

# Climate Change & Nature Based Solutions

Sara Burns, The Nature Conservancy [sara.burns@tnc.org](mailto:sara.burns@tnc.org)  
Stefanie Covino, Mass Audubon [scovino@massaudubon.org](mailto:scovino@massaudubon.org)

# Key Observed Climate Changes in MA



**Temperature:**



**2.8°F**

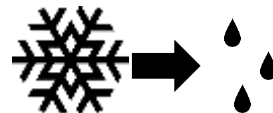
Since 1895

**Growing Season:**



**10 Days**

Since 1950



**Sea Level Rise:**



**10 inches**

Since 1922

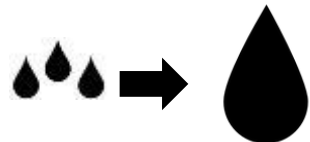


**Strong Storms:**



**71%**

Since 1958



# Future Expectations



Annual precipitation likely to increase

Extreme precipitation more likely



Outdated assessments do not capture continual change.

Sea level rise will drive greater flood risk.



**There are real solutions.**

**One of the best adaptation practices  
is preserving natural areas.**



## -Based Solutions



**Nature-Based Solutions** *use* natural systems, *mimic* natural processes, or *work in tandem with* traditional approaches to address natural hazards like **flooding**, **erosion**, **drought**, and **heat islands**.

Incorporating nature-based solutions in local planning, zoning, regulations, and built projects can help communities reduce their exposure to these impacts, resulting in reduced costs, economic enhancement, and safer, more resilient communities.

# What is Green Infrastructure?

A network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas that support native species, maintain natural ecological processes, sustain air and water resources and contribute to health and quality of life.

(McDonald, Benedict and O'Conner, 2005)



# Free ecosystem services:

## Free services provided by the natural landscape

Every \$1 invested in land conservation offers a **\$4 Return on Investment** in terms of these ecosystem service values

- **Flooding:** Floodplains provide flood protection and reduce infrastructure damage
- **Public Health:** Managing stormwater and reducing retention ponds reduces creation of mosquito habitat
- **Air Quality & Public Health:** Trees reduce the urban heat island effect, reducing smog creation and resulting asthma occurrences as well as reducing nitrogen dioxide and particulate matter
- **Water Quality:** Streamside vegetation filters pollutants and reduces erosion
- **Water Quantity:** Forests and wetlands store water, improve water quality, and recharge groundwater
- **Recreation:** Clean, flowing waters support recreation, including boating, fishing, and swimming while open space provides areas for hiking and biking
- **Quality of Life:** Open space and street trees create a more enjoyable walking environment, benefiting community connection, health, and economic benefit in downtowns and commercial areas
- **Property Value:** Healthy, mature trees add an average of 10-30% to a property's value

# What is Low Impact Development?



















“LID is an approach to land development (or re-development) that **works with nature to manage stormwater** as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that **treat stormwater as a resource** rather than a waste product. ”

- EPA



Source: Whole Buildings Design Guide, wbdg.com

# Co-benefits

Benefit	Reduces Stormwater Runoff												Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding									Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality		
Practice																			
Green Roofs	●	●	●	●	○	○	○	●	●	●	●	●	◐	●	◐	◐	◐	●	●
Tree Planting	●	●	●	●	○	◐	○	●	●	●	●	●	●	●	●	●	◐	●	●
Bioretention & Infiltration	●	●	●	●	◐	◐	○	○	●	●	●	●	●	◐	◐	○	○	●	●
Permeable Pavement	●	●	●	●	○	◐	●	◐	●	●	●	○	○	●	○	○	○	○	●
Water Harvesting	●	●	●	●	●	◐	○	◐	◐	◐	○	○	○	○	○	○	○	○	●



Yes



Maybe



No

Source: Center for Neighborhood Technology's The Value of Green Infrastructure



CHARLES D. BAKER  
GOVERNOR

OFFICE OF THE GOVERNOR  
COMMONWEALTH OF MASSACHUSETTS  
STATE HOUSE • BOSTON, MA 02133  
(617) 725-4000

KARYN E. POLITO  
LIEUTENANT GOVERNOR

By His Excellency  
CHARLES D. BAKER  
GOVERNOR

**EXECUTIVE ORDER NO. 569**

**ESTABLISHING AN INTEGRATED CLIMATE CHANGE STRATEGY  
FOR THE COMMONWEALTH**

WHEREAS, climate change presents a serious threat to the environment and the Commonwealth's residents, communities, and economy;

WHEREAS, extreme weather events associated with climate change present a serious threat to public safety, and the lives and property of our residents;

WHEREAS, the Global Warming Solutions Act (the "GWSA") directs the Secretary of Energy and Environmental Affairs and the Department of Environmental Protection to take certain steps to reduce greenhouse gas emissions and prepare for the impacts of climate change, including setting statewide greenhouse gas emissions limits for 2020, 2030, 2040 and 2050;

WHEREAS, the statewide greenhouse gas emissions limit for 2020 is 25% below the 1990 level of emissions and the corresponding limit for 2050 is 80% below the 1990 level of emissions, but no interim limits have yet been set for 2030 or 2040;

WHEREAS, the Commonwealth can provide leadership by reducing its own emissions from state operations, planning and preparing for impending climate change, and enhancing the resilience of government investments;

WHEREAS, the transportation sector continues to be a significant contributor to greenhouse gas emissions in the Commonwealth, and is the only sector identified through the GWSA with a volumetric increase in greenhouse gas emissions;

WHEREAS, the generation and consumption of energy continues to be a significant contributor to greenhouse gas emissions in the Commonwealth, and there is significant potential

16 PM 12:14

NO STATE SECRET



# Municipal Vulnerability Preparedness Process



By His Excellency  
CHARLES D. BAKER  
GOVERNOR

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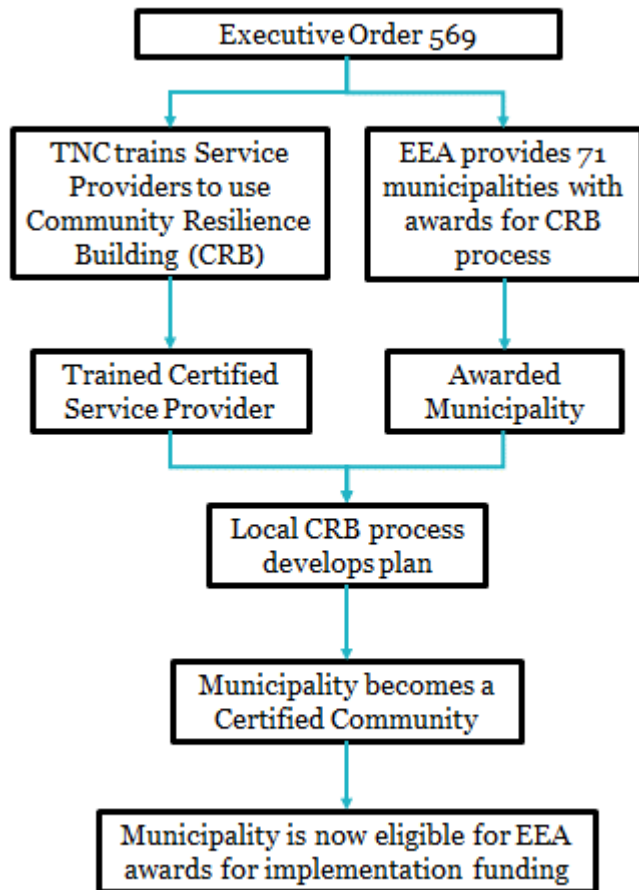
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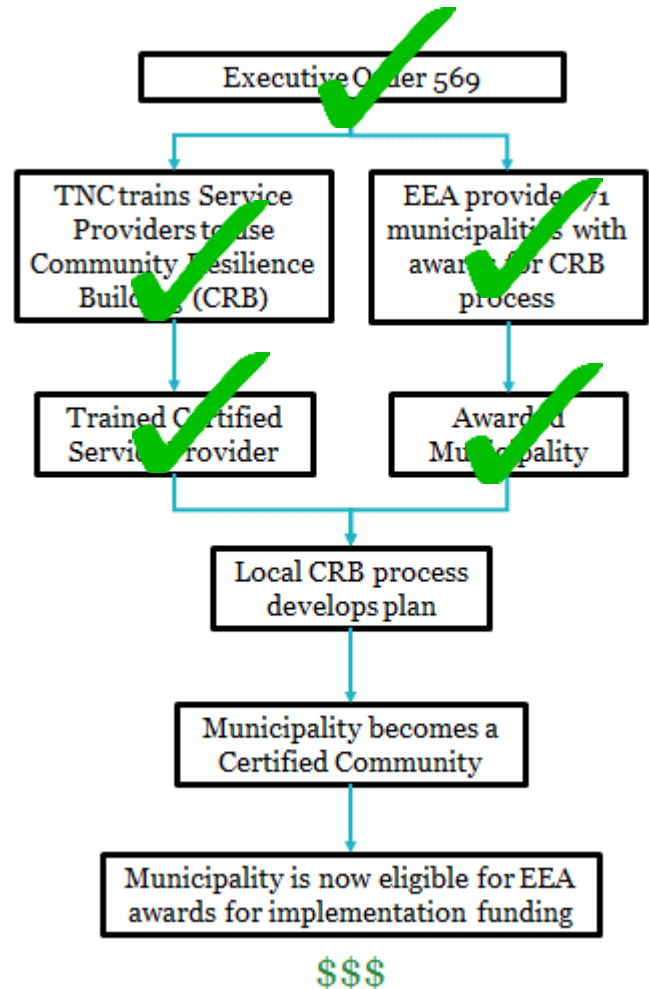
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# Where is MVP Now?

- Communities are choosing their provider
- Providers are planning their CRB process



# Community Resilience Building WORKSHOP GUIDE



- Stakeholder based vulnerability and strength identification process.

- Participants identify opportunities to increase resilience, develop solutions, and prioritize actions.

- Prioritized action plans are developed including time horizon information

# Increased flooding



Photo Credit: Alison Bowden



Photo Credit: Alison Bowden



Photo Credit: Alison Bowden

# Land protection = water protection

- Quabbin & Wachusett Reservoirs serve 2.5 million
- Over 20 years, Massachusetts Water Resources Authority spent \$130M to protect 22,000 acres of watershed lands
- Avoided ratepayer cost of \$250M on a filtration plant and \$4M/yr in operations



# Mill River: Whittenton Dam Removal, Taunton



## ● Costs

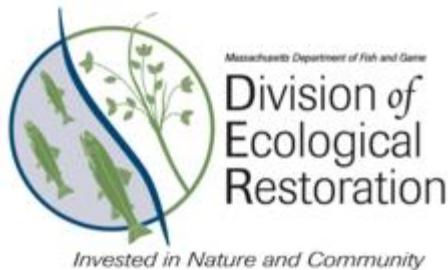
- Estimated repair cost: \$1.9M
- Ongoing maintenance cost: variable
- 2005 evacuation cost: \$1.5M
- Dam removal cost: \$440,000

## ● Benefits

- Increased revenue from river-based recreation
- Increased property values
- Improved water quality

# DER Research on Dam Removal

DER projects produce an average employment demand of **12.5 jobs** and **\$1.75 Million** in total economic output from each \$1 Million spent, contributing to a growing “restoration economy” in Massachusetts



# Weir Village Park, Taunton

- Redevelopment project demolishing old F.B. Rogers Silver factory in Taunton
- Building new city park and boat ramp to improve access and public safety
- Working with TNC to construct rain gardens to reduce runoff impairments into Taunton River



# Mass Audubon's Broad Meadow Brook Wildlife Sanctuary, Worcester

- Redevelopment at largest urban wildlife sanctuary in New England
- Capturing all stormwater on site through LID BMPs
  - Rain gardens
  - Pervious pavers
  - Rain barrels
  - No-mow areas
  - Stormwater grates



# Natural Landscaping & Grasses vs. Traditional Turf



## Cost Savings

- Annual maintenance savings: \$4,500/acre
- Installation savings: \$4,000-8,000/acre

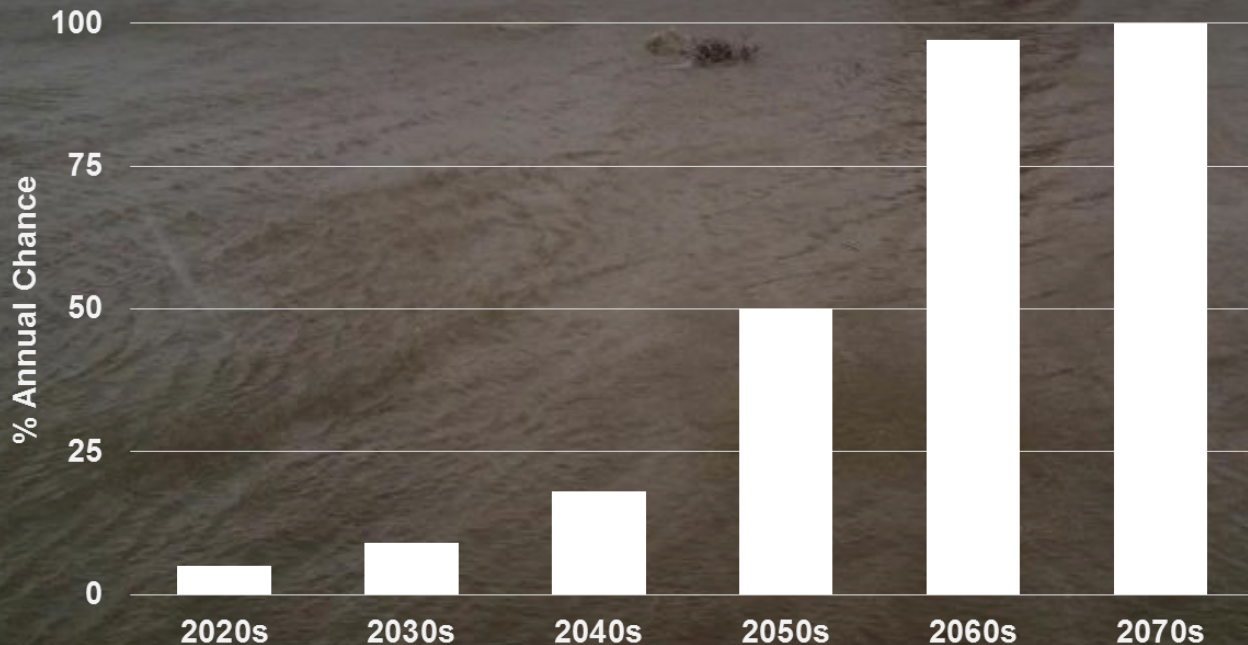
## Additional benefits

- increased curb appeal
- improved stormwater retention

# Coastal Flooding

## Projected Single-year Likelihood of Coastal Floods Exceeding 4 Feet

Providence, Rhode Island



**Nature on  
its own is  
resilient  
and reacts  
to  
changes**

Source: Google Earth





**Our  
infrastructure  
doesn't react  
the same way**



## HELP ME CHOOSE

### Hazard Types

- ☐ Coastal Erosion
- ☐ Tidal Flooding
- ☐ Coastal Flooding
- ☐ Riverine Erosion
- ☐ Riverine Flooding
- ☐ Stormwater Flooding

### Region

- ☐ Coastal West
- ☐ Great Lakes
- ☐ Gulf of Mexico
- ☐ Mid-Atlantic
- ☐ Midwest
- ☒ Northeast
- ☐ Pacific Northwest
- ☐ Rocky Mountain West
- ☐ Southeast
- ☐ Southwest

### Community Type

- ☒ Rural
- ☐ Suburban
- ☐ Urban

### Scale

- ☐ Community
- ☒ Neighborhood
- ☐ Site

### Cost

- ☒ \$
- ☐ \$\$
- ☐ \$\$\$
- ☐ \$\$\$\$

CLEAR ALL



### Coastal Marshes

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Coastal wetlands occur along marine, estuarine, and freshwater coastlines and may be...



### Beaches and Dunes

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Beaches and dunes occur in a variety of shapes, sizes, compositions, and...



### Restoring Offshore Features

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Restoration is the process of establishing or reestablishing a habitat that closely...



### Restoring Coastal Features

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Natural coastlines have evolved to absorb wave energy and provide a buffer...



### Regulatory and Policy Approaches to Address Hazards

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Flooding is a natural process that, in the absence of human settlements...



### Planning Approaches to Reduce Natural Hazards

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Flooding is a natural process that, in the absence of human settlements...



### Enhanced Floodplain Mapping

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Flooding is a natural process that, in the absence of human settlements...



### Open Space Preservation through Land Acquisition

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

This strategy focuses on the public acquisition of undeveloped land to lessen...



### Living Breakwaters

Coastal Erosion Riverine Flooding Stormwater Flooding Coastal Flooding Stormwater Flooding Tidal Flooding

Breakwaters are offshore structures designed to limit wave energy by creating a...

# Swansea Marsh and Habitat Conservation

- 37 acres in Palmer River Corridor purchased and conserved by Town of Swansea, Wildlands Trust, and Blount Fine Foods for \$110,000
- Major storms in 2010 and 2012 damaged stormwater and transportation infrastructure

## Resilience Benefits

- Dissipated energy from storm, tide, and flood events
- Avoided cost of infrastructure repairs and replacement
- Protected water quality
- Future marsh migration



<http://wildlandstrust.org/news/2016/3/1/public-private-partnership-saves-37-acres>

# Massachusetts Forests Mitigate Climate Change

- MA forests **sequester 14%** of the state's gross annual carbon emissions
- Average acre stores **85 tons carbon**
- Capacity **increases** over time as forests mature



# They also provide free ecosystem services

- Shade
- Windblock
- Shelter
- Sponge
- Carbon
- Filter

MA forests provide over  
**\$3.8 billion** each year in free  
ecosystem services



# UMass Amherst Guide: Increasing Forest Resiliency

## Characteristics of Resilient Forests

Formal plans for the future of the property



**Minimal forest stress** from invasive plants, insects, and diseases, and deer

### High Forest Complexity



- ✓ Diversity of tree species
- ✓ Ample tree regeneration of future-adapted species

- ✓ Vigorous trees of various sizes and ages
- ✓ Variety of tree arrangements
- ✓ Appropriate amount of deadwood



Healthy soil and water

Protected threatened, endangered, and at-risk species



## Step 1

### Assess Forest Resiliency

(Click all that apply)

#### GOAL 1: Keep Forest Forested and Connected

- ☐ 1.1: Formal plans have NOT been made to keep the forest as forest.
- ☐ 1.2: The property is either part of a riparian forest or connected to large areas of forest.

#### GOAL 2: Reduce Stresses

- ☐ 2.1: Invasive plants are found on or near the property.
- ☐ 2.2: Invasive insects or tree diseases are found on or near the property.
- ☐ 2.3: There are significant effects from deer on the vegetation.
- ☐ 2.4: There is significant soil compaction or erosion.

#### GOAL 3: Reduce Vulnerability

- ☐ 3.1: The forest does NOT have many different types of tree species of various sizes, ages, and spatial arrangements.
- ☐ 3.2: The forest does NOT have young trees predicted to be well adapted to future conditions.
- ☐ 3.3: The forest has a high abundance of preferred prey species for invasive insects or diseases.
- ☐ 3.4: The forest has areas with dense, crowded tree stems.
- ☐ 3.5: There are NOT 3 or more large snags (≥10" diameter) per acre.
- ☐ 3.6: There are NOT 5 or more large logs (≥16" diameter) per acre.
- ☐ 3.7: Where resources do NOT have riparian buffers.

#### GOAL 4: Provide Refuge

- ☐ 4.1: The property includes threatened, endangered, or at-risk species.
- ☐ 4.2: The property can harbor species that we may lose from the landscape.

## Step 2

### Increase Forest Resiliency

(Implement the recommended action for each statement in red)

#### GOAL 1: Keep Forest Forested and Connected

##### ACTIONS

- 1.1: Engage in conservation-based estate planning.
- 1.2: Conserve riparian forests and the connections between them.

#### GOAL 2: Reduce Stresses

##### ACTIONS

- 2.1: Identify and remove invasive plants, and prevent their introduction.
- 2.2: Monitor for invasive insects and diseases, and implement measures to control or slow their spread.
- 2.3: Manage deer to ensure ample regeneration.
- 2.4: Maintain riparian soil and water health by avoiding soil compaction, stabilizing eroded streambanks, and establishing forested buffers around water resources.

#### GOAL 3: Reduce Vulnerability

##### ACTIONS

- 3.1: Maintain and/or promote diverse species, sizes, ages, and spatial arrangements.
- 3.2: Promote the establishment of tree species predicted to be well adapted to future moisture and temperature conditions.
- 3.3: Increase the representation of northern tree species.
- 3.4: Reduce stem crowding by thinning to concentrate limited resources on remaining trees in order to increase forest vigor.
- 3.5: Increase the amount of large snags.
- 3.6: Increase the amount of large logs.
- 3.7: Establish forested buffers around all water resources.

#### GOAL 4: Provide Refuge

##### ACTIONS

- 4.1: Protect threatened, endangered, and at-risk species.
- 4.2: Identify areas of your land that may support species predicted to thrive in wet, and establish small reserves around these and other areas of high ecological value.

## Step 3

### Monitor and Evaluate



Evaluate past conservation actions to ensure that the goals have been reached



Monitor your woods for stresses and vulnerabilities


Revisit Steps 1 and 2 if past actions haven't achieved goals or new stresses or vulnerabilities arise


Step 1  
Assess Forest Resiliency


Step 2  
Increase Forest Resiliency

# Green Infrastructure Mapping in Taunton Watershed

## Legend

 Taunton Watershed Boundary


 Streams

 Town Boundaries

## Land Use/Land Cover

 Open (Ag. Bare; Non-forest vegetation)

 Commercial/Industrial/High Dens Res

 Low Density Residential


 Forest (incl. Forested Wetland)

 Wetland

 Water

 Cranberry Bog

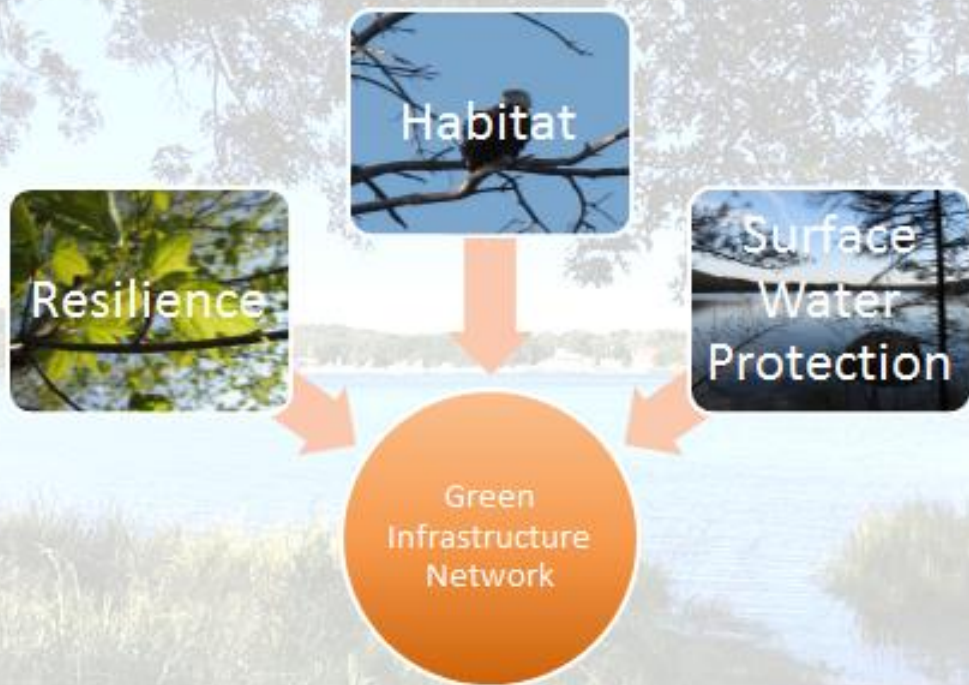
## Major Routes, by Administrative Type

 Interstate

 U.S. Highway

 State Route



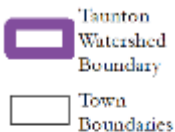


# Resilient Landscapes

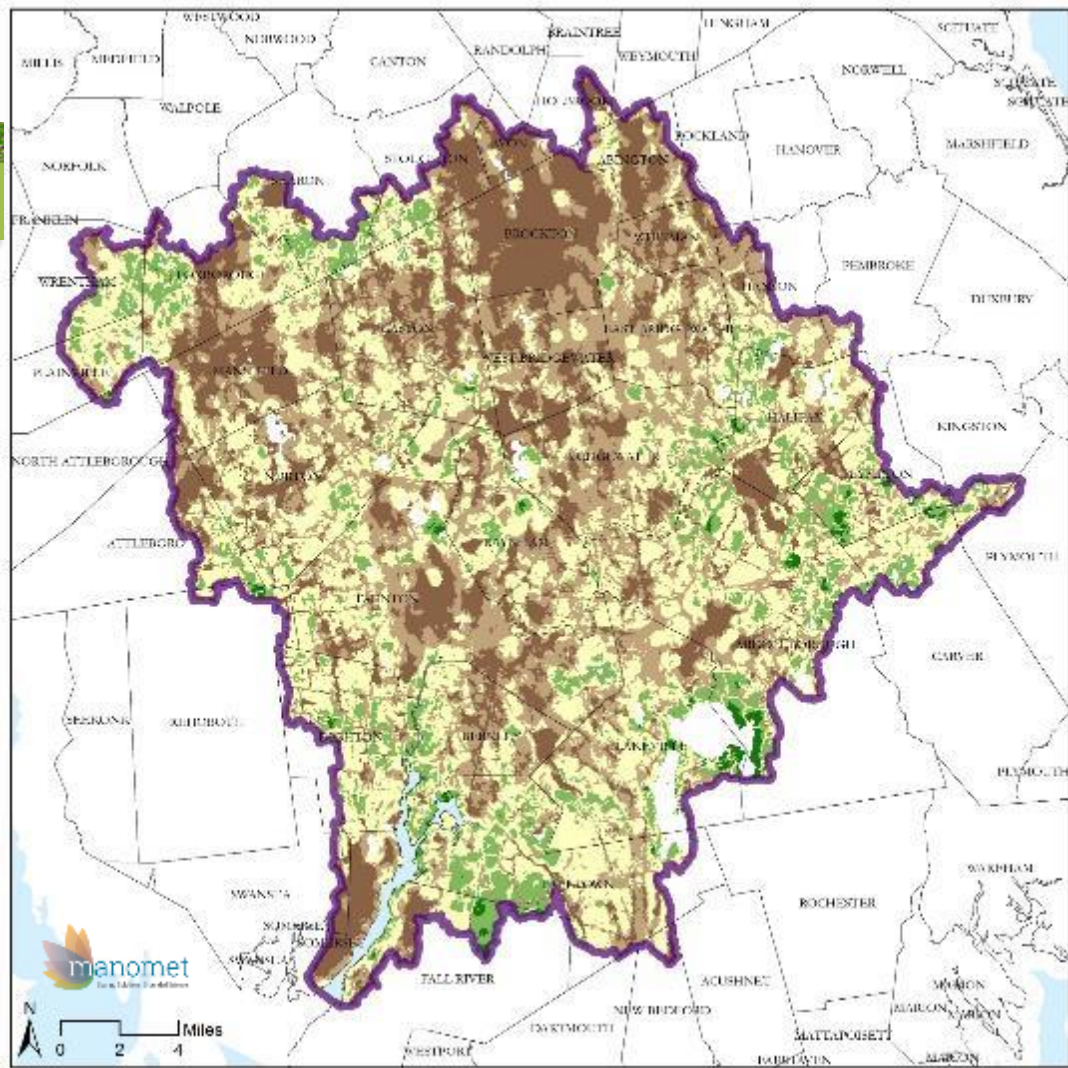
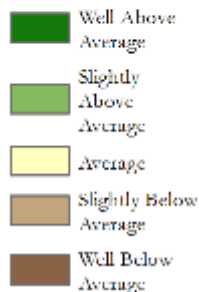


Complex  
topography  
+  
Connected  
natural cover  
+  
High quality  
biodiversity features

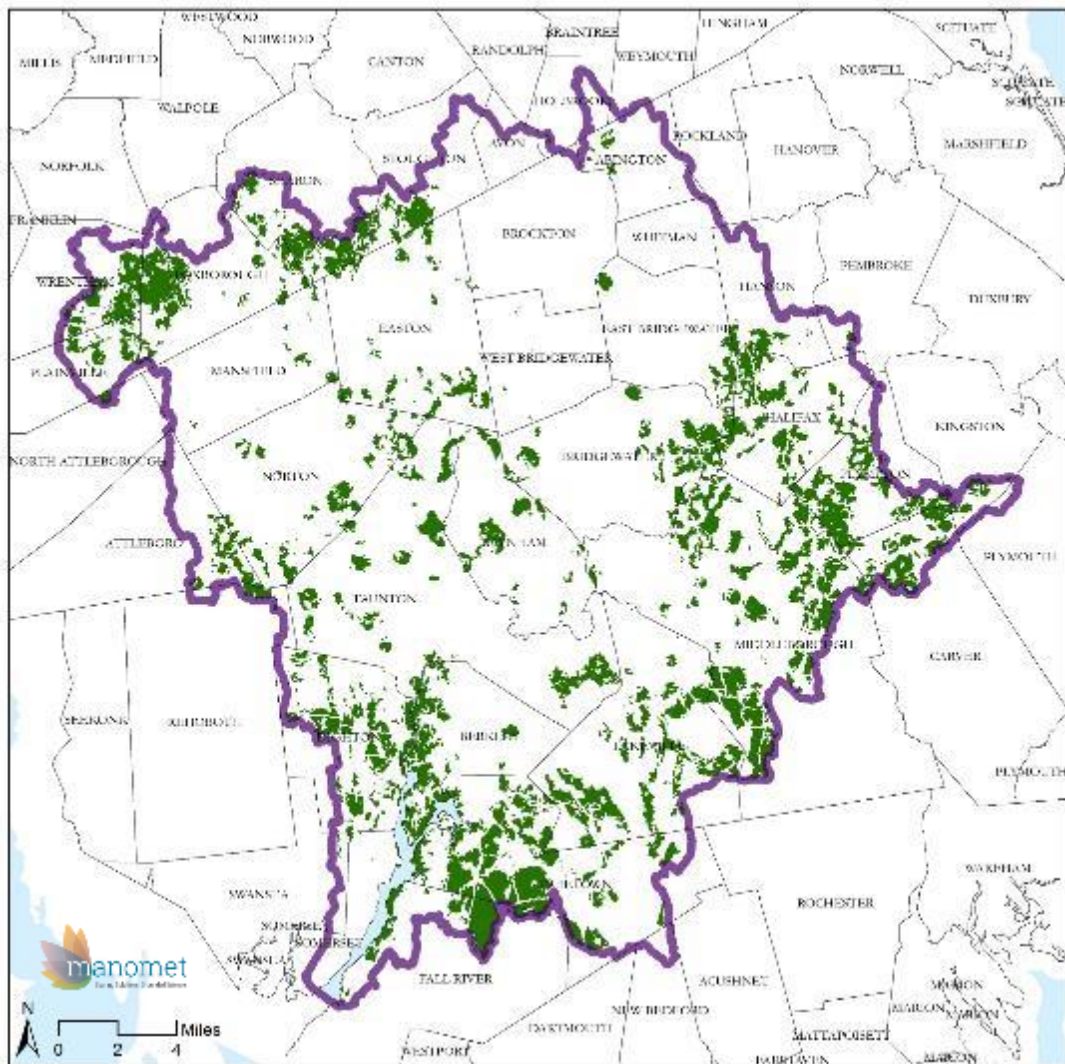
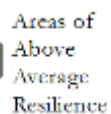
## Legend



## Resilience





### Areas of Above Average Resilience




## Resilient Landscapes

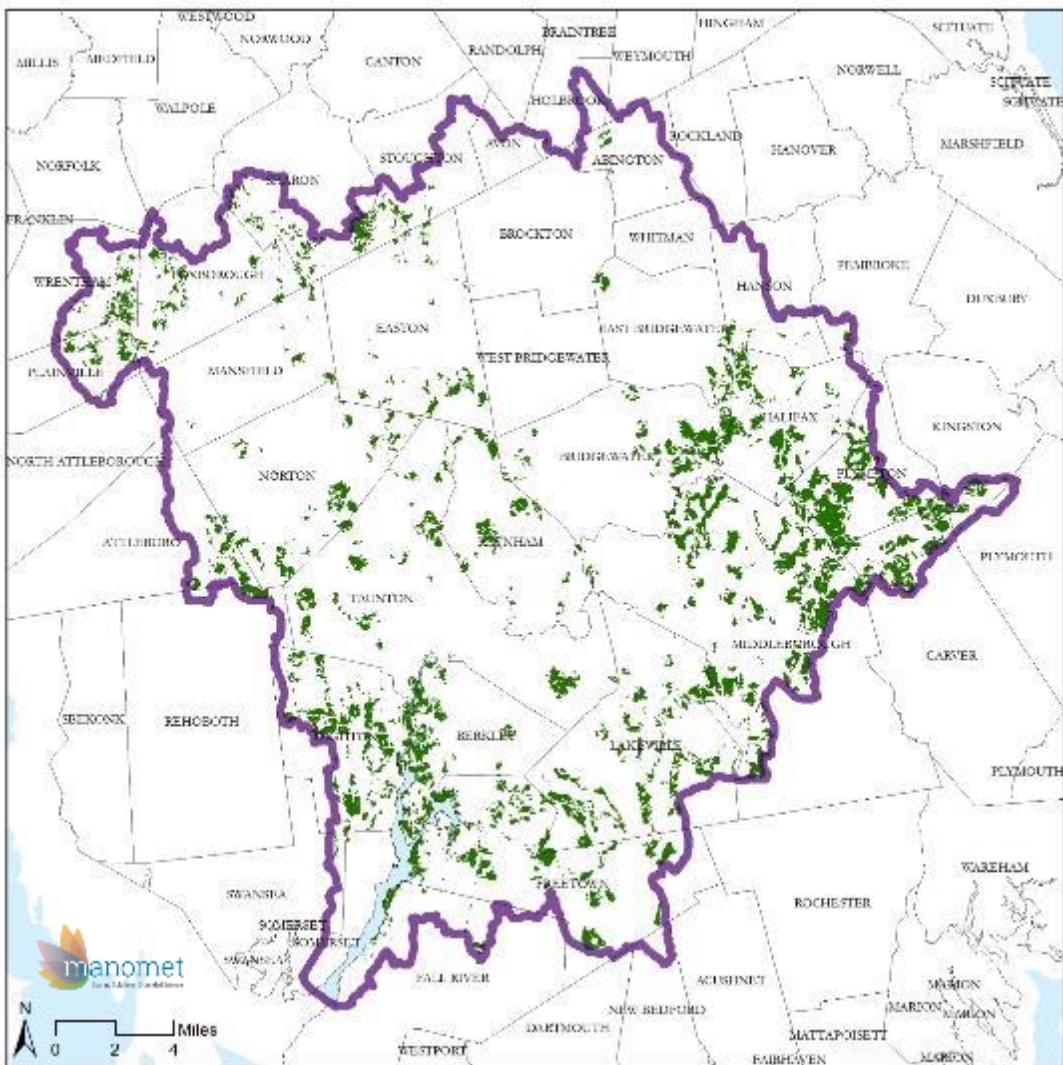
Areas of Above  
Average Resilience  
that are  
**Undeveloped &  
Unprotected**

### Legend

-  Taunton Watershed Boundary
-  Town Boundaries

### Resilience

-  Undeveloped and Unprotected Areas of Above Average Resilience

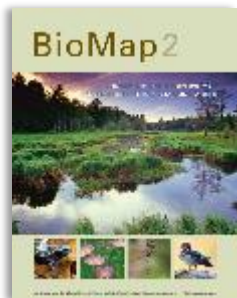


# Green Infrastructure Network Components...

Areas of  
Above  
Average  
Resilience



BioMap2 Core and  
Critical Natural  
Landscape Areas  
that are  
**Undeveloped &  
Unprotected**



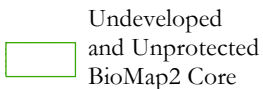
**Legend**



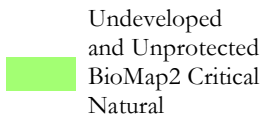
Taunton  
Watershed



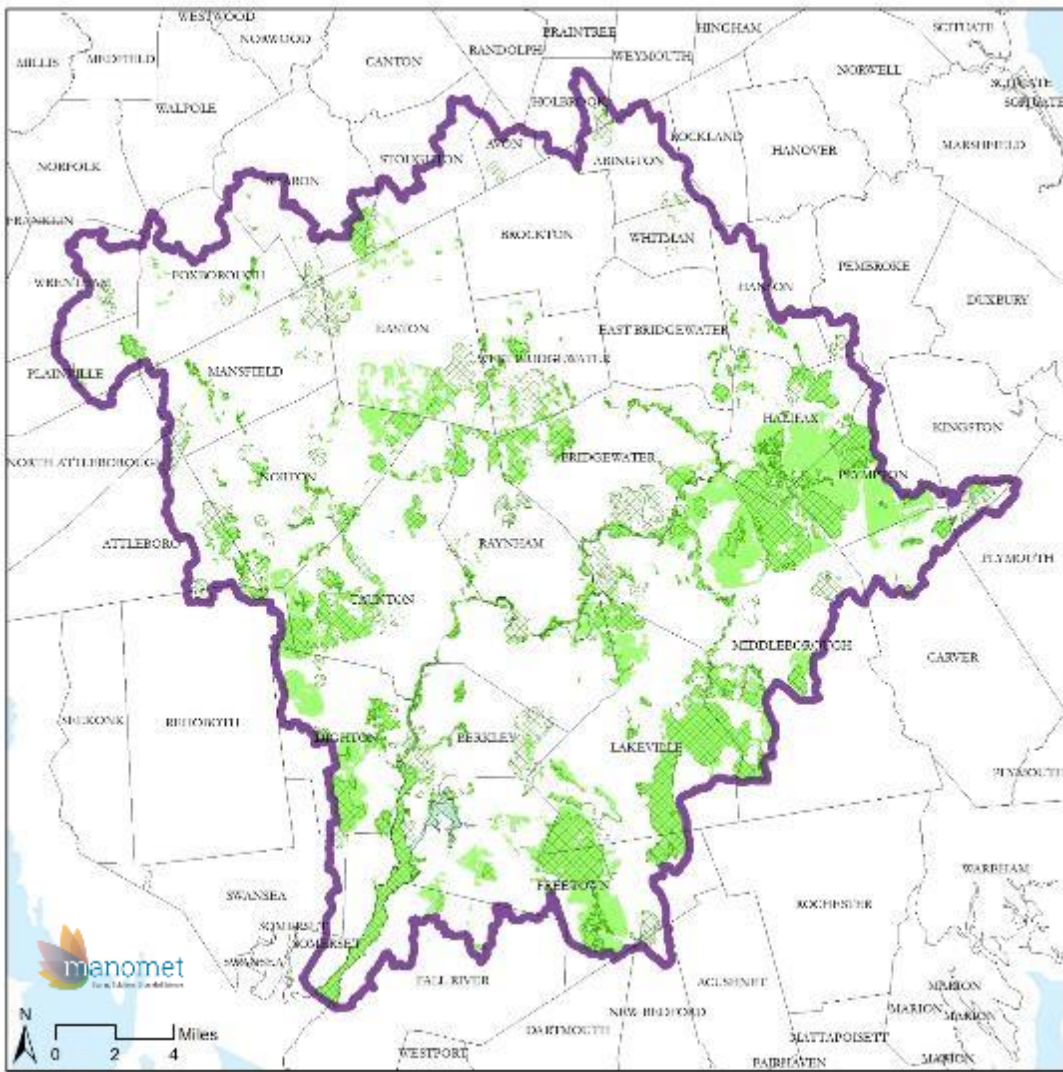
Town



Undeveloped  
and Unprotected  
BioMap2 Core



Undeveloped  
and Unprotected  
BioMap2 Critical  
Natural

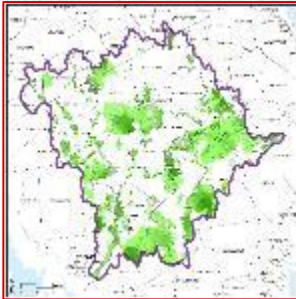


# Green Infrastructure Network Components...

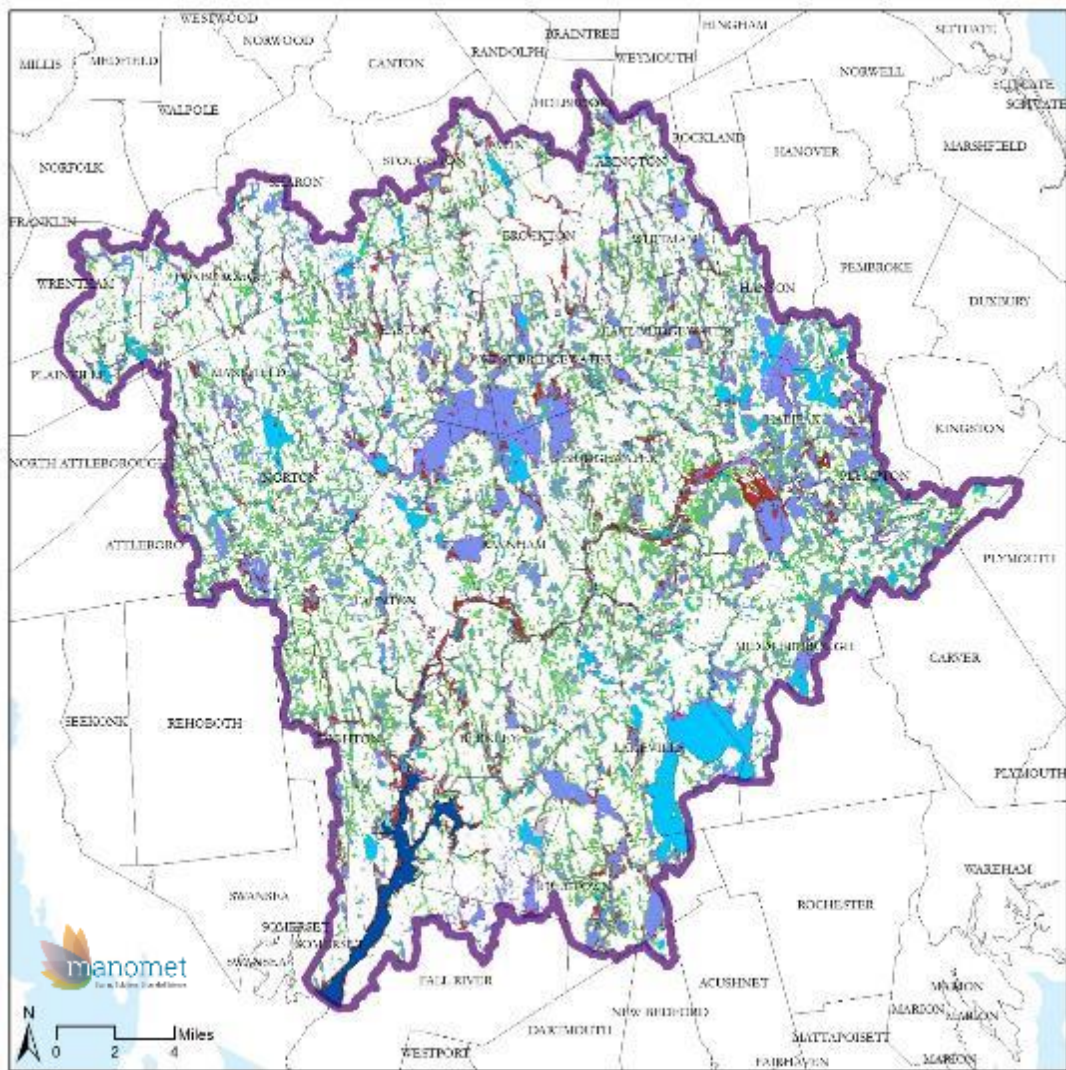
Areas of  
Above  
Average  
Resilience



BioMap2  
Core &  
Critical  
Natural  
Landscape



Surface water, wetlands,  
and Riparian buffer areas  
that are  
**Undeveloped  
& Unprotected**



# Green Infrastructure Network Components...

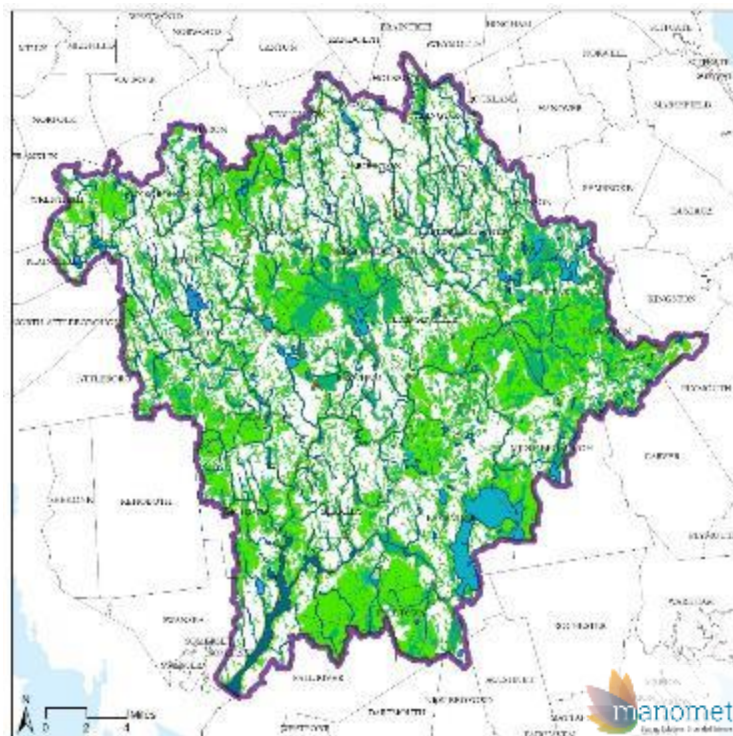
Areas of  
Above  
Average  
Resilience



BioMap2 Core &  
Critical Natural  
Landscape



Areas within 100ft  
of Surface Waters,  
Wetlands, and  
Flood Zones;  
Areas  $\leq$  4m  
elevation  
(vulnerable to sea  
level rise)








## Legend

Green Infrastructure Network	Town Boundary	Surface Waters & Wetlands	Estuarine and Marine Deepwater
100-year and High Risk Coastal Flood Areas	Truro Watershed Boundary	Freshwater Pond, Lake, or Stream	Estuarine and Marine Wetland
	Major Stream	Freshwater Wetland	Other

# Taunton Watershed Green Infrastructure Network

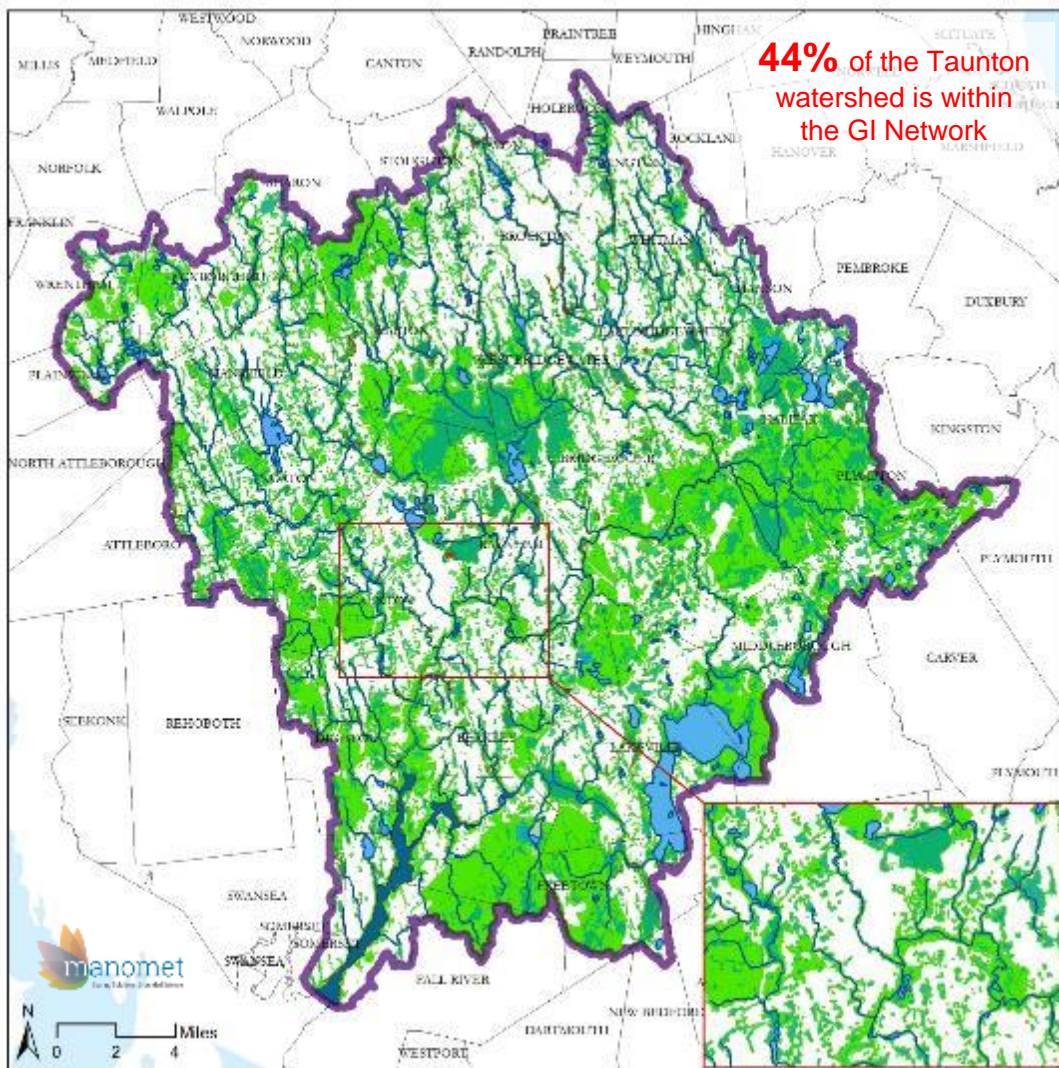
**44%** of the Taunton watershed is within the GI Network

## Legend

-  Green Infrastructure Network
-  100-yr and High Risk Coastal Flood Areas
-  Town Boundaries
-  Taunton Watershed Boundary
-  Major Streams

## Surface Waters & Wetlands

-  Freshwater Pond, Lake, or Stream
-  Freshwater Wetland
-  Estuarine and Marine Deepwater
-  Estuarine and Marine Wetland
-  Other





# Resources for Nature-Based Solutions

## Guidance/Case Studies

- [Naturally Resilient Communities](#) successful project case studies from across the country to help communities learn and identify nature-based solutions
- [EPA's Soak Up the Rain](#) stormwater outreach tools, how-to guides and resources
- [EPA's RAINE](#) database of vulnerability, resilience and adaptation reports, plans and webpages at the state, regional and community level.
- [Climate Action Tool](#) explore adaptation strategies and actions to help maintain healthy, resilient wildlife communities in the face of climate change.

## Mapping/Planning

- [Mapping and Prioritizing Parcels for Resilience \(MAPPR\)](#) identify the priority parcels for protection and climate change resilience
- [Living Shorelines in New England: State of the Practice](#) and [Profile Pages for Solutions](#) are case studies, siting criteria, and regulatory challenges for coastal resilience in New England.
- [Low Impact Development Fact Sheets](#) cover valuing green infrastructure, conservation design, development techniques, regulations, urban waters, and cost calculations.

## Cost/Benefit

- [EPA's Green Infrastructure cost/cost-benefit/tools](#) Database of tools for comparing solution costs
- [Massachusetts Division of Ecological Restoration's](#) economic benefits of aquatic restoration based on Massachusetts case studies

## Bylaws/Ordinances

- [EEA's Smart Growth Toolkit](#) access to information on planning, zoning, subdivision, site design, and building construction techniques
- [Guide for Supporting LID in Local Land Use Regulations](#) provides a framework for communities to review their zoning, rules, and regulations for a number of factors.

# Conclusion

- Importance of stewardship, planning ahead for these critical resource areas
- GI offers efficient ways to both mitigate and adapt to climate change in many types of environments (beach, forest, watershed protection)
- Many options to implement site specific LID practices, including urban areas



# Thank you!

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