Natural climate solutions in Massachusetts:

How landowners are using wetlands, farms, and forests to fight climate change

Laura Marx: The Nature Conservancy (MA)
Sebastian Gutwein: Regenerative Design Group
Sara Grady: Mass Audubon

Image Credits (L to R): Emma Gildesgame, Belle Isle saltmarsh, Meredyth Babcock, Westfield River forest

We know how to solve climate change...

- REDUCE EMISSIONS

- REMOVE EMISSIONS

- ADAPT TO EMISSIONS

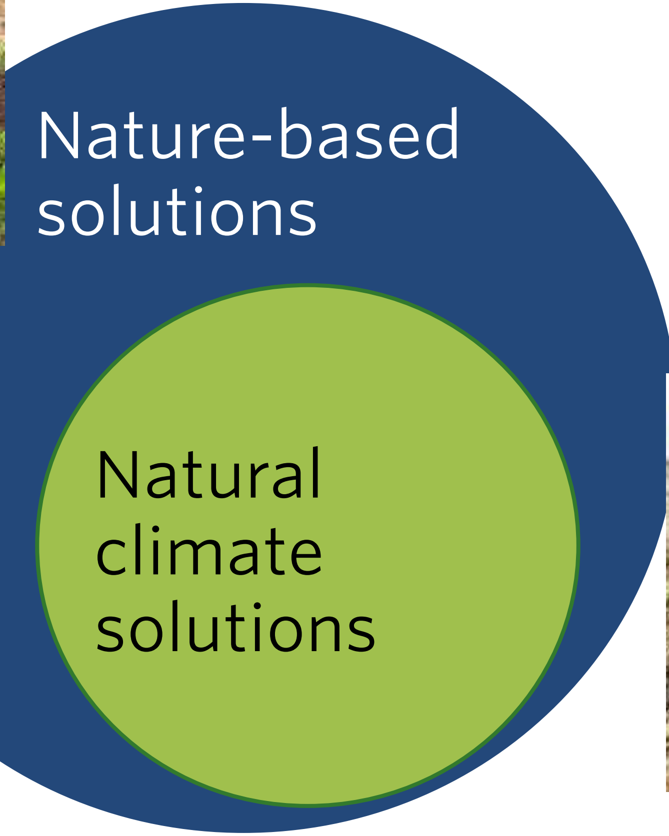
NATURAL CLIMATE SOLUTIONS

Protect, **restore** & better **manage**

forests, **farms, grasslands,** & **wetlands**

to **reduce** and/or **remove** carbon emissions.

Nature-based solutions: Using nature to solve a problem



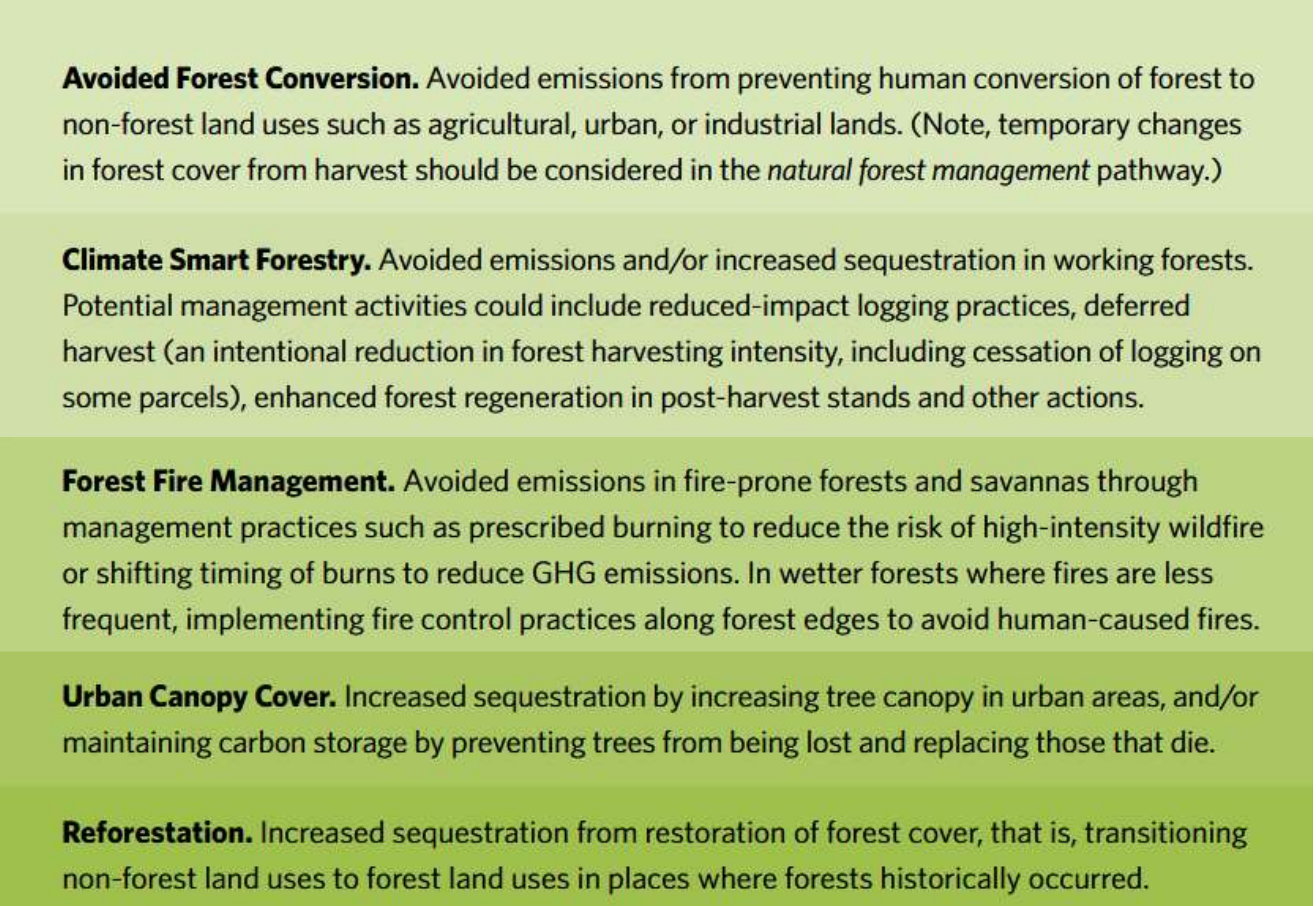
Nature-based solutions

Natural climate solutions

Photo credits: Rain garden, Marion Soil and Conservation Water District; Reforestation, Erika Nortemann, TNC

As land trusts, you all work to avoid the loss of lands and waters. Your very mission is a natural climate solution.

The Nature Conservancy's St. John preserve, Westhampton



Avoided Forest Conversion. Avoided emissions from preventing human conversion of forest to non-forest land uses such as agricultural, urban, or industrial lands. (Note, temporary changes in forest cover from harvest should be considered in the *natural forest management* pathway.)

Climate Smart Forestry. Avoided emissions and/or increased sequestration in working forests. Potential management activities could include reduced-impact logging practices, deferred harvest (an intentional reduction in forest harvesting intensity, including cessation of logging on some parcels), enhanced forest regeneration in post-harvest stands and other actions.

Forest Fire Management. Avoided emissions in fire-prone forests and savannas through management practices such as prescribed burning to reduce the risk of high-intensity wildfire or shifting timing of burns to reduce GHG emissions. In wetter forests where fires are less frequent, implementing fire control practices along forest edges to avoid human-caused fires.

Urban Canopy Cover. Increased sequestration by increasing tree canopy in urban areas, and/or maintaining carbon storage by preventing trees from being lost and replacing those that die.

Reforestation. Increased sequestration from restoration of forest cover, that is, transitioning non-forest land uses to forest land uses in places where forests historically occurred.

Out of 21 global NCS pathways, ~16 are opportunities in MA

Avoided Coastal Wetland Impacts. Avoided emissions by preventing degradation and/or loss of saltwater wetlands (including mangroves, salt marshes, and seagrass beds) from drainage, dredging, eutrophication, or other anthropogenic disturbances.

Avoided Freshwater Wetland Impacts. Avoided emissions by preventing degradation and/or loss of freshwater wetlands (primarily peatlands) from peat fires, drainage, dredging, eutrophication from fertilizers, or other anthropogenic disturbances.

Coastal Wetland Restoration. Avoided emissions by restoring degraded saltwater wetlands (including mangroves, salt marshes, and seagrass beds) through activities such as rewetting or increasing salinity by reestablishing hydrologic connectivity, as well as increased sequestration by restoring vegetation.

Freshwater Wetland Restoration. Avoided emissions from degraded hydric soils by restoring the hydrologic function of drained or converted freshwater wetlands (primarily peatlands)[12] and increased sequestration by restoring vegetation.

Trees in Agricultural Lands. Increased carbon storage from adding or protecting trees in crop or pasture lands. This could include silvopasture (trees in grazing lands), tree intercropping/alley cropping (trees in rows with annual crops in between), riparian buffers, shelterbelts/windbreaks, and/or farmer-managed natural regeneration (changing management to allow trees to naturally regrow in some areas).

Nutrient Management. Avoided emissions from fertilizer manufacture by reducing the over-application of nitrogen fertilizer through adoption of the "4R" best practices (right source, right rate, right time, and right place)[13].

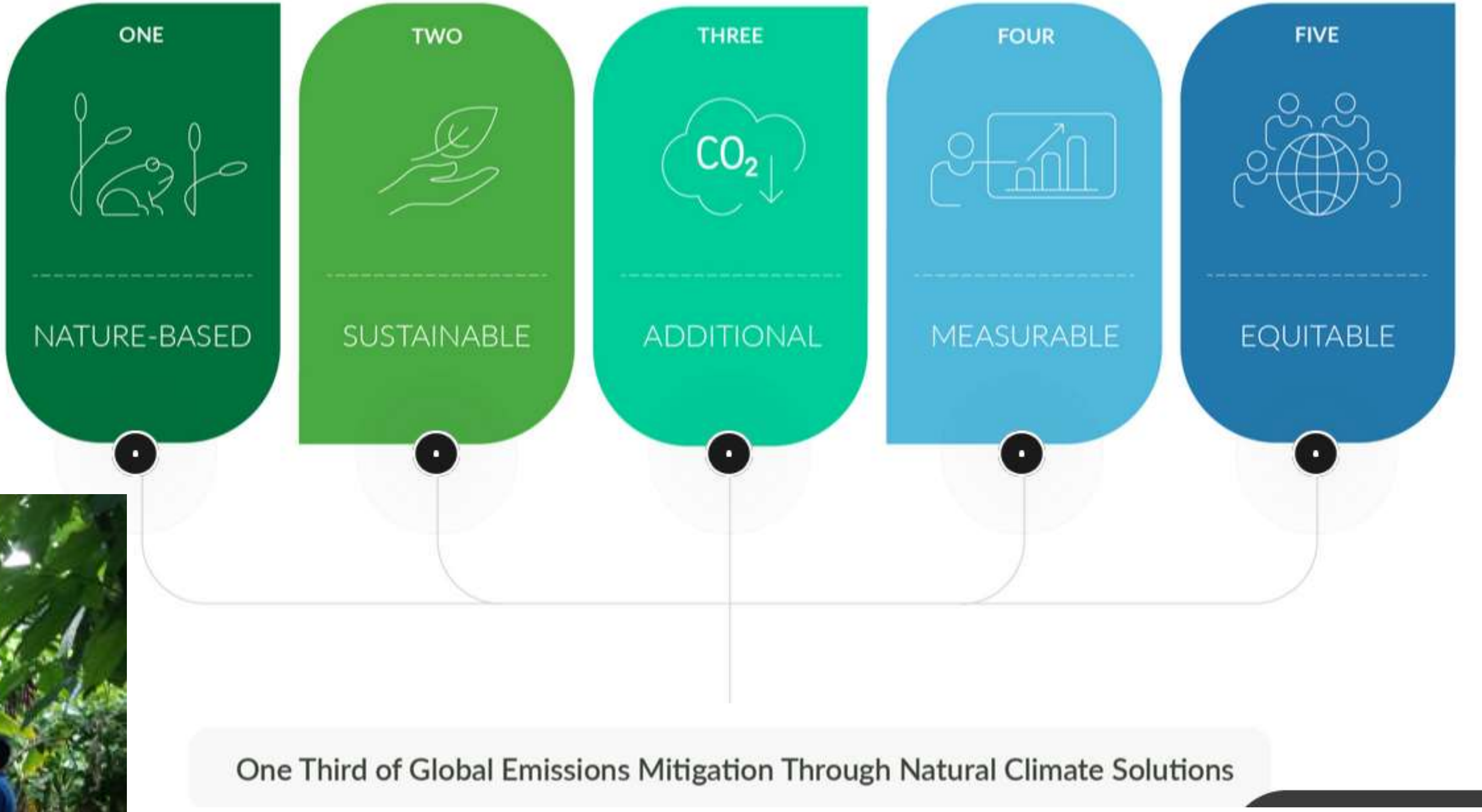
Biochar. Increased sequestration in agricultural soils by converting crop residues to charcoal and applying these as soil amendments to agricultural fields. This pathway does not include forest residues to avoid possible perverse incentives that may inadvertently reduce carbon stored in forests.

Cover Crops. Increased sequestration in agricultural soils from growing additional crops when the main crop is not growing. When legume crops are used, decreased emissions from fertilizer manufacturing resulting from reduction in use of inorganic fertilizer are also included.

Reduced Tillage. Increased sequestration in agricultural soils by adopting reduced- or no-till practices in croplands.

Legume Crops. Avoided emissions from reduced use of nitrogen fertilizers by switching cultivation from grains to legumes in alternating years.

Legumes in Pastures. Increased sequestration in soils due to sowing legumes in planted pastures; restricted to areas where this would result in net sequestration. Also includes, where relevant, avoided emissions from fertilizer application to pastures.



ONE
NATURE-BASED

TWO
SUSTAINABLE

THREE
ADDITIONAL

FOUR
MEASURABLE

FIVE
EQUITABLE

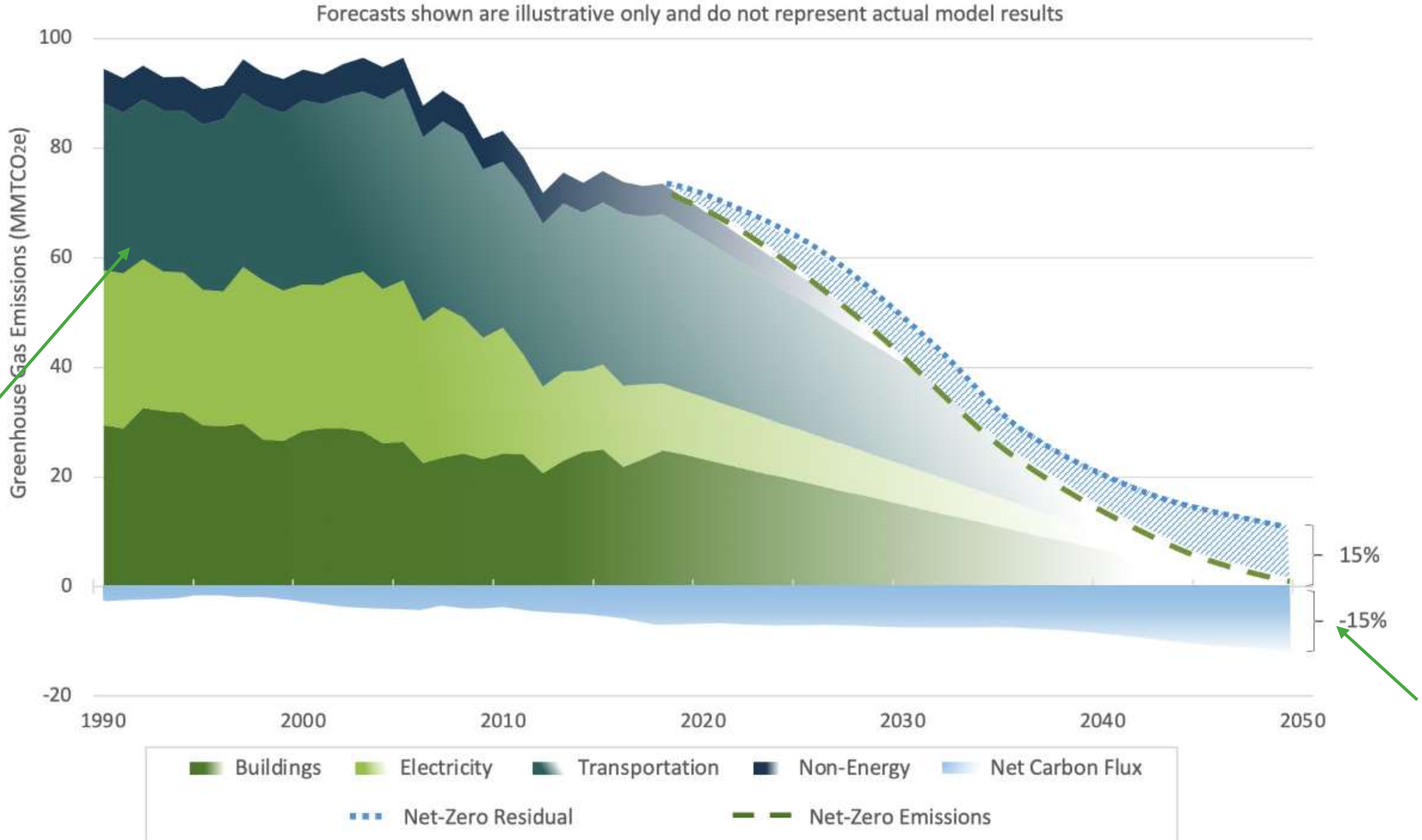
One Third of Global Emissions Mitigation Through Natural Climate Solutions

Images: Top, treeplantation.com, Bottom, Laura Marx, TNC

Ellis, P.W., Page, A.M., Wood, S. *et al.* The principles of natural climate solutions. *Nat Commun* **15**, 547 (2024). https://doi.org/10.1038/s41467-023-44425-2

Natural climate solutions are the only way we can reach “net zero” in Massachusetts (from MA EEA’s 2050 Decarbonization Roadmap)

Figure 1. Net Zero requires deeper emissions reductions than the Commonwealth’s previous “80% by 2050” target, as well as a new requirement to balance any remaining emissions with the same amount of carbon removal from the atmosphere.



Biggest action needed is reducing fossil fuel use

But net zero also requires natural climate solutions.

What you can do #1:

There is a role for nearly every acre:

✓ Planning development more compactly, and avoiding some of the highest-carbon forests and wetlands

✓ Reducing nutrient run-off to avoid killing salt marsh plants and eelgrass, maintaining their ability to store decades or centuries' worth of carbon underground

✓ Practicing climate-smart forestry in our forests to produce wood while also growing more wood and trees and carbon over time

✓ Adding cover crops to fields to restore the soil and store more carbon in what would normally be an off season

Many people and organizations are already working on natural climate solutions, and the next 3 case studies will show you some examples.

Images: MA Healthy Soils Action Plan

Soils case study

Image: NRCS


Ecological Landscape Design


Educational Landscapes + Trainings

Regenerative
DesignGroup
COOPERATIVE


Research , Analysis, + Planning


Regenerative Agriculture

MA Healthy Soils Action Plan

Funded by the Massachusetts Office of Energy and Environmental Affairs

BSLA
Boston Society of Landscape Architects

The Masssachusetts and Maine Chapter of the American Society of Landscape Architects

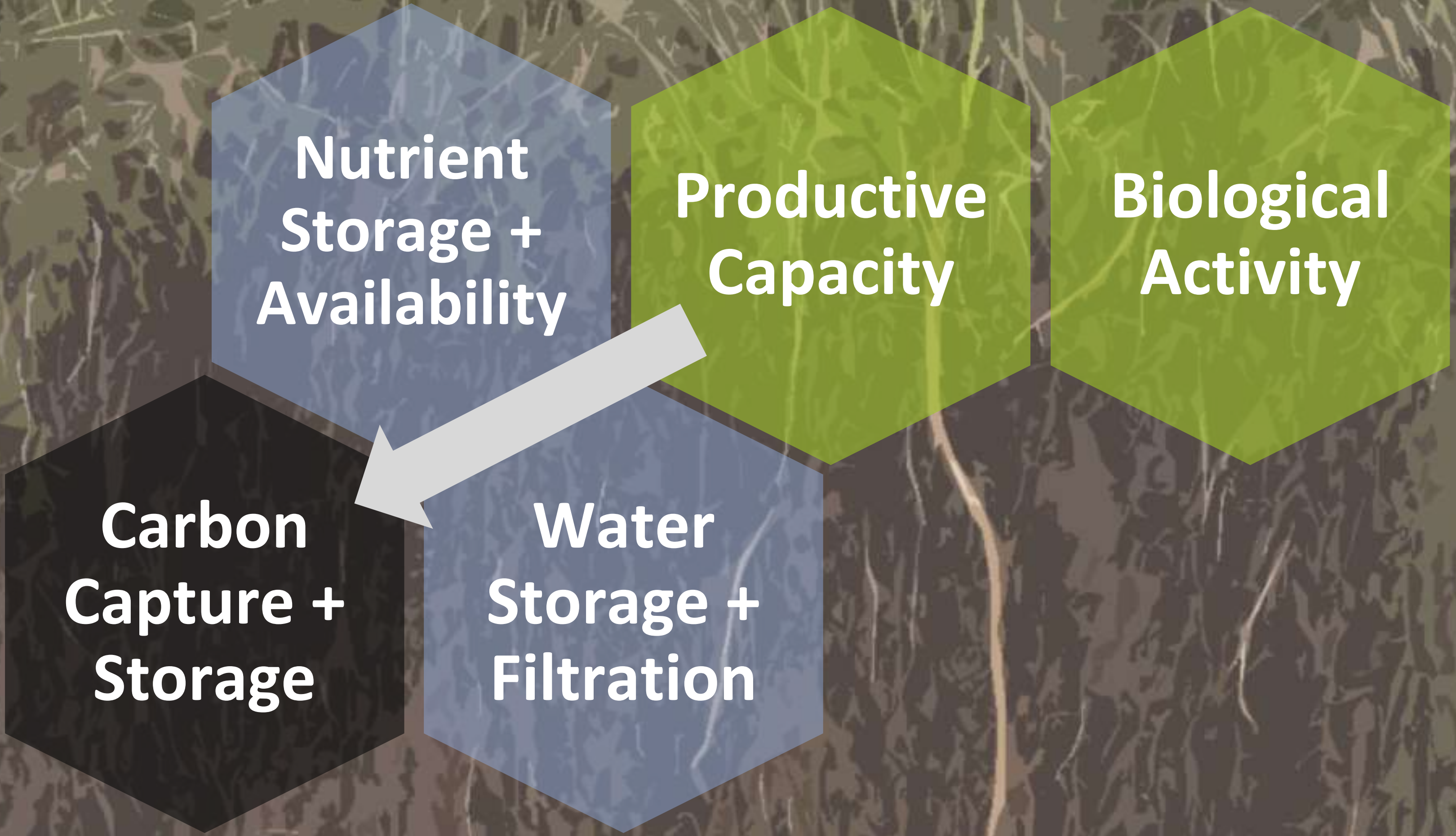
2023 Special Recognition Award

Significant value to Landscape Architecture

Why are healthy soils so important for climate change mitigation and adaptation?

Regenerative DesignGroup

Carbon the Cornerstone of Healthy Soil Functions



Nutrient Storage + Availability

Productive Capacity

Biological Activity

Carbon Capture + Storage

Water Storage + Filtration

Geodiversity

Biodiversity requires diversity of habitats.
This means a diversity of soil types not only high functioning soils.

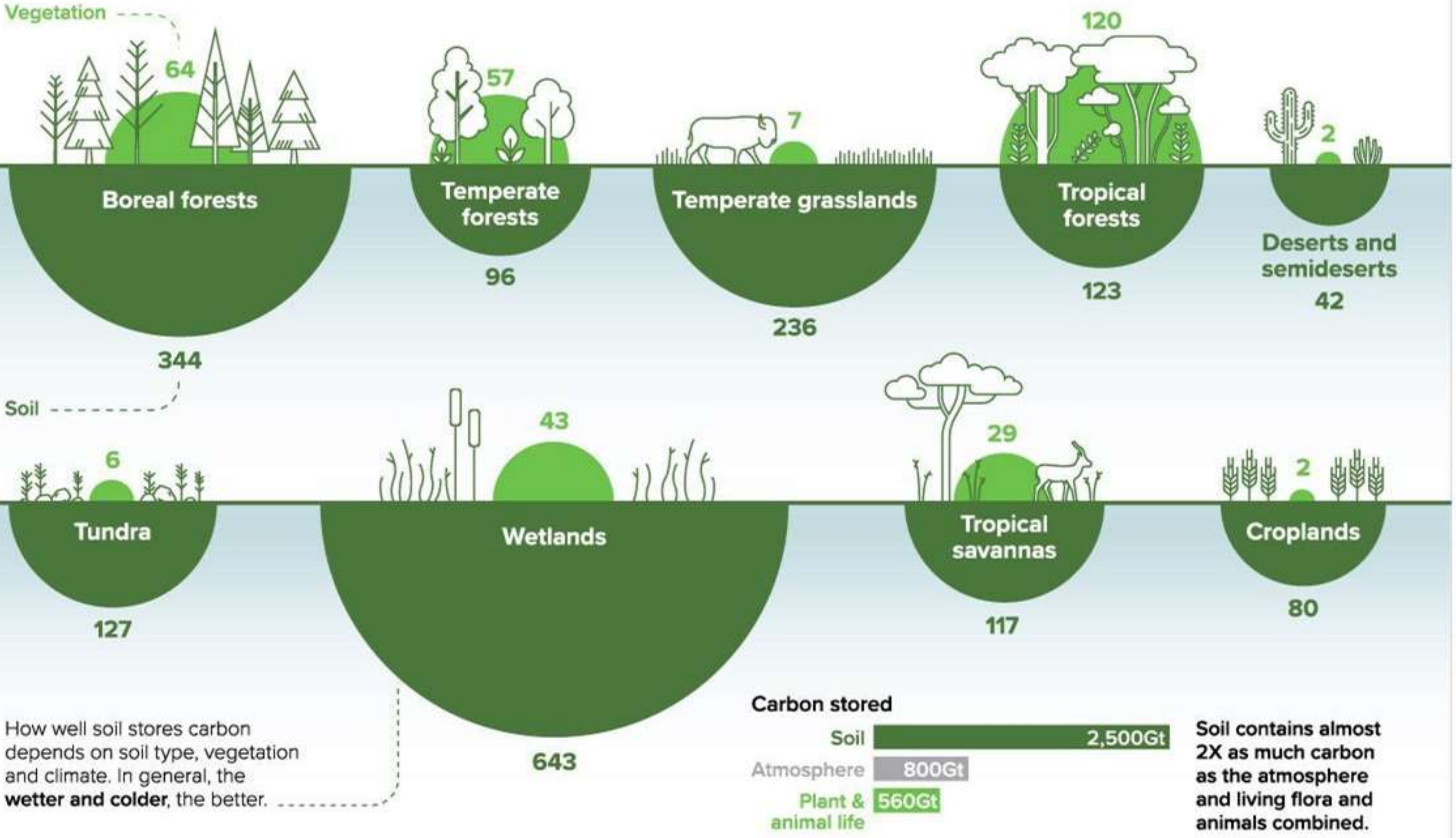
Where is the Soil Carbon?

Carbon Storage

Tonnes of Carbon

The world's forests absorb around **15.6 gigatonnes** of CO_2 each year. That's around 3X the annual CO_2 emissions of the United States.

However, around **8.1 gigatonnes of CO_2 leaks back into the atmosphere** due to deforestation, fires and other disturbances.



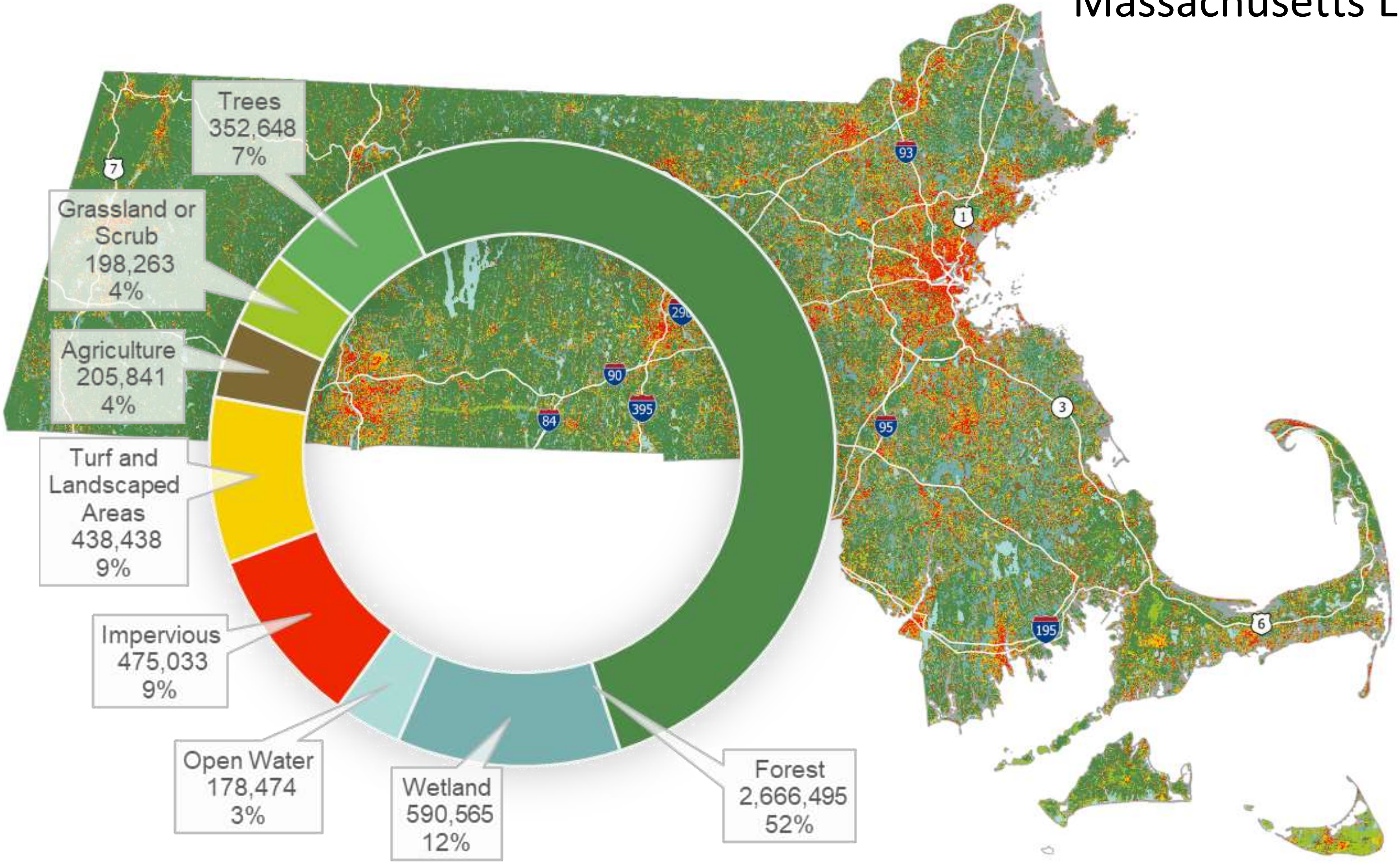
How well soil stores carbon depends on soil type, vegetation and climate. In general, the **wetter and colder**, the better.

Soil contains almost 2X as much carbon as the atmosphere and living flora and animals combined.

Average stored carbon in tonnes per hectare at a ground depth of one meter

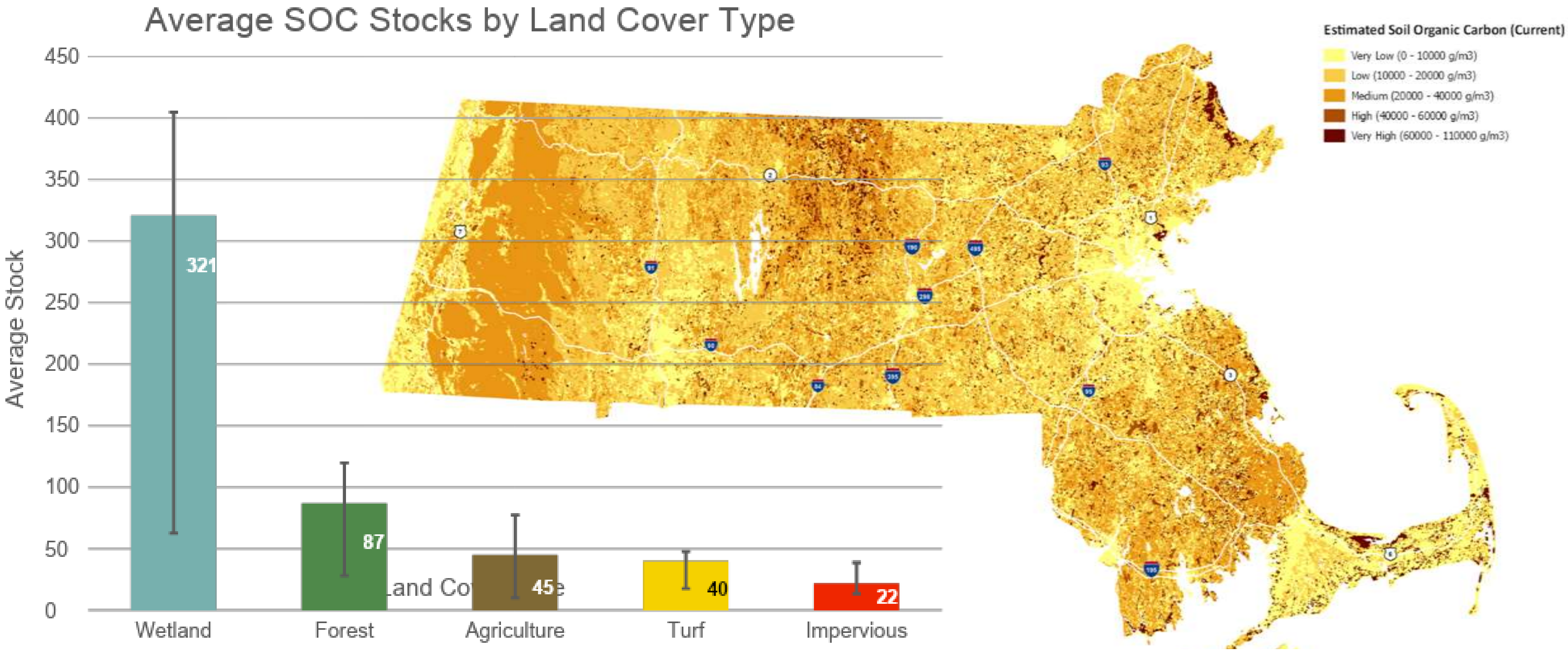
Sources: IPCC; NASA

Massachusetts Land Cover



Regenerative DesignGroup

Soil Carbon Concentration



Final estimate of SOC stocks for Massachusetts Healthy Soils Action Plan

Average land cover tons of SOC values per acre from the NRCS Rapid Carbon Assessment & meta-analysis, adjusted for forest variability, were assigned to acreage of each land cover from simplified 2016 High Resolution Land Use Land Cover layer from MassGIS.

396 Million Metric Tons

Estimated Soil Organic Carbon

Existing SOC Stocks by Land Cover Type

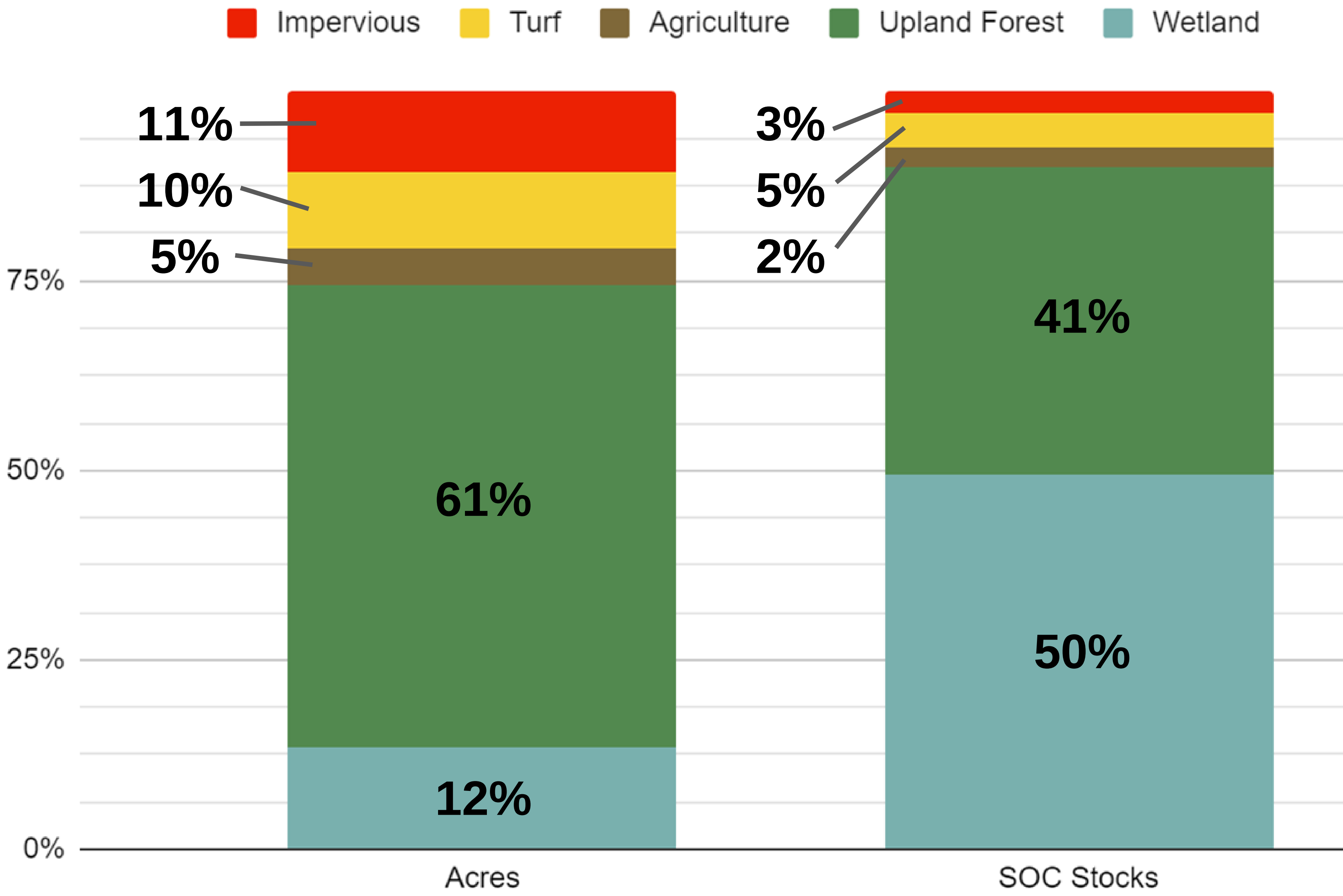
Soil Organic Carbon (SOC) in Massachusetts

396 million metric tons,

equal to 1.5 billion tons CO_2

Regionally specific ratios + conditions:

- Most wetlands in MA are forested wetlands
- Combined with land use change patterns to inform strategic soil conservation planning



What Impacts Soil Carbon?

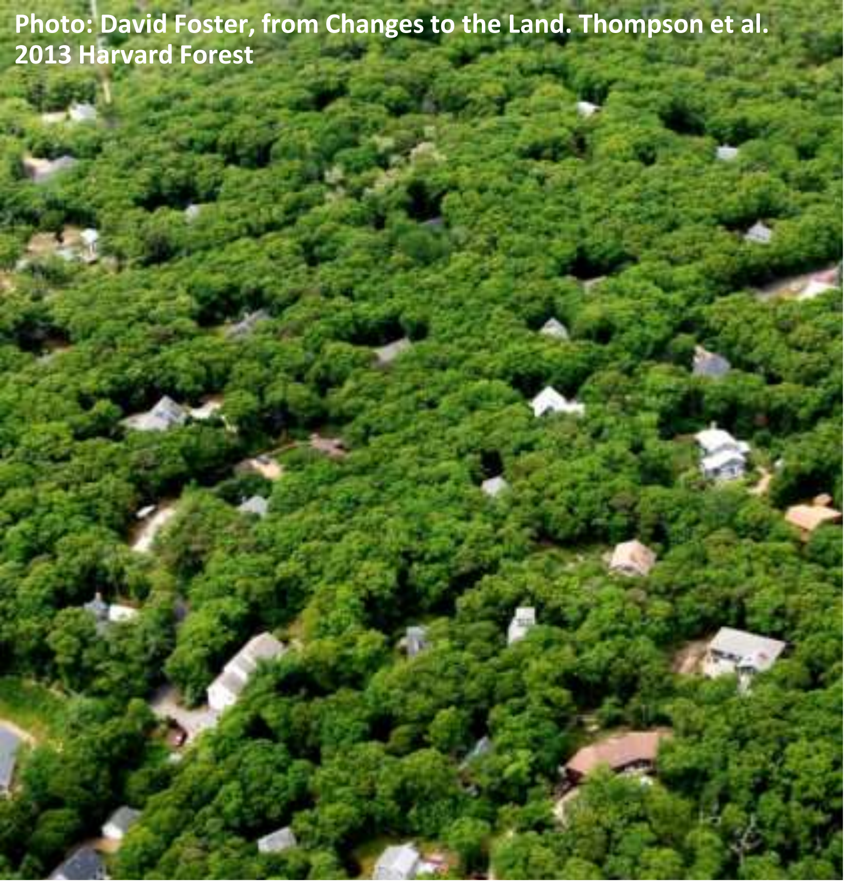


Photo: David Foster, from Changes to the Land. Thompson et al. 2013 Harvard Forest

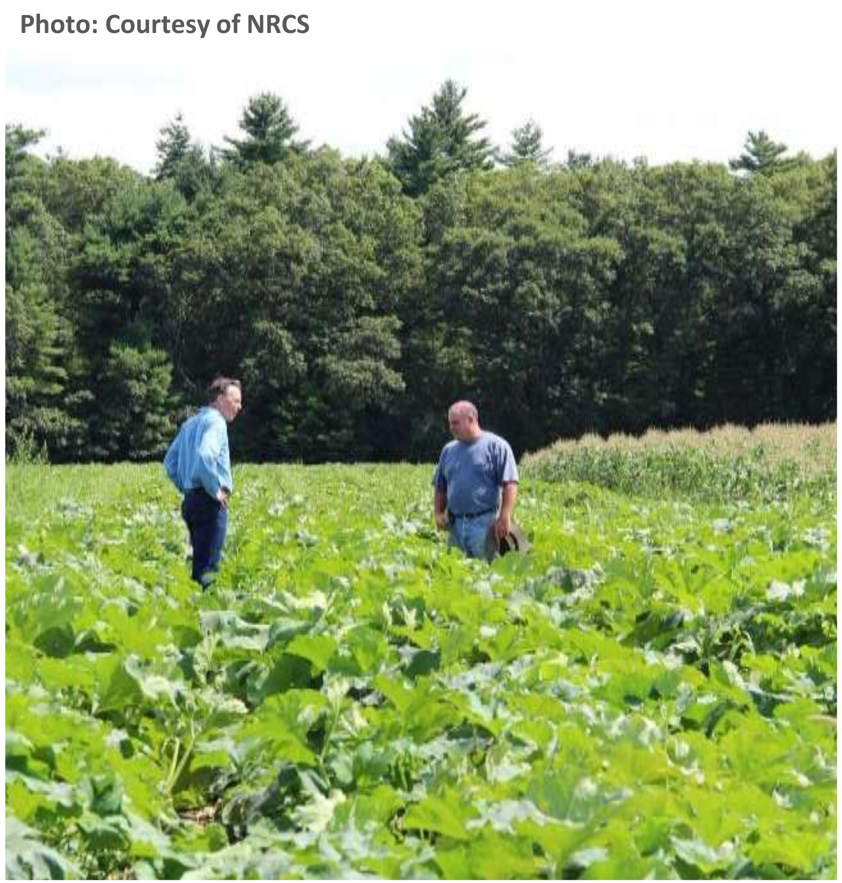


Photo: Courtesy of NRCS


Photo: NASA Earth Observatory image by Robert Simmon, using Landsat

Soil Health Vulnerabilities

Land conversion | Management | Climate Change

Soil Formation (Pedogenesis)

5 SOIL FORMING FACTORS

INVISIBLE

- Time: Short to geologic

VISIBLE

- Parent Material
- Climate and Climate Change
- Organisms/ Biota
- Landscape Position/ Topography

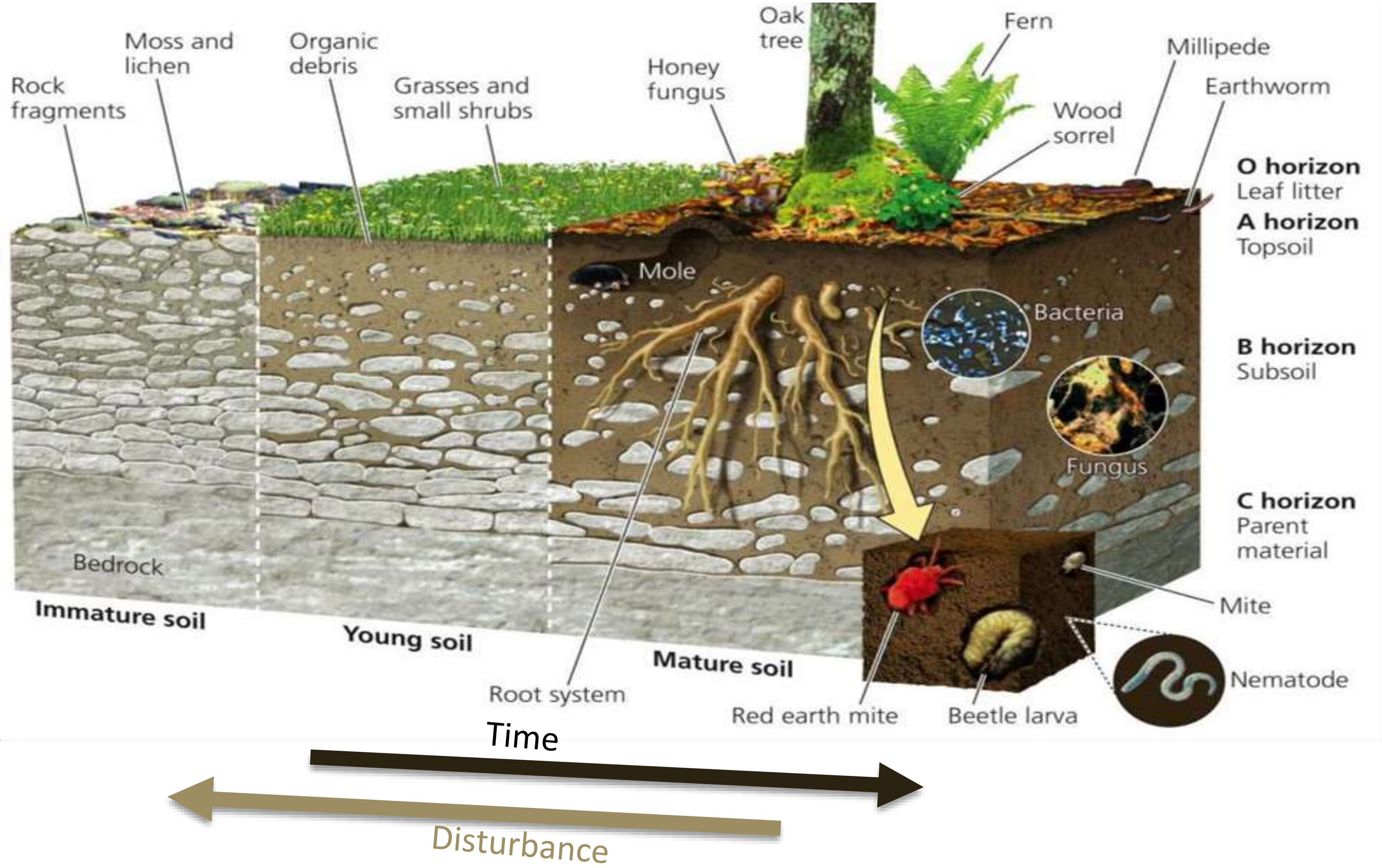
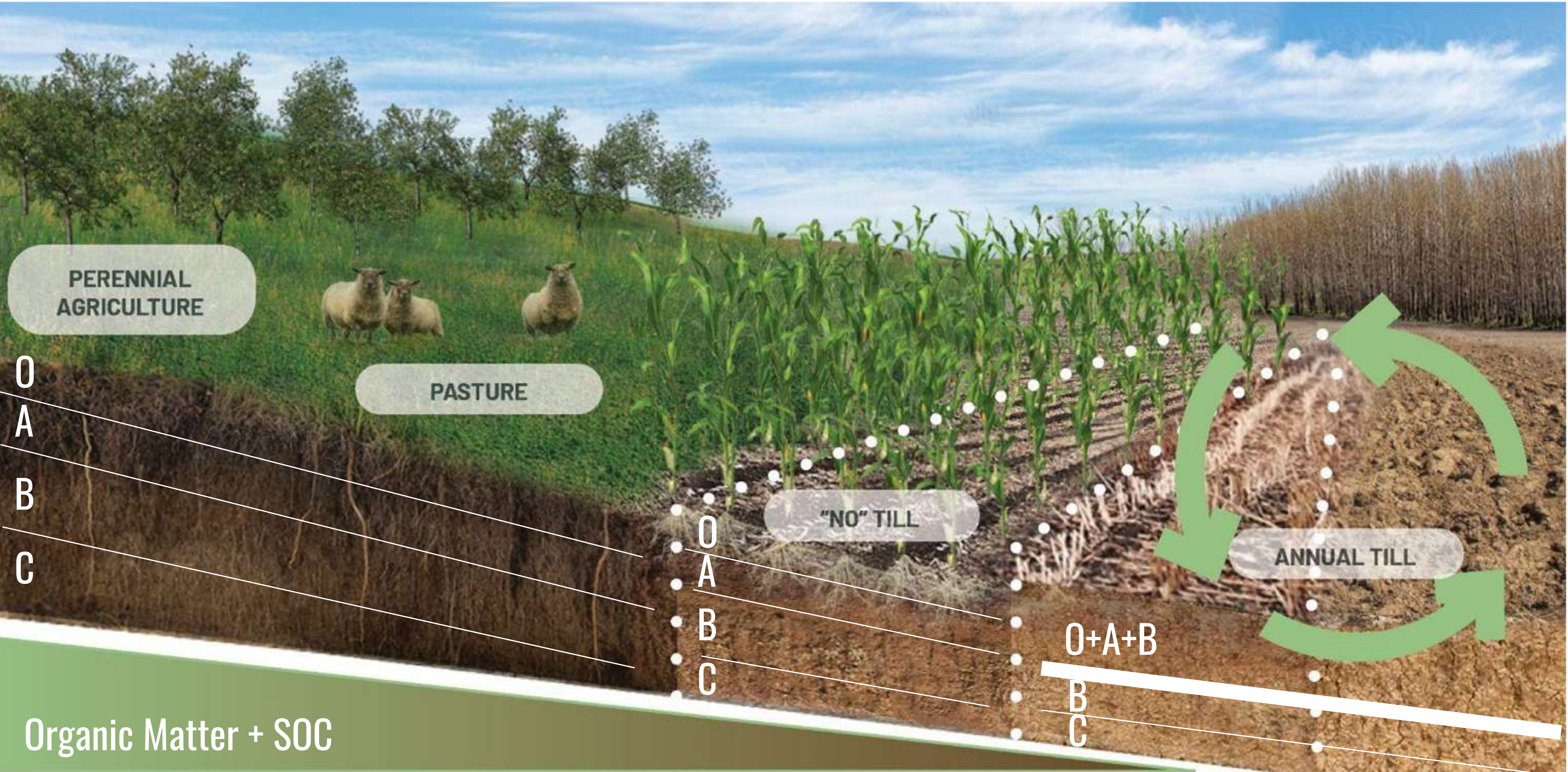


Image: University of Minnesota Extension

Agricultural Soils: Patterns of Disturbance

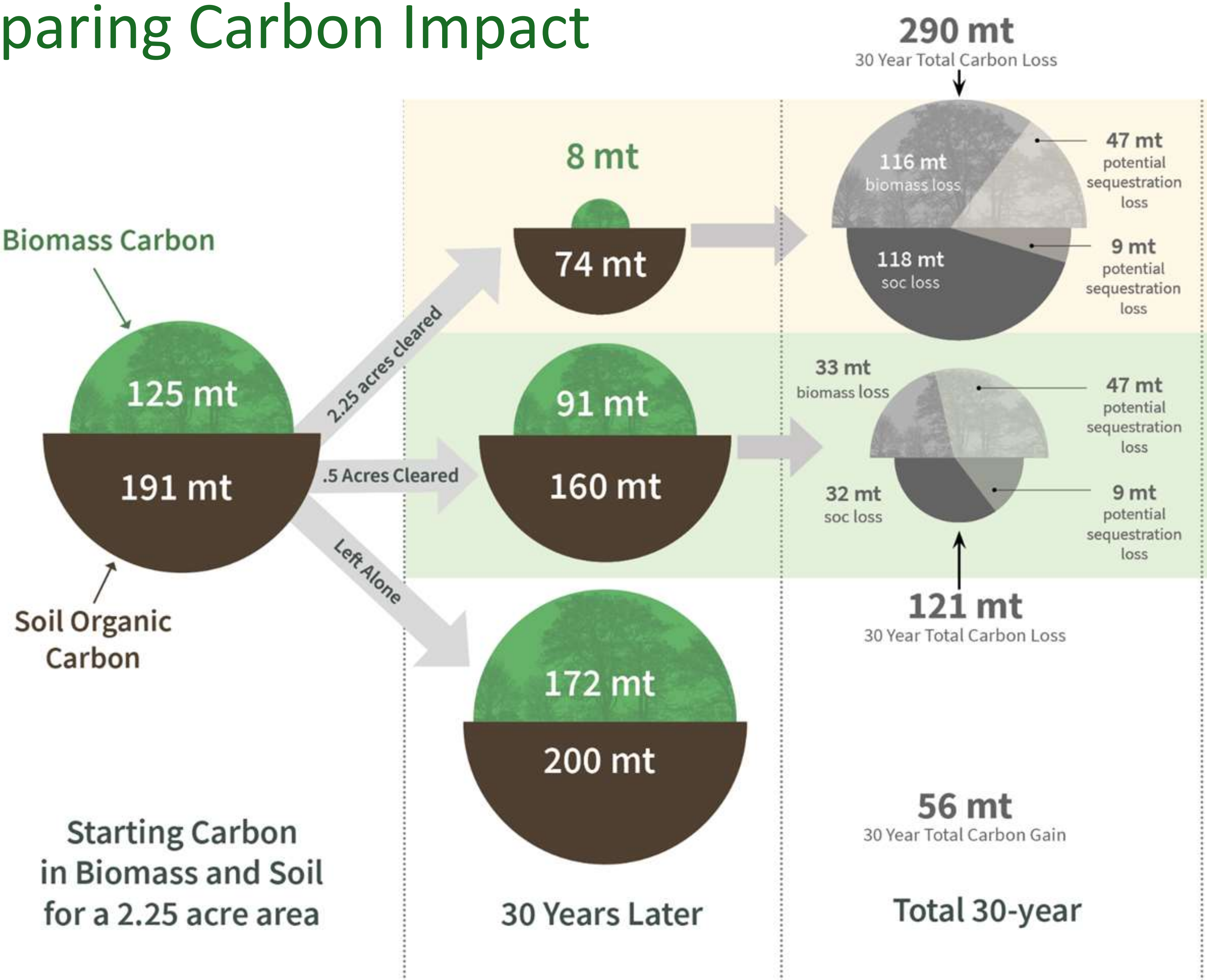


Construction Soils: Patterns of Disturbance


Site A
2.25 Acres Cleared


Site B
0.5 Acres Cleared

Comparing Carbon Impact



Biomass Carbon

125 mt

191 mt

Soil Organic Carbon

Starting Carbon in Biomass and Soil for a 2.25 acre area

2.25 acres cleared

.5 Acres Cleared

Left Alone

8 mt

74 mt

91 mt

160 mt

172 mt

200 mt

30 Years Later

290 mt
30 Year Total Carbon Loss

116 mt biomass loss

118 mt soc loss

47 mt potential sequestration loss

9 mt potential sequestration loss

33 mt biomass loss

32 mt soc loss

47 mt potential sequestration loss

9 mt potential sequestration loss

121 mt
30 Year Total Carbon Loss

56 mt
30 Year Total Carbon Gain

Total 30-year

- 2.25 acres
- Mostly Lawn, Meadow, and Perennial Garden Established

- 0.5 acres
- Mostly Lawn and Perennial Garden Established

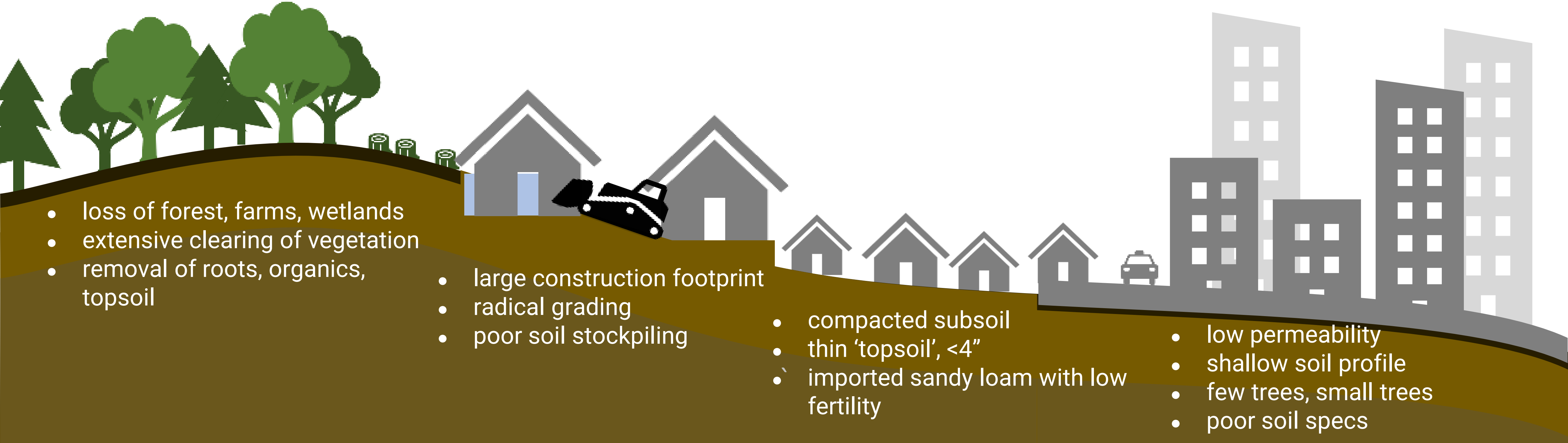
Business-as-usual Development

from Massachusetts Healthy Soils Action Plan 2050 projections for land cover change and carbon flux

Total Area Impacted = >360,000 ac
Forest, Farms, Wetland = - **146,000 ac**
Re-Developed Land = 214,000 ac

Total SOC Losses by 2050 = 25 million metric tons CO2

(Soil disturbance alone, not including biomass + carbon footprint of construction)



- loss of forest, farms, wetlands
- extensive clearing of vegetation
- removal of roots, organics, topsoil

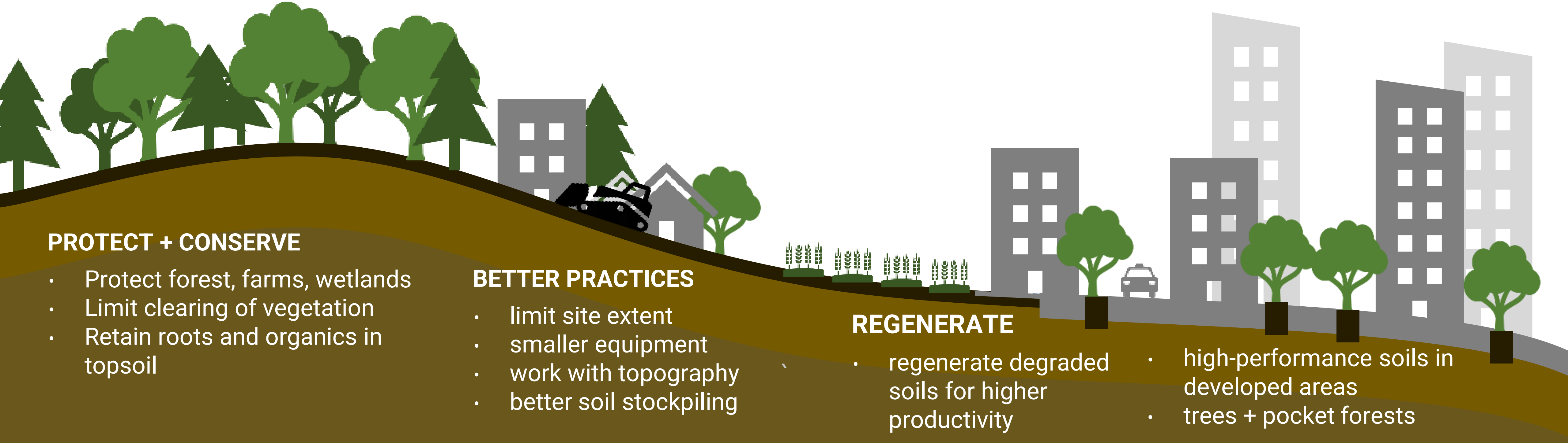
- large construction footprint
- radical grading
- poor soil stockpiling

- compacted subsoil
- thin ‘topsoil’, <4”
- ` imported sandy loam with low fertility

- low permeability
- shallow soil profile
- few trees, small trees
- poor soil specs

Priority Actions + Takeaways

➔ Minimize Site Disturbance
➔ Protect Existing Soils, Especially Wetland Soils
➔ Minimize Imported Soils
➔ Design for High SOC Soils through locally sourced amendments
➔ Manage landscapes to keep and accumulate SOC
➔ Reduce emissions



PROTECT + CONSERVE

- Protect forest, farms, wetlands
- Limit clearing of vegetation
- Retain roots and organics in topsoil

BETTER PRACTICES

- limit site extent
- smaller equipment
- work with topography
- better soil stockpiling

REGENERATE

- regenerate degraded soils for higher productivity
- high-performance soils in developed areas
- trees + pocket forests

www.masshealthysoils.org

Guidance for Implementing Healthy Soils in Landscape and Construction

A multi-firm collaborative project funded by the MA Office of Energy and Environmental Affairs Healthy Soils Challenge Grant program

Regenerative DesignGroup COOPERATIVE

LINNEAN Solutions

BSC GROUP BUILD | SUPPORT | CONNECT

SASAKI Better design, together.

READ

A.D. MAKEPEACE Inspired by nature

Industry Partners

Wetland case study

Mass Audubon Action Agenda Goals

Goal 1

Protect and Steward Resilient Landscapes

Goal 2

Advance Inclusive and Equitable Access to Nature

Goal 3

Mobilize to Fight Climate Change

A restored landscape is more resilient, more welcoming, and more prepared for climate change

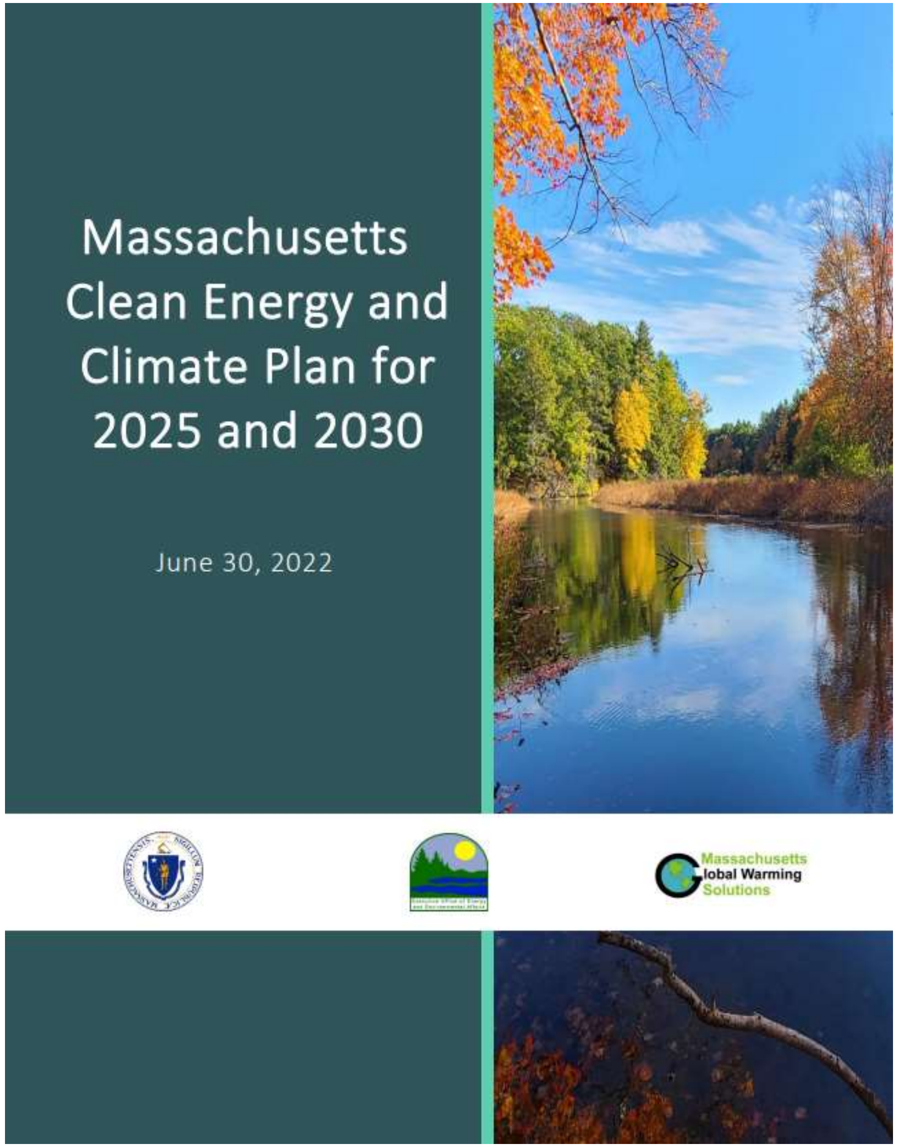
Ecological Restoration Program – started February 2023

Why Wetlands?

- Low oxygen in wetland soil (especially peat) reduces decomposition
- Carbon is accumulated and stored

Massachusetts Clean Energy and Climate Plan for 2025 and 2030

- No net loss of stored carbon by 2030
- Protect open space including wetlands
- Facilitate marsh migration
- Facilitate restoration including streamlining permitting



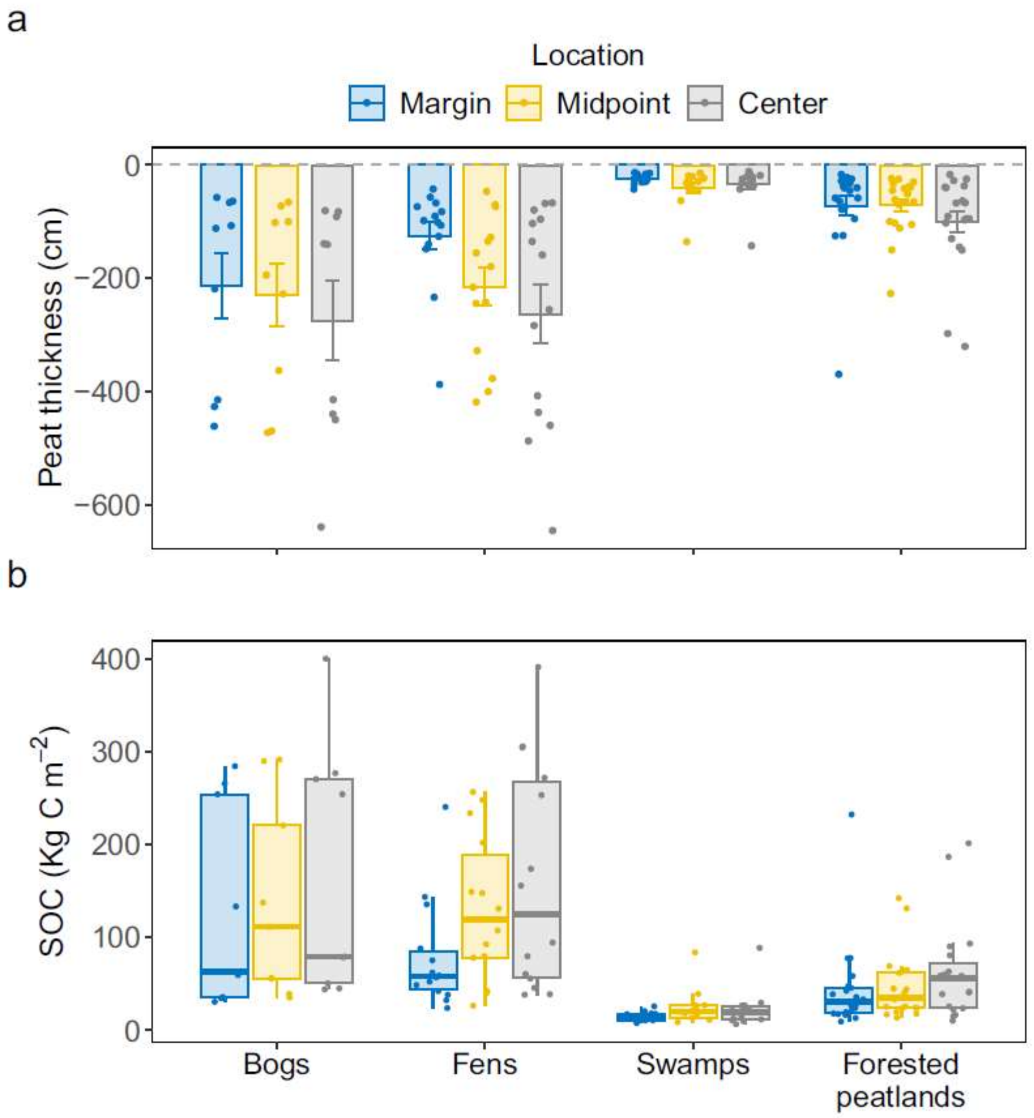
Massachusetts Clean Energy and Climate Plan for 2025 and 2030

June 30, 2022

Massachusetts Global Warming Solutions

Cranberry Bogs
& Natural Peatlands

- Many cranberry bogs are former natural peatlands (agriculturally degraded)
- Carbon content is dependent on peat depth
- More carbon storage when restored to a functional wetland



Goyette et al. 2024

Tidmarsh Case Study

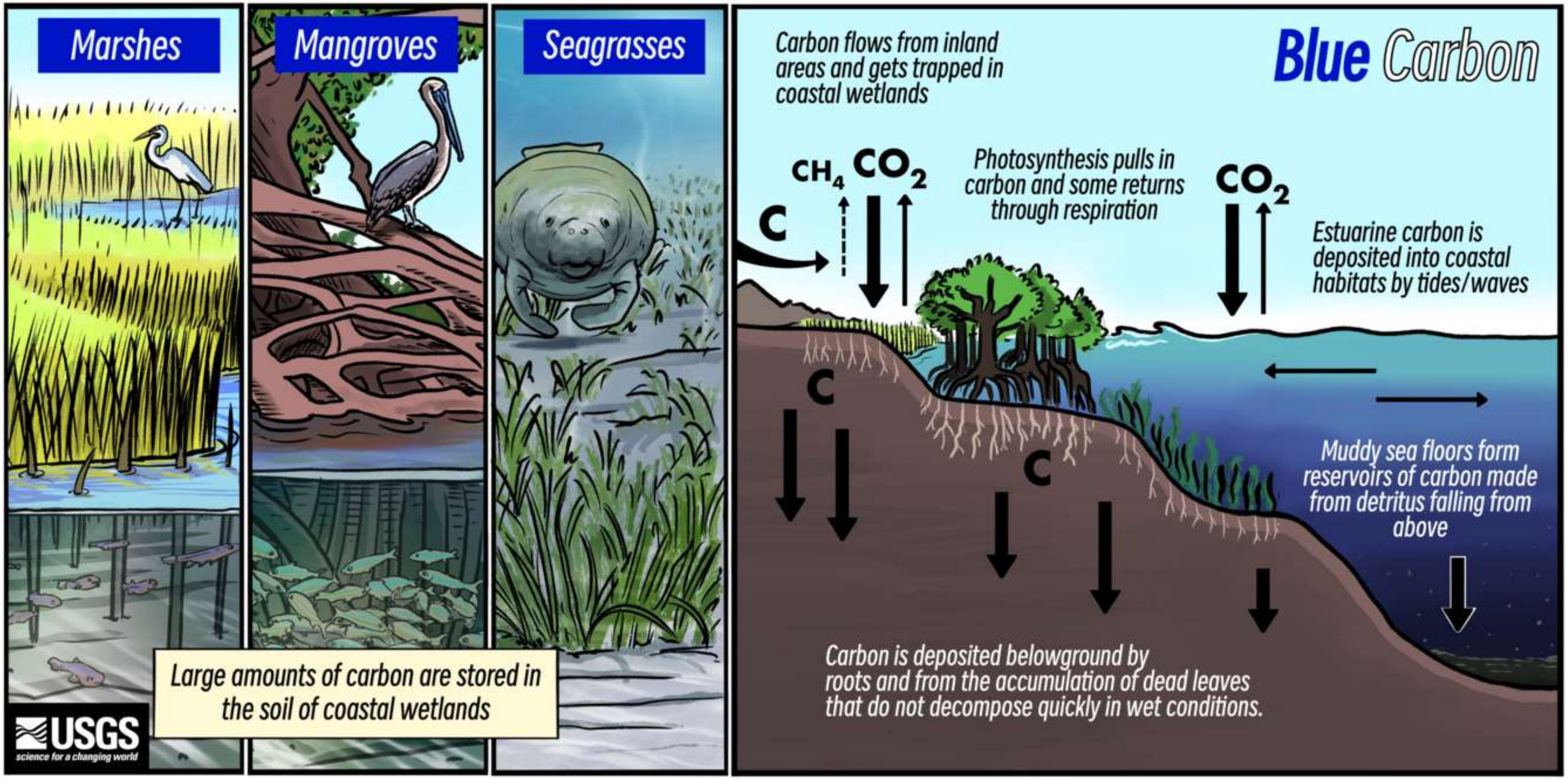
- Largest freshwater restoration in NE – 200+ acres
- Peat 30+ feet deep in places (~900 cm) below the sand
- Impact of ditching – increase decomposition
- Drying trajectory – keep them wet!

Before restoration (2011)

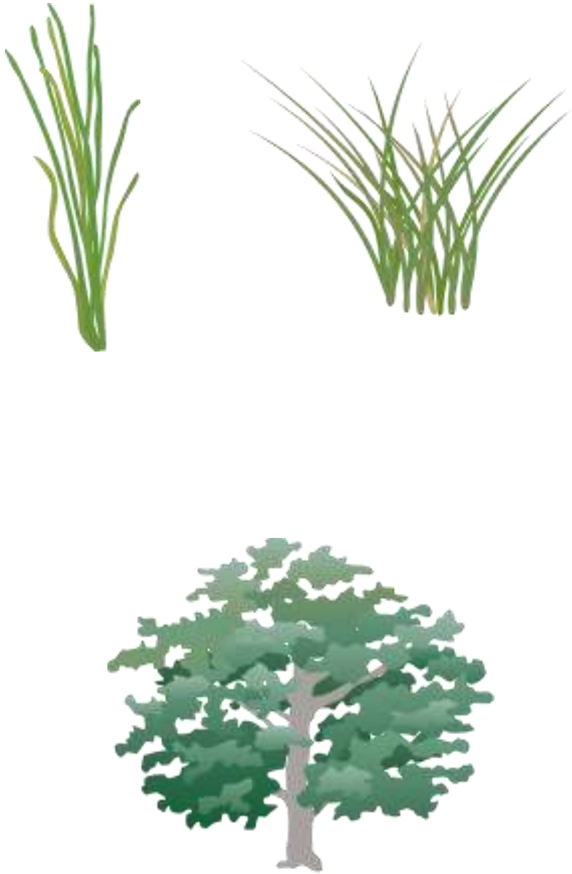
During restoration (March 2016)

Post restoration (July 2016)

Blue Carbon


Marshes
Mangroves
Seagrasses
Large amounts of carbon are stored in the soil of coastal wetlands
USGS
science for a changing world
Blue Carbon
Carbon flows from inland areas and gets trapped in coastal wetlands
C
CH_4
CO_2
Photosynthesis pulls in carbon and some returns through respiration
CO_2
Estuarine carbon is deposited into coastal habitats by tides/waves
C
C
Muddy sea floors form reservoirs of carbon made from detritus falling from above
Carbon is deposited belowground by roots and from the accumulation of dead leaves that do not decompose quickly in wet conditions.

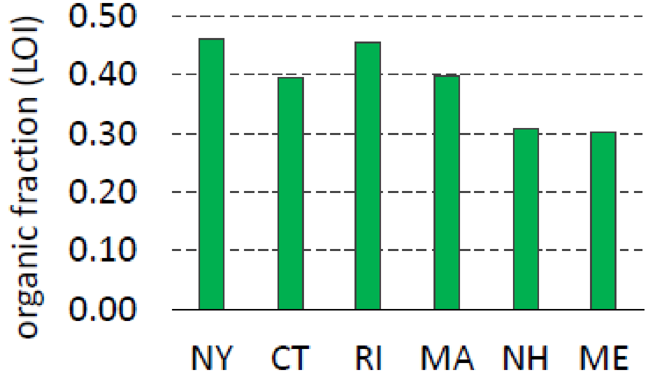
EPA Blue Carbon Report

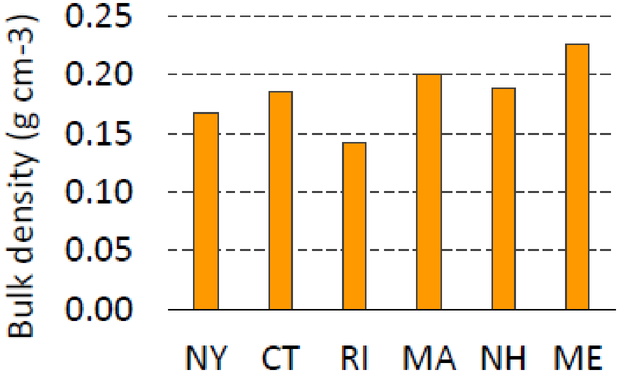


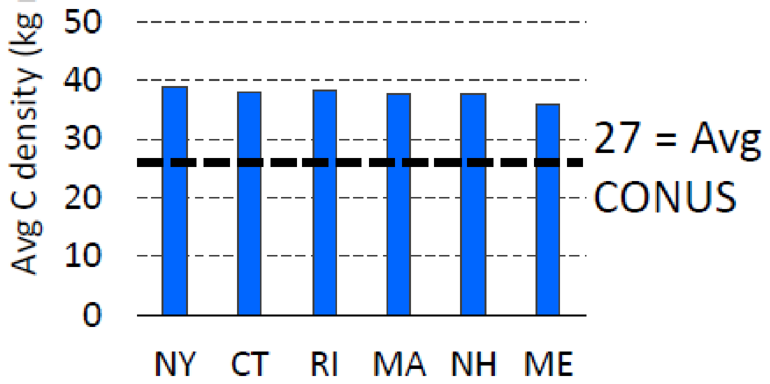
- **Maine To Long Island**
- **218,222 acres** of eelgrass meadows and salt marsh = reservoir of **7,523,568 megagrams of blue carbon**
  - The emissions from 5,994,024 passenger vehicles driven in one year.
  - The burning of 30,521,000,000+ pounds of coal.
  - The emissions associated with the energy use of 3,474,000 homes for a year.
  - The emissions offset by the operation of 7,498 wind turbines for a year.
  - The quantity of carbon accumulated in one year in 32,646,000 acres of upland forest.
- Sequestered carbon in New England is predominately from **salt marsh habitats**

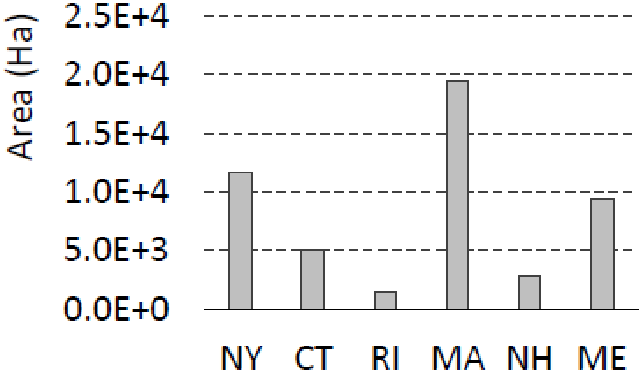
The Blue Carbon Reservoirs from Maine to Long Island, NY, EPA, March 2023

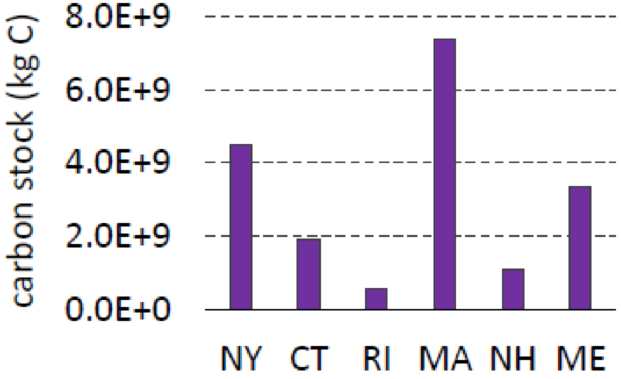
Raster Averaged Marsh Soil Properties across the Northeast US

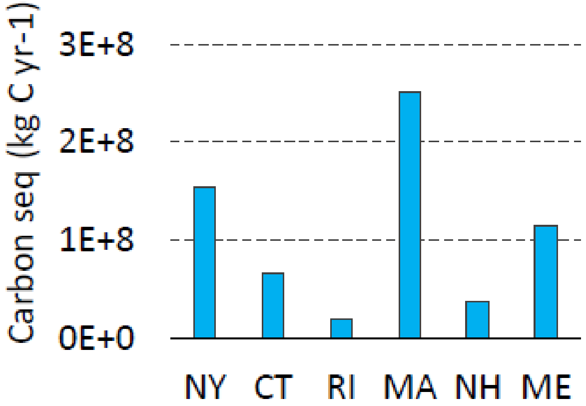

LOI
(avg = 0.38)


Dry Bulk Density
(avg = 190 kg m-3)


Carbon Density
(avg = 38 kg m-3)


Total area by state
(total = 4.99E4 Ha)

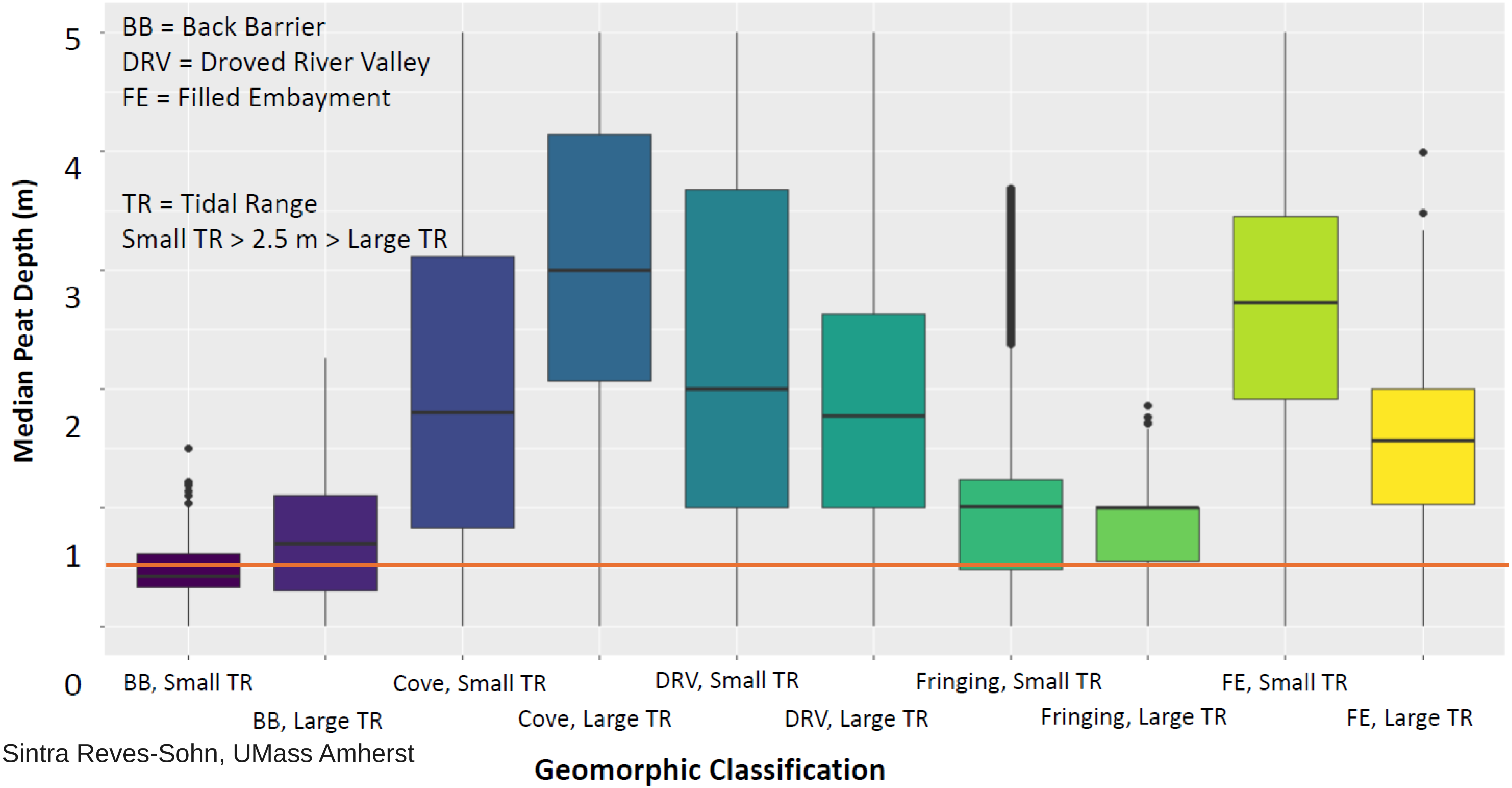

Carbon Stocks*
(total = 19 million Mg)


Carbon Sequestration
(total = 6.4E8 kg yr-1)

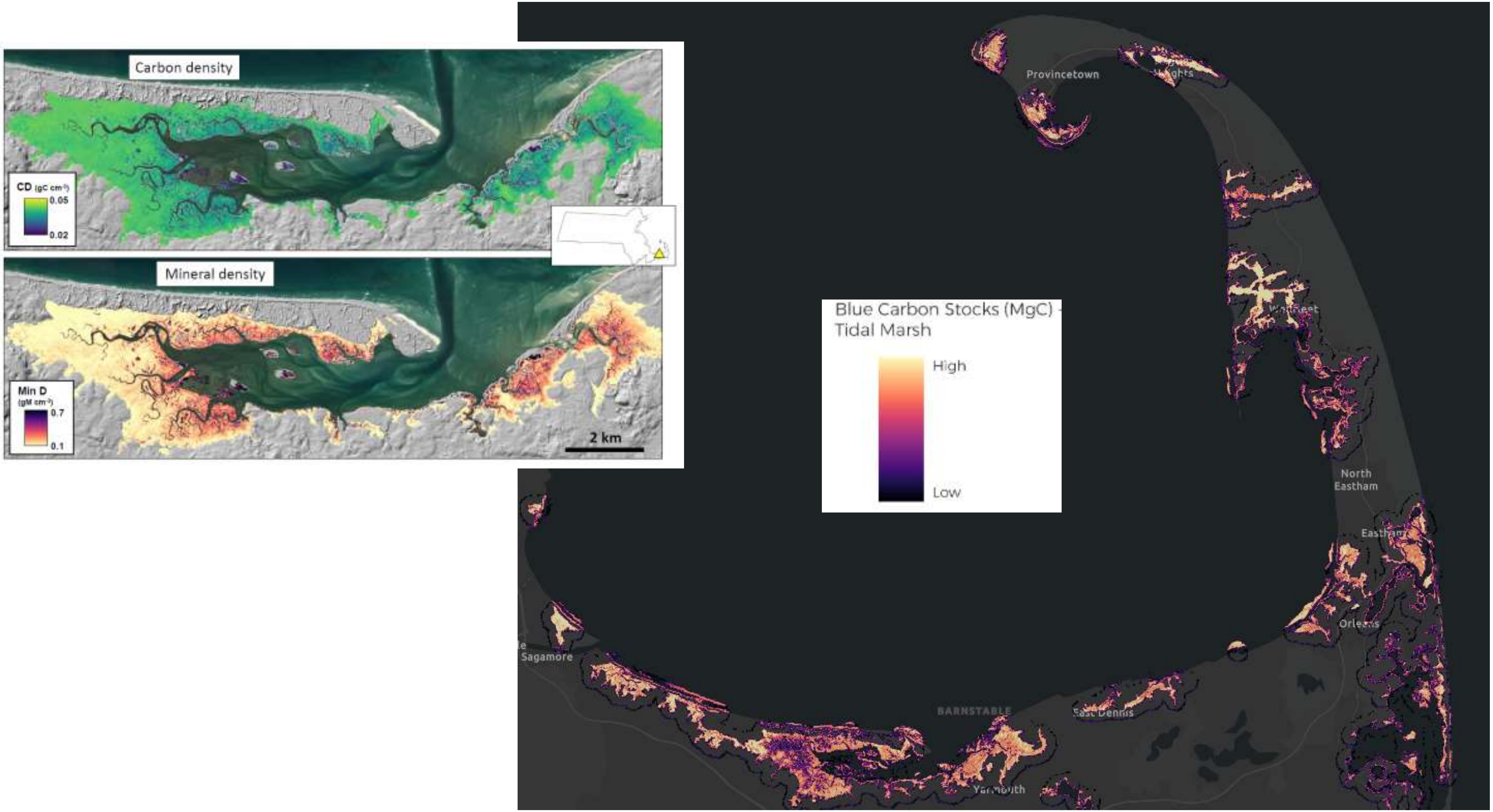
Brian Yellen & team, UMass Amherst

***1 m depth**

Median Peat Depth (m) in Northeast US salt marshes, by Geomorphic Type and Tidal Range



Sintra Reves-Sohn, UMass Amherst



https://www.northeastoceandata.org/blue-carbon/, Brian Yellen & UMass Amherst team

Salt Marsh Restoration Toolbox

Salt marshes need **salinity** and **sediments** from tidal flooding – BUT too much flooding can drown them!

Threat – formation of marsh pools

Solution - runneling

Salt marshes need to drain - BUT overdraining leads to **oxidation & subsidence**

Threat – agricultural ditches in the marsh

Solution – ditch remediation

Salt marshes need **sediment** to keep up with sea level rise

Threat – elevation loss or slow gain

Solution – marsh nourishment

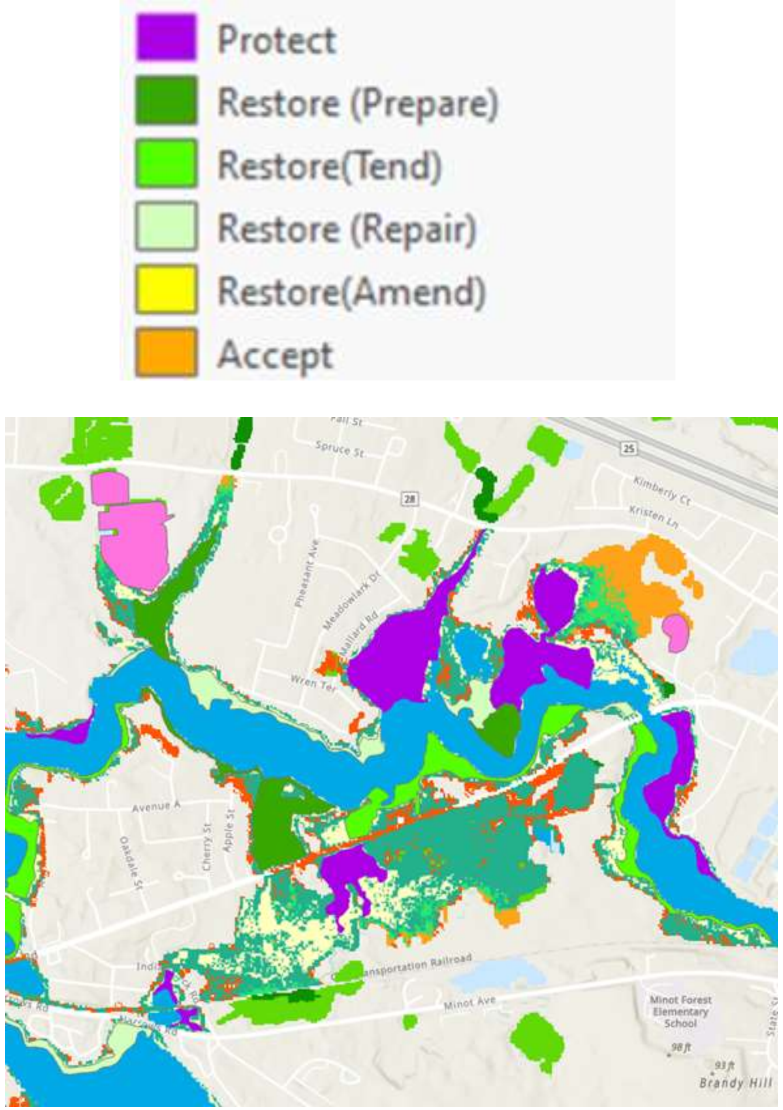
Salt marshes are getting squeezed

Threat – sea level rise and coastal development

Solution (in some locations) - Marsh migration corridors

What can you do? Protect and Restore

- **Protect** wetlands from excess nutrients – leads to decomposition
- **Protect** wetlands so you can restore them, if needed
- **Protect** marsh migration corridors
- **Restore** wetlands to keep them functioning
- **Support** regulatory changes to make protection and restoration easier – existing regs treat restoration like development
- **Promote** the importance of wetlands as a climate solution



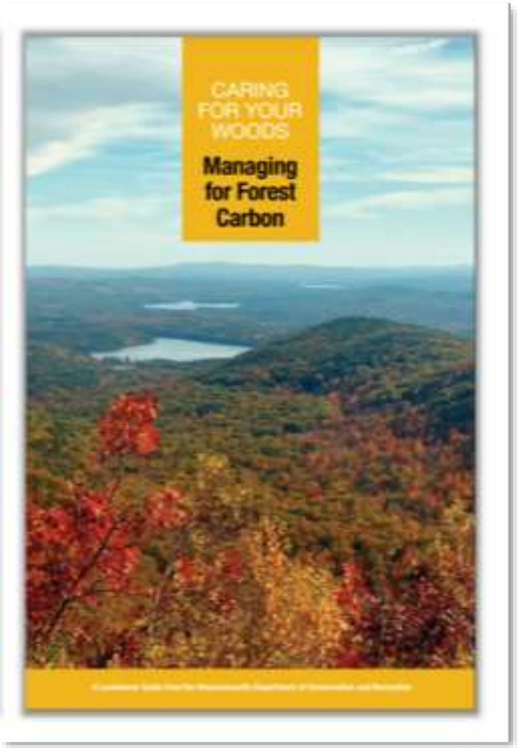
Case study: climate-smart forestry

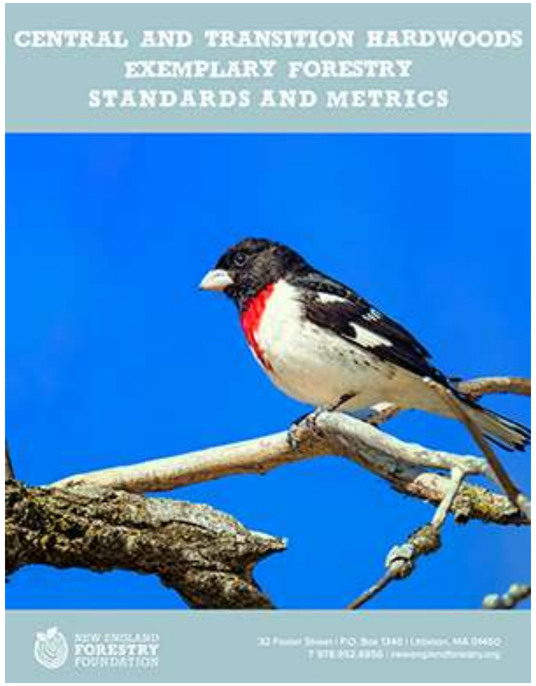
Tim Stout in his VT forest

Mass Audubon, TNC, DCR, NEFF…


Healthy Forests for Our Future:
A Management Guide to Increase Carbon Storage in Northeast Forests

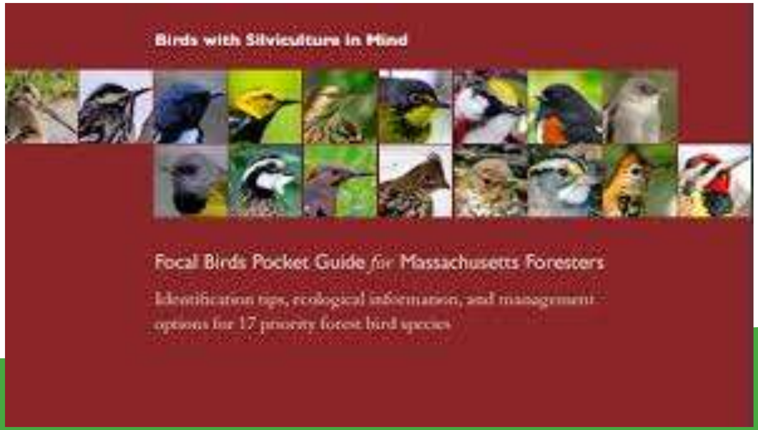
The Nature Conservancy
NIACS


CARING FOR YOUR WOODS
Managing for Forest Carbon


CENTRAL AND TRANSITION HARDWOODS
EXEMPLARY FORESTRY
STANDARDS AND METRICS

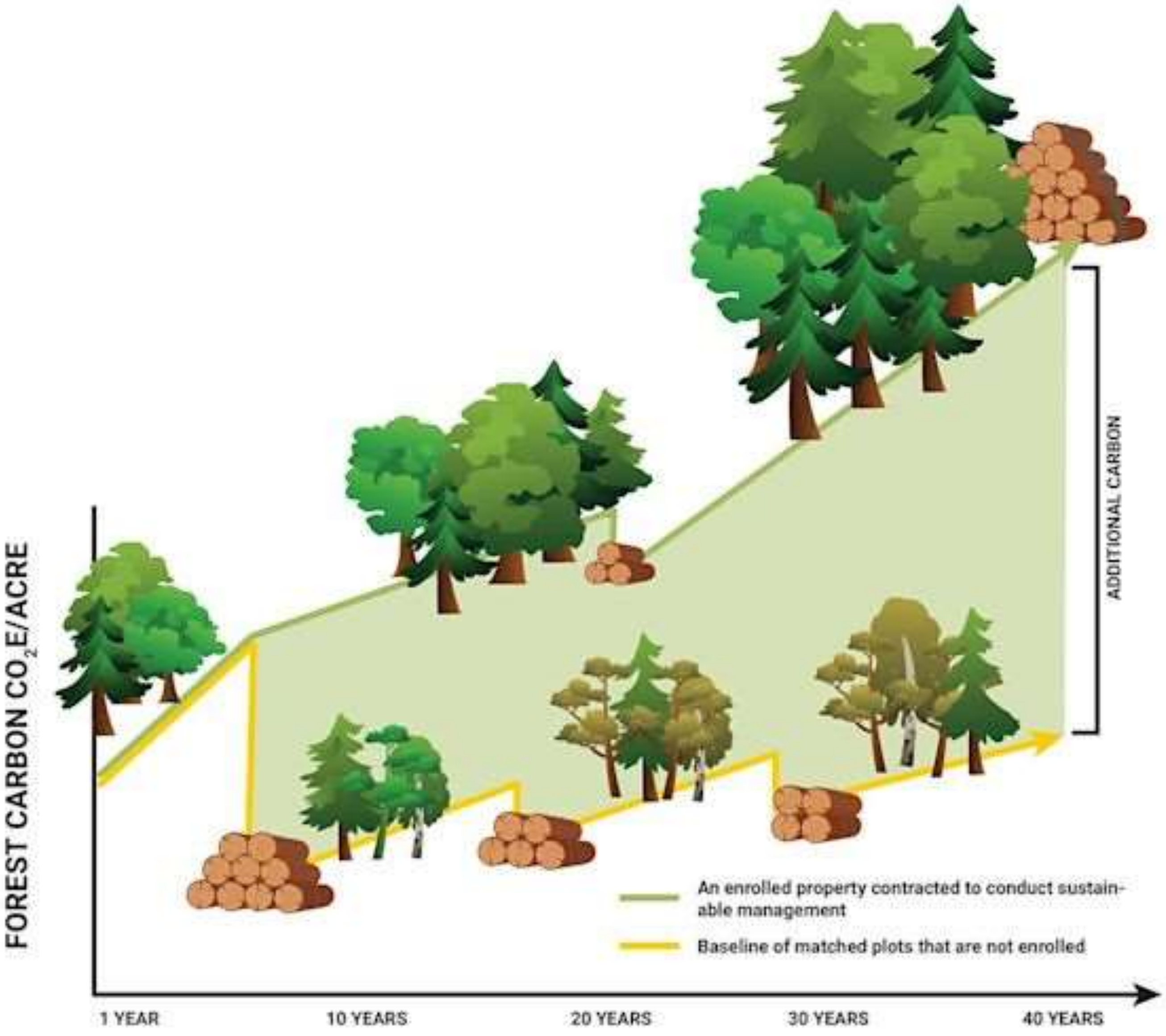
NEW ENGLAND FORESTRY FOUNDATION

The same climate-smart forestry practices are found in many different lists, documents, and programs.


Birds with Silviculture in Mind

Focal Birds Pocket Guide *for* Massachusetts Foresters

Identification tips, ecological information, and management options for 17 priority forest bird species



MARYANN THOMPSON ARCHITECTS | WALDEN POND VISITOR CENTER

IMAGE CREDIT: CHUCK CHOI

Tug Hill, NY: Photo credit Chris Zimmerman, TNC

Programs with funding or other help

1

MA DCR Climate Stewardship Incentive Program (*michael.downey@mass.gov*)

Land trusts are eligible for per-acre payments for 5 practices, including invasive plant treatment, legacy tree retention, and climate informed harvest layout and other practices

2

NRCS Conservation Stewardship Program (*kate.parsons@usda.gov*)

NRCS has a number of climate-informed and climate smart practices and offers a minimum of $4,000 for new participants.

3

Family Forest Carbon Program (*nancy.marek@tnc.org*)

Pays annual payments of $10 or $15 per year for 20 years for a contract adopting climate-smart forestry practices

4+

Forest Carbon Works, NEFF's Grow Resilient Oak-Hickory forests, Municipal Vulnerability Preparedness program for municipalities, etc.

Q & A / Group discussion

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