Building Community Resilience Through Local Regulations

Participant Guide to Massachusetts Bylaws & Best Practices

Module 1: Let Nature Do the Work!

The Value of Green Infrastructure for Climate Change Resilience

Context

This document is part of a comprehensive curriculum program, *Building Climate Resilience Through Local Regulations*, developed by Mass Audubon in collaboration with other nonprofit organizations and federal, state and regional agencies. The curriculum contains 8 modules, each of which guides the user through different components of improving community resilience through local regulations that support green designs and nature-based climate solutions. Each module includes a participant guide (e.g., this document) and a PowerPoint presentation.

The full curriculum, supplemental resources and additional information on bylaw review and best practices are available through: Massachusetts Rivers Alliance and Mass Audubon. The SNEP Network's website provides additional resources including an interactive virtual storymap and webinar recordings.

Acknowledgements

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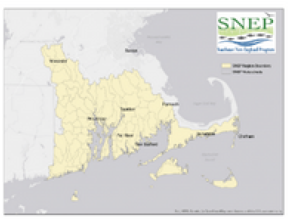

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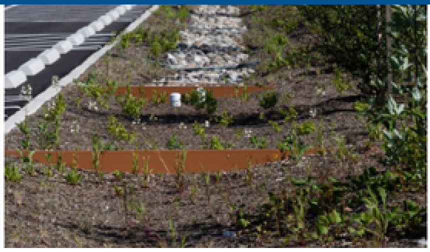
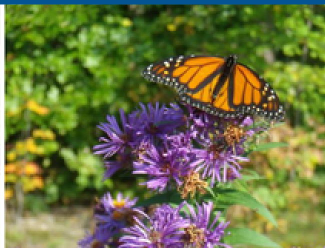
The Southeast New England Program (SNEP) Network brings together local environmental organizations, academic institutions, regional planners, and consultants who collaborate to provide municipalities, tribes and organizations in Rhode Island and Southeast Massachusetts access to free training and technical assistance to advance stormwater management, ecological restoration, and sustainable financing goals across the region. The SNEP Network is administered through EPA's partnership with the New England Environmental Finance Center, a non-profit technical assistance provider for EPA Region 1. The SNEP Network supports this bylaw review curriculum as a key resource for communities to update their local regulations for improved nature-based climate solution implementation. Find out more about the SNEP Network at www.snepnetwork.org.

Module 1 | *Let Nature Do the Work!*



Introduction

Massachusetts is home to a wide range of ecosystems that provide important benefits, or “ecosystem services,” to communities.[1] When communities are developed, native habitat for local flora and fauna is transformed into an environment more suitable to people. Yet the transformation of forests and farmlands into buildings and pavement creates unintended impacts. These effects are exacerbated by a changing climate, with more intense storms and more frequent droughts and heat waves. Much of the built infrastructure we rely on is most effectively protected by maintaining the capacity of land to absorb water, provide shade and cooling, and retain other important functions. This module presents the value of natural systems and nature-based solutions for healthy and safe communities.

Objectives

After completing this module, participants will be able to answer the following questions:

- What is green infrastructure and how does it function?
- What consequences result from the loss of green infrastructure?
- Where do climate change and green infrastructure intersect?

Existing Infrastructure

Infrastructure is generally thought of as the engineered fixtures that enable communities to function in a fast-paced society: roads and bridges connect people and places; utility networks power homes and businesses; and dams, water supply systems, sewers, and stormwater systems keep water flowing. These built structures are referred to as “gray infrastructure” throughout this module. Aging infrastructure is plaguing many New England communities, including those in Massachusetts. Potential costs and service disruptions from failures, repairs, upgrades and maintenance are daunting, with a $40 billion backlog in water infrastructure needs alone.[2]

Deferred maintenance is not the only threat to the built infrastructure that ensures communities operate smoothly; these structures are also vulnerable to damage from environmental stressors. Much of the state’s infrastructure was built over 100 years ago, No-one then could have foreseen the extreme weather

conditions caused by climate change. Even now, new and replacement infrastructure is often constructed to work with historic patterns of precipitation, not the shifting conditions we are experiencing due to climate change. More frequent and intense storm events cause significant damage to the built environment and more frequent droughts stress water supplies. Communities today need more resilient infrastructure solutions to ensure their continued growth and development withstands new climate hazards now and into the future.

Nature itself provides the best models of sustainable strategies to address environmental challenges. For example, natural lands absorb, manage, and filter water to serve ecosystem needs and recharge groundwater. These strategies are often referred to as “nature-based climate solutions,” and often incorporate green infrastructure. Mass Audubon defines green infrastructure as: “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.”

Other organizations define green infrastructure more broadly, and include constructed features like rain gardens, tree boxes, and green roofs. Green infrastructure can be incorporated into the built environment by protecting natural features within a development site or mimicking its functions when the project is designed and built. But the most effective way to leverage the benefits of green infrastructure is by protecting existing natural features and retaining their ecosystem functions.

The Green Infrastructure Network

The natural Green Infrastructure Network (GIN) is a GIS (Geographic Information System) model that maps natural areas most in need of protection and conservation. Developed in 2017 by Plymouth-based environmental organization Manomet, the model includes 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. Statewide, the GIN includes 2.9 million acres — roughly 43% percent of Massachusetts’ total area.[3] The GIN identifies lands of highest ecosystem services and climate resilience value, for planning and open space protection prioritization purposes.

As of 2012, more than one third of the lands included in the GIN have been protected; and 76% of lands conserved between 2012 - 2017 were within the network. These strides illustrate the high priority Massachusetts communities place on natural resources: statewide, land is being conserved faster than it’s being developed. Yet our most important natural resources are still under threat. During the same period, nearly 40% of new development (9,300 acres) occurred within the GIN. More work is needed to protect these critical areas.

The Importance of Green Infrastructure

Resilient lands, important habitat, riparian buffers, and areas vulnerable to sea level rise are critical to the health and safety of Massachusetts communities, including the protection they provide for the investments made in the built environment. To learn more about ecosystem services provided by different types of natural lands, see Mass Audubon's "The Value of Nature" guide. Some of the most important functions are summarized below.

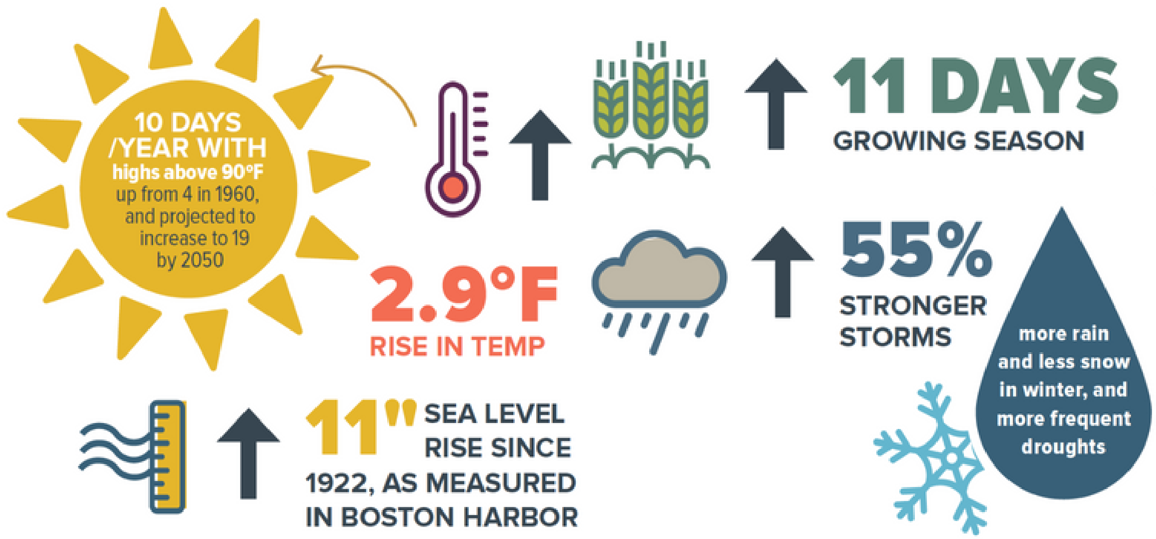
Carbon Sequestration

Natural areas are important for carbon sequestration, or the process of capturing carbon dioxide (CO_2) from the environment and storing it on Earth. This function is critical to combating climate change, as CO_2 is the most abundant greenhouse gas trapping heat in the Earth's atmosphere and causing global warming. The most abundant natural system sequestering carbon in Massachusetts are forests. The Commonwealth has roughly three million acres of forests, storing on average between 80 and 100 tons of CO_2 in each acre — that's roughly 7% of the state's annual carbon emissions![4](Note: the specific CO_2 storage of any given area depends on the forest's health and maturity.)

Massachusetts' abundant coastal and wetland resources are also crucial to capturing CO_2: the annual sequestration rate of healthy coastal ecosystems (e.g., salt marshes, seagrasses, mangroves, etc.) is 10 times greater than that of terrestrial forests.[5] The Commonwealth's salt marshes are among the most productive ecosystems in the world.[6] Destruction of these valuable resources would release a significant amount of that stored carbon into the atmosphere, one of many reasons it is so important to protect them.[7] Inland wetlands are also important carbon sinks: 20-30% of soil carbon globally is held in wetlands, which only comprise 5-8% percent of the world's land area.[8] Massachusetts is fortunate to boast such rich and varied natural areas that mitigate climate change by reducing CO_2 in the atmosphere.

Clean Air

Natural systems not only sequester carbon; they actually help clean the air itself. Each year, New England's forests remove an estimated 760,000 tons of air pollutants, which would otherwise cause smog and ground-level ozone. This air filtration protects public health by reducing respiratory illnesses and asthma, valued at roughly $550 million in health benefits.[9] Urban green spaces also benefit communities by filtering air and mitigating urban heat island effect on a smaller, localized scale: "trees cool the air by casting shade and releasing water vapor, and their leaves can filter out fine particulate matter (PM)—one of the most dangerous forms of air pollution, generated from burning biomass and



fossil fuels." [10] According to The Nature Conservancy, localized effects from trees offer the greatest return on investment for large and densely populated cities; but "neighborhoods in virtually any city could benefit from plantings." [11]

Modeling from one study suggests that homes screened by trees experience reductions of indoor particulate matter concentrations by more than 50%, and "the efficacy of roadside trees for mitigation of PM health hazard might be seriously underestimated in some current atmospheric models." [12] The study warns of the human health impacts from particulate matter, emphasizing the urgent need for these natural services: "exposure to airborne particulate pollution is associated with premature mortality and a range of inflammatory illnesses, linked to toxic components within the particulate matter (PM) assemblage." [13]

Water Filtration

Natural vegetation not only benefits air quality, but also filters pollutants from water. Massachusetts forests take up about half of the state's average 40 inches of annual precipitation each year. Water and nutrients absorbed through their roots support growth and photosynthesis. [14] The remaining 50% of that water either runs off the land as stormwater (stormwater will be thoroughly addressed in subsequent modules), or is filtered through soil and vegetation as it makes its way into the ground and recharges groundwater supplies.

Each forested acre draining into the public water supply filters 543,000 gallons of drinking water each year! That water is worth $2,500 a year, and meets the annual water needs of roughly 19 people.[15] Across New England, forests save communities hundreds of millions of dollars in water filtration services each year.[16] According to the US Environmental Protection Agency (EPA), every $1 invested in water-source protection yields an average $27 in avoided water treatment costs.[17]

Flooding

According to the Federal Emergency Management Agency (FEMA), floods are among the most common and widespread natural disasters. [18] This is a rising concern for communities, as climate change increases the damage caused from flood events. Fortunately, natural infrastructure can mitigate flood impacts, protecting ecosystems and the built environment. When rain falls faster than the ground can absorb, it needs somewhere to go. Wetlands act as natural sponges — soaking up to a million gallons of water per acre and slowly releasing it back into the environment when it's needed. Wetland vegetation amplifies these benefits by taking up water and holding soil in place, reducing erosion. Wetlands also provide a vegetated buffer that slows floodwaters down, allowing for groundwater recharge and reducing potential flood heights downstream by up to 20%.[19]

Stormwater

When a site is cleared for development, the loss of vegetation results in less water absorbed through plant processes (evapotranspiration) or infiltrating into the ground. Adding impervious surfaces (e.g., asphalt, rooftops, concrete, etc.) further exacerbates stormwater runoff. Stormwater picks up pollutants from these surfaces as it travels, eventually flushing these unwanted contaminants into local waterways. Stormwater pollution is the single greatest source of contamination to Massachusetts waterways, responsible for more than 50% of the state's water quality impairments, underscoring the vital importance of retaining natural features within or adjacent to developed areas.

Storm Surge

Coastal areas are particularly and increasingly vulnerable to flooding, especially from storm surge. More than 89,000 homes in Massachusetts are threatened by high tide flooding, and projected sea level rise dramatically increases that figure.[20] Storms not only cause flooding, but also generate high wave heights that cause additional damage. Salt marshes, seagrass beds, and coastal wetlands help absorb and dissipate this wave effect,[21] reducing annual flood losses by roughly 16%. During Hurricane Sandy in 2012, for example, coastal wetlands prevented $625 million in direct flood damage.[22] As sea levels rise, natural buffers such as salt marsh and seagrass will need space to migrate and adapt to the changing shoreline. If properly managed, they will continue to protect coastal communities from powerful weather systems and climate impacts.

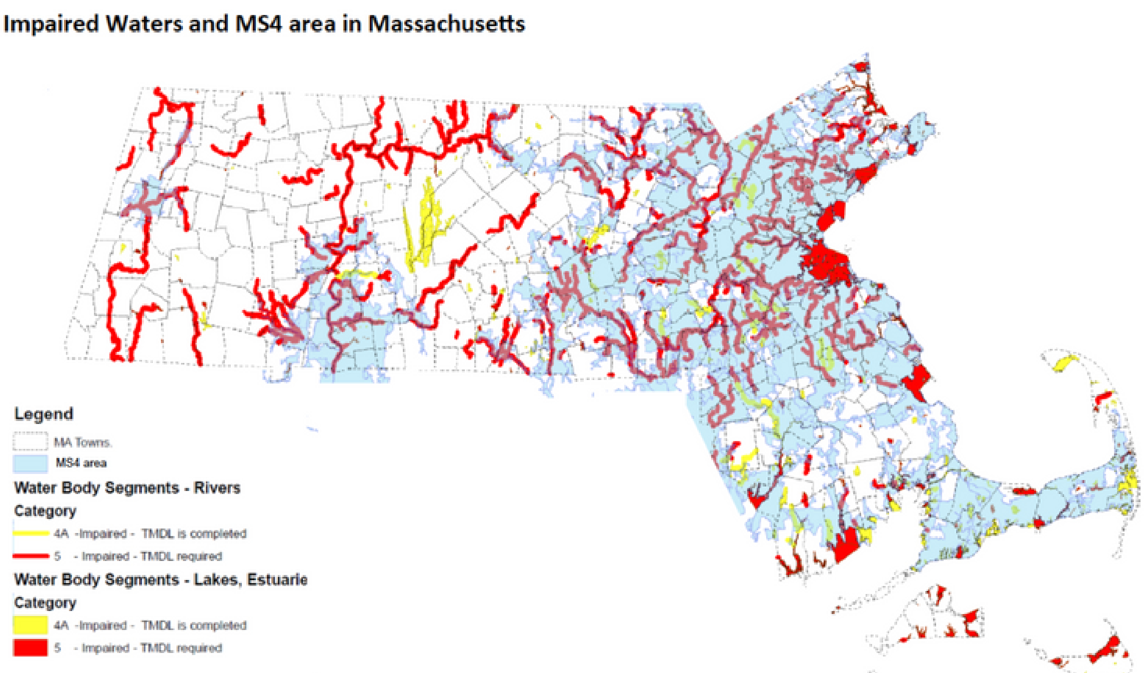


Figure 1. Map of impaired list of waters and municipal storm sewer system areas (2012). *Source: US EPA Region 1.*

Impacts of Traditional Development

Traditional development often involves clearing and grading an entire site, losing the natural ecosystem services that its native flora and fauna provide. When natural vegetation is replaced with pavement and other impervious surfaces, there are many impacts including loss of groundwater recharge, increased runoff and pollution, and flooding and erosion. Excessive pavement also creates heat islands, increasing impacts from heat waves, and reduces groundwater recharge, exacerbating the impacts of drought on stream flows and water supplies. Local land use rules that support the retention and replacement of natural green infrastructure functions can avoid and minimize these impacts.

Building Community Resilience

Maintaining the functionality of natural green infrastructure to absorb, filter and infiltrate water, provide shade and cooling, and the many other beneficial services nature provides is one of the most cost effective ways communities can provide resilience to climate change impacts. Wetland buffers, natural shorelines, and vegetated riparian areas help protect communities from increased flood risks. Forests, urban trees, and other vegetation cool and filter both air and water, improving both environmental and human health. Natural systems and green infrastructure can supplement built stormwater and flood protection systems. Incorporating these natural processes into engineered systems enhances system function and capacity.

Severe weather affects communities differently, depending on the natural features, resources, and topography of the landscape. Green infrastructure can often be adapted to meet the needs of any community context, improving the function of engineered stormwater infrastructure. Protecting existing green infrastructure, incorporating green features into development, and restoring degraded lands bolster climate resilience, and provide many additional community benefits.

Conclusion

This module introduced the important functions of green infrastructure in the context of a changing climate. Natural functions highlighted include carbon sequestration, air and water filtration, and flood buffering. Forested, wetland, coastal, and even urban ecosystems provide critical services that protect the health and safety of community members and the built environment they depend on. Module 2 will explore strategies for preserving green infrastructure during development and utilizing natural systems for stormwater management and other benefits. The additional modules in this series provide more information about how to achieve these benefits with best practices in land use regulations.

End Notes

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