# THREE BAYS WATERSHED:

## Landscape-Based Solutions to Improve Water Quality

University of Massachusetts, Amherst
Department of Landscape Architecture and Regional Planning
Master's of Landscape Architecture Graduate Studio | Fall 2017

Jack Ahern, Professor

Students:
Andrew Capelluti  Allison Gramolini  Maggie Kraus  Sara Lawler
Mimi Lo  Kate O'Connor  Doug Serrill  Alysha Thompson  Diance Tian

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December 2017

ACKNOWLEDGEMENTS

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**Cape Cod Commission**
**US Environmental Protection Agency**
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Prince Cove

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Abandonned Cranberry bogs in the headwaters of the Marstons Mills River

# INTRODUCTION

The Three Bays Watershed and Marstons Mills River corridor is located in BArnstable, Sandwich and Mashpee on Cape Cod, Massachusetts. The watershed is part of three separate villages within the Town of Barnstable: Cotuit, Marstons Mills and Osterville. The Three Bays Watershed is comprised of Cotuit Bay, North Bay and West Bay. The watershed is an iconic Cape Cod landscape with unique ecological, historical, recreational and cultural resources. The watershed is situated in a complex landscape matrix that includes a mix of residential and commercial development, as well as a mix of ecological communities including: dunes, salt and freshwater marshes, shrub and forested swamps, cranberry bogs, coastal grasslands and Oak and Pitch Pine forests.

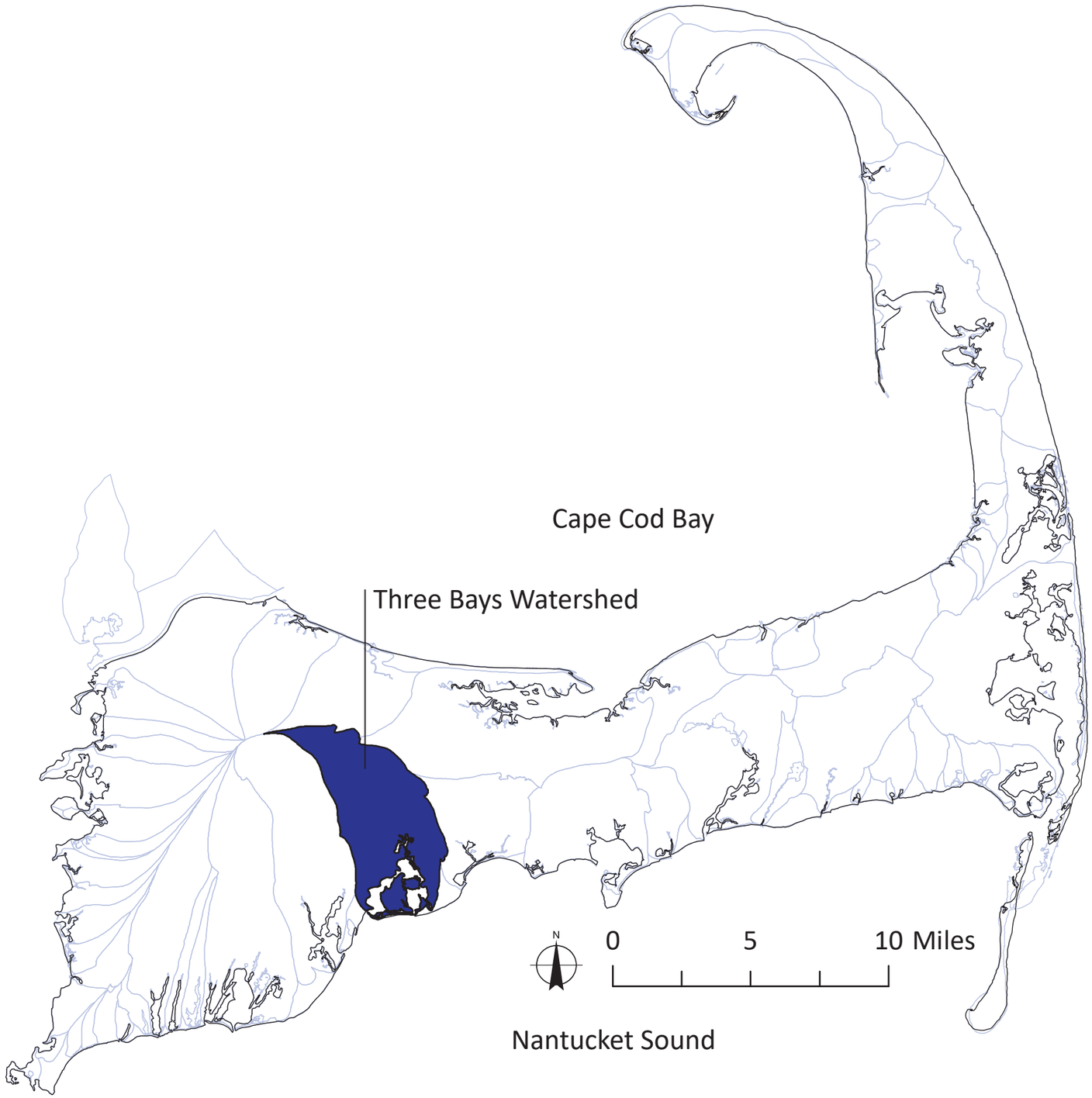
Presently, the water quality of the Three Bays is seriously impaired and routinely exceeds water quality standards for nitrogen. In 2016, a summer algal bloom occurred within the Three Bays, which caused fish kills and put the commercial oyster industry at risk. The ecological and cultural impacts brought increased public awareness to the developing water quality issue within the Three Bays. The causes of this water quality impairment include septic system leaching, stormwater discharge and runoff from adjacent lands.

This studio looked holistically at a study area within the Three Bays Watershed - centered on the Marstons Mills River, the primary tributary of the Three Bays. This is an important river corridor as it runs through the complex matrix of the Cape and feeds directly into the Three Bays. The studio's holistic approach assessed: current and future development trends; the configuration and connectivity of protected landscapes along the Marstons Mills River corridor; cultural and recreational resources, with a special focus on water quality and possible landscape solutions to address this issue. The studio was given "priority sites" along the Marstons Mills River corridor in order to design pilot/demonstration site-scale interventions in the watershed to address several key issues: water quality, stormwater management, habitat connectivity and recreational trails and access.

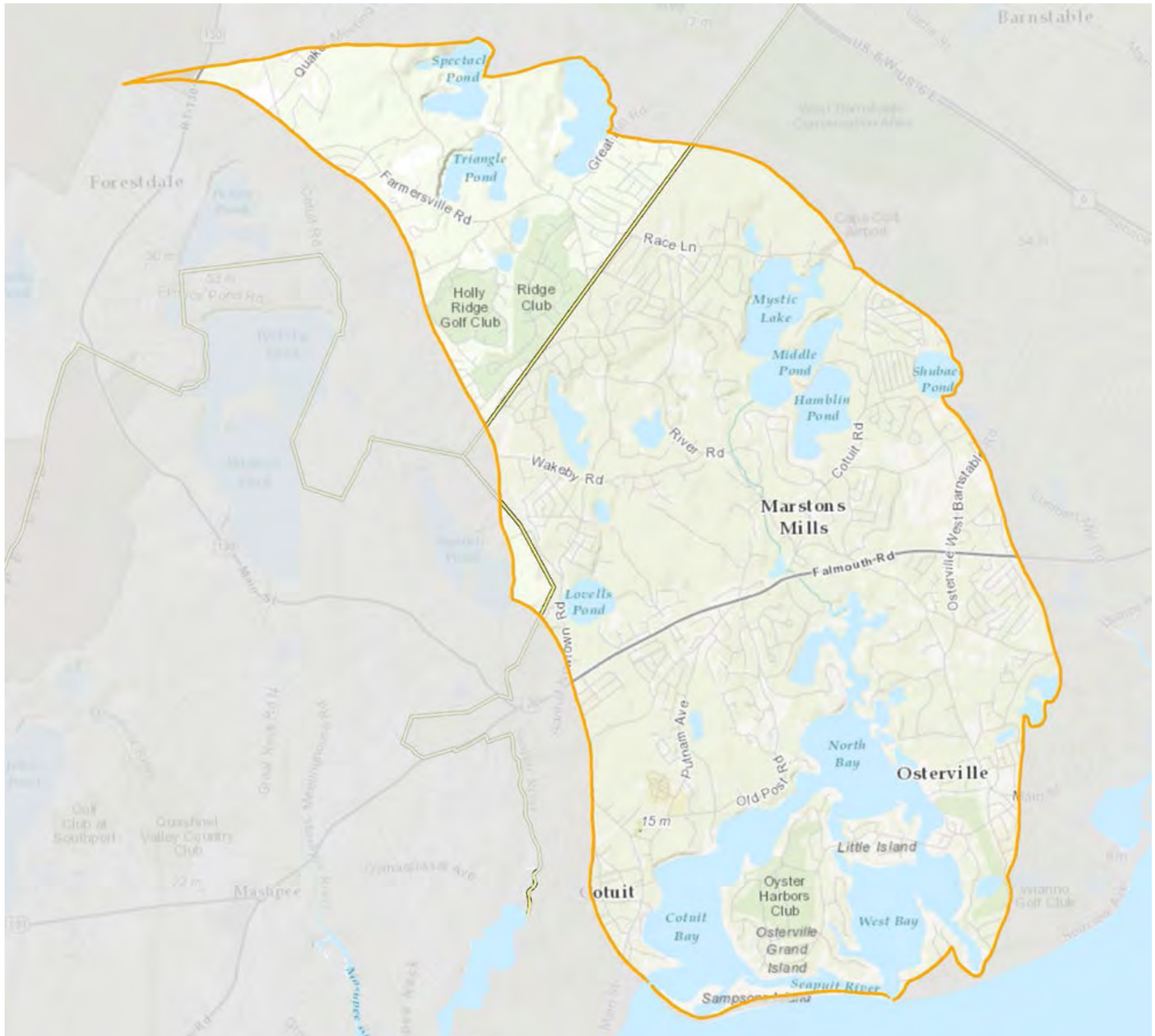
The Town of Barnstable, The Horsley Witten Group, the Barnstable Clean Water Coalition and the Association to Preserve Cape Cod (APCC) have received funding from the US Environmental Protection Agency for coastal watershed restoration in the Three Bays Watershed titled "Cleaning up the Bays". The Studio collaborated with the Barnstable Clean Water Coalition (BCWC) and other key stakeholders, to perform assessments and field studies. The results of the studio, summarized in this report, provide stakeholders with watershed and site-specific pilot/demonstration projects, recommendations and conceptual designs, which address and provide landscape solutions for surmounting water quality issues that face the Three Bays Watershed specifically and for Cape Cod in general.

# THE THREE BAYS WATERSHED

The Three Bays Watershed includes 12,458 acres of land in the towns of Barnstable, Sandwich and Mashpee. The watershed includes 54 ponds and two rivers: the Marstons Mills River and the Little River. The watershed's surface and groundwater flows discharge into the Three Bays (North, West and Cotuit Bays) and from there mixes with tidal flows from Nantucket Sound.



# THE THREE BAYS WATERSHED BY THE NUMBERS




Acres | 12,458

Parcels | 7,093

92% developed residential parcels

1.6 acres/parcel (approx.)

Contributing Towns |

Barnstable (majority of watershed), Sandwich, and Mashpee

Freshwater Ponds | 54

Major Freshwater Streams | Marstons Mills River & Little River


Cape Cod Commission. “Watershed Report: Three Bays,” June 2017.

Horsley, Scott, et.al. “Three Bays Estuary,” Barnstable, Cape Cod, 2016
Watershed Restoration Plan: A Green Infrastructure Approach. Journal of Green Building.

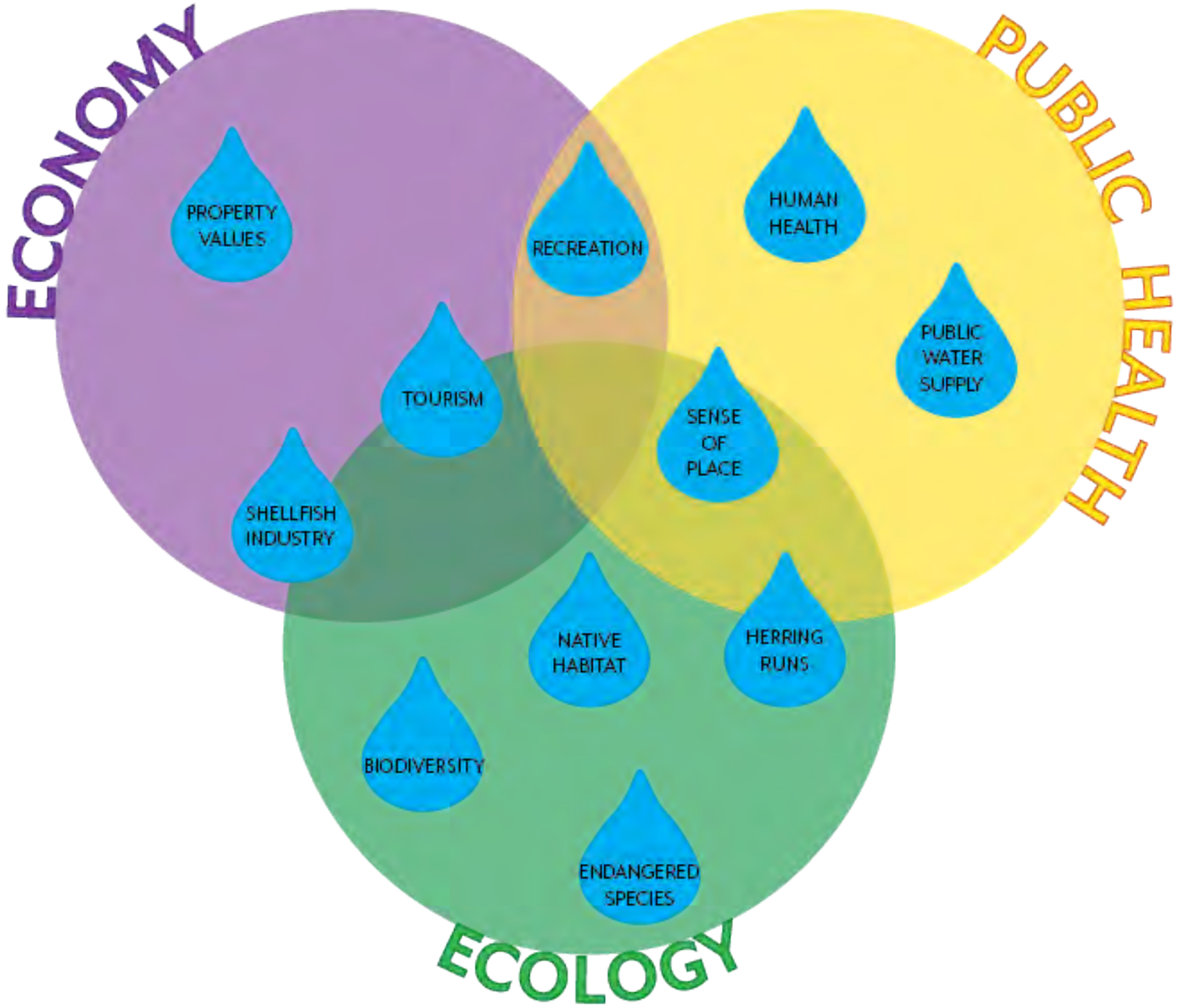
# HISTORIC AND CULTURAL CONTEXT

Cape Cod's landscapes are deeply tied to historic, economic and cultural activities. The history of the region is rich with development patterns and industrial uses that reflect not only the geography and topography of Cape Cod but also the people who settled here. Marine industries and cranberry bogs were commonly seen in historic Cape Cod landscapes, as they are today. The structural remnants and community knowledge related to these practices are still central to the lives and livelihoods of current residents. These economies are also an enormous part of the tourism industry that draws countless visitors to the region each year. Despite the historic significance of cranberry bogs on Cape Cod, recent advances in cranberry production in other parts of the United States have started to impact the productivity and economic viability of the small-scale bog operations common on Cape Cod.

Various historic landscape typologies can still be seen throughout the watershed, particularly in the focus area of Marstons Mills village. Understanding the connections between the village and its historical context was central to the process of assessing and designing for the issues of water quality and restoration. The long history of cranberry production, agricultural practices and marine industries emerged as an opportunity to bring the history of the study area to the forefront of the design proposals in this report.

Photographs from:
www.digitalcommonwealth.org

# WATER QUALITY CONCERNS



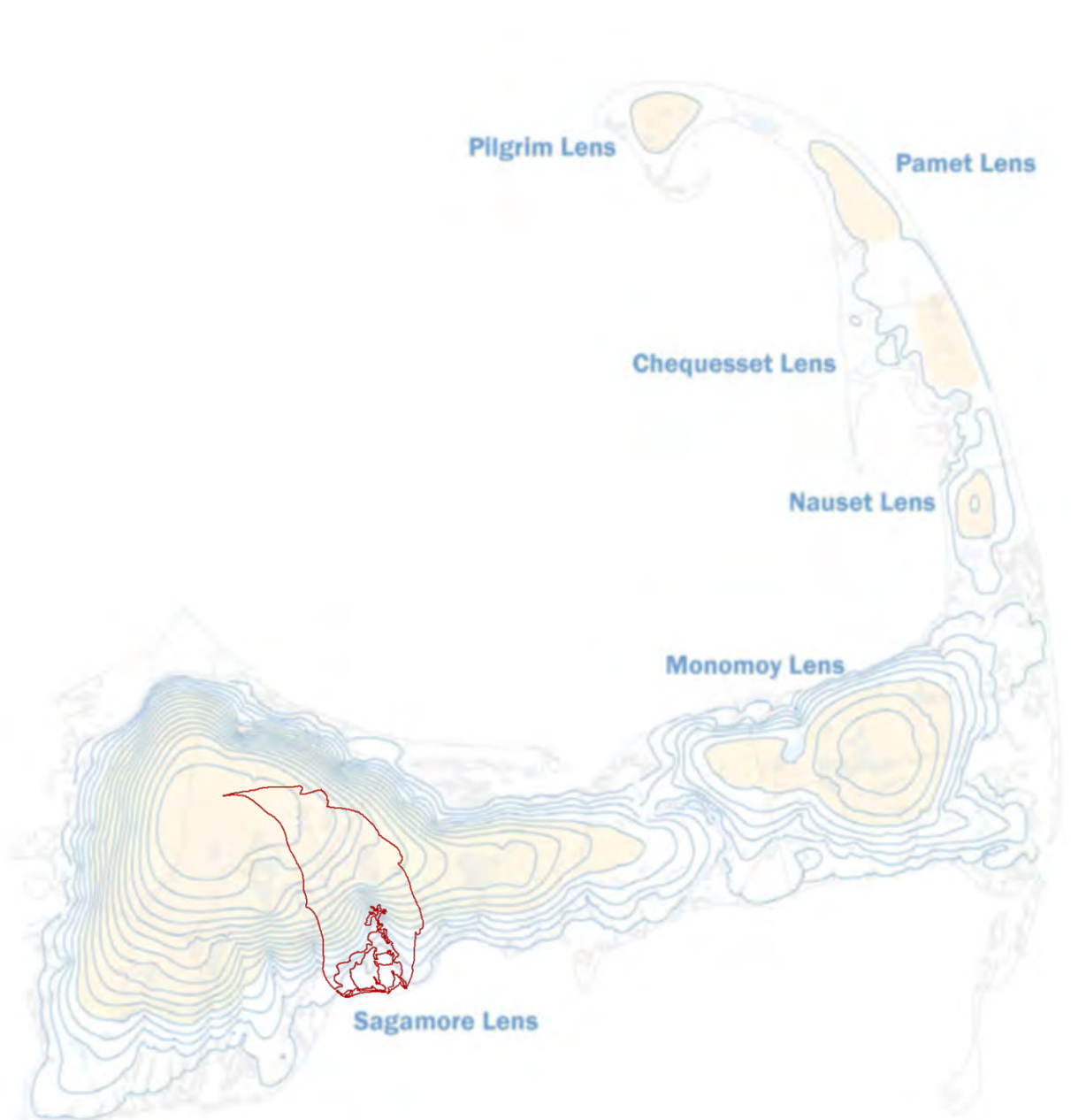

Cape Cod's unique landscape features contribute to the severity of the water quality concerns outlined throughout this report and much of the research that informed this work. High levels of nitrogen and bacteria in the water are exacerbated because Cape Cod has a sole source aquifer. This sensitive hydrological environment increases the impacts of poor water quality on the health of aquatic and terrestrial ecosystems, human populations and the region's economy.

# SENSITIVE GROUNDWATER ON CAPE COD

## Sole Source Aquifer

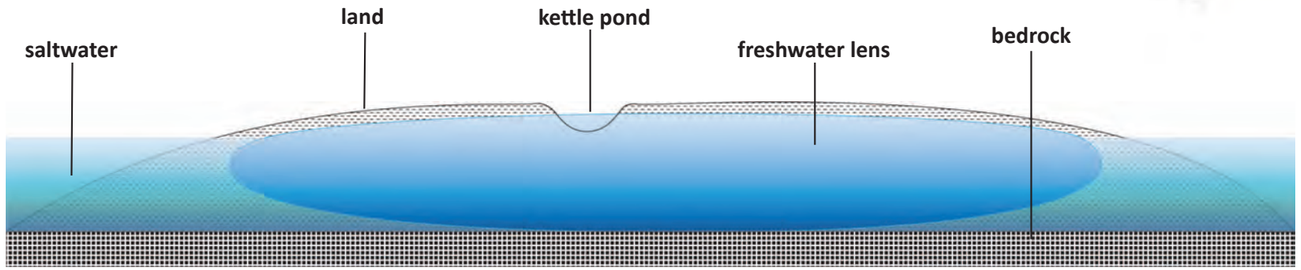
Cape Cod is relatively unique in that the post-glacial sand and gravel deposits that underlay the entire landscape allow relatively unrestricted movement of groundwater, which results in single source aquifers that take the form of freshwater lenses sitting on top of the saltwater beneath the entirety of the Cape's land surface. The Three Bays Watershed is a part of the Sagamore Lens.

The permeable sandy soils in the area also result in a high level of leaching of nutrients and other contaminants from surficial and septic field sources into the groundwater.

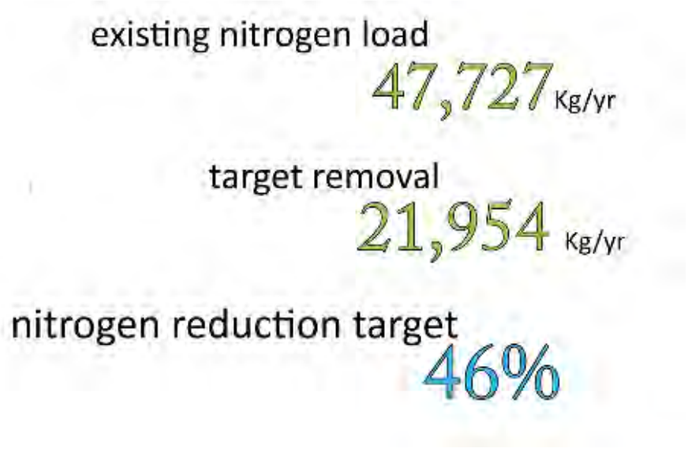



Cape Cod Commission. "Cape Cod Area Wide Water Quality Management Plan Update," June 2015

## Conceptual Cross-Section of Cape Cod



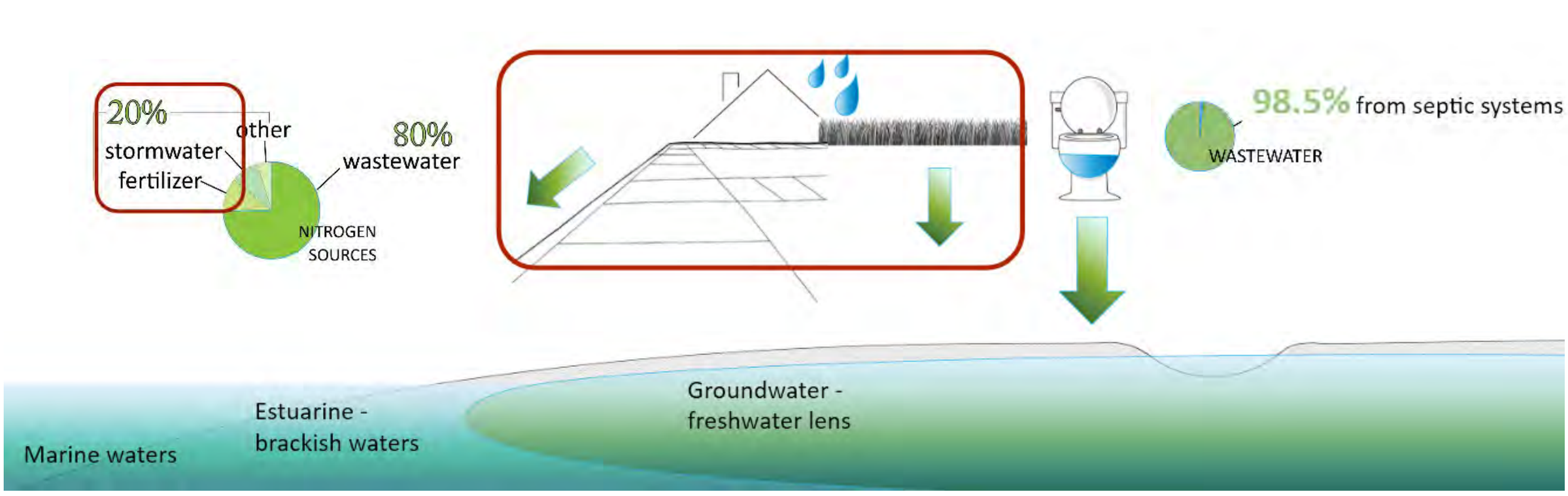
# NITROGEN IN THE THREE BAYS AND CAPE COD




Nitrogen enters the surface and ground waters of the Cape through a variety of pathways. The majority of the anthropogenic sources are from wastewater (80%), 98.5% of which is from septic systems (CCC Watershed Report 2017). Organizations such as the Alternative Septic System Research Facility (MASSTC division of the Barnstable County Department of Health and Environment) are working to develop solutions to minimize the wastewater sources of nitrogen entering the groundwater.

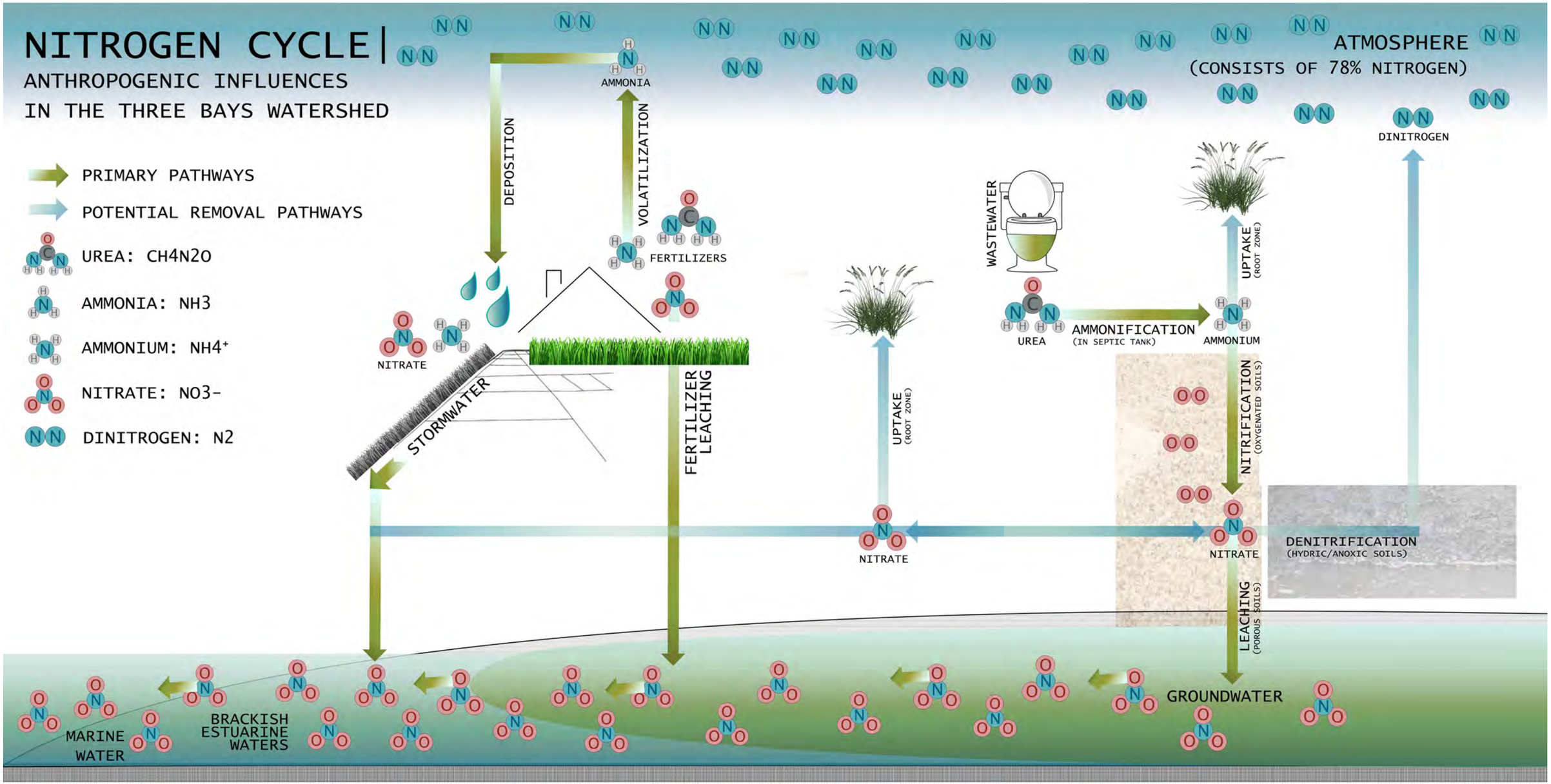
The focus of this study is the non-point sources of nutrient loading from stormwater runoff and fertilizer leaching. Although this portion makes up a smaller fraction of the nitrogen loading(20%+-), it is a very important, high impact fraction because it is fast moving, and efforts to manage it can have a more immediate effect. Landscape-based solutions are also able, in some cases, to directly treat already-impaired water bodies and nitrogen-containing sediments.

Massachusetts Estuary Project, 2006; Cape Cod Commission. “Watershed Report: Mid Cape,” 2017;
Cape Cod Commission. “Cape Cod Water Quality Management Plan, Update: 208 Plan,” 2015

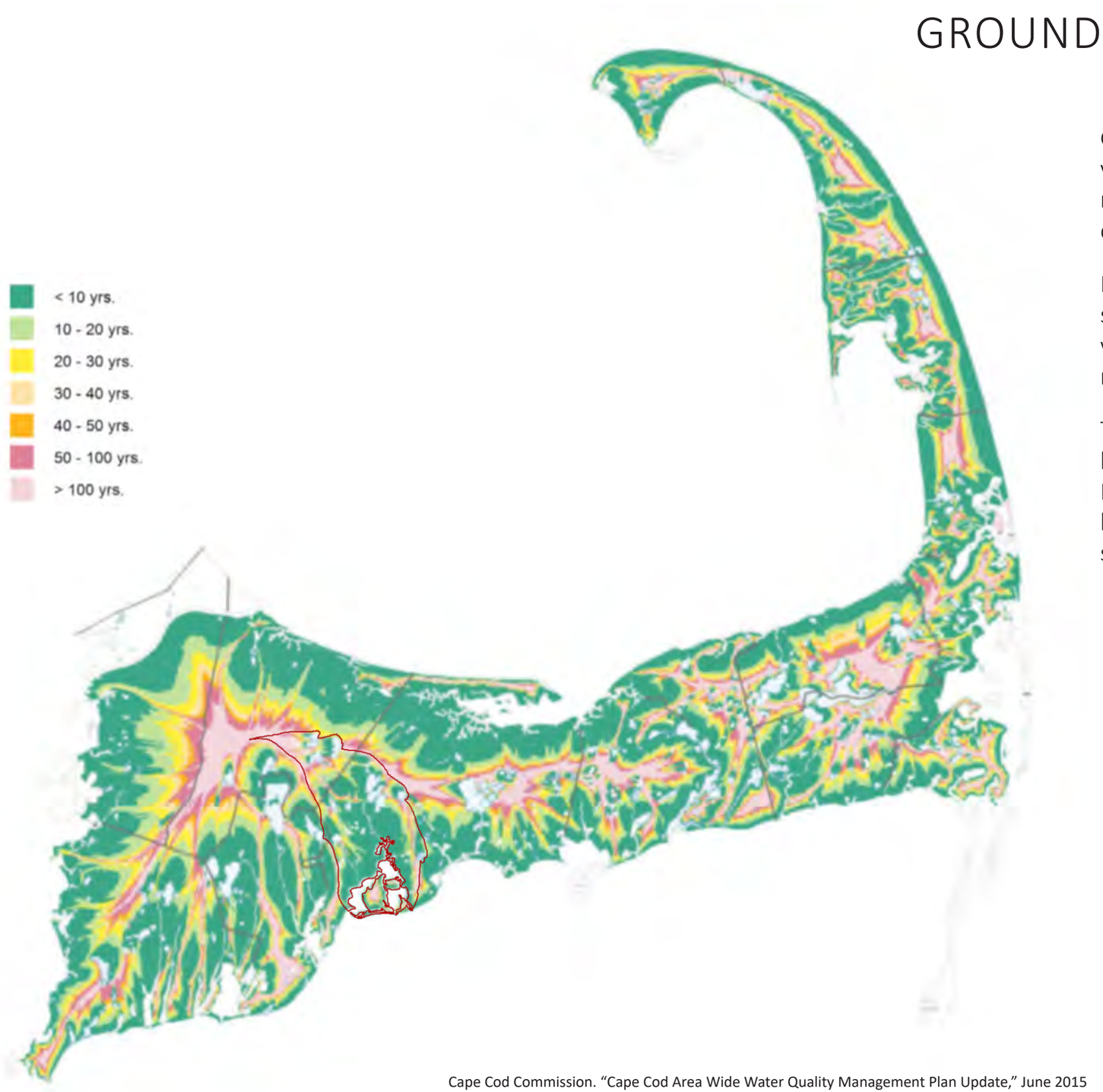


# UNDERSTANDING THE NITROGEN CYCLE

Understanding anthropogenic effects on the nitrogen cycle in the sensitive Cape Cod environment can help inform and guide landscape-based remediation strategies and tactics.



# GROUNDWATER MOVEMENT IS VERY SLOW




Cape Cod Commission. “Cape Cod Area Wide Water Quality Management Plan Update,” June 2015

Groundwater moves very slowly on Cape Cod. It can take over 100 years for inland groundwater to reach coastal waters. This means that nutrient loading already present in inland groundwater may not be detected in coastal waters for some decades.

However, in most of the Marstons Mills River Corridor study area, groundwater travel time to the coast is less than 10 years, thus impacts of recent nutrient leaching are already having measurable impacts on water quality.

This shorter travel time also means that more immediate effects can be realized from water quality improvement efforts in the Marstons Mills Corridor study area. Finding solutions here can help prepare for what’s to come from the existing contamination of slowly moving inland groundwater.

# DEVELOPMENT HAS SHORT AND LONG TERM EFFECTS ON WATER QUALITY

Most of the residential and commercial development on the Cape has been rapid and fairly recent, largely over the past 60 years. Almost all of these properties have septic systems, many of which are now failing, and often these residential and commercial landscapes are highly fertilized. This leads to increased nutrient loading in the groundwater, and the slow timescale of groundwater movement means that the nutrient loading from much of this development has not yet reached the coastal estuaries, which emphasizes the need for short-term solutions, now.

The increase in impervious surface from recent development increases total stormwater runoff, peak flows, and erosion, which increases the direct flow of nutrients, sediments, and other contaminants entering the surface waters. These direct inputs have an immediate effect on water quality which is why this fraction of nutrient loading is so important to address in the short term.

Cape Cod Land Use 1951

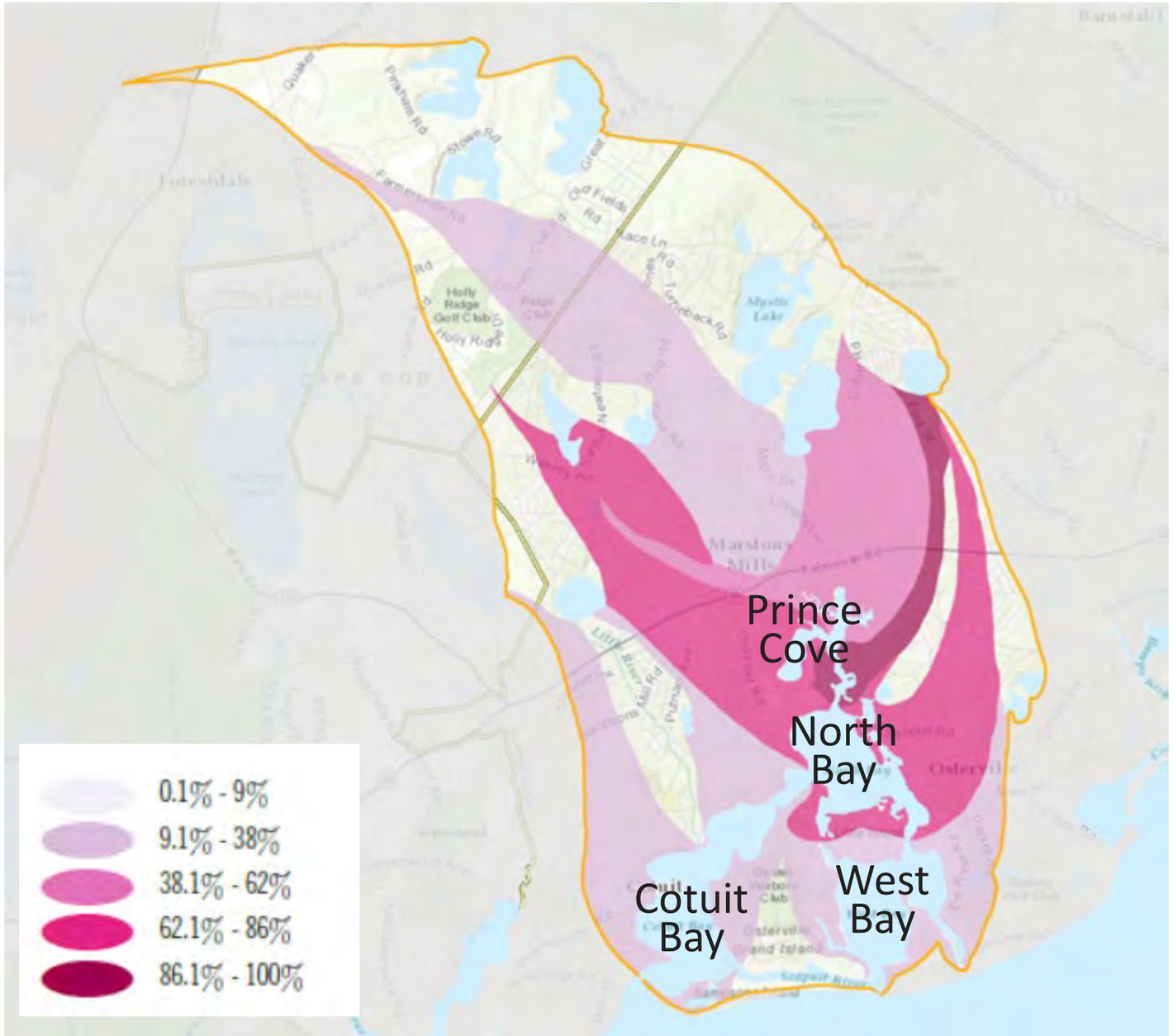
Cape Cod Land Use 1971

Cape Cod Land Use 1985

Cape Cod Land Use 1999

Cape Cod Commission. “Cape Cod Area Wide Water Quality Management Plan Update: 208 Plan,” 2015

# NITROGEN REMOVAL TARGETS BY SUBWATERSHED




Nitrogen removal targets vary across the watershed. The highest removal targets are found in subwatersheds feeding into the North Bay and Prince Cove. These are the most compromised water bodies in the Three Bays Watershed area and are less diluted by tidal flushing than the Cotuit and West Bays.

Cape Cod Commission. “Watershed Report: Three Bays,” June 2017

# EXISTING AND TARGET NITROGEN CONCENTRATIONS IN THE THREE BAYS

Existing nitrogen levels are much higher in the upper areas of the Bays, especially North Bay, Prince Cove, and the mouth of the Marstons Mills River. This further highlights the importance of focusing on the Marstons Mills River Corridor area and Prince Cove for nitrogen-remediating landscape solutions.

## Marstons Mills River

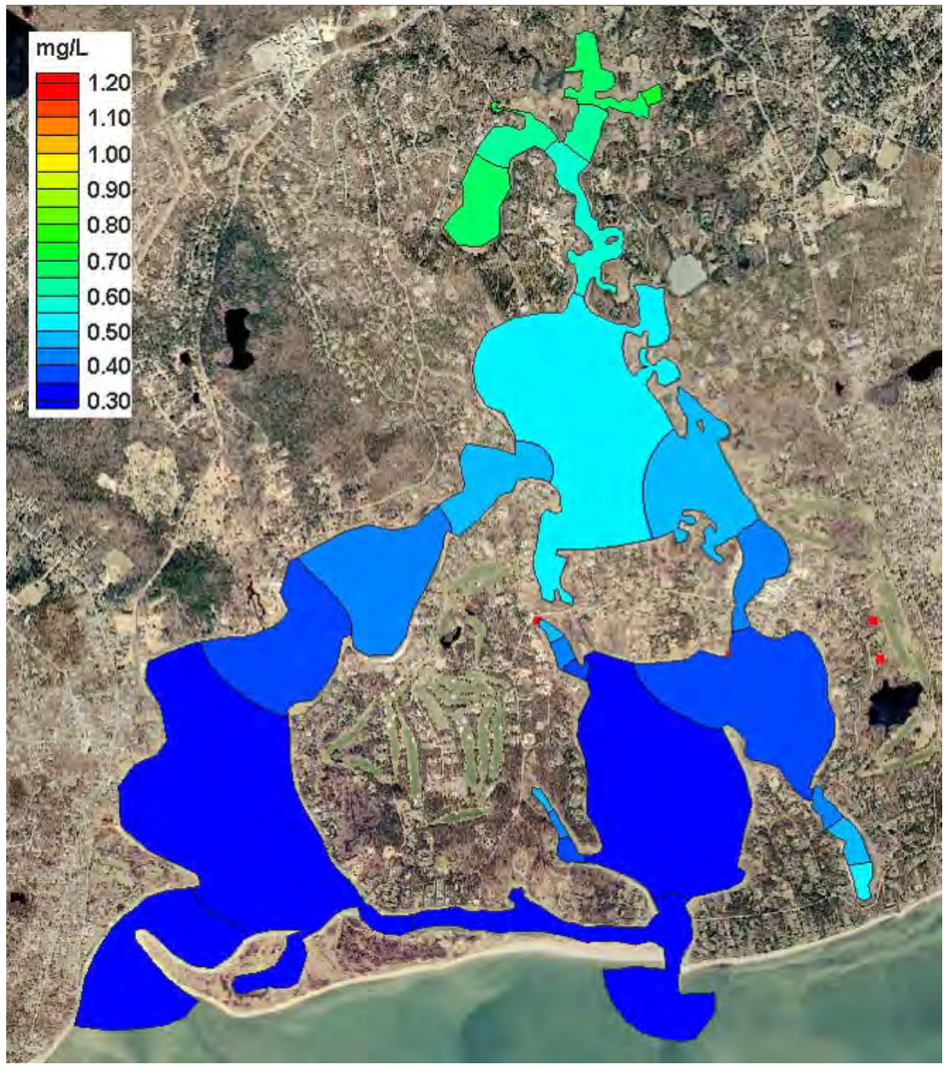
Nitrogen load (kg/day) 14.518
Target load (kg/day) 12.000
**Target removal -17.3%**

## Prince Cove - north

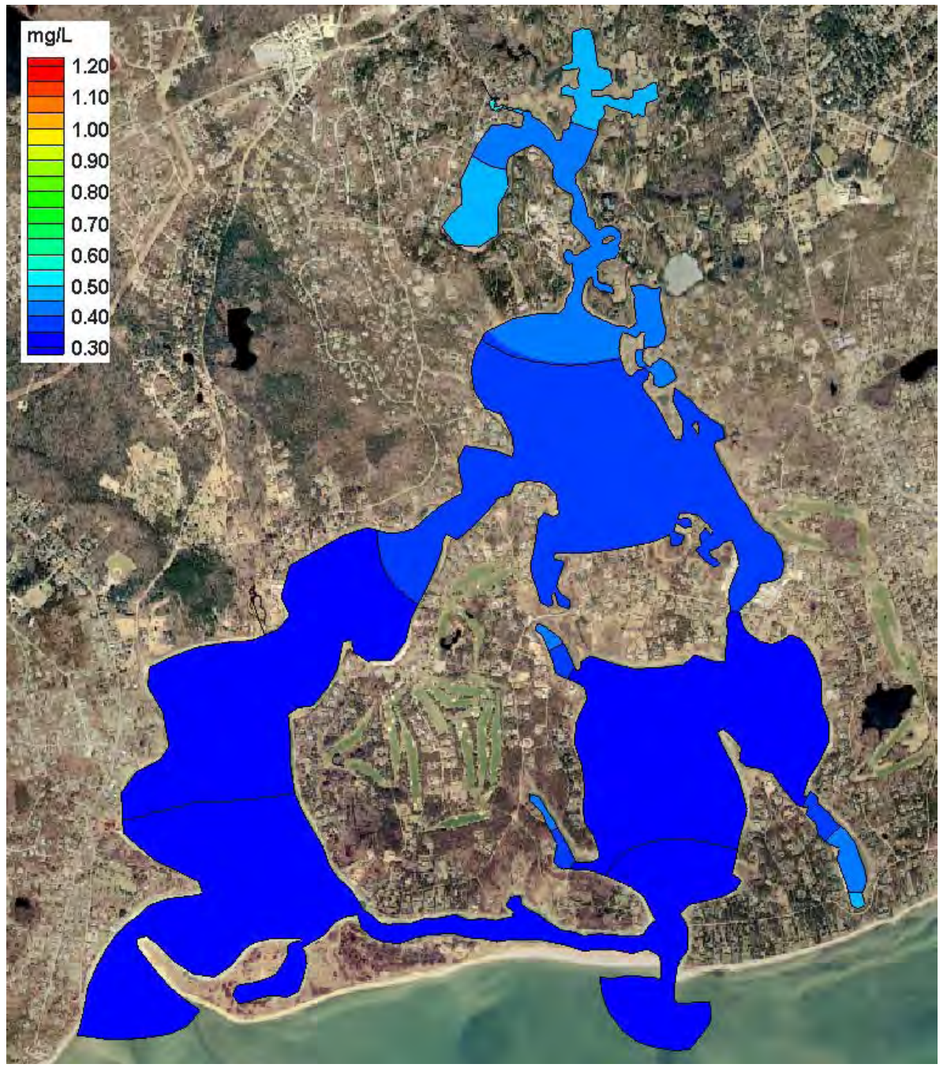
Nitrogen load (mg/L) 0.639
Target load (mg/L) 0.446
**Target removal - 30.1%**

Massachusetts Estuary Project 2006

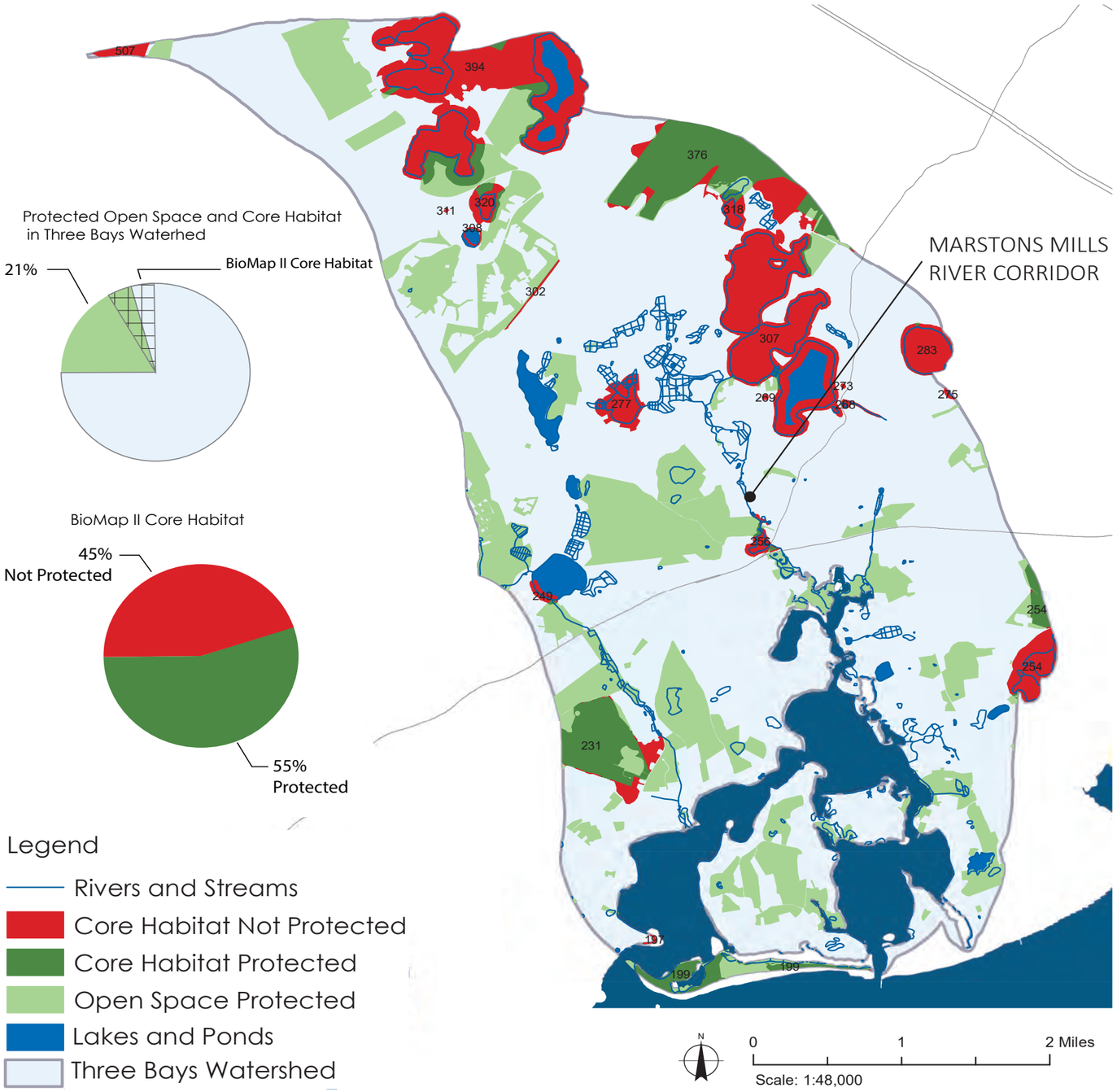
## Existing Nitrogen Concentrations




## Target Nitrogen Concentrations



# OPEN SPACE AND BIOMAP II



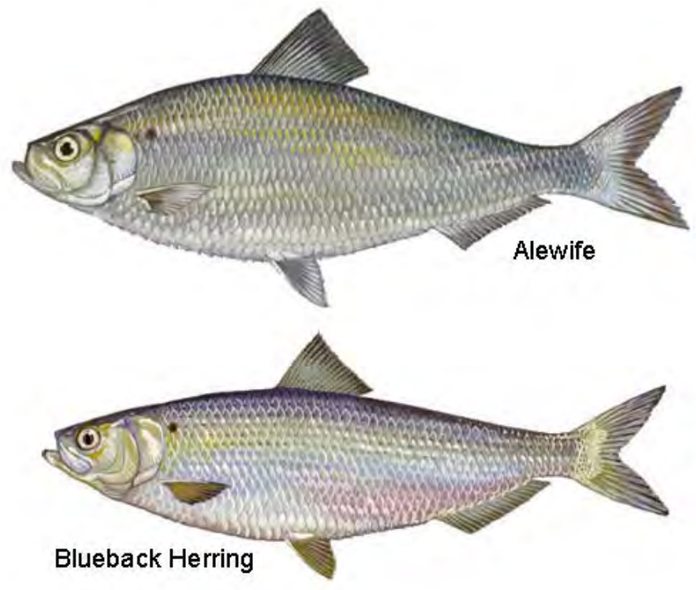

There are 2,061 acres of protected open space within the Three Bays Watershed, or approximately 21% of the land area. These lands are protected for a variety of reasons, from conservation restriction to water management, and managed by a variety of public and private land managers. These open space parcels were cross-referenced with lands listed as “critical habitat” through BioMap II, a state-wide program of the Natural Heritage and Endangered Species Program to assess and prioritize protection for rare, threatened and endangered species. Of the 2,061 acres of protected open space, 548 acres (26%) contain critical habitat. An additional 445 acres (21%) is identified as core habitat, but is not protected. A majority of these lands are along the shorelines of numerous ponds throughout the watershed which are privately owned residential properties.

The existence of these relatively high percentages of critical and core habitat stresses the importance of developing community initiatives to encourage landowners to develop more extensive habitat buffers and conservation-minded landscaping to protect and restore
habitats and biodiversity.

# TARGET/INDICATOR SPECIES

The protection a nd managemet o f indicator a nd target species represent important public goals for conservation planning. Indicator species are like “canaries in the coal mine” which function as bellwethers of ecosystem health. Target species have special cultural significance w hich makes t hem powerful restoration intiative icons. The eastern oyster is an important aquaculture product and also provides ecosystem services such as filtering the water and providing habitat for other benthic organisms. River herring are important wildlife forage as well as being culturally and historically significant through the focus on their annual migration upstream, or “Herring Run.” The eastern oyster and migratory river herring, therefore, can be valuable target/indicator species for restoration initiatives in the Three Bays watershed.

A coalition of New England States which formed in response to a 2010 executive order on marine protection identified the Marston Mill River Corridor as a critical area for restoration projects.




Eastern Oyster (*Crassotrea virginica*)

**RESTORATION: POTENTIAL PROJECTS**

- Eelgrass Beds
- Coastal Wetlands

Potential Restoration Projects

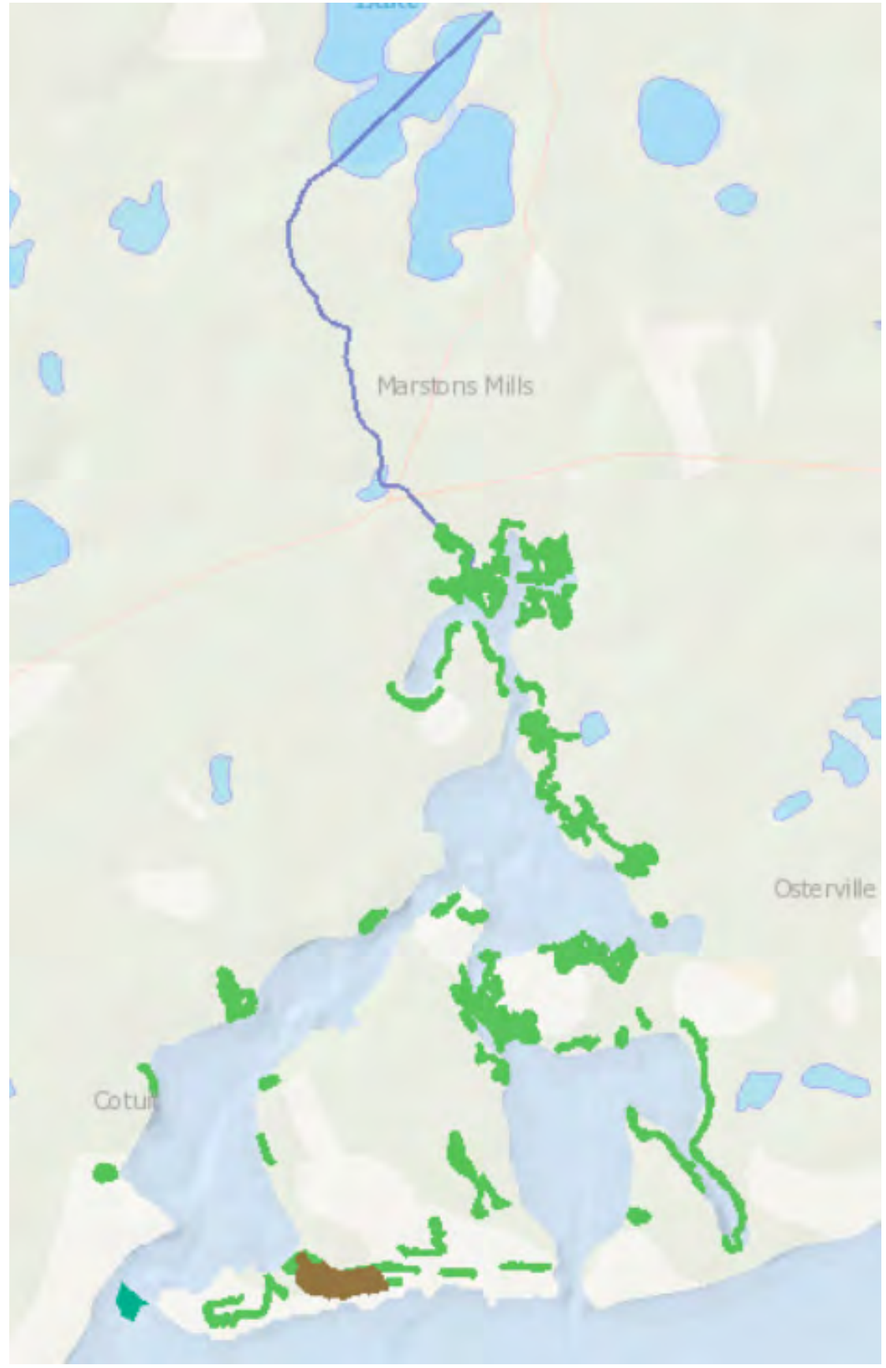
- Dam Removal or Fish Passage
- Eelgrass, Oysters, Other
- Land Conservation
- Watershed and Water Quality
- Wetland

Eelgrass Beds

Coastal Wetlands

- Phragmites australis
- Unconsolidated Shore Organic Irregularly Flooded
- Scrub-Shrub Wetland Coniferous
- Scrub-Shrub Wetland Deciduous
- Emergent Non-persistent Wetland

http://www.northeastoceandata.org/: The National Ocean Policy, established by Presidential Executive Order in 2010, called for the formation of nine regionally focused RPBs to better manage the nation’s oceans and coasts. New England was the first region in the nation to respond to this call, launching the Northeast RPB in November 2012.



# COMMUNITY-BASED HERRING RUN COUNTING PROJECT


Herring play an important ecological and historical role on Cape Cod. People come to watch the annual spring “Herring Run” as they migrate from the ocean to freshwater areas to spawn. These are keystone species whose numbers have been declining. Volunteers now monitor and count the herring as they migrate. This long-standing tradition is an important way for people to become engaged with the Marstons Mills River and the Three Bays watershed, and can be a valuable interface for communicating water quality concerns.

http://www.capecodtimes.com/storyimage/CC/20160320/NEWS/160329954/AR/0/AR-160329954.jpg

# BARRIERS TO MIGRATION/ REQUIREMENTS FOR ESTABLISHMENT

Landscape design challenges to safe fish passage include the need to modify existing  as well as provide new infrastructure. Culverts may be too small and flow too quickly for fish to pass. Improving culverts requires increased volume capacity as well as the addition of a three dimensional bottom topography which mimics in stream riffle conditions (as opposed to a frictionless water-slide type fluvial morphology).

Additionally, oysters require a physical structure on which to establish, such as the Oyster Castles employed in Wellfeet, which can withstand maritime exposures.

## Oyster Castle: An artificial reef base


## Herring Run Fish Ladder

## Established Oyster Reef


Images | Cape Cod Water Resources Project

# EACH OYSTER FILTERS UP TO 50 GALLONS OF WATER A DAY

## Oyster Filtration Demonstration on the Chesapeake Bay

Image| Maryland Seafood

The two tanks shown initially contained the same quality water. The tank without oysters represents the control condition, which is unchanged. The transparency of the water in the tank on the right side, which contains the oysters, graphically demonstrates the ability of oysters to filter sediments and contaminant from water.

## CO-BENEFITS OF A HEALTHY BAY

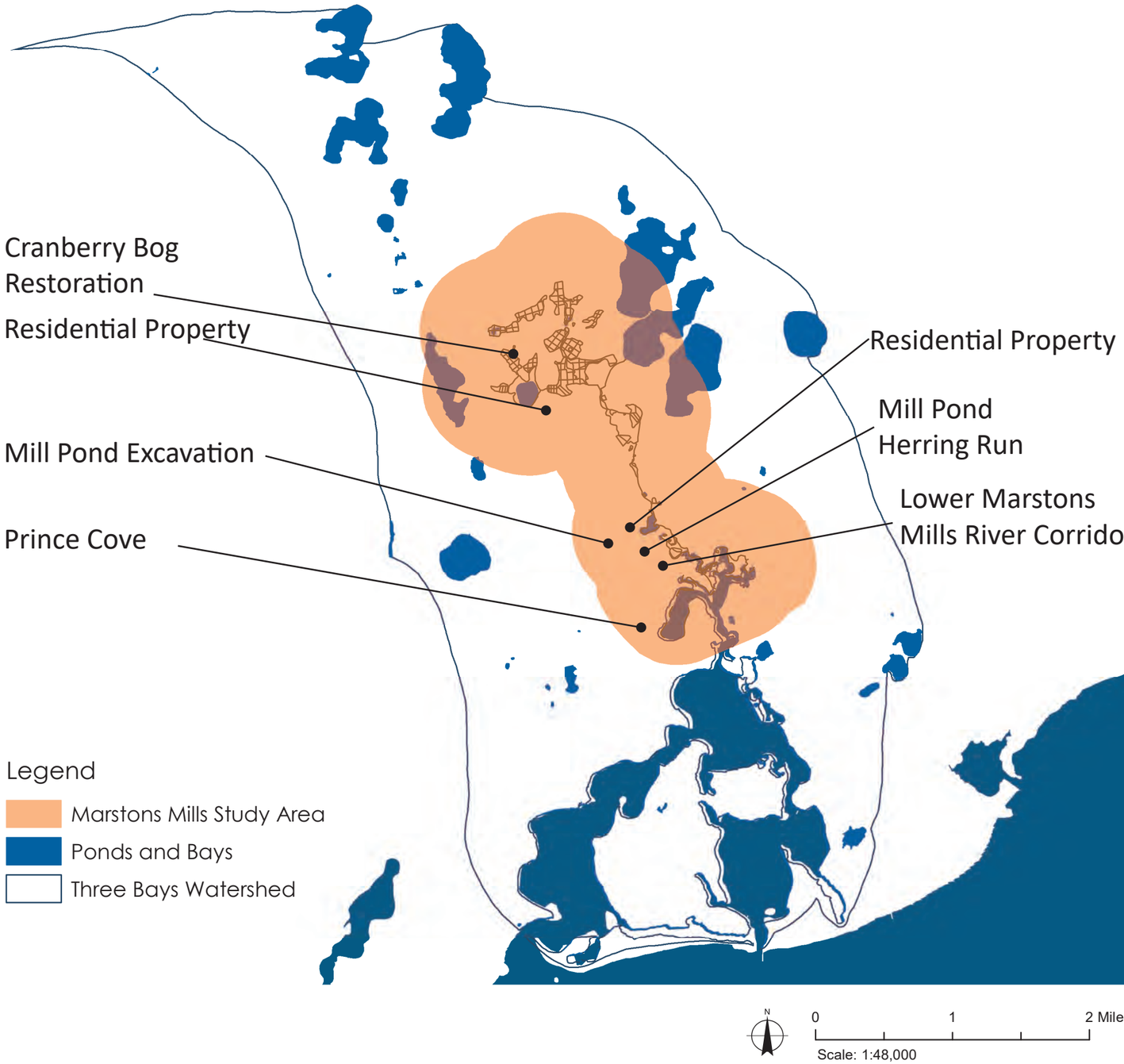
- Water filtration
- Nutrient cycling
- Sediment retention and erosion control
- Carbon sequestration
- Wildlife habitat
- Pollination
- Waste treatment
- Human health
- Recreational opportunities
- Cultural enrichment
- Climate regulation
- Food production
- Property value

# CONCLUSION

Nitrogen has been identified as the primary contributor to water quality degradation throughout the Three Bays Watershed and Cape Cod. The primary contributors of excess nitrogen are: septic systems, stormwater run-off, and fertilizers, 77%, 13%, and 10%, respectively. Cape Cod has experienced significant population growth (400%) over the past 60 years. Over 90% of parcels throughout Cape Cod, and similarly, 92% in the Three Bays Watershed, are zoned for single family residential housing. One of the major consequences of rapid suburban expansion was the installation of decentralized waste water treatment systems. The Cape's geology, defined by sandy, very well-draining soils, has a very low nutrient holding capacity. The volume of nutrients from human sources has exceeded the assimilation capacity of these soils. As a result, Cape Cod is experiencing significant excess nutrients leaching into its sole source aquifer generally and specifically into the Three Bays.

Suburban development has also led to an increase in impervious surfaces on the Cape. Impervious areas increase surface run-off and decrease infiltration into groundwater, which flushes pollutants such as fertilizer and other contaminants into the bays. Currently, the Three Bays Watershed contains 13% impervious surface. "Research indicates that when impervious area reaches 10 percent, stream ecosystems begin to show degradation, and coverage of more than 30 percent is associated with severe, practically irreversible degradation."(LID Manual, 2010). The Massachusetts Estuaries Project conducted an assessment of total nitrogen volumes in the Three Bays Watershed and identified threshold limits approximately 50% lower than current levels in the watershed. Although 20% of the overall watershed contains protected open space, very few parcels along the Marstons Mills River Corridor are protected. Therefore, landscape-based solutions to water quality degradation need to be collaborative and community-driven. Solutions should promote reductions in impervious surfaces and reduction of landscape fertilizers by increasing the use of locally appropriate native vegetation and sustainable landscape practices.

# THE MARSTONS MILLS RIVER CORRIDOR: DEMONSTRATION LANDSCAPE PROJECT SITES




The Marstons Mills River Corridor was identified by the Barnstable Clean Water Coalition as a priority for demonstration project sites to develop landscape-based ecological and cultural design solutions to nitrogen based water quality impairment within the Three Bays Watershed.

Projects were selected in collaboration with our partner organizations, especially the Barnstable Clean Water Coalition and the Association to Preserve Cape Cod. They represent a range of scales and landscape types, and may be used as models or demonstrations for similar projects elsewhere on Cape Cod or in other coastal areas. These projects address cranberry bogs in the headwaters, waterfront residential properties, Mill Pond dredging, interpretive trail development in the lower and Marston's Mills River Corridor, stormwater management, habitat restoration, and aquaculture in Prince Cove.

Landscape-based solutions that address nitrogen contamination have been employed in the demonstration landscape project sites. The goal of this studio is to provide a menu of new design ideas that may effectively lessen nitrogen input to the Three Bays. In addition, the strength of the interdisciplinary approach taken by landscape architects and planners is in its ability to identify and address co-benefits. As an example, the solutions proposed here that target water quality also engage the community, provide recreational opportunities, enhance biodiversity, strengthen the landscape's potential for education and cultural history interpretation, and provide economic benefits.

# SHARING THE WATER:

## AN INTEGRATED LANDSCAPE FOR CRANBERRY BOGS AND NATIVE WETLANDS ON CAPE COD

Sara Lawler

### Site Overview:

Cranberry bogs are a quintessential landscape on Cape Cod that carries great historic, cultural, economic, and ecological importance. During colonial settlement cranberry bogs were sited in naturally occurring peat bogs and wetlands whose hydrology made ideal conditions for cranberry production. Now, as the cranberry business is declining on Cape Cod, some landowners are searching for alternative land uses for their bogs. Re-establishing wetlands in retired cranberry bogs can restore native plant communities and natural hydrology that improve water quality and downstream habitat for human and animal communities. Restored wetlands can coexist in a diverse landscape alongside productive cranberry bogs while the entire landscape shares the invaluable water resource flowing through it.

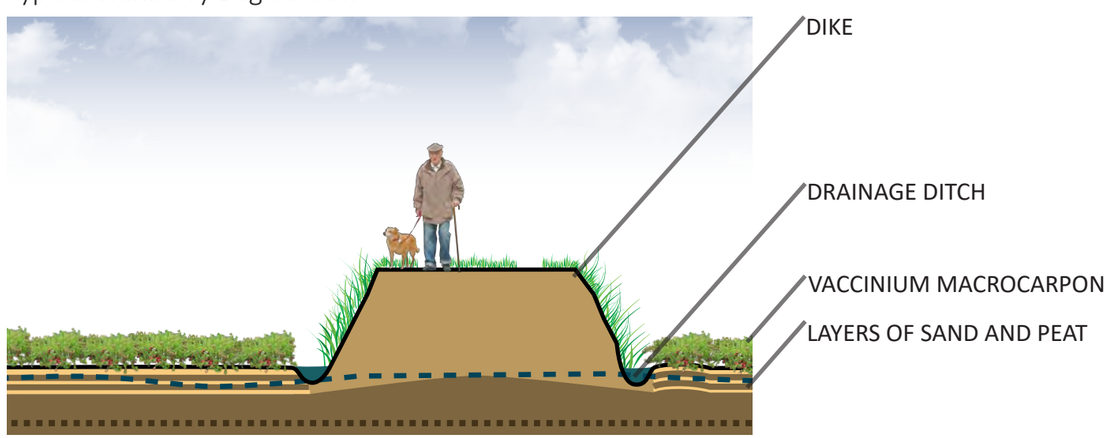
### Precedent Study:

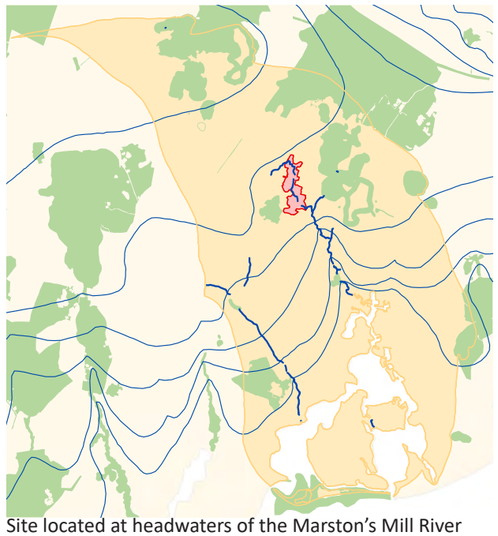
Tidmarsh Farms in Plymouth, MA, restored wetlands from cranberry bogs, is an important precedent for this project. As one of the largest ecological restoration efforts in MA, it inspired this project with large scale hydrological restoration and community monitoring in partnership with MIT Media Labs. While that project serves as a successfully built example, this proposed project differs by maintaining productive cranberry bogs alongside a variety of restored wetland communities. https://tidmarsh.media.mit.edu/

### Existing Conditions:

Cranberry bogs rely on control of water levels to periodically flood and drain bogs at specific times in the annual growing cycle. At this project site, in the upper Marstons Mills River watershed, a system of dikes defines the edges of these bogs and allows for flooding, while also serving as elevated walking paths which an active community of neighbors use regularly. Flumes are the critical control points that allow for the hydrological control of the bogs. As a commercial food production landscape, water quality measurements are made annually, so existing monitoring is already in place, and future monitoring for ecological restoration can use cataloged data and advance current efforts.

Typical Cranberry Bog Section



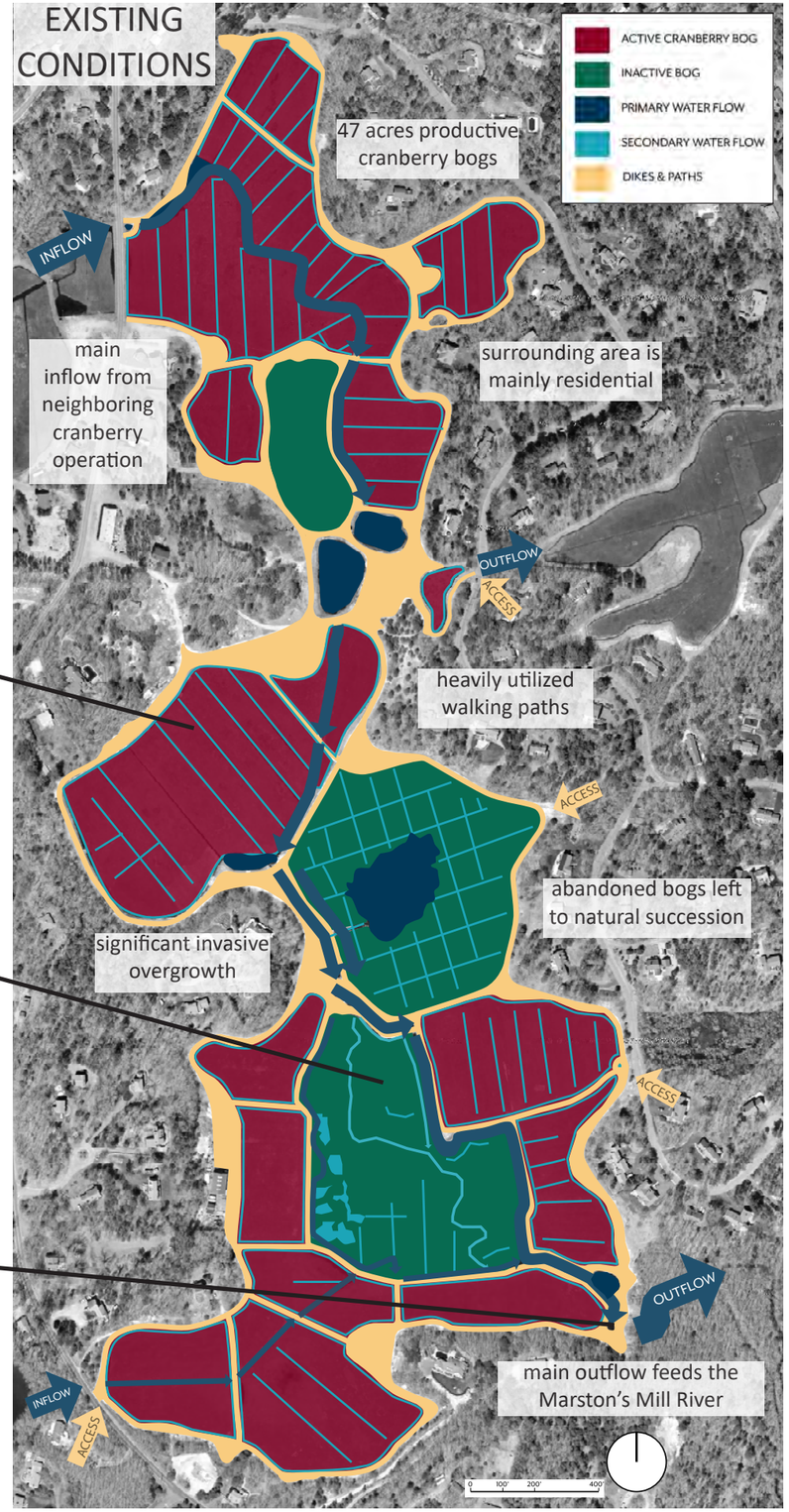



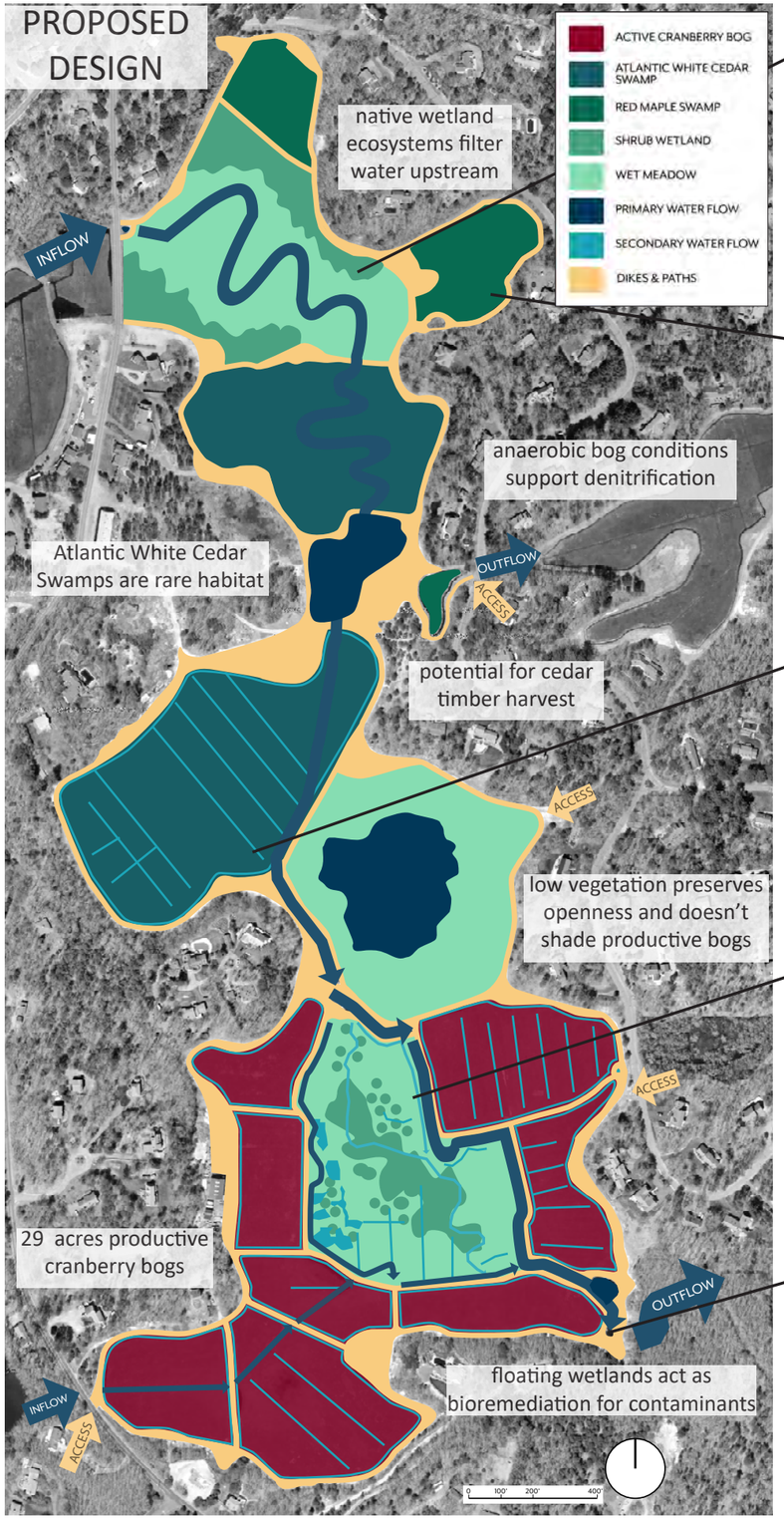
Site located at headwaters of the Marston's Mill River

Typical Cranberry Bog

Overgrown Bog with Natural Succession

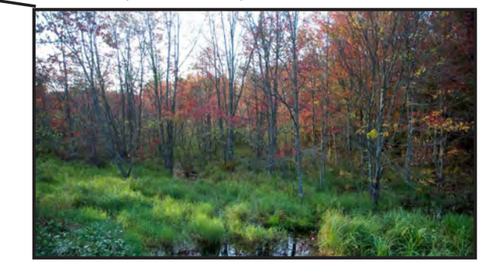
Exit flume to Marstons Mill River






Shrub Wetland

Red Maple Swamp



Atlantic White Cedar Swamp

Marsh and Wet Meadow

Floating Wetlands in Open Water

# SHARING THE WATER:

## DESIGN OBJECTIVES:

1. Keep some cranberry bogs productive
2. Improve and monitor water quality
3. Implement ecological restoration of new and different types of wetlands
4. Remove invasive species
5. Maintain public access

## "Sharing the Water" Proposal:

Protecting water quality at this site in the headwaters of the Marstons Mill River is critical because all downstream habitat is impacted by the inputs made here. Proposed native plant communities including: wet meadows, shrub swamps, Red Maple swamps, and Atlantic White Cedar swamps can provide vegetation buffers that improve riverine health through: nitrogen uptake, diversified habitat, and improved hydrologic connectivity. More diverse plantings can uptake more nitrogen, as all plants do, but the Atlantic White Cedar bogs also provide the anaerobic environment that is crucial for microbial denitrification of water. Atlantic White Cedars require particular hydrologic regimes and can be difficult to establish, but at this bog site the existing system of dikes, flumes, and culverts can provide this control. Management and monitoring could also include timber harvest of this valuable wood.

Wet meadows, shrub swamps, and Red Maple swamps offer other habitats for a more diversified landscape and require less maintenance than the Atlantic White Cedar swamps. The location and successful establishment of these different wetland types is dependent on soil and hydrology conditions and are self-regulating throughout long-term and seasonal changes. Low herbaceous vegetation in wet meadows maintains an open character and keeps the broad views that so many recreational users enjoy and expect at this site, and provide a contrast to the shade, density, and refuge of dense canopy cover in the proposed forested wetland areas. Shrub swamps offer a middle ground characterized by low growing woody vegetation less than 20' high, which can act as a visual screen but will not create shade or canopy. The variety of proposed wetland types serves as an educational opportunity for the surrounding community to participate in monitoring and experience native landscapes of the region and improves the recreational experience through the contrast in vegetation, height, texture, sun, shade, and observable wildlife.

Maintaining some cranberry bogs in production keeps the historic economic land use tradition that is quintessential to cultural identity on Cape Cod, and maintains the existing openness, views, and paths along the dikes in these areas. The bogs kept in production in this proposal are in the southern area of the site where a farmer is interested in implementing some innovative techniques, including reduced fertilizer and pesticide application, which directly impact water quality as well. Locating the future production bogs in the southern portion of the site allows the opportunity for other types of habitat to filter the water higher in the watershed and prevents growing trees from shading the cranberries from southern sun. An abandoned bog in the center of the maintained cranberry bogs allows a buffer of wetland grasses and shrubs to filter water as it moves through the bogs and maintains hydrologic connectivity up and downstream.

## Summary:

This proposal includes maintaining some productive cranberry bogs to continue the cranberry bog tradition on Cape Cod, while the addition of a variety of native wetland habitats provides new opportunities. Increased biodiversity, improved water quality, stronger hydrologic connections, and new recreational experiences are key benefits of the proposed design that add value to this landscape as it transitions from the monoculture of cranberry production.

# SHARING THE WATER: ESTABLISHING NATIVE MARSH & WET MEADOW

Sara Lawler

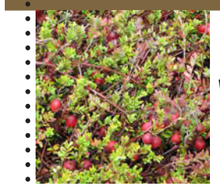
EXISTING

PROPOSED

## CRANBERRY BOG

EXISTING

Layers of sand and peat
Periodically flooded

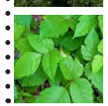


*Vaccinium macrocarpon*

INVASIVE REMOVAL

Bittersweet
*Celastrus orbiculatus*

Multiflora Rose
*Rosa multiflora*



Poison Ivy
*Toxicodedron radicans*

## DIKE

EXISTING

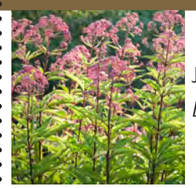
Typically 12’ wide & 4’ high

Access for cranberry farming operations

Recreational use: walkers, joggers, bikers, dogs

## WET MEADOW

Water Depth: 0”- 6”
Hydric Soils



Joe-Pye Weed
*Eupatorium purpureum*

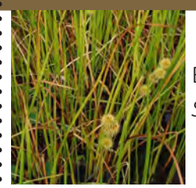
Black-fruited Spike Rush
*Eleocharis melanocarpa*

Threadleaved Sundew
*Drosera filiformis*

Creeping St John’s-Wort
*Hypericum adpressum*

## SHALLOW MARSH

Water Depth: 6”- 18”



Branched Bur reed
*Sparganium androcladum*

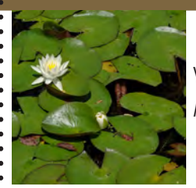
Arrow Arum
*Peltandra virginica*

Soft-stem Bulrush
*Schoenoplectus tabernaemontani*

Northern Arrowhead
*Sagittaria cuneata*

## DEEP MARSH

Water Depth: 18”- 36”



White Water Lily
*Nymphaea odorata*

Little Floating Heart
*Nymphoides cordata*

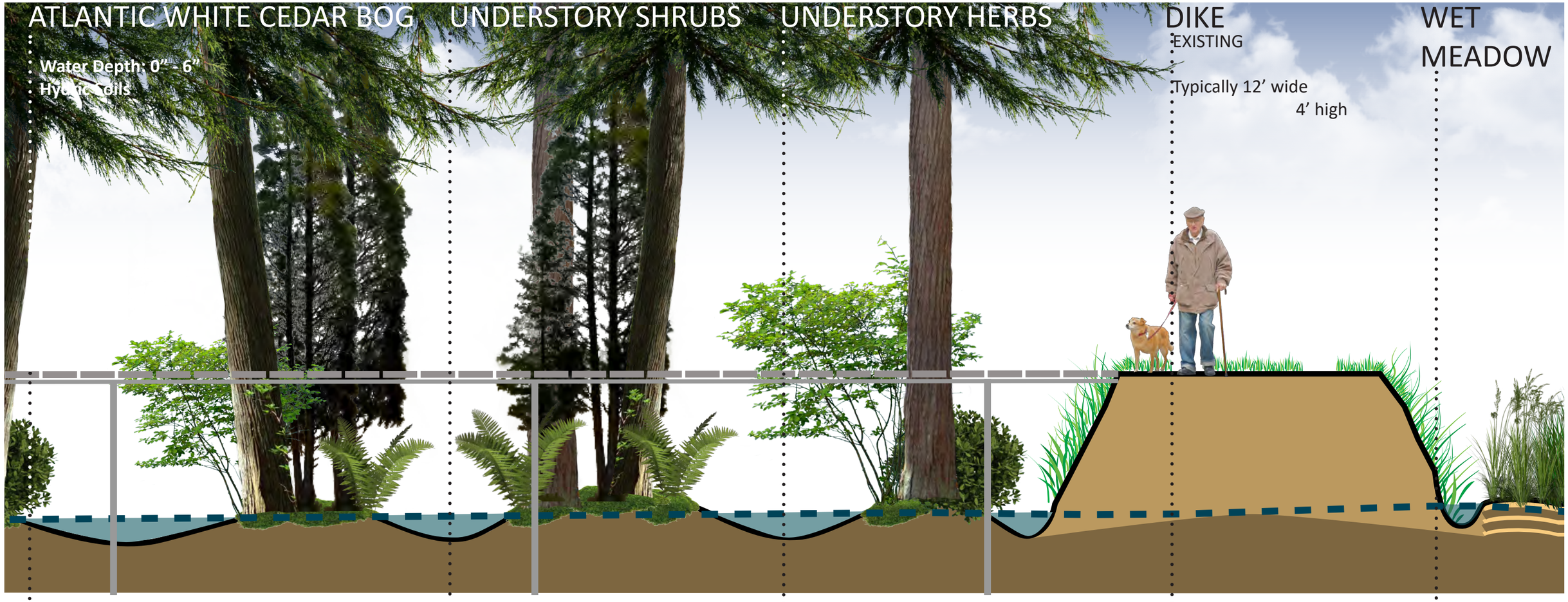
Hard-stem Bulrush
*Schoenoplectus acutus*

Pickerelweed
*Pontederia cordata*

Sara Lawler

Sara Lawler

# SHARING THE WATER: ESTABLISHING ATLANTIC WHITE CEDAR SWAMP


Atlantic White Cedar
*Chamaecyparis thyoides*

Pitch Pine
*Pinus rigida*

Red Maple
*Acer rubrum*

Sweet Pepperbush
*Clethra alnifolia*

Inkberry
*Ilex glabra*

Tall Huckleberry
*Gaylussacia frondosa*

Round-leaved Sundew
*Drosera rotundifolia*

Cinnamon Fern
*Osmunda cinnamomeum*

Peat Moss
*Sphagnum sp.*

Utilize existing dikes to control water

Allow access to this unique habitat with boardwalk trails

Contrast low vegetation with closed canopy cover for diverse habitat and pedestrian experience

Sara Lawler

# POLYCULTURE SOLUTIONS

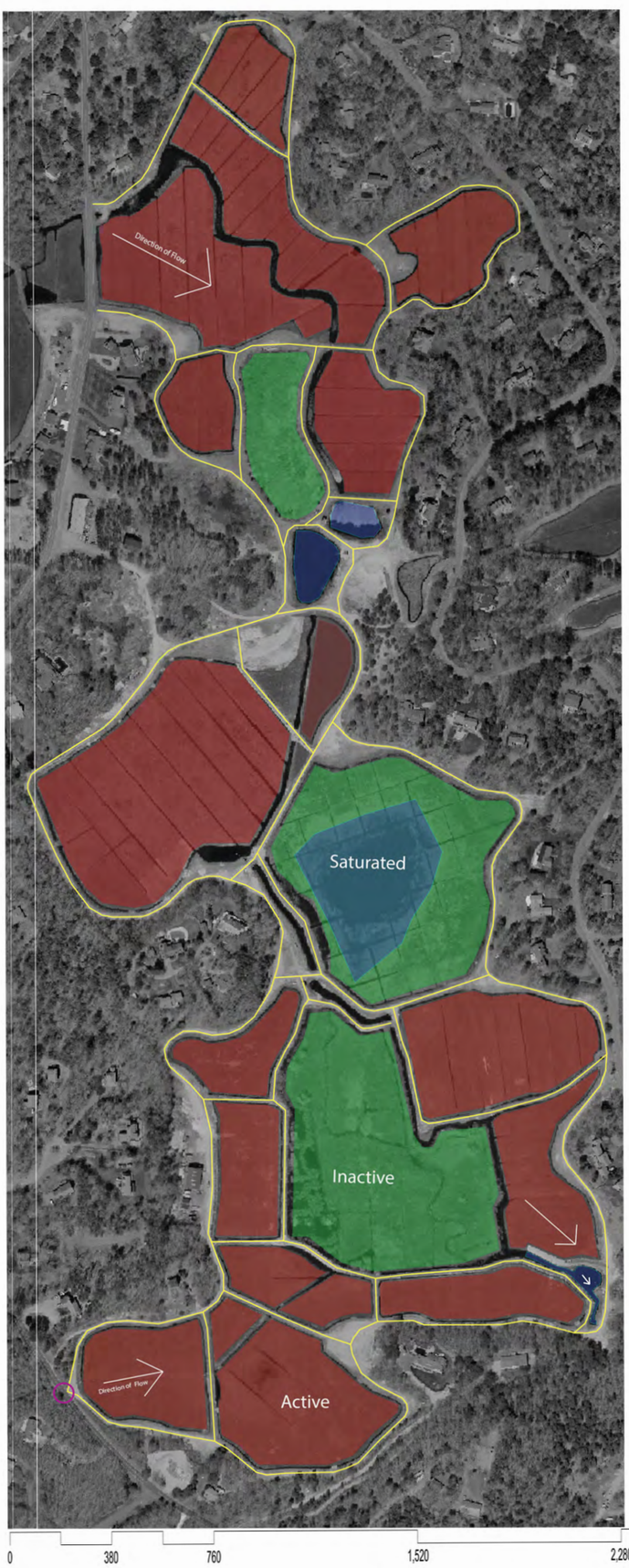
# TO NITROGEN , ECONOMIC, AND ECOLOGIC CHALLENGES

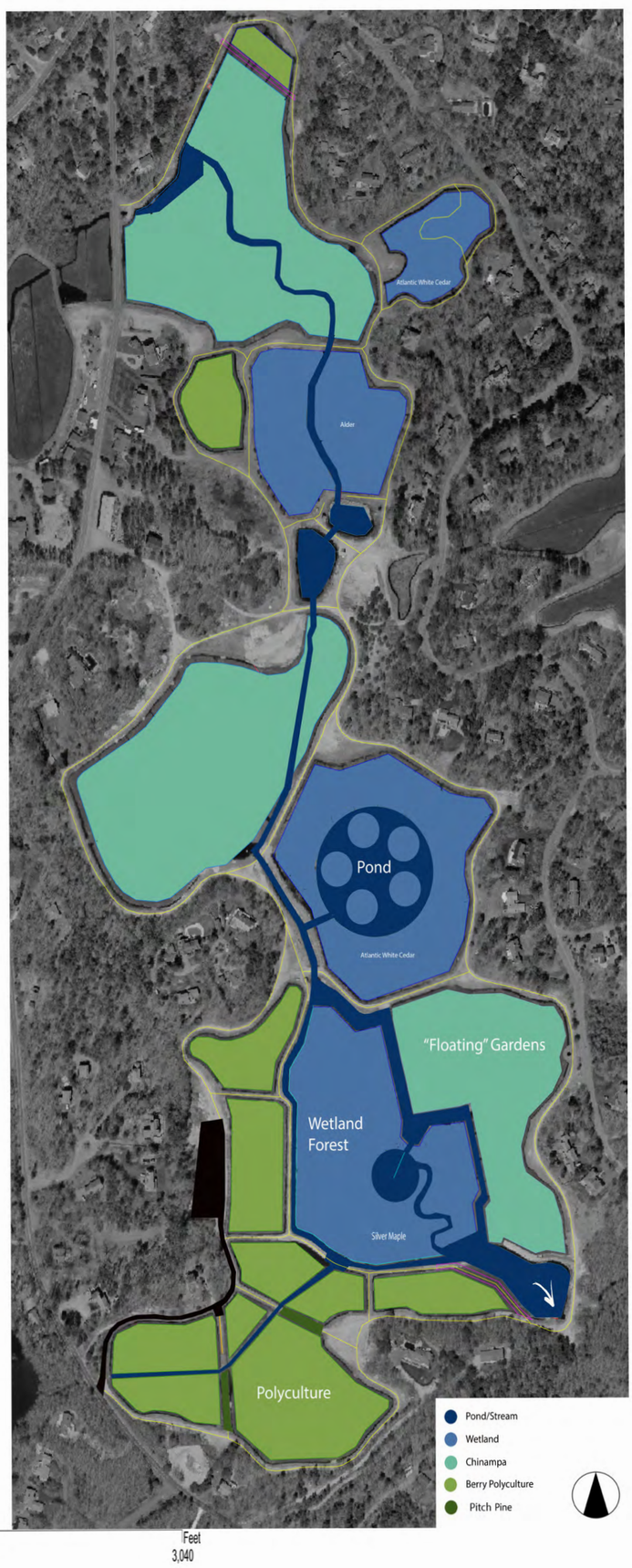
## ANDREW CAPELLUTI

The Existing cranberry bog infrastructure provides a unique opportunity to create plant communities. A diverse collection of multifunctional plants and forested wetlands may reduce the need for applied fertilizers, absorb excess nitrogen, provide usable products and habitat. Channel modifications can improve irrigation, provide paddle access, and facilitate fish passage.

This project directly supports the studio goals for improving water quality in the upper reaches of the Marstons Mills River. Land use in this area consists mostly of residential uses and cranberry bogs. My proposal is located on active cranberry bogs between Middle and Muddy Pond, in Marstons Mills.

Conventional cranberry bogs are a source of nitrogen runoff. The owner of the bogs that this project addresses applies fertilizer at a self-described minimum rate. However for the purpose of this studio exercise, I assumed that nitrogen should be reduced/ absorbed in all cranberry bogs on the Cape, and this project serves as a potential demonstration for nitrogen absorption as though it could be transferred to a variety of bogs on the Cape.



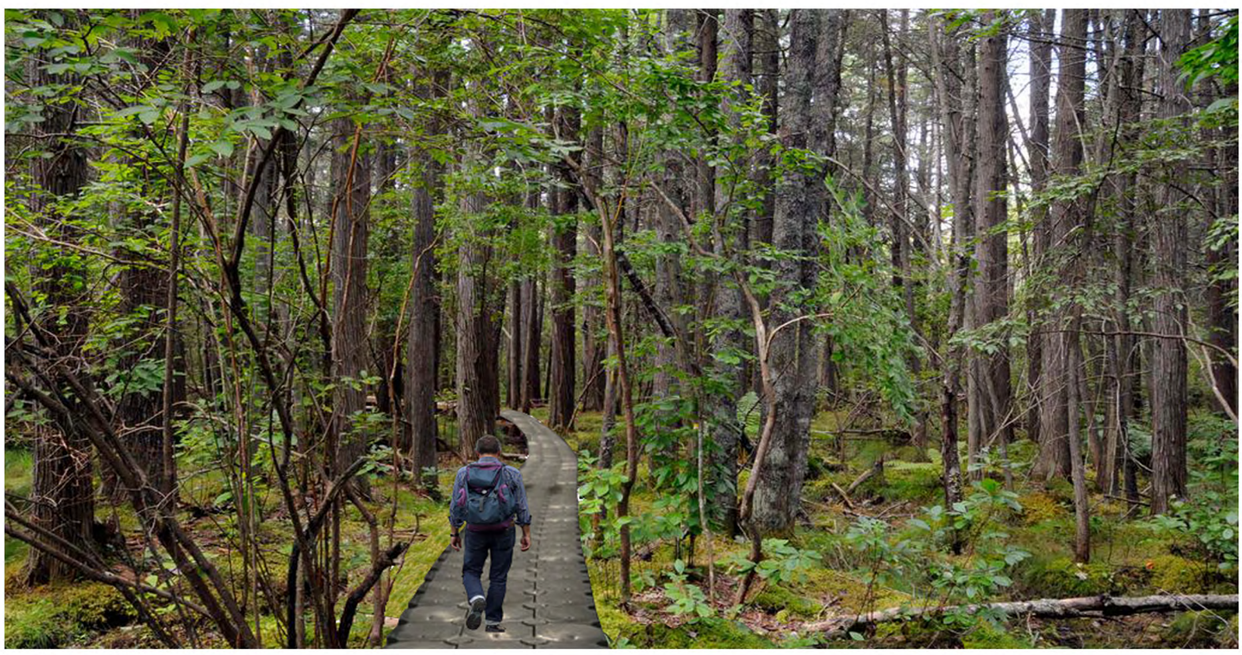



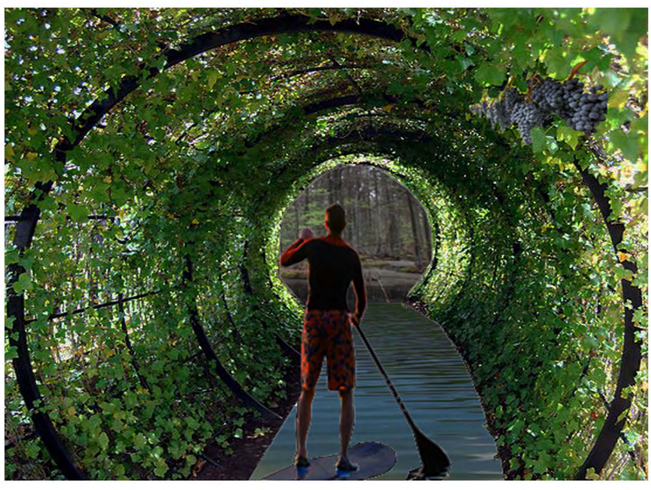

0 380 760 1,520 2,280 Feet 3,040

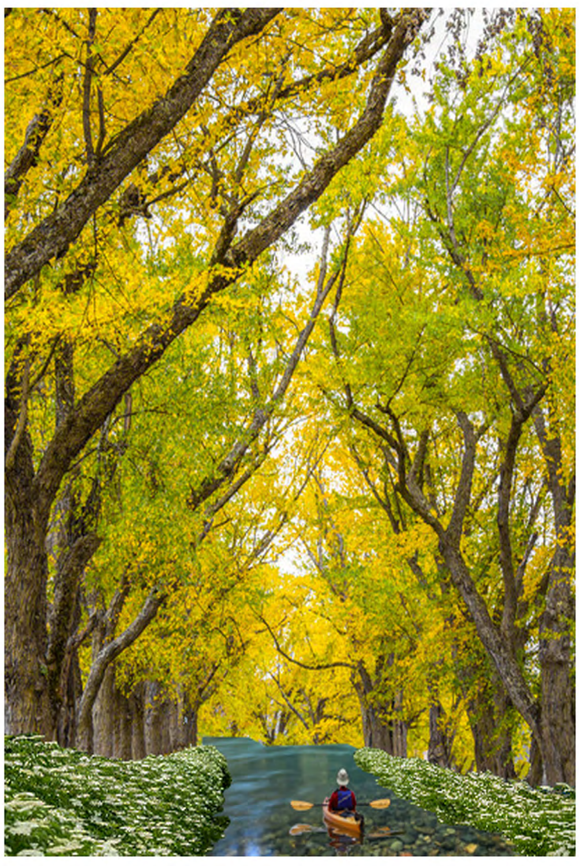
Existing Conditions
Active Acres: 47
Inactive Acres: 35
Total Acres: 99

Proposed Condition:
Floating Gardens: 27 Acres
Polyculture: 14.5 Acres
Wetland Forest: 24 Acres

# POLYCULTURE SOLUTIONS







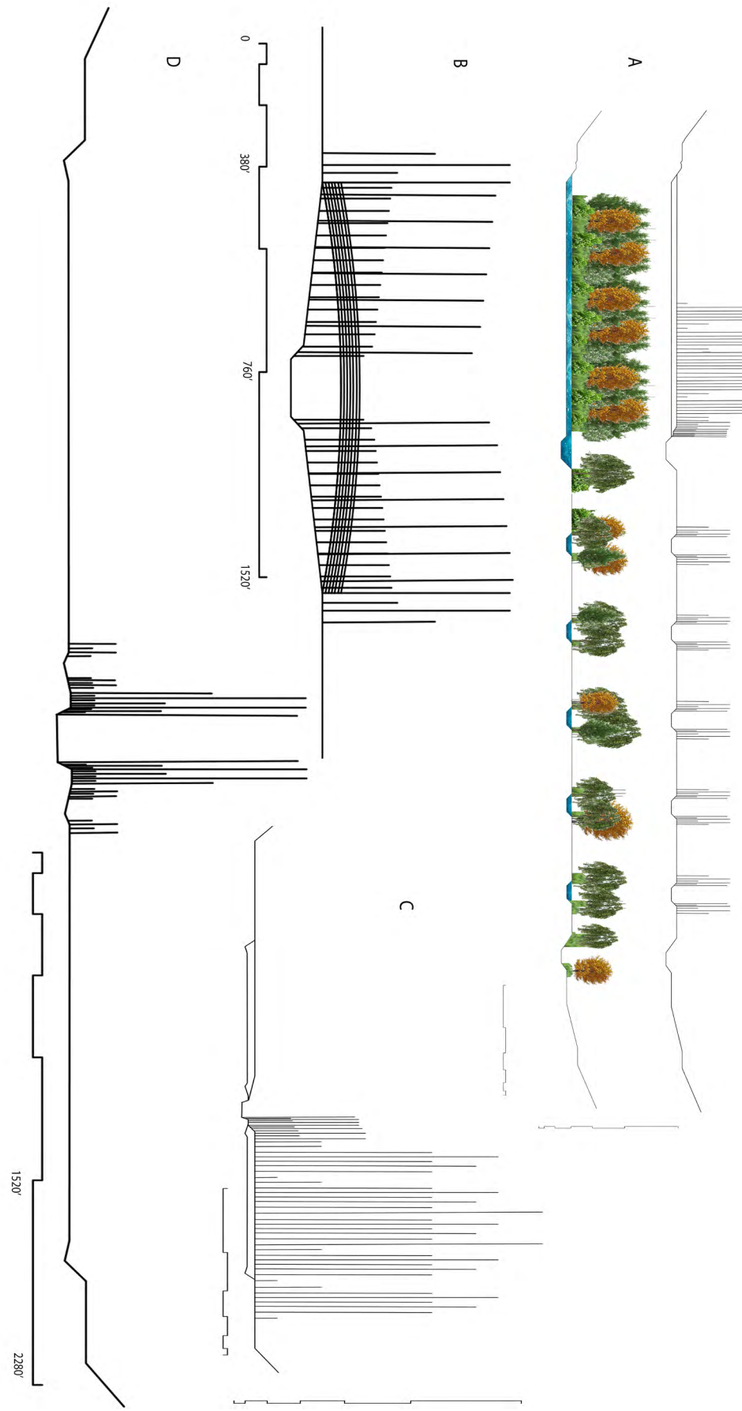
Top: A buffer of native Arundinaria gigantea readily absorbs nitrogen before it enters the channel and provides shade. The fibrous biomass is useful for craft making

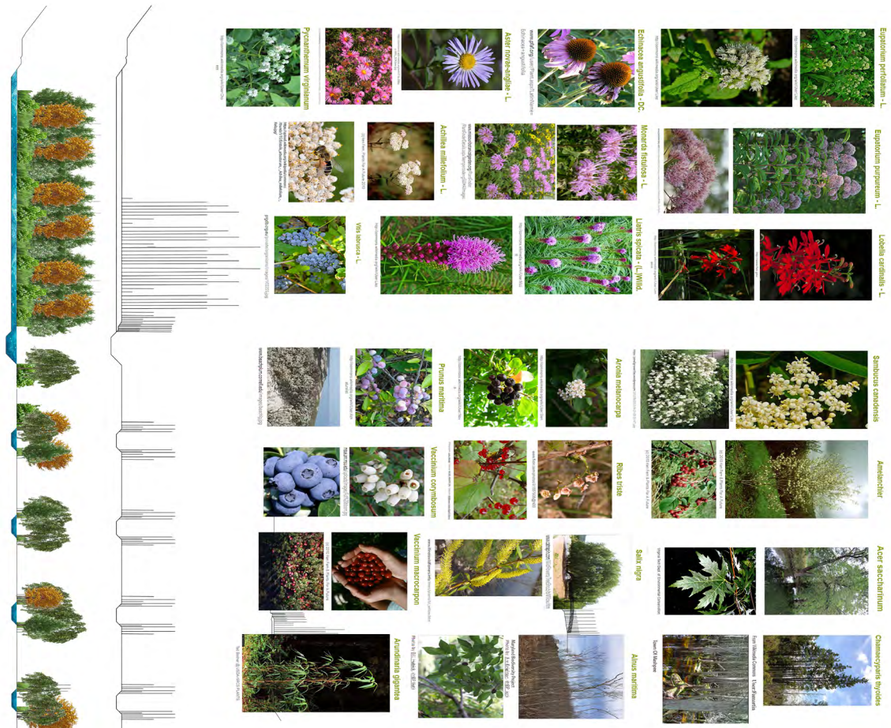
Middle: Restoration of the native and rare Atlantic White Cedar. Periodic inundations require flexible, buoyant, weather resistant paths.

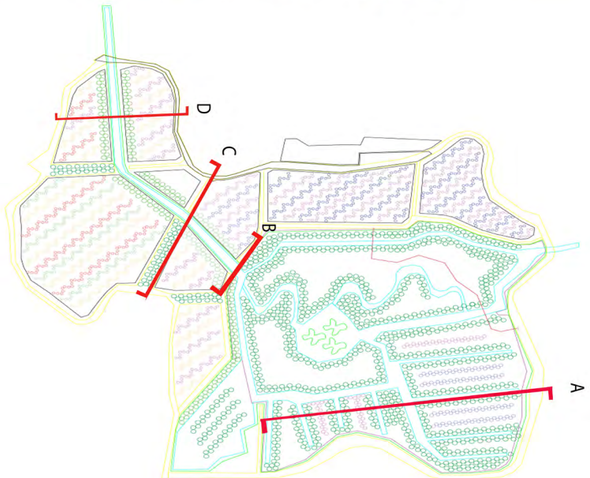
Bottom Left: Native Fox Grapes (Vitis Labrusca) trellised over a channel maximizes efficient space use, provides easy harvest and prevents over heating of water

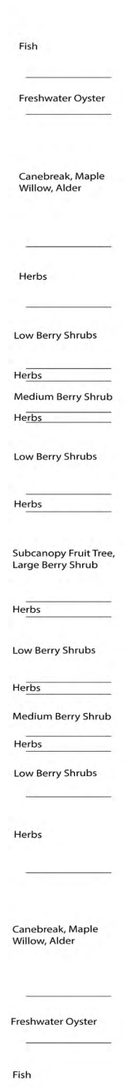
Bottom Right: Silver Maple and Elderberry provide erosion control, habitat, absorb nitrogen, produce syrup and timber products

# POLYCULTURE SOLUTIONS | TO NITROGEN , ECONOMIC, AND ECOLOGIC CHALLENGES




POLYCULTURE SOLUTIONS |

# TO NITROGEN , ECONOMIC, AND ECOLOGIC CHALLENGES

## ANDREW CAPELLUTI

It is also critical that any solution to nitrogen runoff considers the current economic pressure on cranberry bogs. The existing bog infrastructure provides a unique opportunity to create diverse and rare plant communities and to adapt the current cranberry monoculture practice to a polyculture agriculture system.

The goals of my proposal are to maximize nitrogen absorption on site, adapt the cranberry bog to a polyculture agriculture system, provide habitat for particular rare species, and provide paddleboat access for residents and others to experience the productive wetlands.

The demand for nitrogen can be reduced through the addition of 'nitrogen fixing' species such as bayberry, clover, or legumes throughout the system, or applying vegetation-based compost. However, there may always be the case for localized nitrogen additions and the need to balance excess nitrogen produced by nitrogen-fixing species. Therefore, excess nitrogen flowing off site must be monitored and mitigated.

Each bog at this site is currently surrounded by a drainage swale. A buffer of high demanding nitrogen species planted around the edges of the bog can absorb most nitrogen before it enters the Marston Mills River system. Economic gain can be achieved by selecting multifunctional species. For example, the nitrogen absorbing species may also produce usable materials, such a fibers, syrup, fruit or timber. The rare plant family of native canebreaks (Arundinaria), as well as Silver Maple (Acer) or Elderberry (Sambucus) meet these goals.

Each of these species also provides wildlife habitat and forage. Additionally, a tall buffer would cast shade on the swale and reduce the water temperature. Migratory fish depend on cool water habitat and cranberry bogs are currently a source of increased stream water temperatures.

Fish passage:

There is important core habitat on this site for a wide variety of species of special concern and threatened on both the east and west properties adjacent to the site (Core habitat ID 277 (need complete reference) , 307; New England Bluet - Enallagma laterale, Pondshore Knotweed - Persicaria puritanorum, Eastern Pondmussel - Ligumia nasuta, Tidewater Mucket - Leptodea ochracea, Triangle Floater- Alasmidonta undulata, Water willow Stem Borer - Papaipema sulphurata, New England Bluet - Enallagma laterale). [1]

The core habitat associated with Muddy Pond and Middle Pond is dissected by culverts located in the cranberry bogs. As such, the site currently is a barrier to wildlife, especially fish, who need passage throughout the watershed. The upper reaches of freshwater streams are important spawning ground for migratory herring(please add the correct species, there are two, correct? ) . By removing portions of the berm and resurfacing the stream, barriers to fish passage can be reduced or eliminated. The hydrologic controls may remain functional as fish jump over necessary infrastructure (?) . I propose that the swale be widened and deepened to create additional cool water habitat and subsurface spaces for the production of freshwater oyster and fish.

Adopting a Polyculture System:

Local reports are that the cranberry bogs are facing increasing economic pressure and national competition. Asset diversification may be a viable economic strategy for cranberry bogs. Dedicating an entire space for a single crop, 'all eggs in one basket', relying on a monoculture, is an economically risky and ecologically degenerative activity. The infrastructure which currently supports the cranberry bogs provides unique opportunity to produce other wetland species such as elderberry and beach plum to generate multiple benefits and economic assets in the same space.

Wildlife and Wild Type Genetic Reserves:

The existing bog has three fallow wet areas. I propose leaving these areas fallow and improving them for wildlife. These spaces can serve as habitat, but also as an important genetic library which may provide a future toolkit for disease resistance.

In monocultures, which consist of the same species, all individual plants are often genetically identical. This means that all plants have the same immune system and a single disease may annihilate an entire crop- if that particular species does not have immune resistance. Whereas multiple types of immunes response are present in polycultures with multiple species or varieties, and the likelihood of one type of species being able to survive a disease outbreak is increased.

Many commercial crops are bred to have big fruit or be easy to ship and have a long shelf life. Wild species are often the 'toughest'. Genetic variability in wild areas serves as a reserve toolkit for fighting new and unpredictable diseases, especially as new risks are exposed through climate change. If a disease outbreak affects a crop, the domestic species may be bred with a wild species that exhibit disease resistant, in order to produce a new variety of domestic disease resistant fruit. If only domesticated cranberries are provided space to reproduce, important parts of the cranberry genetic code could be lost. Wild space is a hedge against uncertainty and source of resilience.

Restored Wetland Forests can serve in flood storage capacity, facilitate timber growth, and provide nursery habitat for anadromous fish. Atlantic White Cedar is a rare species that also produces a viable timber harvest. In the future, it may be worth exploring partnerships with marine fishermen in regards to the stewardship of their harvest during a critical time in its life cycle. It may also be worth exploring the role of state sponsored incentives which compensate landowners for wildlife stewardship instead of development, such as transferable development rights.

Water Access:

The flow volume in many parts of the bog is presently suitable for paddling. The existing culverts are too small to allow connectivity between patches of suitable paddle area. Replacing the subterranean culverts with open channels for fish passage can also expand paddle access. Paddling may also provide an efficient means of transporting materials around the bog without having to build solid paths in many areas. Grape vines could be trellised over drainage swale and a paddler could harvest from beneath the trellis as it arches over the swale. There may also be opportunities for recreational paddling to explore the proposed wetland forest types

Summary:

This project explored options to use the existing cranberry bog hydrologic regime control infrastructure to experiment with the nitrogen absorption rates of Arundinaria, Acer, Sambucus and a variety of other species. I would also experiment with the impact of substituting fertilizer for a polyculture which features nitrogen fixing species. Monitoring for change in stream nitrogen concentrations could be achieved by adding nitrogen fertilizer at a known rate, sampling the nitrogen concentration in the water as it enters and exits a bog, using that to established a baseline, and then introducing species to the plots and monitoring for changes in stream concentration.

Citation:

[1] http://maps.massgis.state.ma.us/dfg/biomap/pdf/town_core/Barnstable.pdf

# EVERY LITTLE HOUSE NEEDS NEATURE

Diance Tian
Three Bays Watershed Studio
Instructor: Jack Ahern

## Existing Conditions

This project is a typically sized residential property in Three Bays, which makes it a good demonstration project for designing a residential landscape in a more environmental friendly and aesthetic way. In addition to presenting a design for a specific site, this project presents “Cape-friendly” landscape design ideas that can be applied to other properties. “Cape-friendly” landscapes feature native plants and reduced lawn area to limit the need for fertilizers, pesticides and irrigation.

This property is located in Marstons Mills. To the west is the River Road, to the north east is the cranberry bog, to the south are other properties. The site is on a hillside slope from River Road to a cranberry bog. Within the property boundary a wetland buffer runs from the northwest to the southeast. The wetland buffer is regulated to protect the cranberry bog from development, the law allows no development within the buffer. In addition, well established Pitch Pines and Scrub Oaks are located adjacent to the house.

In the Three Bay Watershed, it is important to engage local residences in nitrate reduction and removal because. Meanwhile, the increasing urbanization of the watershed makes environmentally friendly residential design more important.

Currently, there are two main goals and issues that need to be addressed through landscape design. The first is the use of native plants to create an attractive meadow and other native plantings. The second condition is how to regrade the topography of the project to support a more livable and enjoyable daily life experience.

# EVERY LITTLE HOUSE NEEDS NEATURE

Diance Tian
Three Bays Watershed Studio
Instructor: Jack Ahern

### Client's Requirements

The client has several design requirements regarding the landscape elements:

- A paved driveway (preferably pea stone)
- A paved terrace in the back yard
- A meadow with native plants
- Keep the existing rocks that function as a retaining wall
- A path from the front door to back yard
- Manage views of the cranberry bog

## PLANTS

### Shrubs

- **Bayberry**

Typically 5' to 6'; can reach 10'
Female plants produce small, BB-sized waxy fruits

- **Beach Plum**

Grows to 6' tall
White flowers
Fruits are dull purple color

- **Inkberry**

4' to 8' tall
Flowers are a small and dull white Small black fruits in September

### Meadow

- **Little Bluestem**

1.5' to 2' tall

- **Seaside Goldenrod**

4' to 6' tall
Golden flower

### Unmowed Grass

- **New England Aster**

Up to 4' tall
Blue flowers

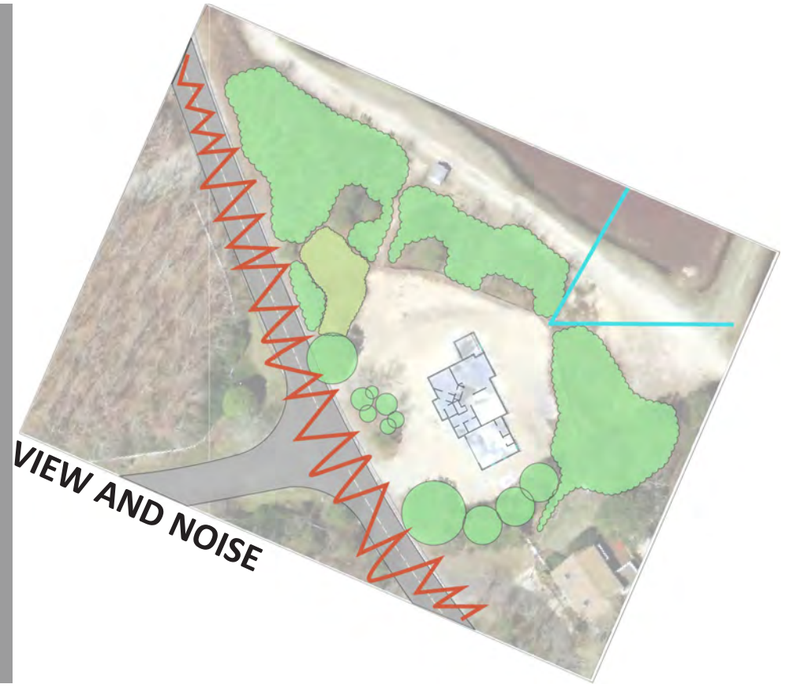
- **Baptisia**

3' to 4' tall
Blue, lavender, yellow or white flower

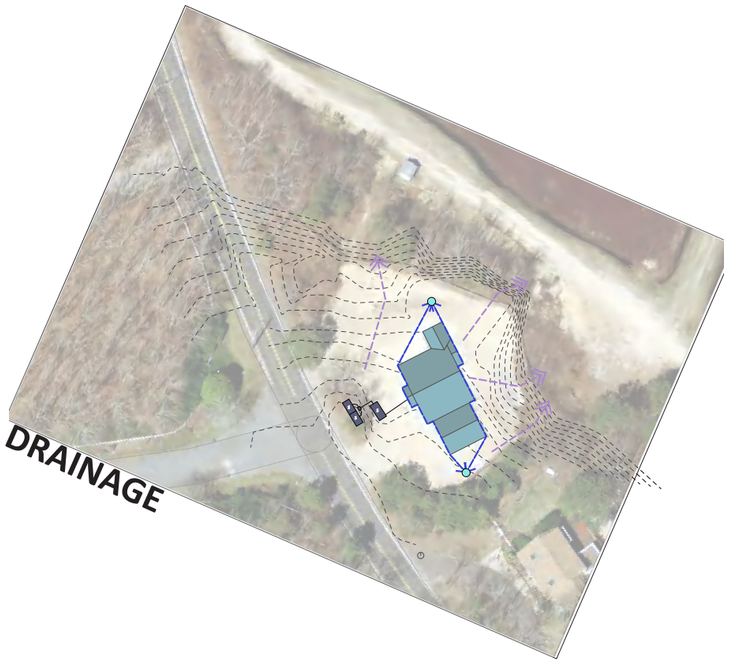
- **Rudbeckia**

2' to 4' tall
Yellow flowers

## DIAGRAMS



VIEW AND NOISE



DRAINAGE

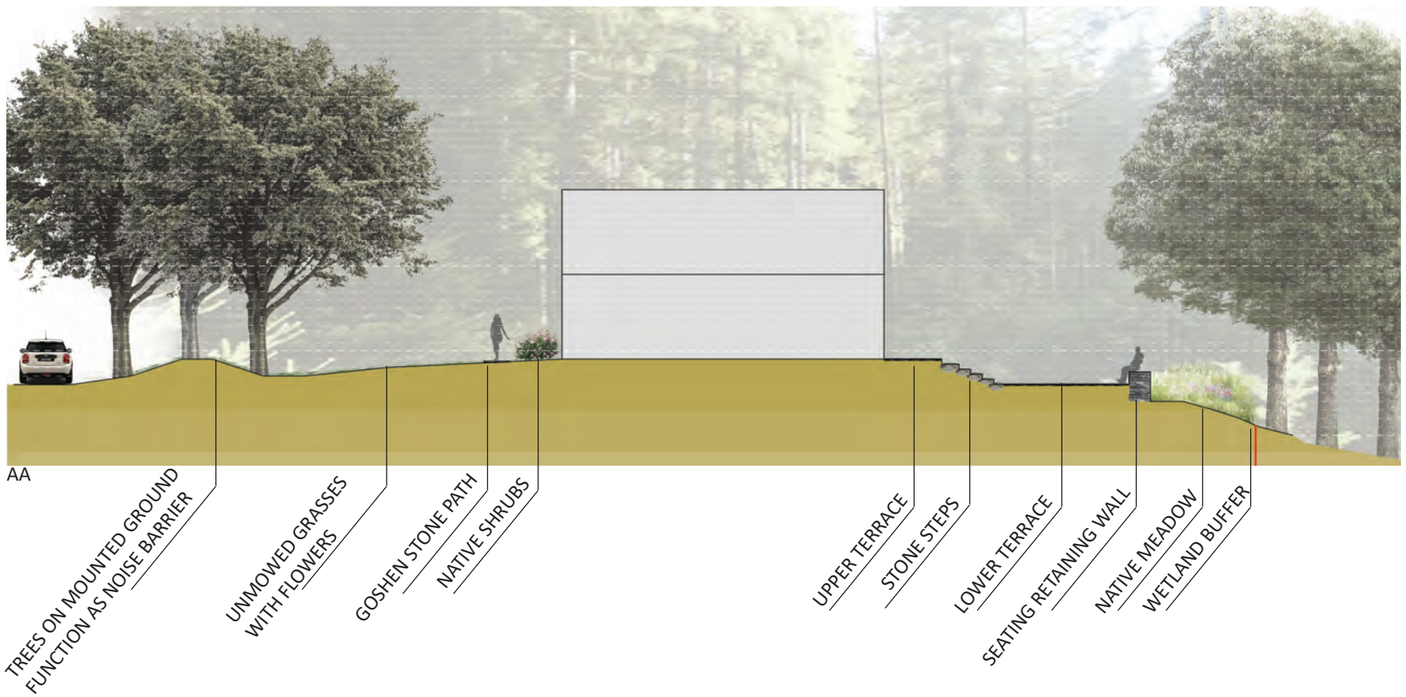
PROPOSED AND EXISTING PLANTS

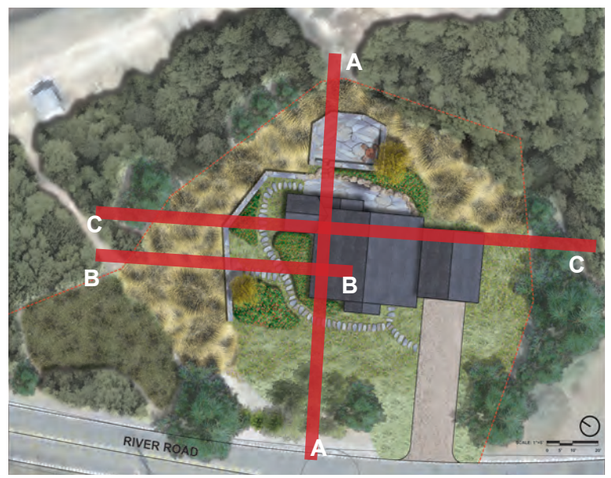
# EVERY LITTLE HOUSE NEEDS NEATURE

Diance Tian
Three Bays Watershed Studio
Instructor: Jack Ahern

**Proposed Design**

- A landscape design that meets the requirements of the client and the existing conditions
- The driveway is paved with pea stone or shells
- A path made of irregular cut stone connects the front door and driveway.
- Another path also made of irregular cut stone connects the front door with the backyard. Low-grow shrubs are planted along the path, with a mowed edge to create a visually-interesting walk.
- A stone retaining wall has been proposed at the north side of the house to create a gentle sloped surface adjacent to the house. The retaining wall is 3 feet tall and 2 feet wide at the top with flat stones to serve as a sitting wall. On the north side of the house and between the path and the retaining wall, there is a stone paved sitting area that has a view to the meadow. A gray birch is proposed here to provide summer shade.
- On the backside of the house, two stone terraces are proposed. The upper terrace is connected to the house, which provides an area for siting and an overlook. A retaining stone wall surrounds the upper terrace. At the north west end of the upper terrace, stone steps connect to lower terrace paved with irregular cut stone. A stone retaining and free-standing wall surrounds the lower terrace. The retaining wall rises 18 inches above the lower terrace to function as a seating wall. Another gray birch has been planted at the south west side of the terrace for shading.
- Some designated pruning on the trees within wetland buffer to maximize the view to the cranberry bog.
- On the west side of the property, an existing mound that has several exiting trees functions as a barrier between the house and road traffic. However, there is an open gap between the mound and the existing forest. So, the mound has been designed to expand northwards and 3 Eastern Red Cedar have been planted.
- Two meadows are proposed at the north side of the house and south-east side of the lower terrace. The meadow plants include native grasses and wildflowers.
- By designing with native plants and permeable pavements, future maintenance will be reduced. Using native plants rather than lawn means no fertilizers are needed, which leads to fewer nitrates released into the watershed. Meanwhile, native plants can provide food and habitat for local species.

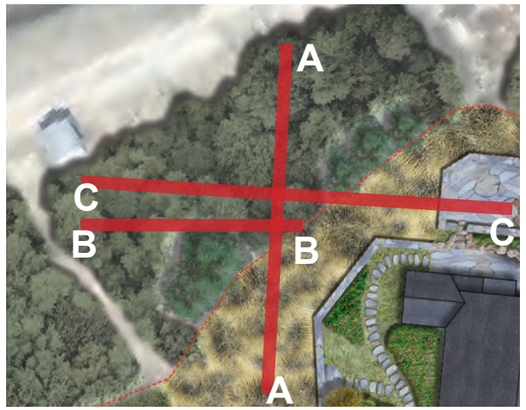


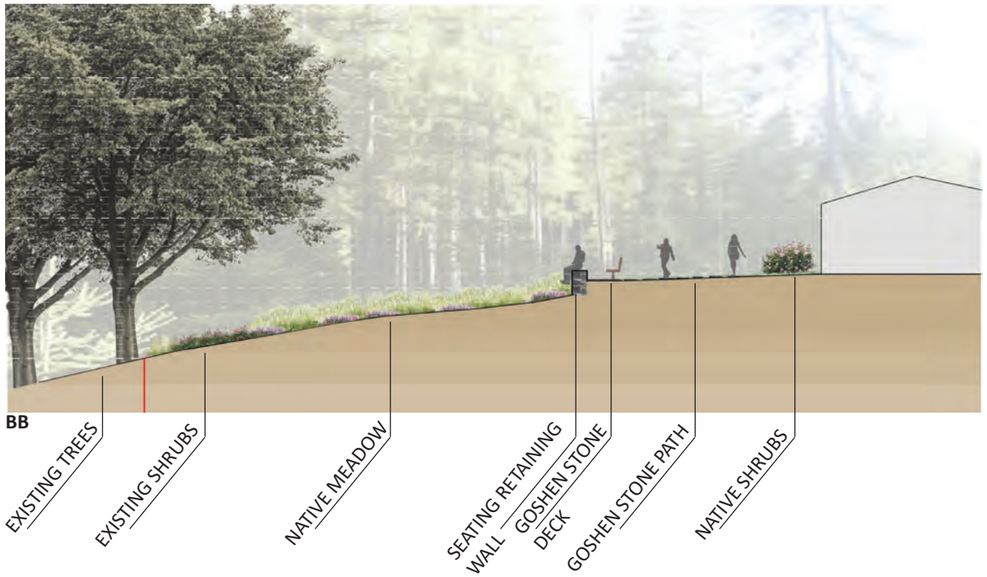



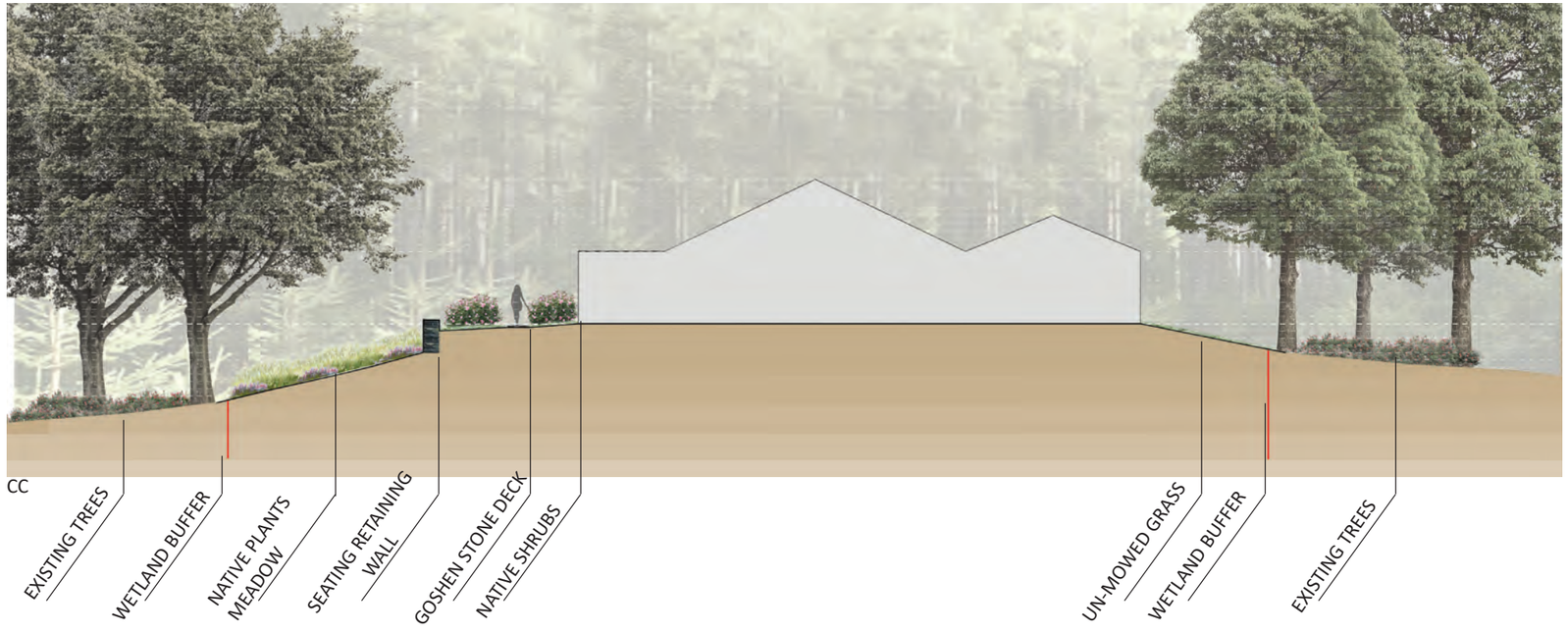
# EVERY LITTLE HOUSE NEEDS NEATURE

Diance Tian
Three Bays Watershed Studio
Instructor: Jack Ahern

**Summary**
All ground areas are proposed to be permeable, either with vegetation or permeable pavement. Various native plants have been proposed to minimize nitrate concentration from fertilizer, pesticides and irrigation. In addition, native plants can provide food and habitat for local species. Designated pruning of the trees within the wetland buffer to maximize the view to the cranberry bogs. The design itself is duplicable - it can be adopted to other Cape residential landscape designs with on site-by-site adjustment. Considering the urbanization process in Cape Cod, the nitrates in Three Bays Watershed can be decreased if a substantial number of properties use native plants as an alternative to lawns in their landscape design.




# PARCEL BY PARCEL IN THE THREE BAYS WATERSHED

## Improving Water Quality Through Residential Ecological Design

By Doug Serrill

### PROJECT SUMMARY

### INTRODUCTION

Clean water is a fundamental part of the quality of life on Cape Cod and it is currently in decline. Water quality degradation is causing significant ecological, economic, and cultural impacts throughout the Cape. Human settlement is the primary contributor to excess nitrogen leaching through groundwater, specifically from septic systems, stormwater run-off, and landscape fertilization. Excess nitrogen is causing declines in the shellfish and fisheries industries, impairment of aquatic and estuarine habitats, such as those of the herring and the oyster, and the overall quality of life for Cape residents and visitors. One study conducted by the Cape Cod Commission in the Town of Barnstable found that for every 1 percent increase in Nitrogen, there is a 0.61 percent decline in property values. This issue is having a very real and direct impact on every facet to life on the Cape.

### RESIDENTIAL LANDSCAPES IN THE THREE BAYS WATERSHED AND MARSTONS MILLS RIVER CORRIDOR

Landscape-based solutions to address excess nitrogen can have a positive impact of reducing nitrogen loads as well as

providing other ecosystem services such as, increasing biodiversity, improving pollinator and wildlife habitat, and increasing ecological connectivity. The Three Bays Watershed is largely a residential watershed. Of the 7,093 parcels in the watershed, 92% are zoned residential. Only 21% of the watershed is protected open space, and there is even less limited protected open space within the Marston's Mills River Corridor. There are 304 parcels that are within a 100-foot buffer of the Marstons Mills River, yet only 19 are protected as open space.

This indicates that there is a significant need to identify landscape solutions for many residential properties that benefit both the homeowner and the environment.

### THE MANN PROPERTY AS A MODEL

The Mann Property is 2.4 acres and located on the northeast edge of the historic Mill Pond.

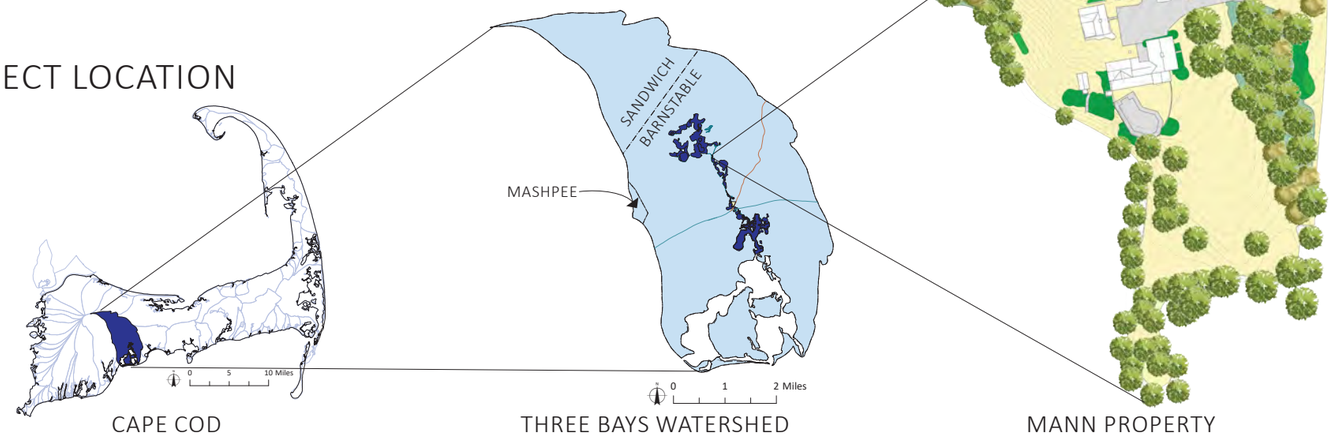
The property includes a 1730 house and four other buildings. The site is located along a gentle ridge that offers excellent views over the Mill Pond. Water on the site drains away from the buildings west toward the pond and into a swale to the east that runs south into the pond. Woodland groves on the north and east sides create a sense of privacy. A hedgerow of shrubs encloses the southern edge of the property from views of the pond.

This property is representative of many waterfront properties. Although solutions are inherently site-specific, three broad landscape archetypes: Waterfront Buffer, Meadow, and Woodland Edge, are provided that could be applied on other waterfront properties throughout the watershed – and more generally, across Cape Cod. These archetypes promote the use of native flora to create low-maintenance landscapes that do not require supplemental irrigation or chemical inputs, while improving wildlife and pollinator habitat, and increasing overall habitat connectivity along the Marstons Mills River corridor and beyond.

### WATERFRONT BUFFER

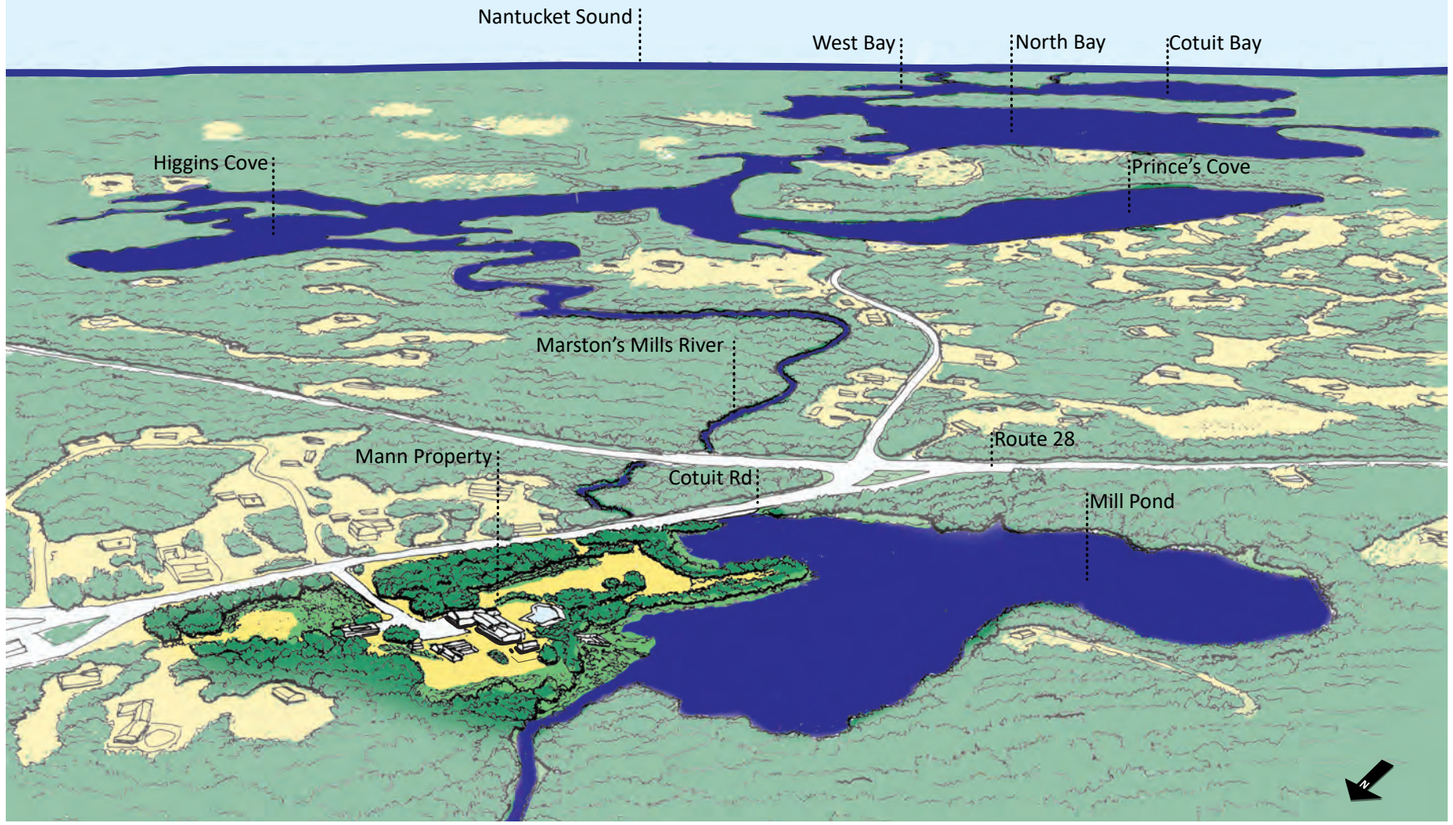
Currently, the pond edge abuts lawn with narrow hedgerows of sweet pepperbush dotted with honey locust, maple, and willow, as well as open sections taken over by jewel weed and grape vines. The pond has filled in with sediment over the

### PROJECT LOCATION

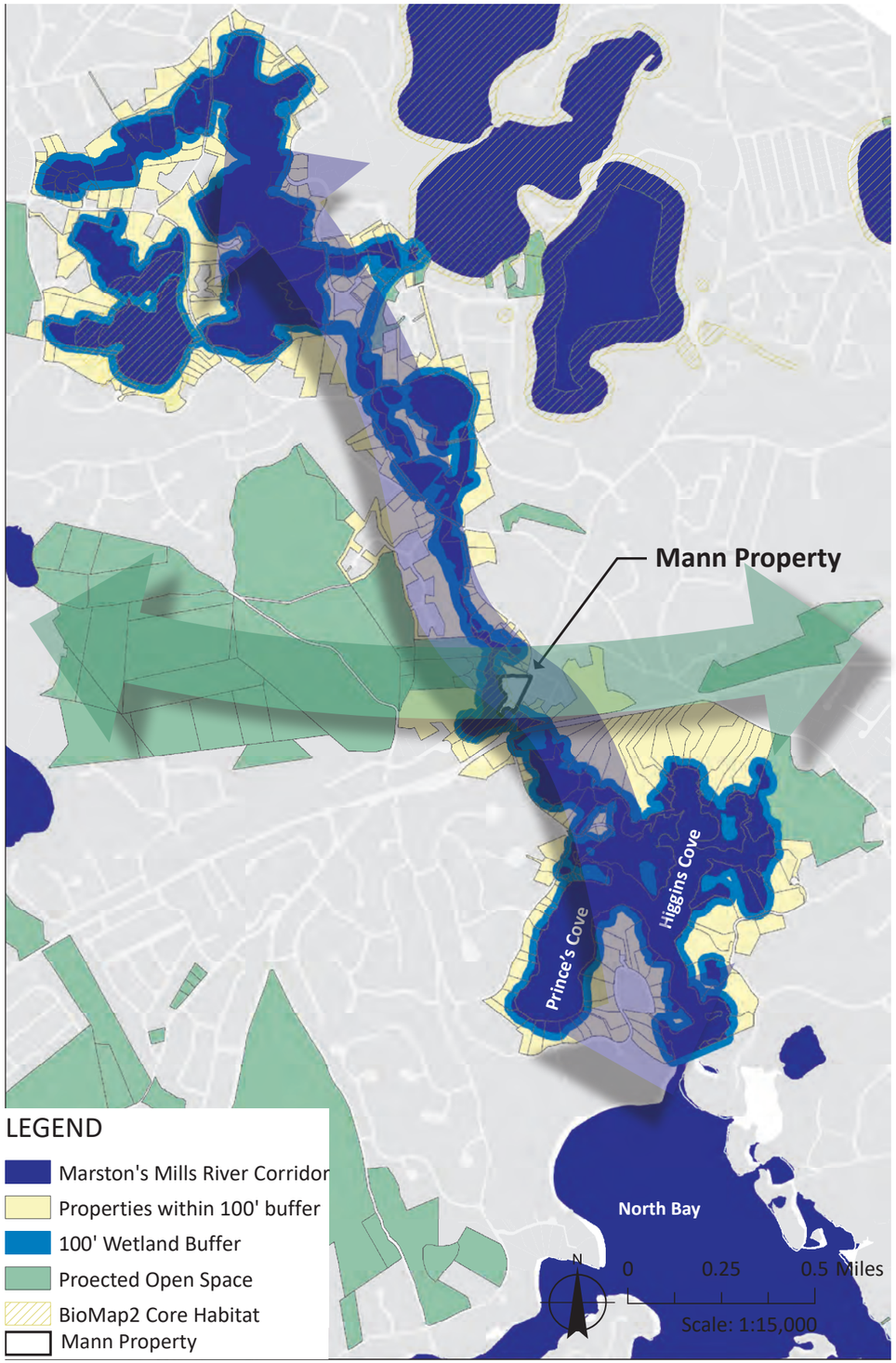



CAPE COD THREE BAYS WATERSHED MANN PROPERTY

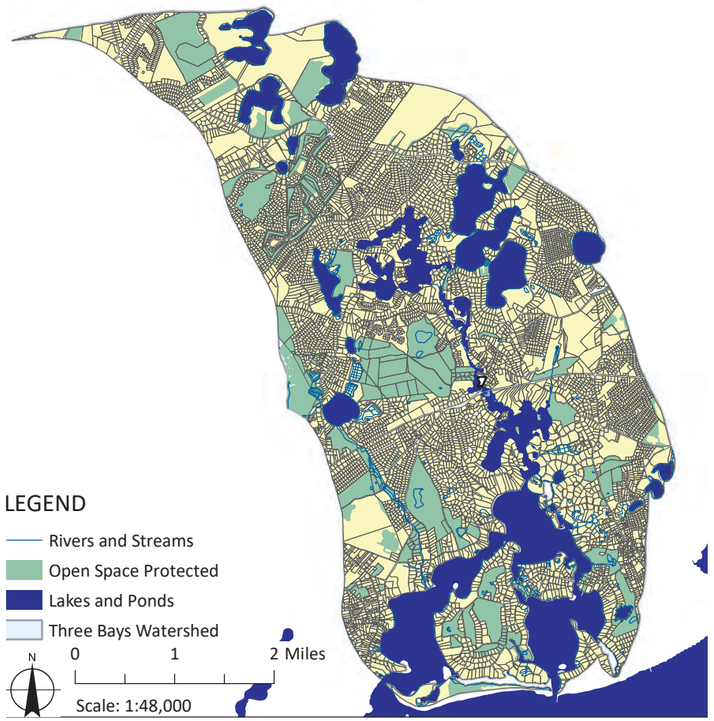
### THE MANN PROPERTY IN THE THREE BAYS WATERSHED



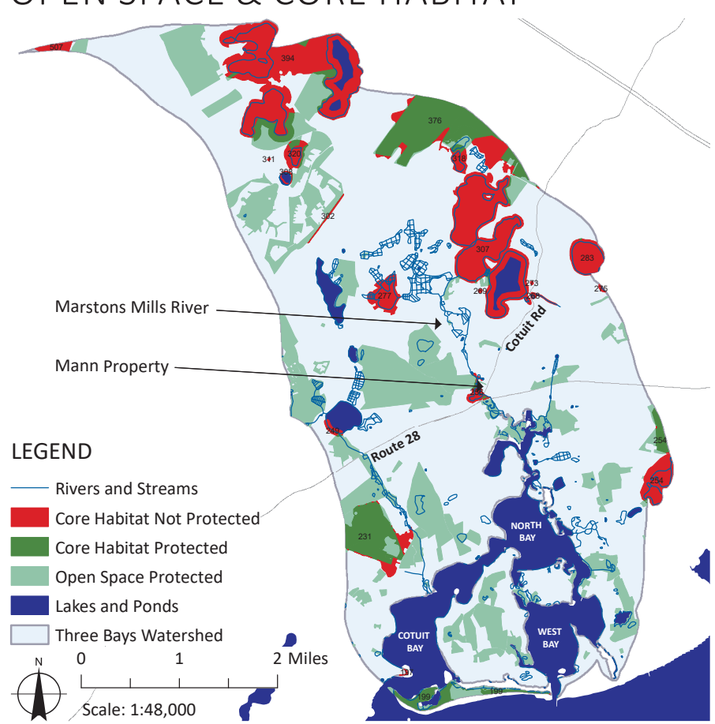
## CONNECTIVITY




## A RESIDENTIAL WATERSHED




## OPEN SPACE & CORE HABITAT




years and the pond edge is now dominated by water willow and jewel weed. These current conditions offer only a narrow buffer of vegetation and limited habitat connectivity. The proposed Waterfront Buffer increases diversity of native flora by developing a wider buffer of vegetation with a deeper root zone to filter more run-off and capture more nitrogen in sub-surface flows, and provides important wildlife habitat. Lawn can be replaced with a low-maintenance grass and wildflower edge and the shrub edge can be widened to increase species diversity.

### MEADOW

The current landscape contains large areas of well-maintained lawn. Although lawns have many uses and aesthetic qualities, they require significant regular maintenance, including mowing, supplemental fertilizers, and often other chemical applications. Lawns offer very limited floral diversity and habitat opportunities. Lawns also have a very shallow root system, limiting their ability to filter and absorb excess nutrients. Meadows offer a striking alternative that, once-established, offer a low-maintenance landscape solution. They provide greater water filtration and excess nutrient absorption, increased biodiversity, and pollinator and wildlife habitat.

### WOODLAND EDGE

The current woodland groves along the north and east borders of the property include a mix of native and non-native trees. The understory contains a mix of planted shrub beds and a suite of non-native, invasive shrub and vine species, including Japanese barberry, oriental bittersweet, and porcelain berry vine, among others. Largely, woodlands like these have become very fragmented into many smaller patches throughout urban, suburban, and rural Cape Cod landscapes. Fragmentation decreases forest interior habitat and dramatically increases forest edges. Woodland edges provide openings that non-native, invasive species have exploited and largely taken over, with significant reductions of understory habitat and overall forest health. The proposed Woodland Edge offers a range of native species adapted to the particular conditions of a woodland - ranging from part to full shade, dry to wet moisture tolerance, and eliminates the opportunity for invasive species to establish. Increasing species diversity within the woodland improves its ability to absorb and filter water, and provide more habitat connectivity with surrounding landscapes.

### THE IMPORTANCE OF NATIVE FLORA

Fundamental to these three landscape solutions is the use of the native flora of Cape Cod and the coastal regions of Massachusetts. Native flora has evolved with other species in the ecosystem and plays a critical role in supporting habitat for other species. To have more songbirds in our landscapes, for example, most of their diets consist of insects, and those insects have specialized relationships with native plants. Native flora has also evolved with the climatic and geographic conditions of the region and do not require extra inputs of water and chemicals to thrive. The use of native flora in our landscapes improves our ability to address water quality degradation and deepens our connection to a more authentic landscape of Cape Cod.

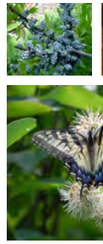
# NATIVE PLANT COMMUNITIES

DEEP MARSH (EMERGENT WETLAND)

SHALLOW MARSH (EMERGENT WETLAND)

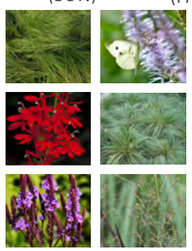
WET MEADOW

SHRUB/ FOREST EDGE



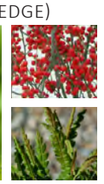
DRY MEADOW (SUN)

WET MEADOW

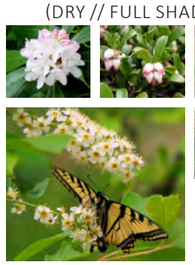


DRY MEADOW (PART-SHADE)

WOODLAND ECOTONE (EDGE)



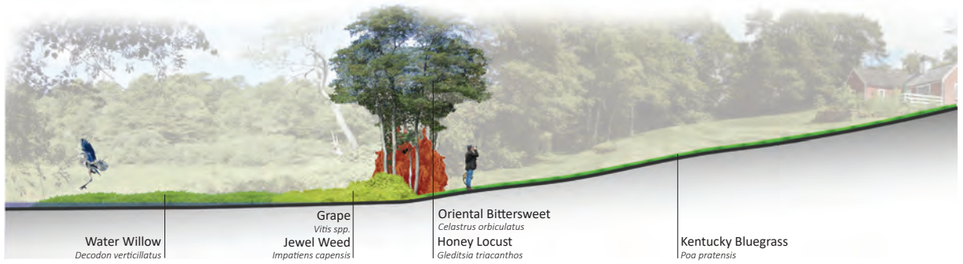
WOODLAND GROUNDCOVER (DRY // FULL SHADE)



WOODLAND GROUNDCOVER (WET // FULL SHADE)

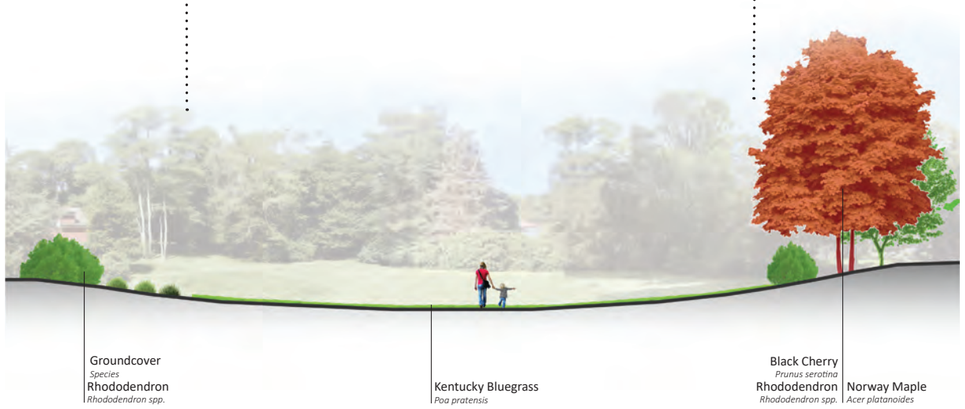
# WATERFRONT BUFFER: Existing Conditions

OPEN WATER | SHALLOW MARSH (Emergent Wetland) | WET MEADOW | SHRUB/ FOREST EDGE | UPLAND BUFFER



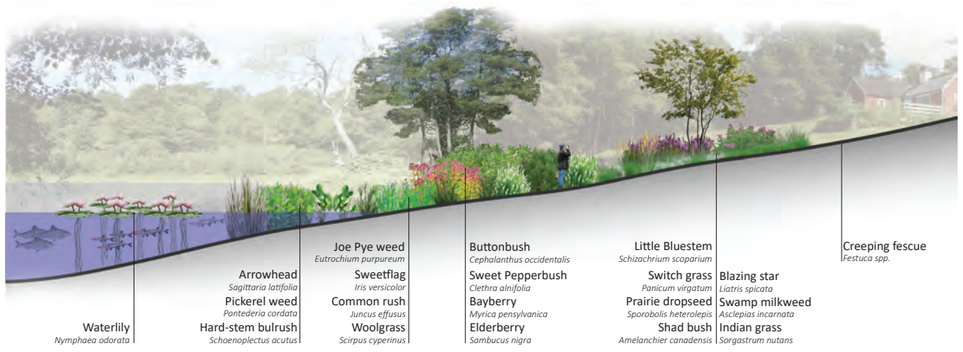

# MEADOW: Existing Conditions

SHRUB EDGE | LAWN | WOODLAND EDGE



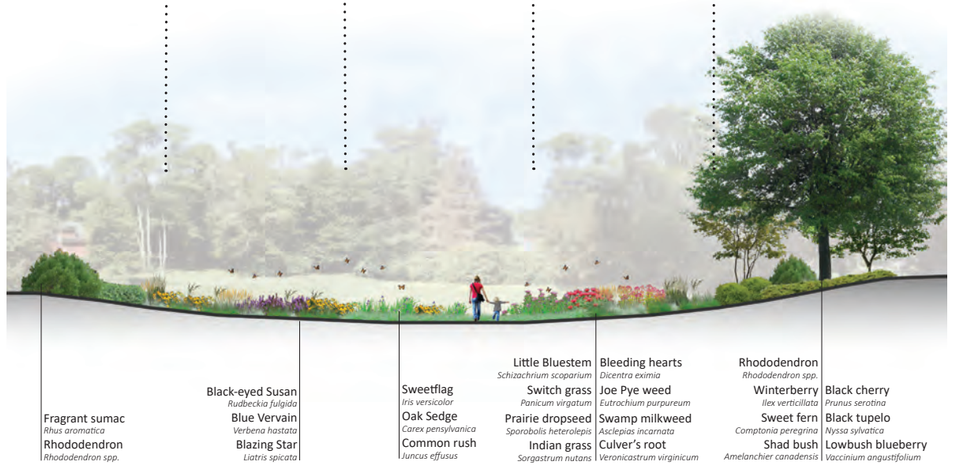

# WATERFRONT BUFFER: Proposed Conditions

OPEN WATER | DEEP MARSH (EMERGENT WETLAND) | SHALLOW MARSH (EMERGENT WETLAND) | WET MEADOW | SHRUB/ FOREST EDGE | DRY MEADOW | "NO-MOW" LAWN

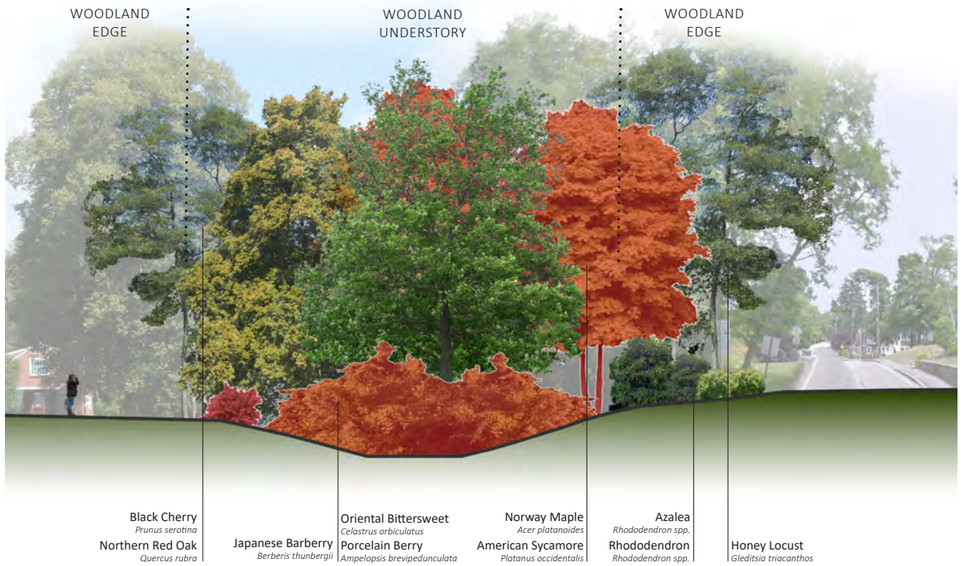



# MEADOW: Proposed Conditions

SHRUB EDGE | DRY MEADOW | WET MEADOW | DRY MEADOW | WOODLAND EDGE



## WOODLAND EDGE: Existing Conditions




## WOODLAND EDGE: Proposed Conditions


# SITE ASSESSMENT

### REGULATIONS

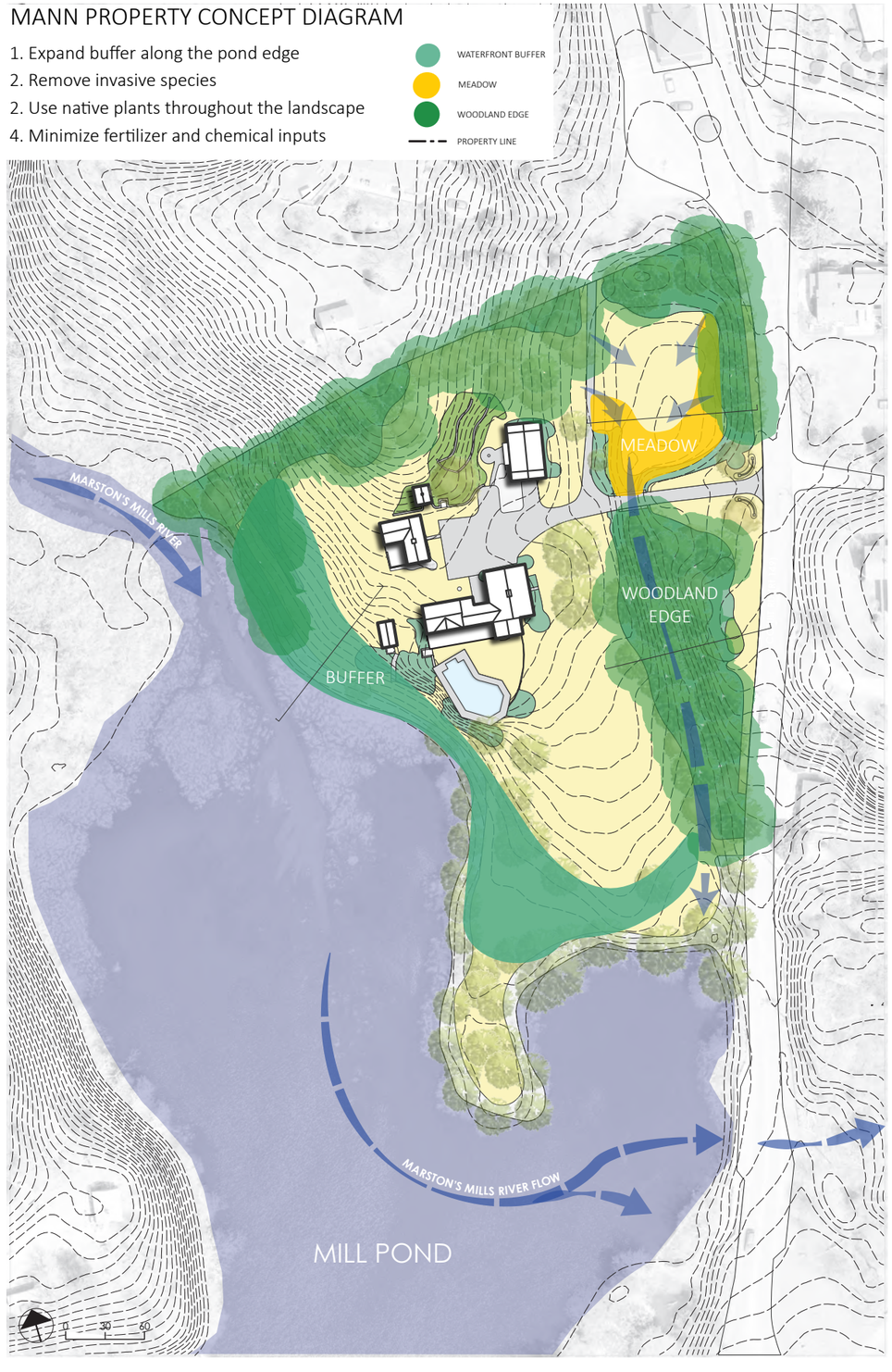
### HYDROLOGY

### DESTINATIONS

### VIEWS

## MANN PROPERTY CONCEPT DIAGRAM

1. Expand buffer along the pond edge
2. Remove invasive species
2. Use native plants throughout the landscape
4. Minimize fertilizer and chemical inputs



# **Restoration, recreation:** Herring Run Loop in Marstons Mills

*Re-imagining the Mill Pond as a water quality corridor with ties to village history*

Maggie Kraus

## *Site Overview*

This project responds to the issue of impaired water quality in the Mill Pond, within the larger context of the Three Bays Watershed in Barnstable, MA. In recent years the Three Bays Water quality has become increasingly more important for residents and tourists alike. With nitrogen at unprecedented levels in the Three Bays watershed, the community is facing a monumental and time-sensitive task: reduce nitrogen output and restore the bays to a healthier, more productive state. The proposed Herring Run Loop is designed as a water quality corridor that creates space for people, plants, and wildlife to interact in a way that promotes awareness and stewardship of the watershed. This landscape design seeks to provide a conceptual toolkit which builds on the town's vision for a boardwalk along Mill Pond, while focusing closely on herring habitat and recreational opportunities. It will support the annual migration of the culturally significant herring populations; restore native plant communities; and encourage healthier ecological processes to the Mill Pond by way of increased community stewardship.

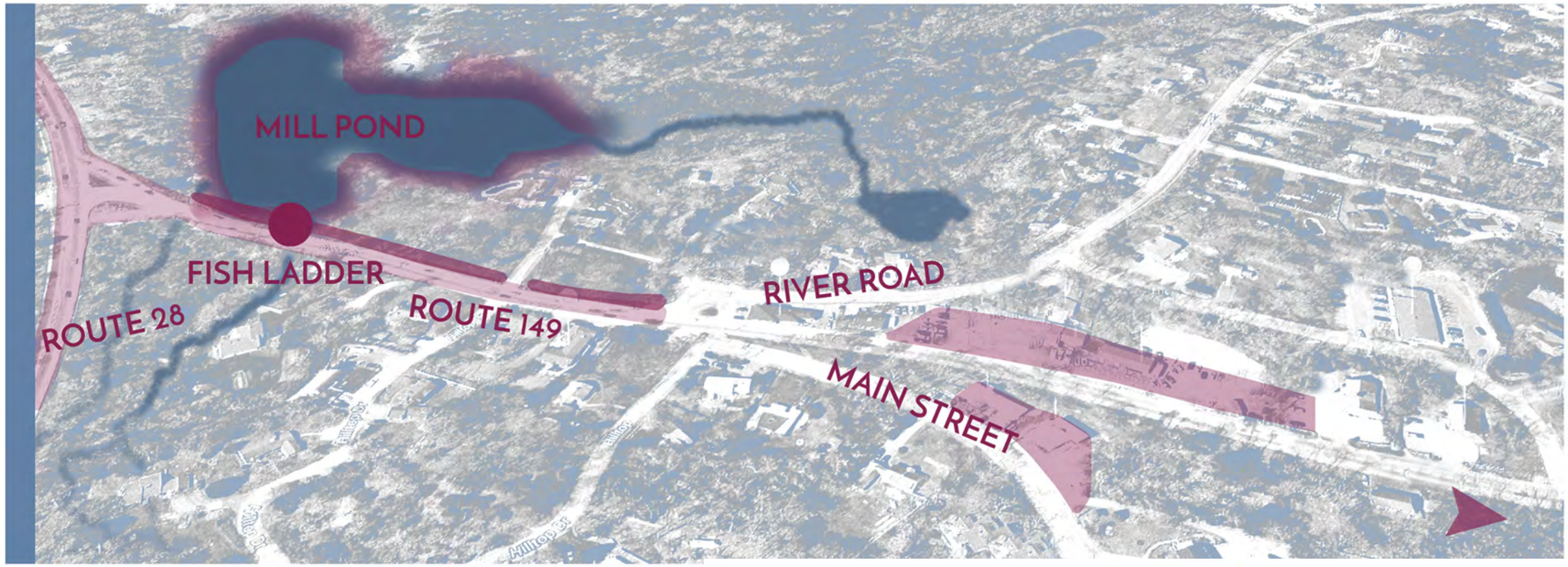



**Figure 1**: Aerial diagram of the current Mill Pond corridor

## *Identifying Challenges*

The graphic in the top right (Figure 1) illustrates some of the major components of the existing Mill Pond corridor. Routes 28 and 149 bring excess noise and contaminants to the site; the existing fish ladder attracts visitors but offers an unceremonious arrival to the site; dense thickets of invasive plants (oriental bittersweet, barberry) encircle the pond's edge and crowd out native plant communities; pedestrian sidewalks are narrow and, at times, disappear entirely; a lack of coherent connections between the Mill Pond and the historic Marstons Mills village center make it hard to wayfind in this area.

Figure 2 illustrates some of the ecological, cultural and structural issues at work in this area. Stormwater runoff in residential parcels discharge nitrogen and other pollutants into groundwater. Current attitudes towards lawn maintenance contribute to compromised water quality by way of lawn fertilizer and septic leeching. Finally, the proliferation of repetitive development patterns across the region have made Cape Cod feel further removed from its vernacular architecture and land use history.

**Figure 2**: Infographic of major ecological, cultural, and structural challenges in and around the watershed


**Figure 3**: Photographic section detailing some existing conditions along Route 149 in Marstons Mills. Featured are some constraints pertaining to visual access to Mill Pond, physical access to the water, continuity of circulation, and private property rights.

## *Existing Conditions and Constraints*

The current partial pathway along Mill Pond is unwelcoming and largely out of sight. A concrete ramp begins abruptly with little to no protection from the roadway and the sights and sounds of nearby traffic. There are dense thickets of invasive vegetation surrounding the Herring Run and the pond's edge, creating a sense that the place is entirely uncared for. While the current fish ladder supports the migration of alewife and blueback herring, there have been complaints that its design presents unnecessary challenges for the fish and could be improved. Moving north from the herring run is a barren sidewalk tucked close to the road which extends and eventually arrives unceremoniously to the foot of Main Street and the small village center of Marstons Mills. As a whole, the pathway lacks ecologically-sound spaces for wildlife and fish, as well as presenting a feeling of incoherence and even danger at times.

**Figure 5:** Views from Route 149 illustrate how dense vegetation surrounds a high-traffic vehicular corridor and impacts the few opportunities to view Mill Pond.

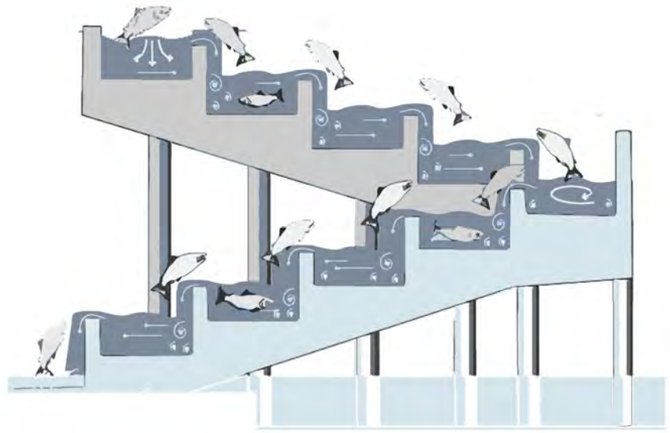


**Figure 4**: Fish Ladder diagram adapted from National Oceanic and Atmospheric Administration (NOAA)

Fish ladders are common on Cape Cod and connect residents, as well as tourists, with the culturally significant migration of herring each year. The current fish ladder functions adequately, however some residents expressed an interest in re-designing the run to make fish passage easier and more visible to human visitors.

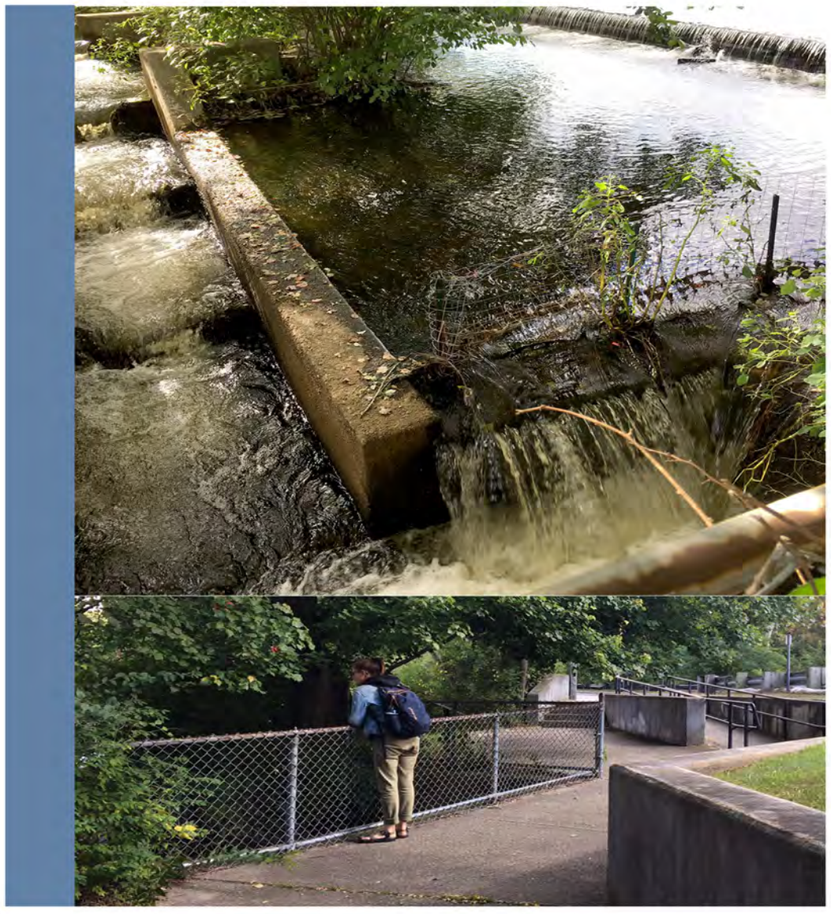


**Figure 6:** Views of the current fish ladder and viewing area (photos by Maggie Kraus)

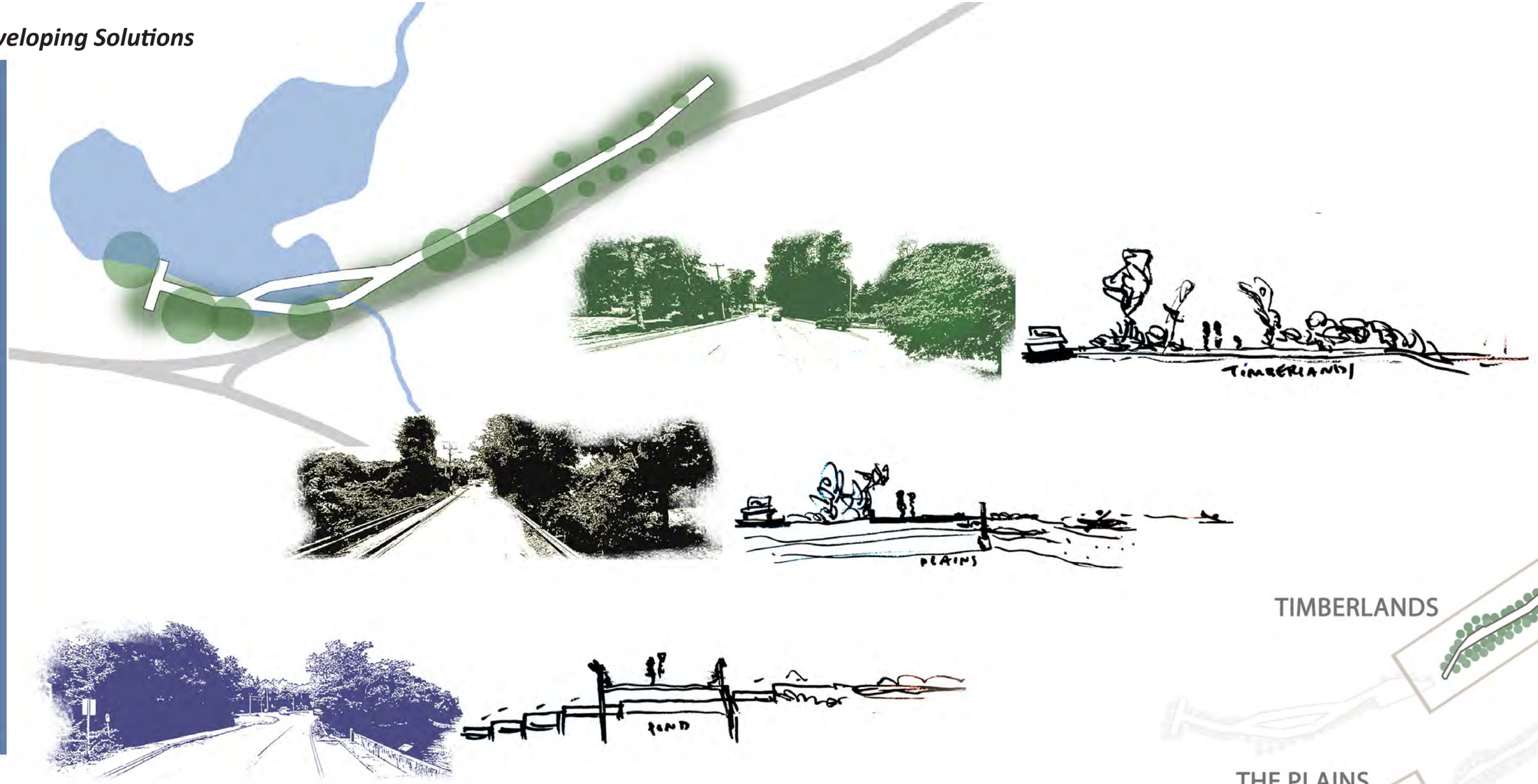



**Figure 7**: The proposed Herring Run Loop draws upon inspiration from three historically significant landscapes defined by the local historical society: Timberlands, The Plains, and The Ponds.

The proposed Herring Run Loop is characterized by three zones named after historically significant landscape types of Marstons Mills: Timberlands, The Plains, and The Ponds. The trail begins with the Timberlands zone at the intersection of River Road and Route 149 in Marstons Mills. Not far from the historic Marstons Mills village center, the trailhead will be marked by parking, made possible by a partial reconfiguration of River Road. Currently, River Road culminates in a large curved intersection which presents safety issues for pedestrians. By closing off this curve and realigning the road to have a right-angle intersection, vehicular lanes will be more clearly defined. Close to nearby amenities and restaurants, as well as the historic town center, the parking area and trailhead will provide visitors an opportunity to engage in a variety of activities. The trail begins with dense vegetation on the west side of the path in order to block the noise and traffic from Route 149, a well-traveled county road. Low hanging trees and vegetation will create a sense of enclosure as visitors enter the pathway, with lanes for walking and biking, and seating areas.

## *Conceptual Plan and Rendered Views*

The Mill Pond's edge will be restored with native plants, creating more opportunities for native wildlife habitat. Barberry and Oriental Bittersweet will be removed and replaced with native pond edge plants, improving the ecology of the site as well as enhancing the visual cues of a planted Cape Cod landscape. By engaging the public in a recreational landscape that acknowledges the important of water quality and the local heritage embedded in the herring run, more people will be willing to join the dialogue about how to keep Three Bays waters healthy.


**Figure 8**: Conceptual site plan of Herring Run Loop

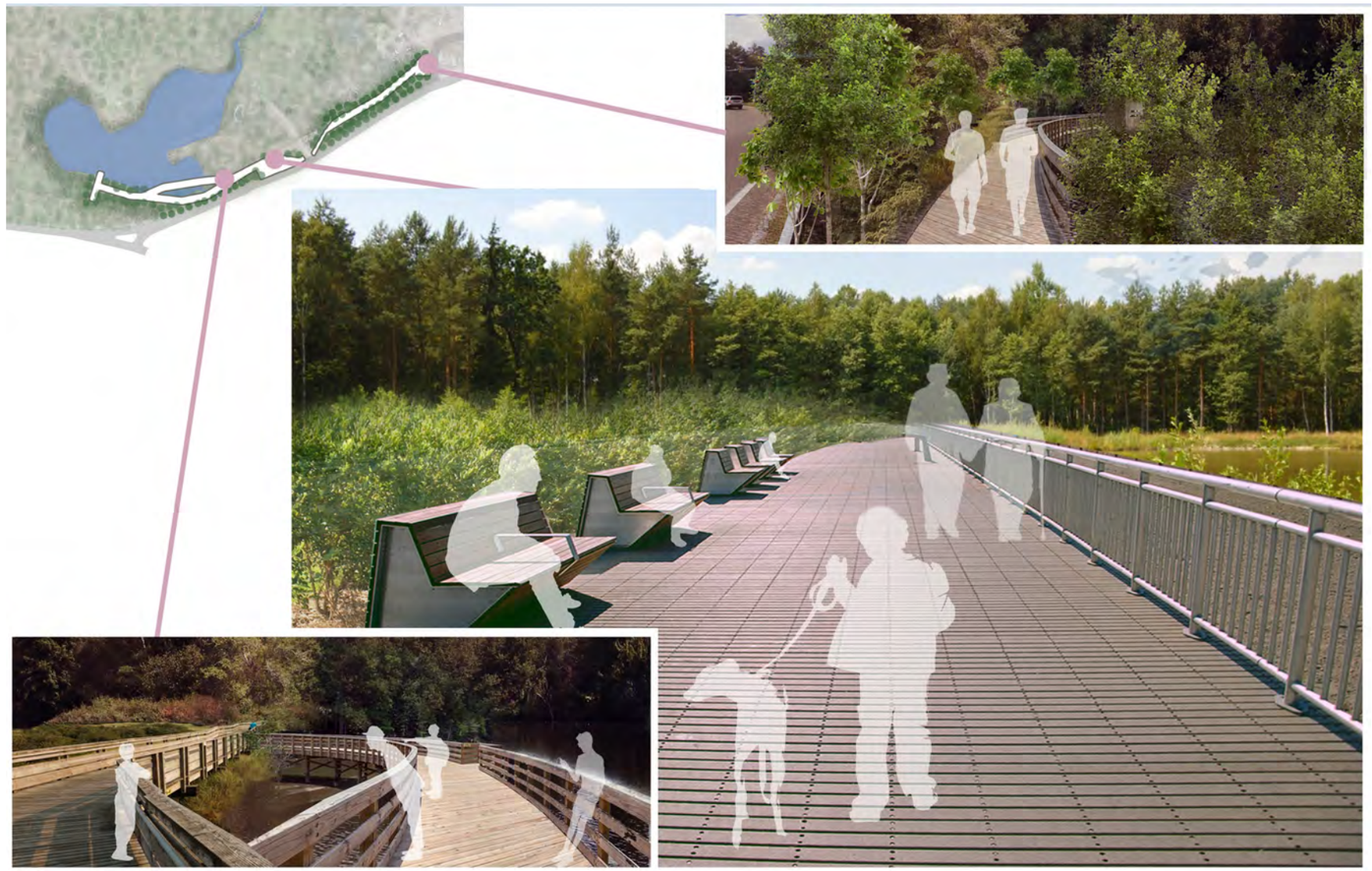


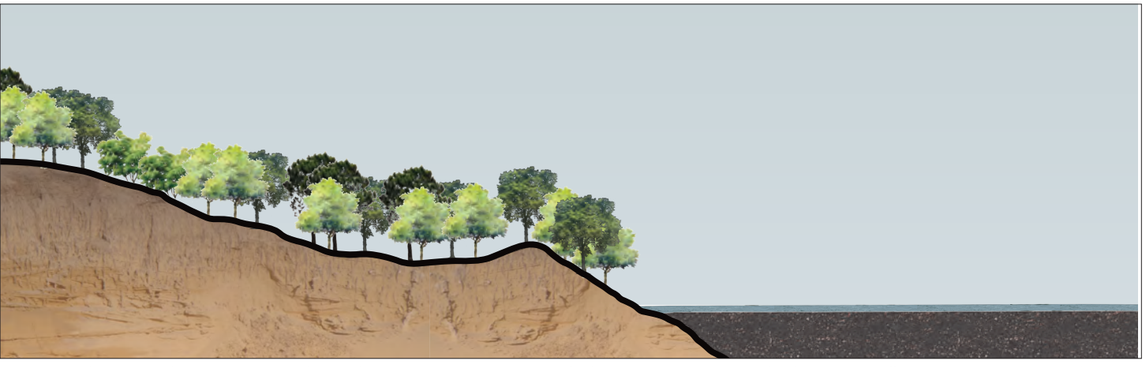
**Figure 9**: Rendered views of the Timberlands trailhead (top right), The Plains pavilion (middle), and The Ponds viewing area (bottom left).

The section below illustrates Herring Run Loop as seen from Route 149. Continuity of the pedestrian pathway is achieved by way of an easement along the Mann property. Dense native plantings create a visual and physical buffer between users of the site and the vehicular traffic that currently dominates the site. The length of the pathway allows for ADA compliant slopes, which makes it possible for users with mobility needs to enjoy Herring Run Loop. Users can descend south towards the re-designed herring run and viewing platform and enjoy enhanced views of the pond from new seating areas.


**Figure 10**: Section view of Herring Run Loop

# MILL POND MUCK: TURNING A BURDEN INTO AN OPPORTUNITY

ALLISON GRAMOLINI

The pond, was once thought to average 10-20’ deep, is now as shallow as 6” in some places due to many years of sediment buildup. This prevents it from being a functional aquatic ecosystem and from allowing recreation like boating and fishing which has been important to Cape Cod culture for generations.

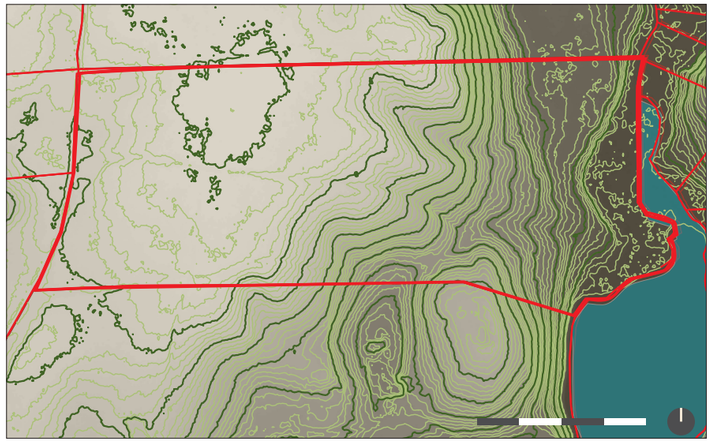
Mill Pond is an important landmark of Marstons Mills, both culturally and ecologically. It’s the former site of a historic gristmill, one of six mills that gives the village its name, and has been a popular fishing spot for generations of Cape Codders. It is one of Marstons Mills’ most frequently visited tourist attractions, and is viewed as a symbol of the village. It’s also a key link in the annual herring run, when alewives and blueback herring make their way back up the Marstons Mills River from the ocean to upstream Middle Pond to spawn; and has long provided habitat for a wide variety of freshwater wildlife. Unfortunately, the health of Mill Pond is seriously threatened. Decades of erosion, both natural and man-made, have built up in the pond so much that its average depth is thought to be less than a foot in places. Without intervention, the pond will eventually fill in completely, threatening both species like the alewife that depend on it, and this symbol of the community’s cultural heritage.

In response, the Town of Barnstable has begun planning to dredge the pond, restoring parts of it to depths of 10-20 feet. This raises the question of what to do with the approximately 30,000 cubic yards of sediment that may be removed. Dredging is a common practice in both freshwater and coastal waterways, and often dredged material is deposited in open ocean. However, in recent years, beneficial reuses of dredged material on the landscape have become more common, especially as a source of nutrients and to build topsoil for restoration projects (ACE, 1-4; Clark and Knight; Darmody and Marlin. The Town of Barnstable has purchased a 14-acre parcel of land from the Archibald family immediately adjacent to the pond, which could be used as a staging area for dredging and for dewatering the sediment. The question remains as to whether the sediment would then stay on-site or be transported elsewhere, and how it would be distributed. This project attempts to raise some of the issues and questions that need to be considered, and to present conceptual solutions.

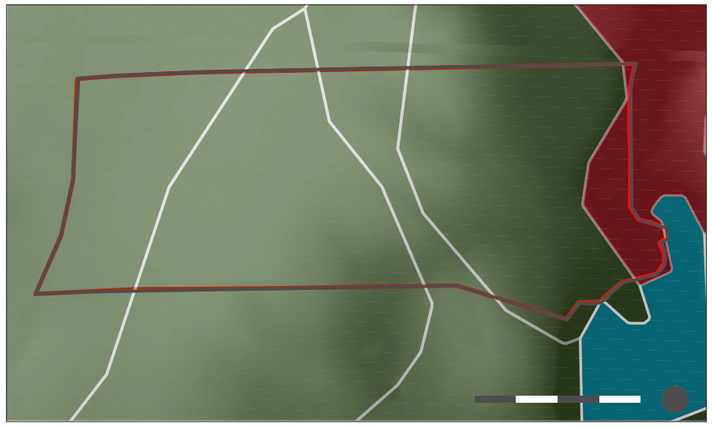
The Army Corps of Engineers has been using dredged material to rebuild habitat and studying its development over time since the 1970s, and numerous successful ecosystems have been established(Reference?. Establishing wetlands is often a good option in low-energy, shallow-water areas such as Mill Pond; these ecosystems are highly biologically productive, and can provide flood protection that economically benefits surrounding homes as well (5-36. Upland habitat creation can be valuable as well, especially if specific habitat types or habitats for endangered species are in short supply in the surrounding area. At Nott Island Wildlife Management Area in Connecticut, for example, grasses and legumes were planted to provide grazing and nesting habitat for deer, waterfowl, and small mammals, and has been highly successful (5-67. There are strong precedents for establishing and maintaining valuable ecosystems on dredged substrate that can be highly ecologically beneficial; they may also provide economic benefits in the forms of increased recreation, boosts to property values, and reduced flood risk.

Despite the established benefits, the utility of dredged material is always highly site-specific, and can have negative consequences as well. Deposition can be highly destructive to intact ecosystems – especially those with established, woody vegetation, which takes years to decades to recover. Because depositing dredge material can require cutting down trees and completely submerging existing soil and vegetation, material should be “strategically” deposited on areas that are compromised or disturbed including landscapes affected by invasive species. Areas already dominated by quick-growing or early-succession ecosystems such as herbaceous or grassland ecosystems are also preferred, since they are far quicker to re-vegetate and can be productive within a few years. Therefore, a thorough analysis of the vegetation on the site should be conducted to identify areas that are already disturbed by invasive species establishment, as well as areas whose natural vegetation is early successional and could be readily re-established. These identified areas could then be considered as receiving sites for dredged materials.

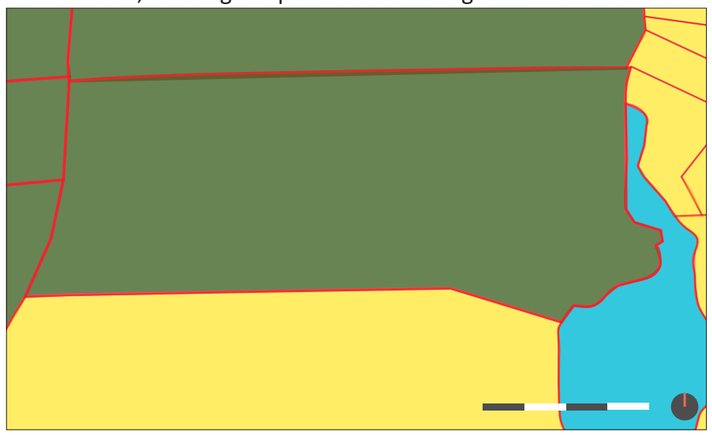
Slopes on the Archibald property are shallow inland in the western portion of the property, though there is a steep drop-off nearer the pond itself. Since the process of dredging and deposition will require trucks and other heavy equipment to access the pond, a haul road will need to be built on the property that can handle heavy loads. During the conceptual process undertaken in this project, determining a potential route for the road was challenging due to the site’s steep slopes. It is likely that any road construction would require a substantial amount of cut and fill, which also entails widespread vegetation removal. Further, steeply-sloped, bare soils are difficult to stabilize, and tend to erode quickly. Stabilizing the slope with erosion-control fabric and quick establishment of new vegetation would be required to prevent road construction from adding additional sediment to the dredge project.



Slopes and topography vary widely. Providing  access to the shoreline can be challenging, but a variety of ecosystems could be restored.



The Archibald  property is surrounded by designated open space on three sides, creating the potential for contiguous wildlife habitat.



Soils on the property are identified as coarse sandy loam, shown in green. This soil type is classified by the NRCS as well-drained to excessively drained, which may speed up the dewatering process.

An important potential benefit of using this property for dredge material deposition is the ability to create locally-rare ecosystems that can support biodiversity. Cape Cod is characterized by several distinctive landscape types that, as a network, provide habitat for a whole suite of coastal species, many of which are specific to Cape Cod or found in few other places. These include pitch pine forest; low-lying coastal heathlands and meadows; and a variety of wetland habitats distinguished by flooding frequency. Given the popularity of coastal areas for human settlement, many of the coastal plains and former wetland areas have been developed. Heathland and wetland habitats are now scarce on the Cape, and many species are threatened or endangered. The opportunity to create habitat for diverse threatened wildlife species such as ground-nesting birds is an important opportunity.
Dredging the pond and subsequent landscape changes have great potential for ecological restoration and for recreation. However, more information is needed before specific plans can be drawn up.

A wide variety of specific tests are required by the EPA before dredging begins to determine the physical and chemical properties of the sediment, as well as its net quantity, and to identify any contamination (as outlined in ACE section 5). These tests include factors such as plasticity, texture, and the ability to retain water and nutrients. The sediment's water retention ability will determine its potential future purposes, as well as the expected time it may take to fully dry, and the net quantity that will remain. Tests are also conducted to identify contaminants like heavy metals, which may come from roadway runoff or from former industrial sites in the Three Bays Watershed. Because ecological processes naturally concentrate heavy metals in plant roots and eventually in bottom sediments, dredging out a pond may release any heavy metals present. If these or other contaminants, such as hydrocarbons or pesticides, are identified and exceed EPA clean water guidelines, the material may need to be capped or isolated. Sometimes, dredge material with levels of contamination can be deposited in a beneficial way if it is capped with at least two feet of clean topsoil, or planted with species that do not transport contaminants to their shoots (ACE 5-11).

In addition to these tests, next steps for this project should include a detailed vegetation analysis and evaluation of options for future haul-road and trail construction. Since depositing dredged sediment can be destructive to existing healthy forests, areas that are already affected by invasive species establishment or otherwise degraded should be preferentially chosen for sediment deposition. The property's vegetation should be thoroughly mapped according to its current ecological integrity in order to identify suitable areas. Additionally, the logistics of allowing dredge equipment access to the pond through the Archibald property should be thoroughly investigated. This project proposes one potential option for constructing a road that would allow heavy equipment access; however, alternative configurations should be identified and the lowest-impact option selected. This should be done in conjunction with vegetation analysis, and vehicle access should also preferentially be directed through areas with the lowest ecological integrity.

Once access to the site and suitable areas for deposition have been identified, specific plans for vegetation reestablishment can be created. This project illustrates suggested target ecosystems for restoration and the species they may benefit, as well as case studies of previously successful precedents. In addition, depending on the ultimate quantity of sediment once dried, and the amount of land determined to be suitable by the vegetation analysis, alternatives may be considered for deposition of any remaining sediment. Past projects have combined dredged material with municipal yard waste to create topsoil for sale; added it to beaches to replace eroded sand; and used it as fill in construction projects. Further exploration may be done to assess which of these is most appropriate for Cape Cod.

Looking east towards the pond through the trees highlights the potential for beautiful views, as well as the steep eastern slope.

Vegetation on the property is characterized by pitch pine forest interspersed with grasses, understory shrubs, and exposed sandy soil.

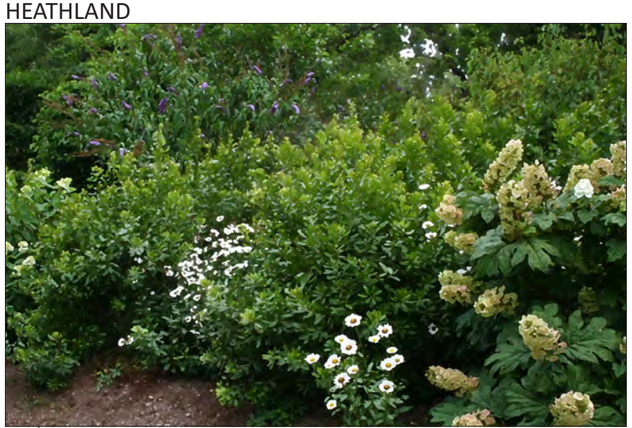
Currently the only parking for the area is a gravel parking lot, used primarily by the Water District.

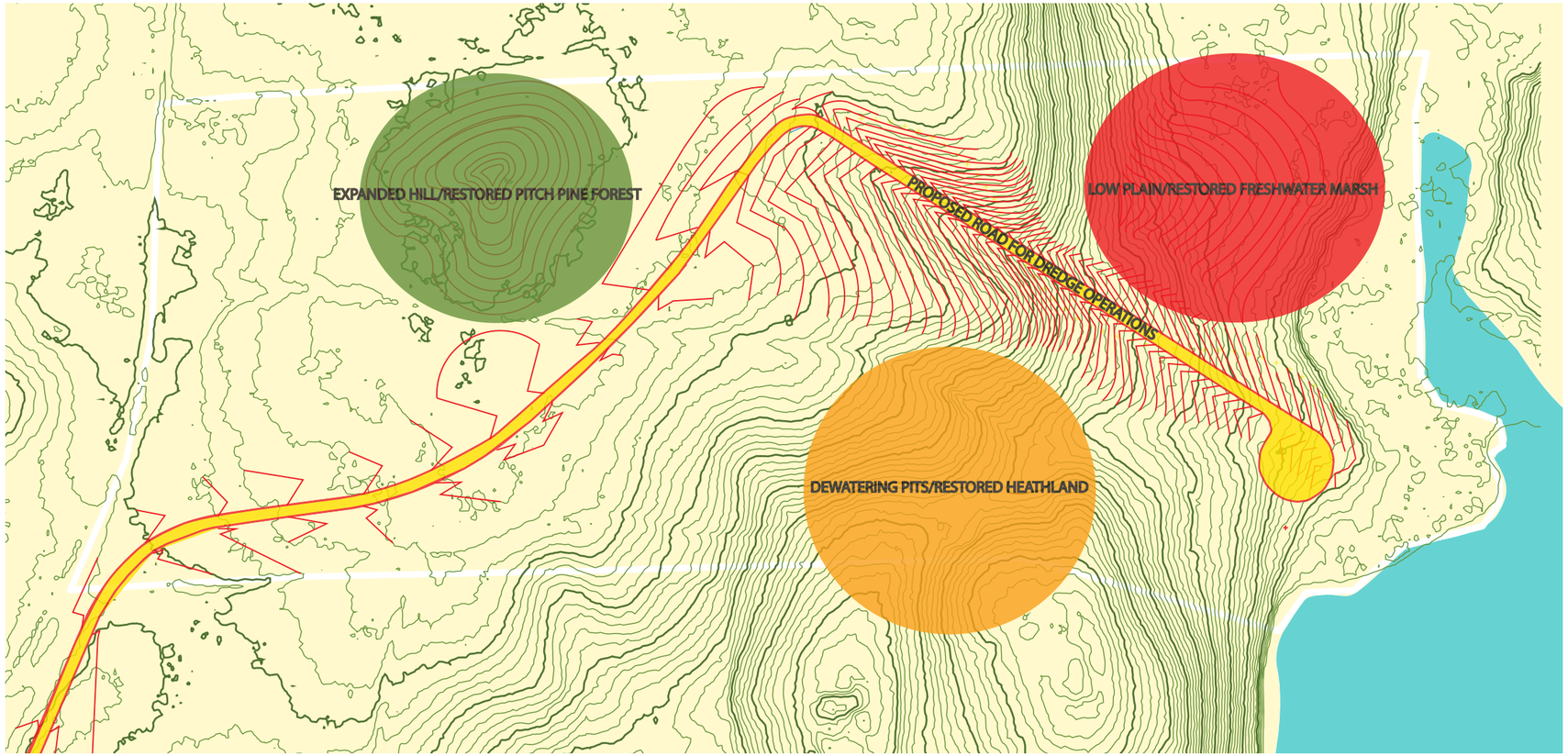
# MARSHES AND MEADOWS

FRESHWATER MARSH

PITCH PINE FOREST

HEATHLAND





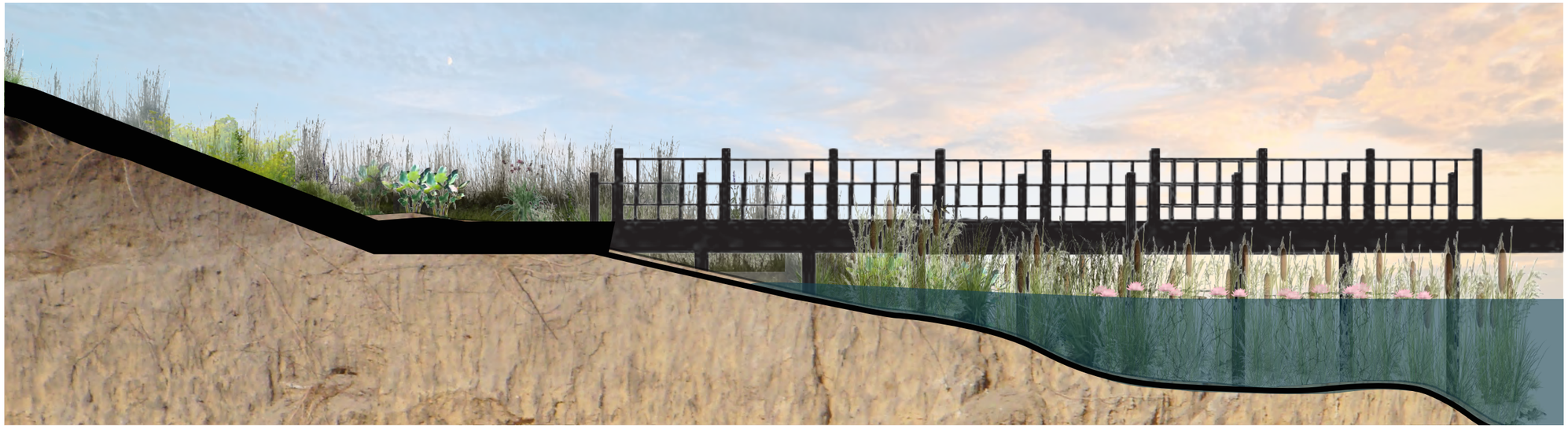

As a narrow coastal peninsula, Cape Cod is characterized by distinct ecosystems including pitch pine-oak forest, coastal shrub and heathlands, and wetland ecosystems that vary based on elevation, salinity, and how often they are flooded. These vegetation communities are specific to low-lying coastal areas. Wetlands and heathlands in particular are locally rare, since their occurrence closer to the coast means they are also highly desirable for residential development. The potential restoration of the Archibald property provides a unique and exciting opportunity to create wetlands and heathlands that can be important habitat for wildlife, and equally important for recreation and environmental education. The potential range of habitat types creates an opportunity for this to be a showcase or microcosm of Cape Cod ecology, which would be highly valuable for schools as well as for recreational users.

Many wildlife species are most successful when they have access to large contiguous land areas that are not disrupted by human settlement. Since the Archibald property is bordered on three sides by protected open land, restored ecosystems here can provide exceptional habitat.

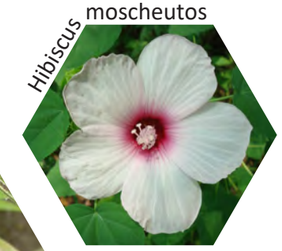
Establishing wetlands is often a good option in low-energy, shallow-water areas such as Mill Pond's shoreline; these ecosystems are highly biologically productive. In addition to wildlife benefits, restored wetlands can provide flood protection that economically benefits surrounding homes as well (5-36). Upland habitats such as pitch pine-oak forest and heathland are equally important when specific habitat types or habitats for endangered species are in short supply in the surrounding area, as both are on Cape Cod. In this context, the varied topography of the Archibald property is an important asset, as it enables the creation of a wide range of ecosystems adapted specifically to varied elevation.

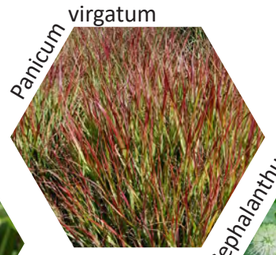
Establishing target species or target wildlife communities is helpful for creating restoration goals and evaluating their success. At Nott Island, for example, vegetation including grasses and legumes was selected to provide grazing and nesting habitat for waterfowl, songbirds, and small mammals. Since many bird species use two or more distinct habitat types for different purposes – for example, feeding in shoreline environments and nesting in grasslands – they are an excellent target for restoration goals. Potential target species and supporting vegetation are identified here, although local conditions should be considered more specifically if restoration moves forward.

WATER'S EDGE: PEDESTRIAN PATH AND BOARDWALK

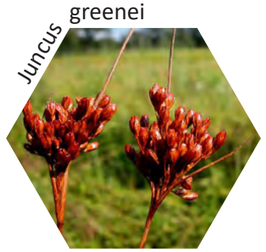




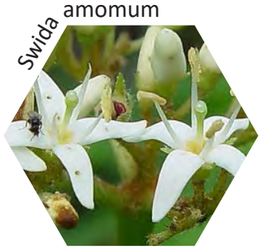




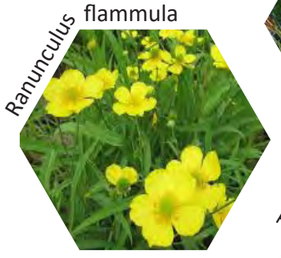




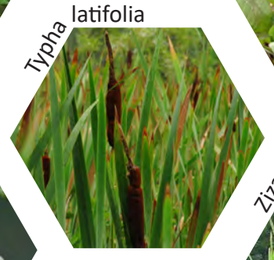


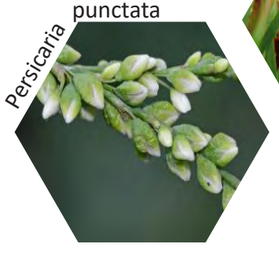




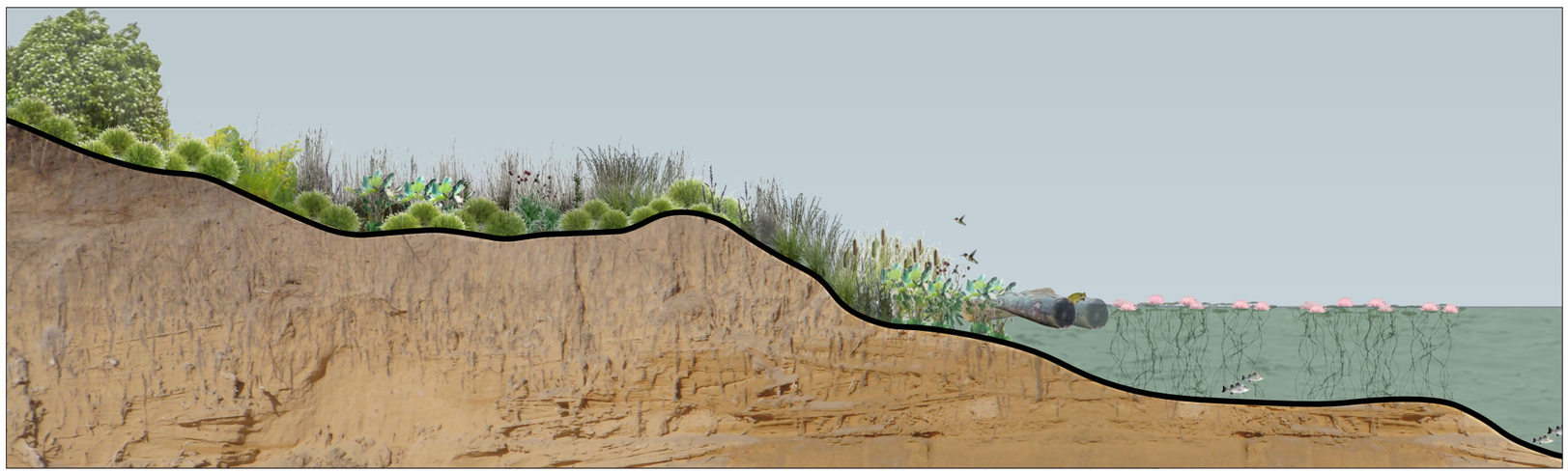




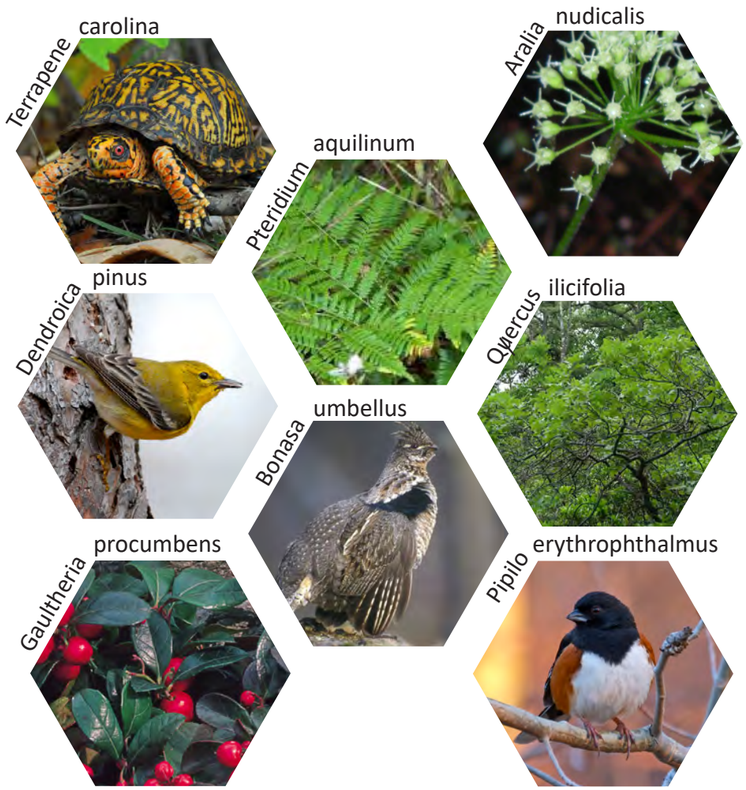





WATER'S EDGE: MARSH AND AQUATIC PLANTS



PROPOSED SECTION: HEATHLANDS

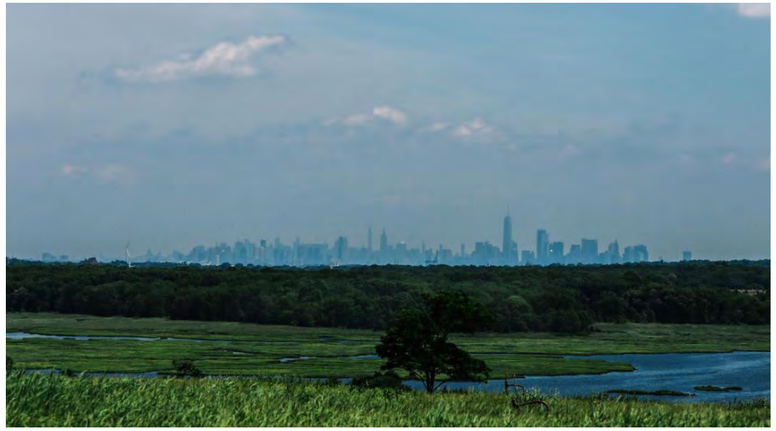

PROPOSED SECTION: EXTENDED HILL WITH PITCH PINE FOREST

## PRECEDENTS: CAT ISLAND
## GREEN BAY, WISCONSIN

Green Bay, Wisconsin's harbor was historically protected by the Cat Island chain of barrier islands. However, the chain began to dissipate in the 1960s, and further erosion from waves led to large-scale wetland loss. The island chain is an important stop on the flight path of many migratory birds, including threatened and endangered shorebirds like the piping plover. But by 2007, a wildlife survey found only six nesting pairs in the entire state of Wisconsin due to widespread wetland loss. Through a collaboration between the Army Corps of Engineers, the University of Wisconsin-Madison, and the shipping industry, material dredged from the bay to clear shipping lanes was added to the island chain to create an additional 272 acres of wildlife habitat. Since the restoration began in 2012, 29 species of migratory shorebirds have been spotted nesting there, and the project also reduces coastline erosion by absorbing wave energy before it hits the shore. Both port operators and environmental groups are calling the project a "win-win."

Aerial view of the Cat Island project, including the stone seawall used as a base for stability.
Photo by the Army Corps of Engineers

The western shore of the restored island chain and a wetland area called Peter's Marsh.
Photo: Gary Fewless, published by UW-Madison



View of the New York City skyline across Freshkill's restored wetlands.
Photo: Vice News

## PRECEDENTS: FRESHKILLS PARK
## STATEN ISLAND, NEW YORK CITY

Once the world's largest landfill, Freshkills Park on Staten Island, New York will be three times the size of Central Park once completed. Designed by James Corner Field Operations, the park will eventually feature recreational facilities including a bike trail, equestrian facilities, a playground, soccer fields, and basketball courts, in addition to hundreds of acres of restored wetland and bird habitat. Once a low-lying marsh, the capped landfill created hilly topography that provides stunning views of the city, and visitors can kayak through tidal wetlands without ever leaving New York City.

Plans for Freshkills Park include restored wildlife habitat and walking trails, as well as 47 acres of solar arrays managed by SunEdison.
Photo: MikeBloomberg.com

## PRECEDENTS: NOTT ISLAND
## LYME, CONNECTICUT

At Nott Island Wildlife Management Area in Lyme, Connecticut, years of environmental damage ultimately became a boon for local wildlife. It was first grid-ditched in the 1930s, which disrupted its natural hydrology and ecosystem function. In the 1960s, sandy sediments from the Connecticut River were deposited on the island, turning tidal marsh into pasture that was later taken over by invasive Phragmites. The Connecticut Department of Environmental Protection chose to take advantage of these conditions by creating 40 acres of tidal wetland and 20 acres of coastal grasslands, a locally-rare habitat. The area is managed for waterfowl, deer, and songbirds. Coastal grasses and legumes were chosen specifically to provide grazing and nesting habitat. The restoration has been highly successful for local wildlife.

Coastal grasses provide important habitat at Nott Island.
Photo: Al Braden

Bald eagles are among the bird species spotted at Nott Island.
Photo: theday.com

# A Symphonic Landscape

Kate O'Connor/Mimi Lo

Sound
/sound/ noun
vibrations that travel through the air or another medium and can be heard when they reach a person's or animal's ear.

## ANALYSIS

The potential location for Barnstable Clean Water Coalition's (BCWC) Headquarters is a residential property on Prince Avenue in Cotuit situated in close proximity to Route 28 and the Mill Pond. If purchased, this property would situate BCWC's headquarters in a central location on the Marstons Mills River and adjacent to protected wetlands.

The existing protected site, adjacent to the potential BCWC Headquarters, is 15 acres. This site is owned by the Barnstable Land Trust with a conservation restriction managed by The Nature Conservancy. The site is overgrown with buckthorn, honeysuckle, Oriental bittersweet and phragmites - all invasive species. Invasive plantings are good indicators of the ecological health of the landscape; their presence throughout the site indicates its poor health. Removal of these species, and re-establishment of native species, will help to restore this portion of the Marstons Mill River and the wetlands throughout the site.

The Marstons Mills River running behind the potential headquarters and throughout the 15 acres is either channelized or in a culvert. These features indicate poor water quality and lessen the ecological qualities the stream provides, and provide challenges for fish passage. There is a small existing trail (see the far right Image 4), which runs through a portion of the 15 acres. This proposal will link the trail to the education center at the proposed BCWC headquarters. Also found on site is a small dock on the wetland edge, at the Marstons Mills River which is a beautiful secluded space (see Analysis Map 1).

This design intends to address any issues and opportunities discovered on site.

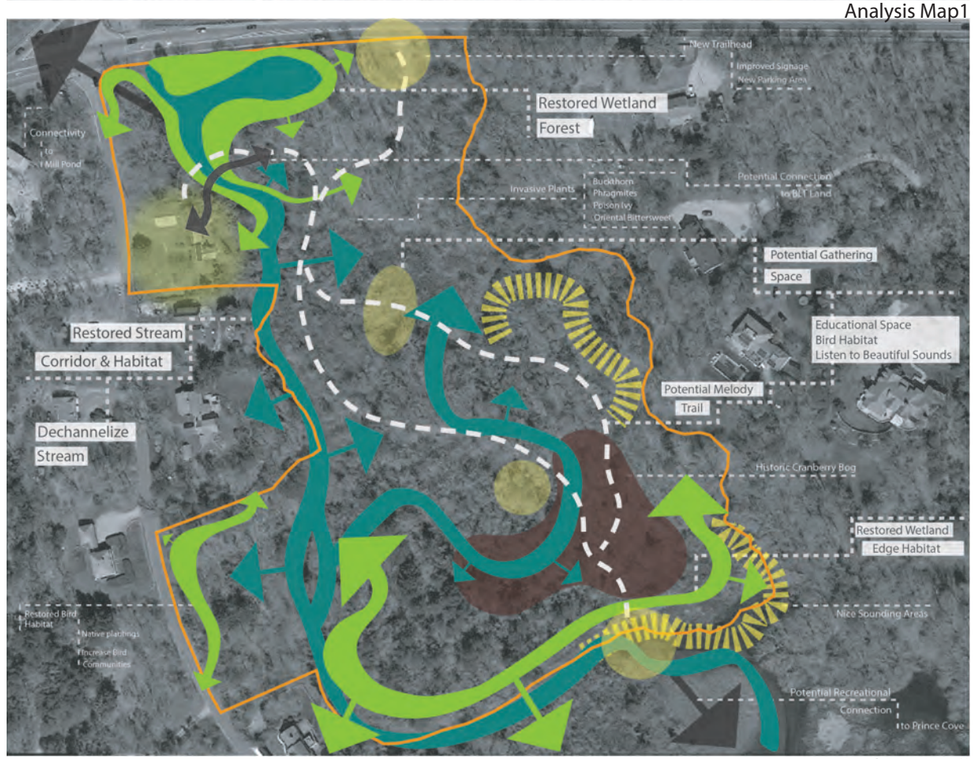
## BIG MOVES

A proposed trail network would enhance connectivity across the site with hiking trails through the property and across to Mill Pond and a newly created kayaking launch on the Marstons Mills River that would link paddlers to Prince Cove and the Three Bays estuary (see Analysis Map 2 and Master Plan page for more detail).

The 15 acres adjacent to the potential Headquarters site would allow for a potential partnership of public and private entities. The land is owned by the Barnstable Land Trust, with the Nature Conservancy holding the conservation restriction on the land. There is opportunity to establish public and private partnerships with the design of the educational sound trail.

Newly enhanced educational spaces will help guide and engage people through BCWC property and on a soundwalk. The five carefully designed interpretive spaces in the protected woodland include: an Educational Deck, the Woody Pitch Pine Forest, a Grape Grove, Cranberry Bog and Kayak Launch – each will help to engage people in the landscape – including through their experience of sound (see Educational Moments page).


Analysis Map1




Analysis Map 2

Image 1 Potential Education Center

Image 2 Relict Mill Foundations

Image 3 Lower Patio By the Property

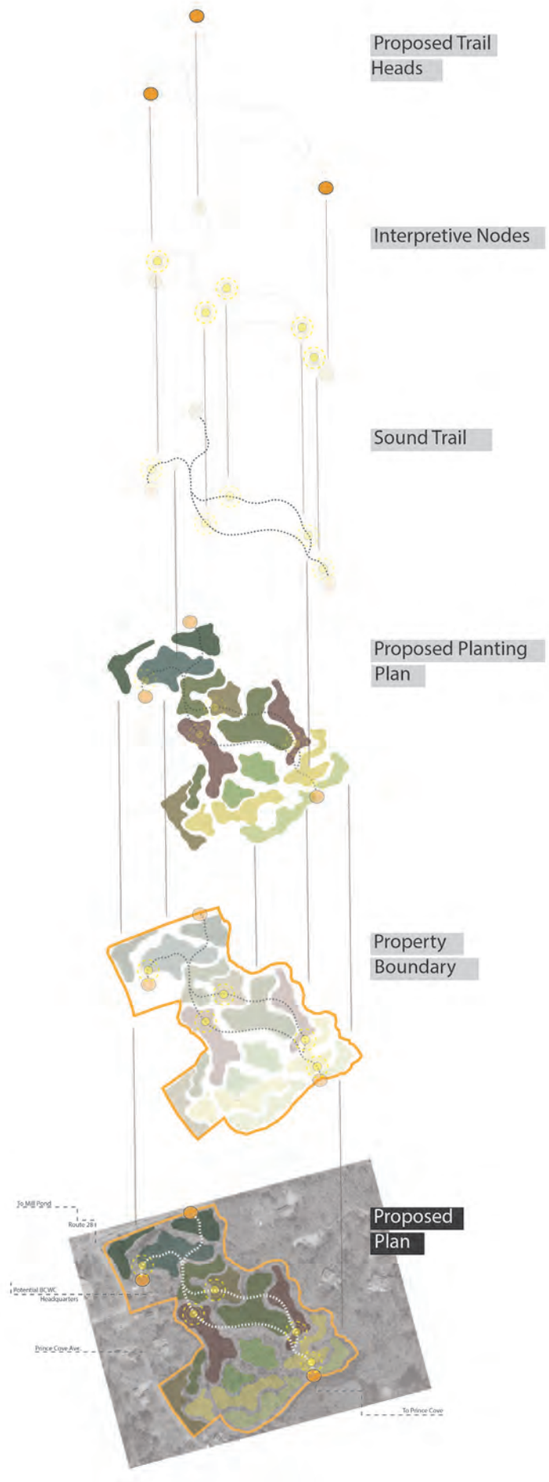
Image 4 Existing Trail

Image 5 Old Cranberry Bog

Image 6 Wetland Edge

# LAYERING

These proposed spaces, restored with appropriate native plantings, will give visitors a pleasant and stimulating experience focused on different habitats and their sounds. These spaces provide habitat for native bird communities and allow people to listen and experience these wonderful sounds. Selective removal of invasive plant species present in the site and re-establishment of native plantings will help to highlight the different wetland ecosystems. These plantings can assist in highlighting the different types of wetland forest, marshy bog and wetland edge. These ecosystems provide subtle but different habitat areas, each with different plantings and different birds (see Wetland Restoration Plant Palette for plant and bird species). As visitors move through this trail they will experience these subtleties and listen to the different sounds. This design is focused on exposing and garnering appreciation for the symphonic landscape at this special place.





The potential new headquarters is proposed to include an outdoor education center for BCWC, currently used as a garage. A proposed educational deck will be an extension on the lower side of the education center. The landscape could become a showcase for BCWC to help explain and demonstrate landscape best management practices that local homeowners could employ on their own property. The landscape around the potential headquarters is designed to treat and manage stormwater on-site. The existing lower patio (see Analysis and Big Moves page) by the stream will be improved and used as outdoor classroom/ gathering space. The headquarters will have active outdoor spaces that could be used for events and educational opportunities. The open space on the south-west side of the potential headquarters will be a new porous parking lot, which will accommodate up to 10 cars.

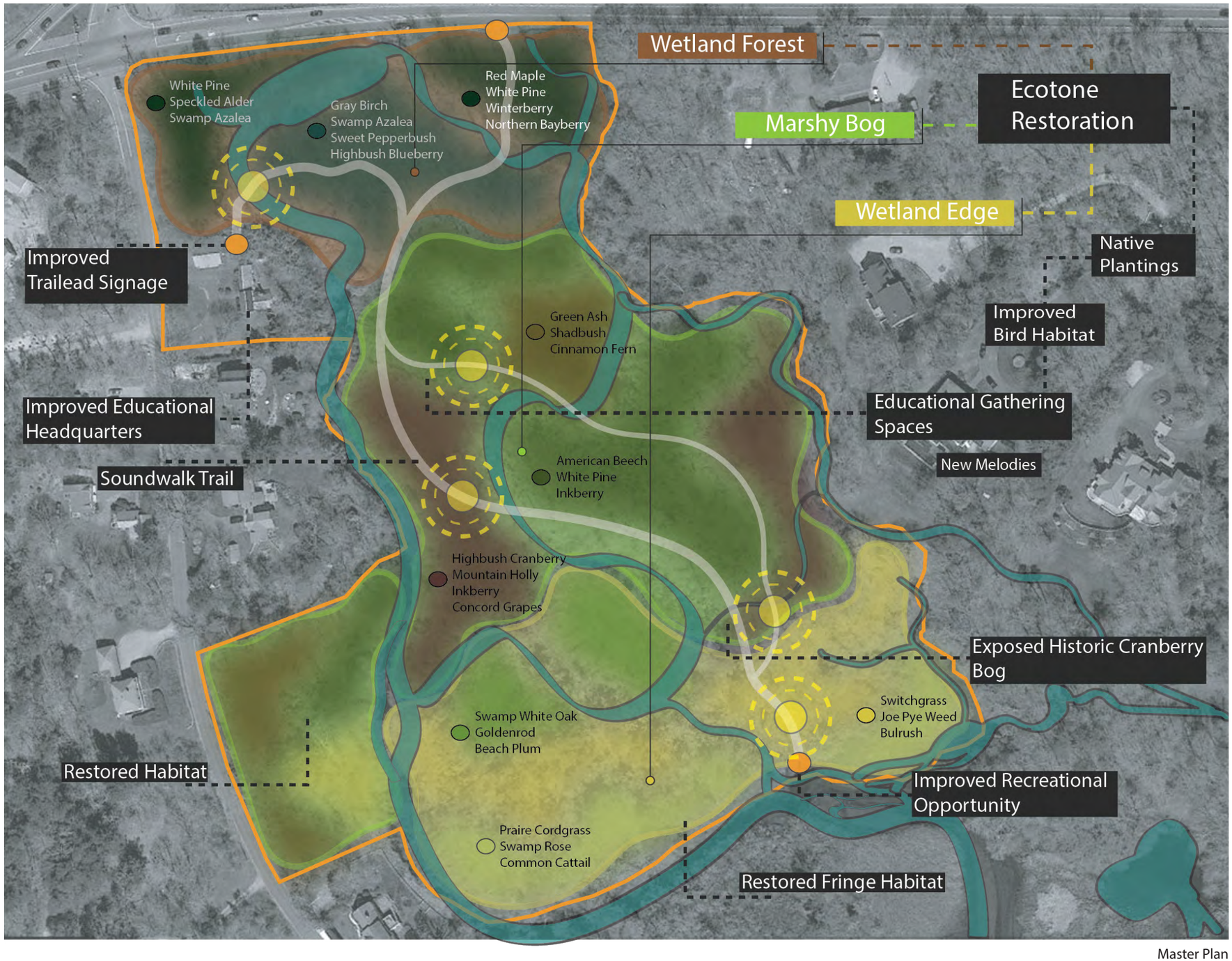
Proposed BCWC Headquarters Detail Plan

# MASTER PLAN

Sound
/sound/ noun
vibrations that travel through the air or another medium and can be heard when they reach a person's or animal's ear.

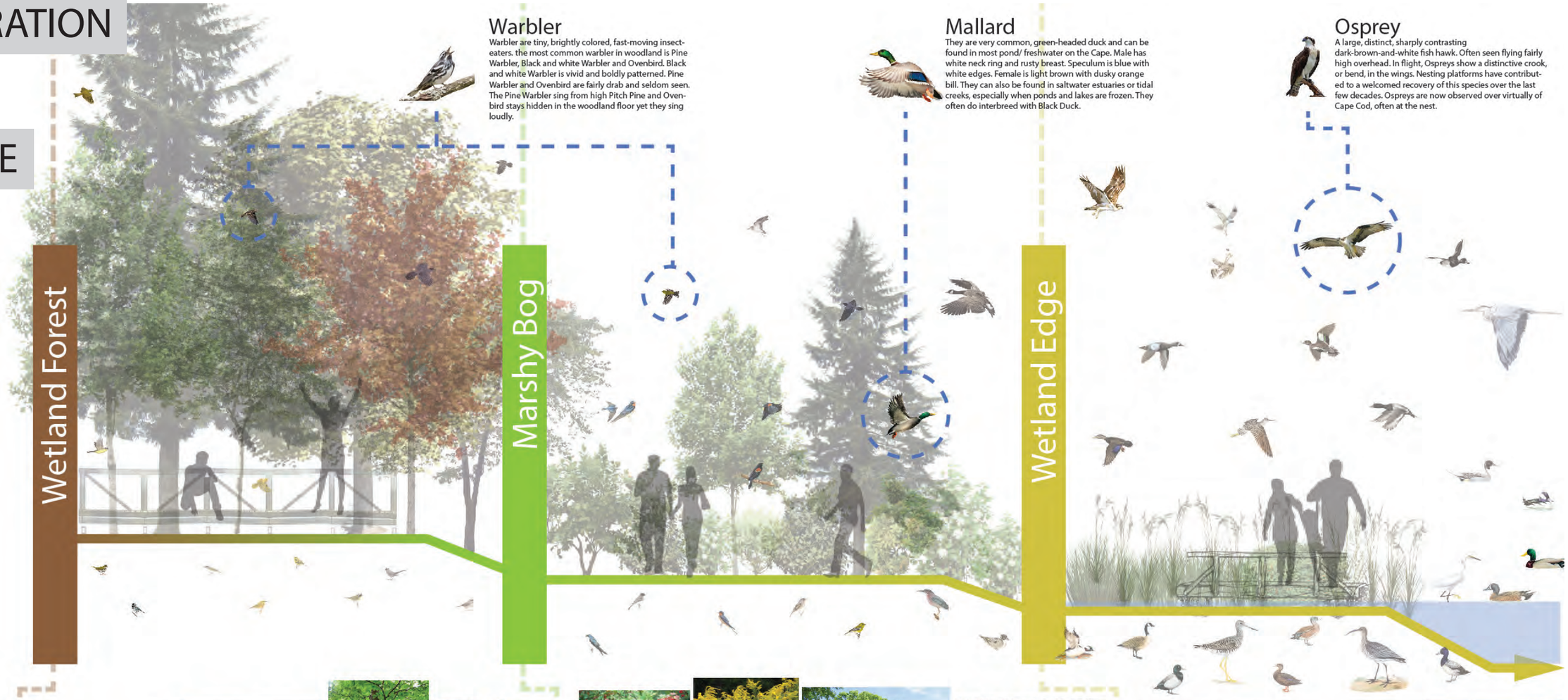
The goal of this design is to create an engaging trail network for a protected tract of wetlands on the Marstons Mills River jointly managed by the Trust for Public Land and the Barnstable Land Trust. The proposal is focused around ecological restoration and on enhancing the visitor's sensory experience of sound.

With proposed removal of the invasive species throughout the site, the design proposes restoration of three wetland ecosystems: Wetland Forest, Marshy Bog and Wetland Edge (see Wetland Restoration Plant Palette page). Paying close attention to planting the appropriate native plantings will help to highlight and enhance different sounds; sounds of the birds, sounds of the insect pollinators and sounds of the wind in the trees. A proposed trail will link five proposed educational "moments" that are each designed to highlight the five distinct environments (see Master Plan and Educational Moments page) and encourage people to experience the sights and sounds of this special "symphonic landscape".




Master Plan

# WETLAND RESTORATION PLANT PALETTE




## Warbler

Warbler are tiny, brightly colored, fast-moving insect-eaters. the most common warbler in woodland is Pine Warbler, Black and white Warbler and Ovenbird. Black and white Warbler is vivid and boldly patterned. Pine Warbler and Ovenbird are fairly drab and seldom seen. The Pine Warbler sing from high Pitch Pine and Ovenbird stays hidden in the woodland floor yet they sing loudly.

## Mallard

They are very common, green-headed duck and can be found in most pond/ freshwater on the Cape. Male has white neck ring and rusty breast. Speculum is blue with white edges. Female is light brown with dusky orange bill. They can also be found in saltwater estuaries or tidal creeks, especially when ponds and lakes are frozen. They often do interbreed with Black Duck.

## Osprey

A large, distinct, sharply contrasting dark-brown-and-white fish hawk. Often seen flying fairly high overhead. In flight, Ospreys show a distinctive crook, or bend, in the wings. Nesting platforms have contributed to a welcomed recovery of this species over the last few decades. Ospreys are now observed over virtually of Cape Cod, often at the nest.

American Beech
Green Ash

White Pine
Red Maple

Gray Birch
Swamp Azalea
Highbush Blueberry

Bayberry
Speckled Alder
Sweet Pepperbush

### Wetland Forest

Highbush Cranberry
Joe Pye Weed
Beach Plum

Goldenrod
Inkberry
Mountain Holly

Swamp White Oak
Serviceberry

Elderberry
Cinnamon Fern

### Marshy Bog

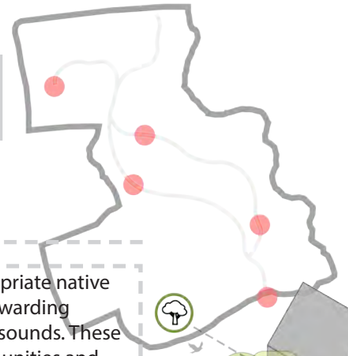
Winterberry
Switchgrass

Common Cattail
Bulrush

Prairie Cordgrass
Swamp Rose

### Wetland Edge

# EDUCATIONAL MOMENTS

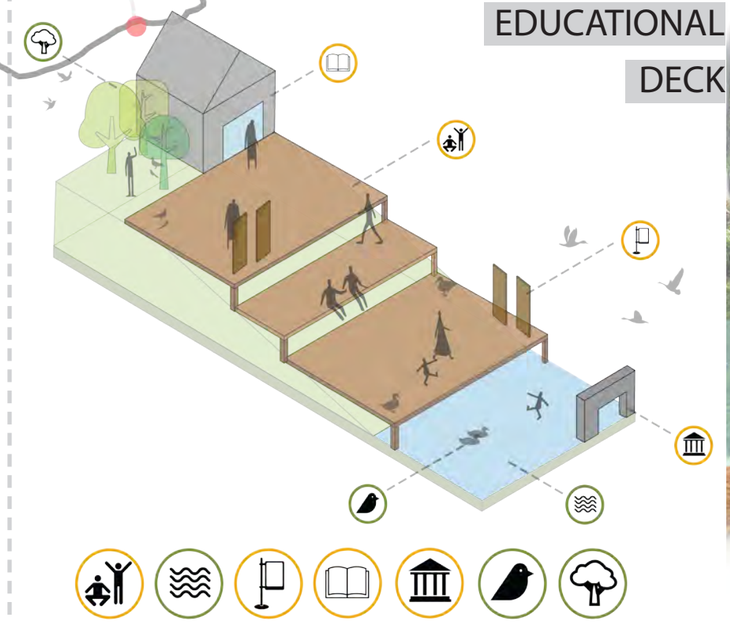


These proposed spaces, restored with appropriate native plantings, will give visitors a pleasant and rewarding experience focused on the different habitat sounds. These spaces provide habitat for native bird communities and allow people to listen to and experience the wonderful sounds of native species. Selective removal of invasive plant species present in the site and re-establishment of native plantings will help to highlight the various wetland ecosystems. These plantings assist in highlighting the wetland types of wetland forest, marshy bog and wetland edge. These ecosystems provide subtle but different habitat areas, each with distinct plantings and birds. As visitors move through this trail they will be able to experience these subtleties and listen to the different sounds. This design is focused on exposing and garnering appreciation for the symphonic landscape.

Educational Deck
A newly designed deck and educational space will support the BCWC's educational goals. The educational deck is proposed to be attached to the lower backside of the proposed education center, which is the existing garage. The deck will allow people to engage directly with the Marstons Mills River. There will be space to view the river from above and bring people down to it. Visual connections will be cleared to view the relict mill foundations (see Analysis and Big Moves page) on site and allow for people to engage in the land-use history through the signage revealing the story of this old mill. The stream is rushing here and visitors will be able to sit and listen to peaceful, stream flow – another special listening experience. A proposed log bridge will allow for direct connection to the BLT land, where people can go on a soundwalk (see Proposed Educational Deck Rendering).

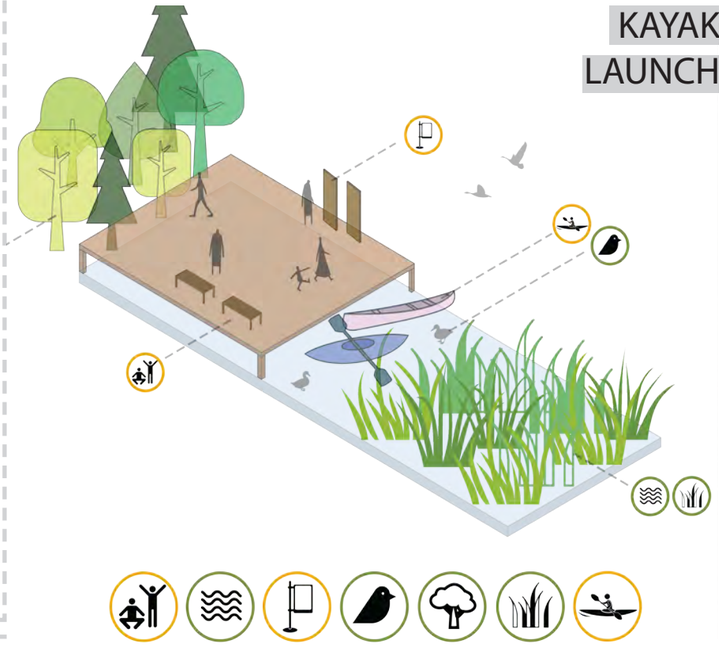
Kayak Launch
Here visitors can arrive on the site by water, or end their walk or continue to explore the Marstons Mils River by kayak or canoe. Visitors will be able to view larger predator birds, including osprey and great blue heron, either at the group viewing area or individually in the more secluded viewing platforms. The design will create potential nesting sites for larger predator birds, helping to improve their habitat while enhancing birding sounds. Visitors will be able to sit in this beautiful space, removed from the busy traffic and enjoy the melodies of the landscape .

## EDUCATIONAL DECK



Proposed Educational Deck Rendering

## KAYAK LAUNCH



Proposed Kayak Launch Rendering

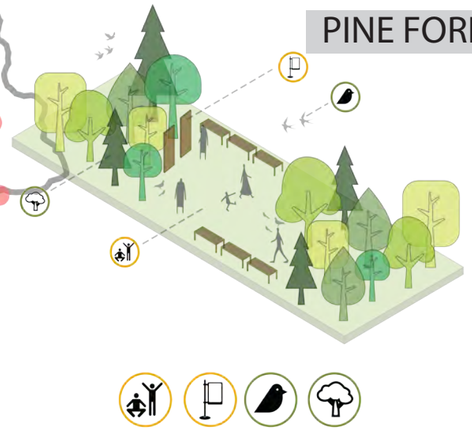
# EDUCATIONAL MOMENTS

Woody Pitch Pine Forest
This is a beautiful, currently cleared space in the wetland forest. A proposed gathering space will enable visitors to sit amongst the trees. Removal of invasive plants will help to restore the native plant communities, including bayberry, inkberry and blueberry. These plants will attract many species of birds including Warblers, Swallows and Sparrows. This space will allow people to listen to woody ground-nesting birds and the wind in the forest and Pitch Pine trees.

Grape Grove
Here visitors can enjoy native grapes and other local berries, like highbush blueberry, elderberry and beach plum. Removal of the invasive plants will help the grape grove to bloom and will attract more local birds. Seasonally, visitors will be able to enjoy different birds including Warblers, Mallards and Scaups while eating grapes and other berries.

Cranberry Bog
Here people will be able to see the remnants of a once active cranberry bog while interacting with native cranberries and other bog plantings, including; inkberry, mountain holly and joe pye weed. Visitors will be able to learn/experience the land-use history through interpretive signage, by being surrounded with this cranberry bog and enjoying the sounds of smaller birds.

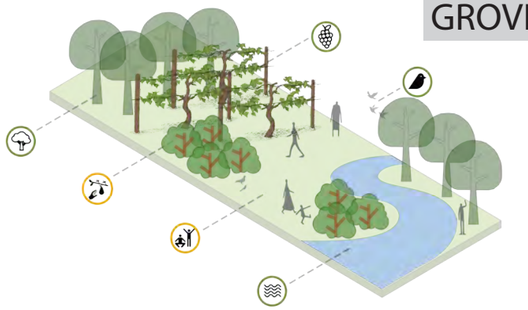
## WOODY PITCH PINE FOREST





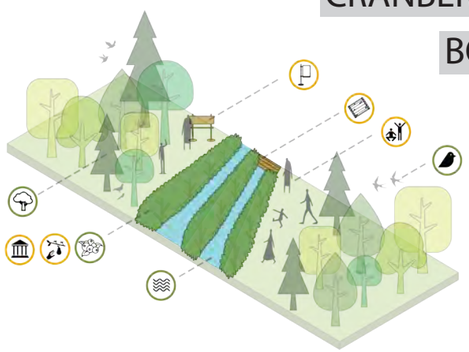
Proposed Woody Pitch Pine Forest Rendering

## GRAPE GROVE



Proposed Grape Grove Rendering

## CRANBERRY BOG



Proposed Cranberry Bog Rendering

# INTERCEPT FILTER GROW

Alysha Thompson
Instructor| Jack Ahern
University of Massachusetts Amherst
LA&RP Landscape Architecture & Regional Planning

This project targets water quality improvement in and around Prince Cove marina in Barnstable. Prince Cove is one of the most compromised water bodies in the Three Bays Watershed. The site is a good location for implementation of water quality improvement technology because it is a highly compromised area and is also an accessible public site with high public visibility. This provides an opportunity to engage the public and enhance information sharing about water quality management.

The goals of this project are to:

(1) Improve water quality and ecosystem health through a variety of techniques, both on land and in Prince Cove through:

- Stormwater management
- Habitat restoration
- Aquaculture

(2) Create space for research and information sharing to advance water quality improvement technologies and to develop reproducible techniques to encourage widespread implementation.

(3) Provide an immersive experience for students and visitors that highlights the importance, sensitivity, and beauty of the estuarine ecosystem.

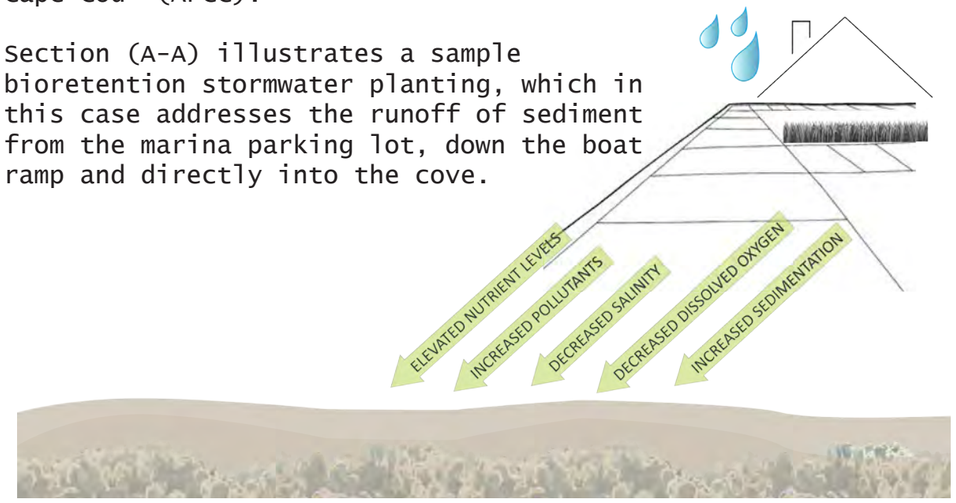
By taking an integrative look at nitrogen contamination, this project addresses the site conditions directly, while also expanding the scope of the enhancements through education and outreach.


## STORMWATER MANAGEMENT|

Stormwater runoff compromises water quality and ecosystem health, carries sediment and contaminants,  and erodes the shoreline.

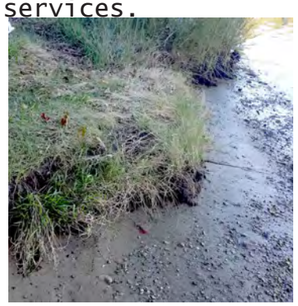
Target areas have been identified for stormwater bioretention plantings on the plan. One of these areas is already being addressed by the Association to Preserve Cape Cod  (APCC).

Section (A-A) illustrates a sample bioretention stormwater planting, which in this case addresses the runoff of sediment from the marina parking lot, down the boat ramp and directly into the cove.




# SALT MARSH RESTORATION|

Restoring the salt marsh and eelgrass beds will help to provide habitat, increase biodiversity, and improve the overall health of the ecosystem. A healthy ecosystem may be more resilient when subjected to excess nitrogen loads, and can also provide nitrogen mitigation services.



Existing conditions| Deteriorating marsh edge

Marsh Loop Trail

This proposed trail will travel through low marsh, high marsh, and upland marsh forest, It includes a boardwalk section with a wildlife viewing blind.

The trail provides an immersive experience for visitors to observe the marsh habitat and to learn about marsh restoration and the importance of a healthy marsh ecosystem.

Boardwalks should be at least 1:1 height to width ratio and five feet high to minimize negative impact on marsh vegetation.

Massachusetts Department of Environmental Protection, Bureau of Resource Protection, Wetlands/Waterways Program. “Small Docks and Piers,” 2003.

## AQUACULTURE |

Aquaculture provides local food and economic opportunities while removing excess nitrogen from the water.

Shellfish farms remove an average of 520 lb nitrogen/acre/year.

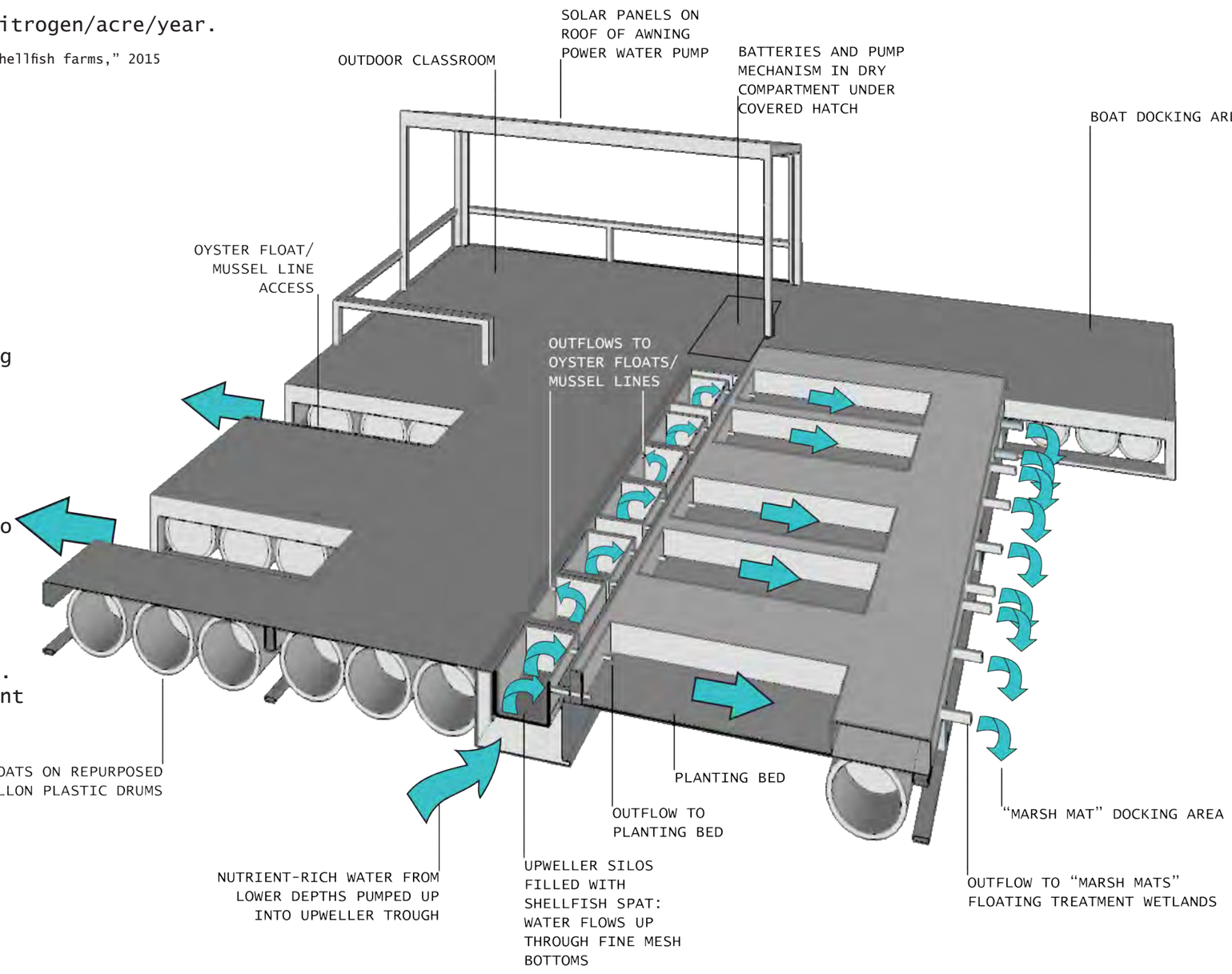
Rose et al. “Comparative analysis of modeled nitrogen removal by shellfish farms,” 2015

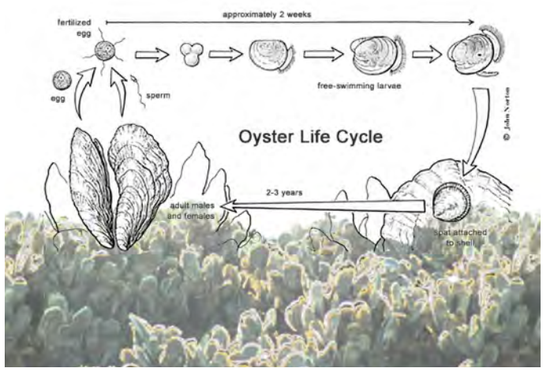
### The “FLUPS Capacitor”
### Aquaculture research and demonstration raft|

Floating Upweller Systems or FLUPSY’s, are used to cycle water through shellfish spat to enhance the growth and development of the juvenile shellfish.

This project utilizes a modified upweller system that brings water up from lower depths through the shellfish spat. The cycling also serves to aerate the water and bring nutrient-rich water up for filtering. The water outflow from the system is then routed through vegetative beds growing aquaculture products such as Salicornia sp., and ultimately drains through floating treatment wetland “marsh mats” before running back into the bay.

Reused/recycled and readily available materials are focused on and used as much as possible in reproducible, affordable designs. Workshops held on the raft can teach equipment building and aquaculture techniques.




### Shell collection station|

Shellfish shells recycled can be processed and used for spat (juvenile shellfish) seeding, reef building material, and as a sorption medium to capture contaminants in stormwater remediation bioswales.


*SALICORNIA SP.*
PICKLEWEED, GLASSWORT

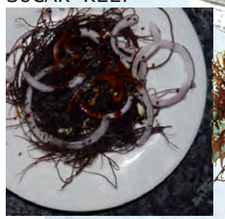
Aquaculture species

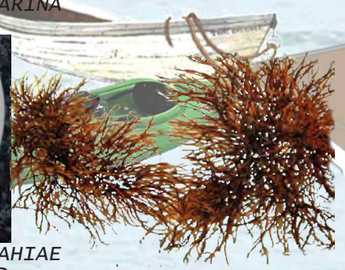
Selected for edibility, economic opportunity, and nitrogen removing capabilities.

When water quality permits, products can be consumed, When water quality is poor, shellfish can be harvested and put through a cleaning, depuration cycle and moved to certified growing areas, and plant material can be harvested and composted for fertilizer.

*MYTILUS EDULIS*
BLUE MUSSEL

*LAMINARIA SACCHARINA*
SUGAR KELP





*GRACILARIA TIKVAHIAE*
GRACEFUL REDWEED

*MERCENARIA MERCENARIA*
QUAHOG

*CRASSOSTREA VIRGINICA*
EASTERN OYSTER

Floating treatment wetland “Marsh Mats”|

Used for nutrient removal, easily harvestable with minimal ecosystem disturbance,these mats can also be used along shorelines where marsh restoration is not a viable option, Harvested material can be composted for fertilizer.

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