pond. The town is working to update this regulation to better manage the existing systems within the 300-foot setback. Homeowners adjacent to ponds can also create or enhance vegetated buffers along the pond shore to minimize the impacts of runoff into the pond that can transport nutrients from lawn fertilizers and stormwater runoff from paved areas. In general, the wider the buffer the better, but even a buffer as small as 20 feet can make a difference.

Demand Local Investments in Wastewater Infrastructure

Summary: Encourage local decision makers to make investments in wastewater infrastructure to reduce water pollution in your community and in the region.

Funding Required: No

Opportunities: Connect with community organizations to identify critical moments for funding advocacy.

Benefits: Improve the health of water resources.

Because the Cape's marine and freshwater resources, including drinking water supplies, are particularly susceptible to the impacts of wastewater pollution, it is paramount that communities invest in solutions that will reduce the likelihood of nutrient pollution. As discussed earlier, these solutions may involve a range of options from traditional sewerage to alternative methods like shellfish propagation. Every solution will involve some level of investment at the local level to make these options a reality in our communities. Decision makers often receive pushback from stakeholders who may be wary of spending for shared water quality investments. It is imperative that residents advocate for and support local decision makers' proposed investments in wastewater infrastructure to ensure their adoption. These measures are often expensive and take some time to implement, but they are also solutions that can have the longest-lasting impact on the health of our water resources.

Support State and Federal Funding for Wastewater Management

Summary: Advocate for state and federal wastewater management investments for your community and the region by contacting your [state legislators](#) or federal [members of Congress](#).

Funding Required: No

Opportunities: Connect with local conservation organizations to identify critical moments for funding advocacy.

Benefits: Improve health of water resources; decrease financial strain on local resources to support large-scale wastewater investments; ensure sustainable revenue sources for long-term updates.

In addition to local investments in wastewater infrastructure, state and federal funding will be a critical piece of the puzzle to solve the Cape's wastewater management issues. Cape communities are in the process of implementing several projects in the region using state and federal funds, but more funding will be needed to fully transition the region to a more sustainable wastewater management system. Residents can support efforts to acquire this funding by advocating for these investments through [state legislators](#) or through our federal [members of Congress](#). Local conservation organizations are a good resource for residents to engage with when determining opportune moments for advocacy.

Invasive Species Management

Summary: Take steps to reduce the number of invasive species in your home and community through actions such as volunteering with local land trusts to help with invasive species removal projects, removing and controlling invasive species in your yard, and ensuring your boating equipment has been cleaned and dried before and after use in a freshwater pond.

Funding Required: Potentially



Figure 34. *Phragmites*, an invasive plant species in Massachusetts (Pixabay).

Opportunities: Volunteer with your local land trust to help with invasive species removal projects; connect with local conservation organizations to identify critical moments for advocacy.

Benefits: Restore local habitats for native flora and fauna.

Invasive species can disrupt local ecosystems by squeezing out native species. They are non-native species that have been introduced deliberately or unintentionally and proliferate here because there is no natural biological control to keep them in check. Invasive species can be plant or animal. Unfortunately, invasive species can be found in nearly every habitat, from ponds to coastal estuaries, or even in your own backyard. Invasive plants, by definition, aggressively spread by seed or roots and will dominate a landscape if not controlled. To protect natural resources, the following are steps residents can take:

- Avoid planting non-native species, especially those identified on the [Massachusetts Prohibited List](#).

- Volunteer with your local land trust to help with invasive species removal projects.
- Encourage local decision makers to invest in the removal of invasive plant species from town-owned properties to prevent their spread, as well as supporting broader invasive species education in the community.
- Remove and control invasive plants in your yard using best ecological practices for that particular species.
- Avoid accepting unidentified “free plants” from someone’s garden (you may regret it).
- Learn more about invasive species at [Invasive.org](https://www.invasive.org).
- Don’t dump aquariums or live fish bait.
- Ensure your boating equipment has been cleaned and dried before and after use in a freshwater pond. Don’t transport firewood to or from another area.

Native Species Planting

Summary: Take steps to support the cultivation of native species in your home and in your community through actions such as learning about native plantings for your yard and encouraging local decision makers to plant native plants on town-owned properties.

Funding Required: Yes

Opportunities: Connect with local conservation organizations to identify best practices for your area; explore online resources for identifying drought tolerant native plantings (e.g., [Grow Native Massachusetts](#)).

Benefits: Enhance biodiversity; provide habitat for pollinators; restore fragmented habitats; improve aesthetics.

Concurrently with invasive species management, we can support biodiversity and habitat value by planting native species in our

landscapes and in the community. Native plants are accustomed to the Cape's poor soils and many are drought tolerant, and do not require fertilizers or pesticides. Native plants are vital to sustaining local food webs by supporting insect and bird populations. Managed landscapes planted with predominantly native plants can help create pathways for pollinating insects and be steppingstones to mend wildlife corridors as a way to mitigate fragmented habitats. In addition, native plantings can replace portions of lawn areas, reducing the need for fertilizer application and watering.

- See [Cape Cod Native Plants](#); [APCC Native Plant Initiative](#); [National Wildlife Federation Native Plant Finder](#) for more information about appropriate native plants for Cape Cod.
- Learn more about [Pollinator Pathway Cape Cod](#) and [Homegrown National Park](#)
- Residents should encourage their local decision makers to utilize native plant species when planting on town-owned properties and invest in education efforts to alert residents



Figure 35. Rose milkweed, a native plant species in Massachusetts (Association to Preserve Cape Cod).

about the benefits of planting natives and protecting the Cape's native wildlife on the Cape. One example is the [Orleans Pollinator Pathway Resolution](#) signed by the town of Orleans select board.

Plant Rain Gardens to Filter Polluted Runoff

Summary: Support the planting of rain gardens at your home or in your community to encourage infiltration and treatment of stormwater runoff.

Funding Required: Yes

Opportunities: Connect with local conservation organizations to identify best practices for your area.

Benefits: Minimize stormwater pollution into local waterways; improve water quality; reduce erosion; increase groundwater habitat; improve aesthetics; increase cooling.

A rain garden is a vegetated depression with native plants that collects stormwater runoff. Runoff from roof, sidewalk or driveway is directed towards the rain garden rather than to a storm drain or water resource. By directing the runoff to landscaped areas, the rainwater infiltrates through the soil. This allows for a simple treatment of stormwater runoff, which can help to remove sediment and bacteria, and reduce nitrogen and phosphorous pollution. Rain gardens help reduce erosion, improve water quality in watersheds, increase groundwater recharge, provide habitat, increase cooling, and improve aesthetics. For more information, see [APCC.org](#).

Minimize Pavement and Maximize Native, Drought-Tolerant Plantings on Your Property

Summary: Support the use of permeable pavement and the planting of native drought-tolerant plants at your home or in your community.

Funding Required: Potentially

Opportunities: Connect with local conservation organizations to identify best practices for your area; explore online resources for identifying drought tolerant native plantings (e.g., [Grow Native Massachusetts](#)).



Figure 36. Spotted bee balm (*Monarda punctata*) (Gerald Beetham).

Benefits: Prevent flooding; recharge groundwater supplies; dilute contaminants; reduce stormwater pollution; enhance water quality; improve aesthetics.

The more pavement and other impervious (i.e., non-absorbent) landcover, the more stormwater runoff is created when there is a precipitation event, picking up pollutants on the way, and causing flooding. Allowing water to soak into the ground

can prevent flooding, recharge groundwater supplies, and dilute contaminants.

- [Planting drought tolerant native plants](#) and trees can help conserve our precious water supply and keep our groundwater clean.
- Where hard surfaces are needed, use properly installed permeable surfaces such as porous pavers, permeable concrete, and porous pave®.

Cut Pesticide Use

Summary: Support the reduction of pesticides used in your home and your community through actions such as employing mechanical means of weed control, avoiding the use of chemical soaps and cleaning products that contain pesticides, and encouraging local decision makers to reduce or remove pesticide usage from town-owned properties.

Funding Required: No

Opportunities: Connect with local conservation organizations to identify critical moments for advocacy in your community.

Benefits: Reduce pollution and protect water quality.

Pesticides, that include herbicides, insecticides, fungicides, rodenticides, and algaecides, are used to kill living organisms. However, they also kill non-target species. As an example, proactively spraying for a pest caterpillar kills all caterpillars, and caterpillars are a critical food source for nesting birds. Valuable pollinators can also be negatively impacted. Even so-called “safe” pesticides still kill. When pesticides are applied to fields, lawns, and other areas, they can make their way to our water resources through stormwater runoff or through groundwater by leaching into

the soil. Pesticides can be toxic to aquatic ecosystems and contaminate drinking water supplies. Once introduced into the water, pesticides are very difficult to remove. In order to protect the health of our drinking water supplies and natural resource areas, it is critical to reduce or eliminate pesticide usage in our communities on the Cape.

- Advocate for the reduction or removal of pesticide usage from town-owned properties and support education materials to inform residents about the impacts of using pesticides.
- Avoid use of pesticides at home. For example, alternatives to chemical pesticides include companion planting (planting certain types of plants to keep certain pests away) or diluted baking soda and water solutions.
- Employ mechanical means of weed control, such as sheet mulching, or repeated cutting.



Figure 37. Pollinators, such as bees, are some of the most vulnerable species to the impacts of pesticides (Association to Preserve Cape Cod).

- Inside the home, avoid the use of antibacterial soaps and cleaning products that often contain [triclosan and triclocarban](#), registered pesticides in antibacterial cleaners that have been found to harm aquatic life.

Eliminate the Fertilization of Turf and Reduce Other Fertilizer Applications

Summary: Support the reduction of fertilizers on turf at home and in your community through actions such as encouraging local decision makers to curtail the use of fertilizer application on town-owned properties.

Funding Required: No

Opportunities: Connect with local conservation organizations to identify critical moments for advocacy in your community.

Benefits: Reduce nutrient pollution and protect water quality.

Fertilizers are one of the contributing sources of pollution to our fresh and saltwater resources on the Cape. Fertilizers are typically added to soil to promote plant growth by providing supplemental nutrients to plants. The primary pollutants of concern in fertilizer are nitrogen and phosphorus. Nitrogen can pose a threat to public health when introduced into drinking water supplies, and both nitrogen and phosphorous can promote the excess growth of nuisance plants and algae. Fertilizers enter surface waters through stormwater runoff and through groundwater by leaching through the soil.

- Encourage local decision makers to curtail the use of fertilizer application to town-owned properties and invest in educational materials for residents to learn about the impacts of pollution from fertilizer application.

- Cut back or eliminate the use of fertilizers. Build soil health with compost, mulch, and leave the leaves.

Proper Septic System Care

Summary: Ensure your septic system is up to date on maintenance and utilized appropriately through actions such as pumping your septic system at least every three years, not flushing medications, and not disposing of cleaning chemicals or paint down the drain.

Funding Required: Potentially

Opportunities: Connect with local conservation organizations to identify best practices for your area.

Benefits: Extends the life of septic systems and prevents bacteria.

Septic systems are not capable of filtering out and removing nutrients or residual pharmaceuticals and these eventually show up in groundwater, our ponds, and coastal embayments.

- Pump your septic system at least every three years.
- Don't use a food grinder, or dump grease down the drain.
- Don't use harsh cleaning chemicals or dispose of paint down the drain.



Figure 38. Septic system (US Environmental Protection Agency).

- Don't flush medications. Find a [waste medication collection kiosk](#) near you where you can safely dispose of expired or unwanted prescription drugs. If you cannot make it to a kiosk, remove all labels and wrap the products before disposing of them in the garbage.

Take Care of Your Gas-Powered Vehicles and Yard Equipment

Summary: Ensure proper maintenance of your gas-powered vehicles and yard equipment through actions such as fixing leaks and washing your car at a carwash with water recycling rather than washing it in your driveway.

Funding Required: Potentially

Opportunities: Connect with local conservation organizations to identify best practices for your area.

Benefits: Reduce nutrient pollution and protect water quality.

Leaks and drips from gas-powered vehicles or yard equipment contribute to stormwater pollution, which can harm aquatic ecosystems.

- Fix leaks; put down a liner in your driveway to collect oil and other materials.
- Wash your car at a carwash with water recycling, rather than washing it on your driveway.

Manage Domestic Animal Waste

Summary: Appropriately manage domestic animal waste through actions such as picking up after your pet and ensuring their waste



Figure 39. Orleans "Mutt Mitt" dispenser (Orleans Pond Coalition).

ends up in the trash or supporting the proper management of manure in farm settings.

Funding Required: Potentially

Opportunities: Connect with local conservation organizations to identify best practices for your area.

Benefits: Reduce nutrient pollution and protect water quality.

Like other contaminants, animal waste can be picked up during precipitation events and flow into our drainage systems,

which are then carried into nearby water resources. Animal waste that gets washed into waterways carries pathogens that affect aquatic organisms and can make people sick. Nutrients released from animal waste can also stimulate the growth of algae and other plant life, making the water unsuitable for recreation.

- Pick up after your pets and dispose of waste in the trash.
- Implement a "Mutt Mitt" program in your neighborhood and the wider community.
- Properly manage manure in farm settings.

Best Practices to Protect Ponds

Summary: Support pond health through actions such as creating and maintaining a vegetated buffer of native plants between your

lawn and the water, avoiding fertilizer and pesticide use in these areas, or controlling erosion to avoid sediment entering the pond.

Funding Required: Potentially

Opportunities: Connect with local conservation organizations to identify best practices for your area.

Benefits: Protect water quality and habitat for wildlife.

Do you have a pond adjacent to your property? You can help protect water quality and habitat by decisions you make in your landscape design and land care.

- Create and maintain a naturalized [vegetated buffer](#) of native plants between your lawn and the water. In general, the wider the buffer the better, but even a buffer as small as 20 feet can make a difference.
- Avoid creating a straight path to the water that might convey stormwater to the pond.
- Control erosion to avoid sediment from entering the pond.
- Avoid fertilizer and pesticide use in these areas.
- Avoid altering the shoreline where unique coastal pond shore plants may exist.
- Upgrade swim floats with exposed Styrofoam flotation to encapsulated flotation to prevent microplastic pollution.

Safely Manage Hazardous Household Products and Choose Non-Toxic Products

Summary: Limit the use of hazardous household products by choosing non-toxic products and ensuring that toxic products are disposed of properly.

Funding Required: No

Opportunities: Explore online resources for identifying non-toxic products to use in your home (e.g., [Environmental Working Group](#)).

Benefits: Minimize the impacts of hazardous and toxic products on our natural resources.

Many chemicals, materials, and products commonly found in the home are toxic and can be harmful to your health and our environment, including the local watershed, because they never break down or take an extremely long time to do so. The state provides [guidance](#) on how to handle these items with care and recycle or dispose of them responsibly. There is a particular growing concern over [perfluoroalkyl and polyfluoroalkyl substances](#) (commonly referred to as PFAS). Products containing PFAS such as Teflon, Gore-Tex and ScotchGuard should be avoided altogether. The best way to keep from polluting is to use [products that are not dangerous to the environment](#) in the first place.

Support Restoration Projects and Efforts to Restore Migratory Fish Passage

Summary: Support community efforts to restore natural resources.

Funding Required: Potentially

Opportunities: Meet with local decision makers to encourage investments in restoration projects; volunteer with conservation-focused organizations who are orchestrating restoration projects; make donations to bolster projects that need public financing support.

Benefits: Improve the health of local and regional natural resources.

As exemplified by the Coonamessett River restoration project in Falmouth, restoration projects can significantly improve the health of local and regional natural resources. From river and bog



Figure 40. Childs River restoration in Falmouth and Mashpee (Association to Preserve Cape Cod).

restoration projects to salt marsh and fish run restorations, removing human-created barriers, and restoring resources to their natural state has immense benefits. For the Cape, there are ample opportunities to remove human-created barriers such as dams and undersized culverts, to reestablish natural water flow and restore habitat for migratory fish. Residents can support these restoration projects by advocating for their local decision makers to make investments in these projects, volunteering their time or resources with conservation-focused organizations that are orchestrating these projects, or making donations to bolster projects that need public financing support.

Assist Verification Efforts for Vernal Pools

Summary: Support efforts to verify the locations of vernal pools by volunteering with local conservation organizations or [reporting vernal pool observations](#) online to MassWildlife's Natural Heritage and Endangered Species program.

Funding Required: No

Opportunities: Connect with local conservation organizations or research institutes to assist in identification.

Benefits: Improve state and local records of vernal pools which are protected under the Massachusetts Wetlands Protection Act.

In Massachusetts, vernal pools are certified by the state based on documentation by citizens. To ensure that state agencies are using the most up to date information about our natural resources, it is critical for residents to support ongoing efforts to verify the locations of vernal pools. Residents can [report their vernal pool observations](#) online to MassWildlife’s Natural Heritage and Endangered Species program. Observations submitted are used to inform endangered species regulations, species recovery and identification of restoration areas for key habitats, and land protection, among other objectives. Residents seeking additional guidance about how to identify a vernal pool and proceed with the certification reporting process can utilize [guidance from the Vernal Pool Association](#).

Support Documentation for Priority and Estimated Habitats

Summary: Support efforts to maintain accurate records for rare species by [reporting rare species](#) to the state or [requesting a voluntary assessment](#) of your property to determine whether there are any Endangered, Threatened, or Species of Special Concern present on a portion of the property.

Funding Required: No

Opportunities: Connect with local conservation organizations or research institutes to assist with identification.



Figure 41. Piping plovers, one of the bird species listed as threatened on both the Massachusetts and Federal Endangered Species Lists (Merri Lee Metzger/Mass Audubon).

Benefits: Improve state records for Priority and Estimated Habitats which can inform whether a proposed project or activity must be reviewed by the state’s Natural Heritage and Endangered Species Program (NHESP) for compliance with the Massachusetts Endangered Species Act (MESA).

As discussed previously, state recognized Priority and Estimated Habitats are in part constrained by whether Threatened or Species of Special Concern have been identified on a property recently. A Priority Habitat is removed from the state listing if it was delineated based on observation records that are more than 25 years old, making it critical that records are updated regularly. Residents can help state officials to maintain the most accurate records possible by [reporting rare species](#) to the state or [requesting a voluntary assessment](#) of their property to determine whether there are any Endangered, Threatened, or Species of Special Concern present on a portion of the property.

REFERENCES

- Association to Preserve Cape Cod. (2001a). *Cost of Community Services Study for Brewster, Massachusetts: A Report on the Fiscal Implications of Different Land Uses*.
- Association to Preserve Cape Cod. (2001b). *Cost of Community Services Study for Truro, Massachusetts: A Report on the Fiscal Implications of Different Land Uses*.
- Association to Preserve Cape Cod. (2021). *State of the Waters: Cape Cod 2021 Report*. <https://apcc.org/wp-content/uploads/2022/02/APCC-State-of-the-Waters-2021.pdf>
- Association to Preserve Cape Cod. (2022). "Salt Marsh Restoration." Retrieved December 1, 2022, from <https://apcc.org/our-work/science/salt-marsh-restoration/>
- Barnstable County Assembly of Delegates. (2008). *Ordinance 08-08: Brewster DCPC*.
- Barnstable County Commissioners, Cape Cod Conservation District, and USDA Natural Resources Conservation Service. (2012). *Why It Matters to Massachusetts' Economy: Supporting Commercial and Recreational Fisheries*.
- Biohabitats. (2022). "Orleans – Floating Wetland Feasibility Study." Retrieved July 19, 2022, from <https://www.biohabitats.com/project/town-of-orleans-floating-wetlands/>
- Brewster Conservation Trust. (2022). "Norum purchase adds land to Punkhorn Parklands." Retrieved July 19, 2022, from <https://brewsterconservationtrust.org/norum-purchase-adds-land-to-punkhorn-parlands/>
- Cape Cod Commission. (2012). *Cape Cod Regional Policy Plan*. https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/Website_Resources/RPP/2012RPP_webJan2013.pdf
- Cape Cod Commission. (2019a). *Wildlife and Plant Habitat Technical Bulletin*. [https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/rpp/rpp_final/Technical%20Bulletins/Wildlife Plant Habitat Technical Bulletin 2019.pdf](https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/rpp/rpp_final/Technical%20Bulletins/Wildlife_Plant_Habitat_Technical_Bulletin_2019.pdf)
- Cape Cod Commission. (2019b). *Open Space Technical Bulletin*. https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/Website_Resources/regulatory/tech_bulletins/Open_Space_Technical_Bulletin_2019.pdf
- Cape Cod Commission. (2019c). *Wetlands Resources Technical Bulletin*. [https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/Website_Resources/regulatory/tech_bulletins/Wetlands Resources Technical Bulletin 2019.pdf](https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/Website_Resources/regulatory/tech_bulletins/Wetlands_Resources_Technical_Bulletin_2019.pdf)

Cape Cod Commission. (2020). *Economic Impact of Cape Cod Harbors*. https://www.capecodcommission.org/resource-library/file?url=%2Fdept%2Fcommission%2Fteam%2FWebsite_Resources%2Feconomicdevelopment%2FHarborStudyReport_Final.pdf

Cape Cod Commission. (2022a). "Districts of Critical Planning Concern." Retrieved July 19, 2022, from <https://www.capecodcommission.org/our-work/dcpc>

Cape Cod Commission. (2022b). "Stormwater." Retrieved July 21, 2022, from <https://www.capecodcommission.org/our-work/stormwater/>

Cape Cod Commission. (2022c). "Wastewater." Retrieved July 21, 2022, from <https://www.capecodcommission.org/our-work/wastewater/>

Cape Cod Commission. (2022d). *Cape Cod Pond and Lake Atlas*. https://www.capecodcommission.org/resource-library/file?url=/dept/commission/team/h2o/wr_lib/Ponds/Ponds%20Planning/Ponds%20Atlas%20Update/Working%20Document/Pond%20and%20Lake%20Atlas%202021%20-%20Final.pdf

Cape Cod Commission. (2022e). "Estuaries." Retrieved December 1, 2022, from <https://www.capecodcommission.org/our-work/estuaries/>

Community Preservation Coalition. (2010). "Open Space: 7. Matthews Property Land Acquisition." Retrieved July 19, 2022, from <https://www.communitypreservation.org/open-space-7-matthews-property-land-acquisition>

Coonamessett River Trust. (2020). "Restoring the River." Retrieved July 18, 2022, from <https://www.crivertrust.org/river-restoration>

Division of Ecological Restoration. (2018). "Coonamessett River Restoration (Falmouth)." Retrieved July 18, 2022, from <https://www.mass.gov/news/coonamessett-river-restoration-falmouth>

Early, J. (2020). "Tobey Woodlands Preserved!" *The Dennis Conservation Land Trust*. Retrieved July 18, 2022, from <https://dennisconservationlandtrust.org/2020/01/18/tobey-woodlands-preserved/>

Gladfelter, E. (2021). "Coonamessett River Projects Completed." *The 300 Committee*.

Highstead. (n.d.). *The Economic Case for Conservation: A Synthesis of the Economic Impacts of Natural Resources and Conservation in New England*. <https://www.wildlandsandwoodlands.org/sites/default/files/The%20Economic%20Case%20for%20Conservation.pdf>

Kaplowitz, M., Macherer, P., Pruetz, R. (2008). "Planners' Experiences in Managing Growth Using Transferable Development Rights (TDR) in the United States." *Land Use Policy*. 25(3), 378-397. <https://doi.org/10.1016/j.landusepol.2007.07.004>

Massachusetts Division of Ecological Restoration. (2021). "Coonamessett River Restoration: Phase 2 Construction." *FY19 MVP Action Project*. Retrieved July 18, 2022, from <https://www.mass.gov/doc/falmouth-fy19-featured-project-case-study/download>

Massachusetts Division of Ecological Restoration. (2022). "How Are Wetlands Restored on Retired Cranberry Farmland?" Retrieved July 20, 2022, from <https://www.mass.gov/service-details/how-are-wetlands-restored-on-retired-cranberry-farmland>

Massachusetts Division of Fisheries and Wildlife. (n.d.). *Estuarine Communities Description: Salt Marsh*. <https://www.mass.gov/doc/salt-marsh-0/download>

Massachusetts Division of Fisheries and Wildlife. (2015a). *American Sea-blite*. <https://www.mass.gov/doc/american-sea-blite/download>

Massachusetts Division of Fisheries and Wildlife. (2015b). *Salt Reedgrass*. <https://www.mass.gov/doc/salt-reedgrass/download>

Massachusetts Division of Fisheries and Wildlife. (2015c). *Slender Marsh Pink*. <https://www.mass.gov/doc/slender-marsh-pink/download>

Massachusetts Division of Fisheries & Wildlife (2015d). *Least Tern*. <https://www.mass.gov/doc/least-tern/download#:~:text=The%20largest%20populations%20occur%20on,America%2C%20south%20to%20northern%20Argentina>.

Massachusetts Division of Fisheries & Wildlife (2015e). *Common Tern*. <https://www.mass.gov/doc/common-tern/download>

Massachusetts Division of Fisheries & Wildlife. (2020). *Saltmarsh Sparrow*. <https://www.mass.gov/doc/saltmarsh-sparrow/download#:~:text=SPECIES%20DESCRIPTION%3A%20The%20Saltmarsh%20Sparrow,several%20sharp%20notes%3A%20tuptup%20shee%20eeee>.

Massachusetts Division of Fisheries and Wildlife. (2022). "Species Spotlight: Plymouth gentian." Retrieved December 1, 2022, from <https://www.mass.gov/news/species-spotlight-plymouth-gentian>

Massachusetts Executive Office of Energy and Environmental Affairs. (2022a). "Conservation Restriction Review Program." Retrieved July 20, 2022, from <https://www.mass.gov/service-details/conservation-restriction-review-program>

Massachusetts Executive Office of Energy and Environmental Affairs. (2022b). "Smart Growth / Smart Energy Toolkit Modules - Open Space Design (OSD)/Natural Resource Protection Zoning (NRPZ)." Retrieved July 21, 2022, from <https://www.mass.gov/service-details/smart-growth-smart-energy-toolkit-modules-open-space-design-osdnatural-resource-protection-zoning-nrpz>

Minis, H. (2022). *Vacant Land Conversion in Brewster*.

National Park Service. (n.d.). "Lakes and Ponds." Retrieved December 1, 2022, from <https://www.nps.gov/caco/learn/nature/lakes-and-ponds.htm>

National Park Service. (2022). "Animals." Cape Cod: National Seashore. Retrieved December 1, 2022, from <https://www.nps.gov/caco/learn/nature/animals.htm>

NOAA. (2019). "The Coastal Squeeze: Changing Tactics for Dealing with Climate Change." Retrieved December 1, 2022, from <https://www.fisheries.noaa.gov/feature-story/coastal-squeeze-changing-tactics-dealing-climate-change>

Orleans Conservation Trust. (2022). "Growing Our Lands." Retrieved July 19, 2022, from <https://orleansconservationtrust.org/growing-our-lands/>

The 300 Committee and Trust. (2017). "About Lower Coonamessett River Conservation Lands." *Lower Coonamessett River Conservation Lands*. Retrieved July 18, 2022, from <https://300committee.org/conservation-lands-2/lower-coonamessett-river-conservation-lands/>

Shaw, J. (2020). "Lost Restaurant Series." *Happy Cape Cod*. Retrieved August 4, 2022, from <https://happycapcod.com/lost-restaurant-series-flemings-restaurant/>

Stats Cape Cod. (n.d.). "Regional Benchmarks." Retrieved December 1, 2022, from https://www.statscapcod.org/benchmarks/balanced/population_trends.php

The Boston Foundation. (2018). *The Work of Leisure: Behind the Scenes of the Massachusetts Leisure, Hospitality and Tourism Industry*. https://assets.simpleviewinc.com/simpleview/image/upload/v1/clients/capecodma/work_of_leisure_report_final_7d637daa-6812-49e7-9312-7c1dccc675f9.pdf

The Compact of Cape Cod Conservation Trusts, Inc. (2022). *Land Protection Summary of Cape Cod Land Trusts*.

- The Nature Conservancy. (2009). *The Pine Barrens of Southeast Massachusetts*. <https://www.mass.gov/doc/nature-conservancy-pine-barrens-of-se-mass-brochure/download>
- Tighe & Bond. (2021). "Celebrating Coonamessett River Restoration and John Parker Road Bridge." Retrieved July 18, 2022, from <https://www.tighebond.com/celebrating-coonamessett-river-restoration-and-john-parker-road-bridge/>
- Tomlinson, M. (2021). "Falmouth Celebrates Completion of River Restoration Project." *CapeCod.com News Center*. Retrieved July 18, 2022, from <https://www.capecod.com/newscenter/falmouth-celebrates-completion-of-river-restoration-project/>
- Town of Brewster. (2022a). "Article XI: Water Quality Protection District." *Zoning*. Retrieved July 19, 2022, from <https://ecode360.com/7607328>
- Town of Brewster. (2022b). "Article XIII Natural Resource Protection Design." *Zoning*. Retrieved July 19, 2022, from <https://ecode360.com/14371920?highlight=natural%20resource,resources&searchId=18294701500937294#14371920>
- Town of Dennis. (n.d.). *Dennis Community Resilience Building Workshop Summary of Findings*. <https://www.mass.gov/doc/dennis-report/download>
- Town of Dennis. (2022). *Town of Dennis FY2023 State Land Grant Application: Tobey West Land Acquisition*.
- Town of Orleans. (2013). *Open Space in Orleans: 25 Years of Success*. <https://www.town.orleans.ma.us/DocumentCenter/View/1662/Open-Space-Committee-25-years-of-Success-PDF>
- Town of Orleans. (2022). "Permeable Reactive Barriers." *Water Quality & Wastewater Planning*. Retrieved July 19, 2022, from <https://www.town.orleans.ma.us/342/Permeable-Reactive-Barriers-PRB>
- Town of Wellfleet. (2021). *Wellfleet Environmental Protection Regulations*. https://www.wellfleet-ma.gov/sites/g/files/vyhlf5166/f/pages/wepr_october_6_2021.pdf
- Town of Yarmouth. (2022). "Yankee Village Property Restoration." Retrieved July 21, 2022, from <https://www.yarmouth.ma.us/1959/Yankee-Village-Property-Restoration-275->
- Truro Conservation Trust. (1987). *Pamet River Greenway Plan*.

UMass Amherst. (2017). "Ecology and Vulnerability Coastal: Coastal Plain Ponds." Retrieved December 1, 2022, from <https://climateactiontool.org/ecogroup/coastal-coastal-plain-ponds>

UMass Amherst. (2022). "Natural Resource Protection Zoning." *MassWoods*. https://masswoods.org/sites/masswoods.net/files/pdf-doc-ppt/natural_resources_protection_zoning.pdf

Young, K. (2019). "Trust looks to purchase, protect Tobey Woodlands." *Cape Cod Times*. Retrieved July 18, 2022, from <https://www.capecodtimes.com/story/news/2019/09/26/trust-looks-to-purchase-protect/2673945007/>