Massachusetts Healthy Soils Action Plan

Draft Findings + Recommendations for Public Review

Programs + Advocacy Discussion

July 29, 2020

***Image**: Big River Chestnuts. Regenerative Design Group, 2020*

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Executive Office of Energy and Environmental Affairs

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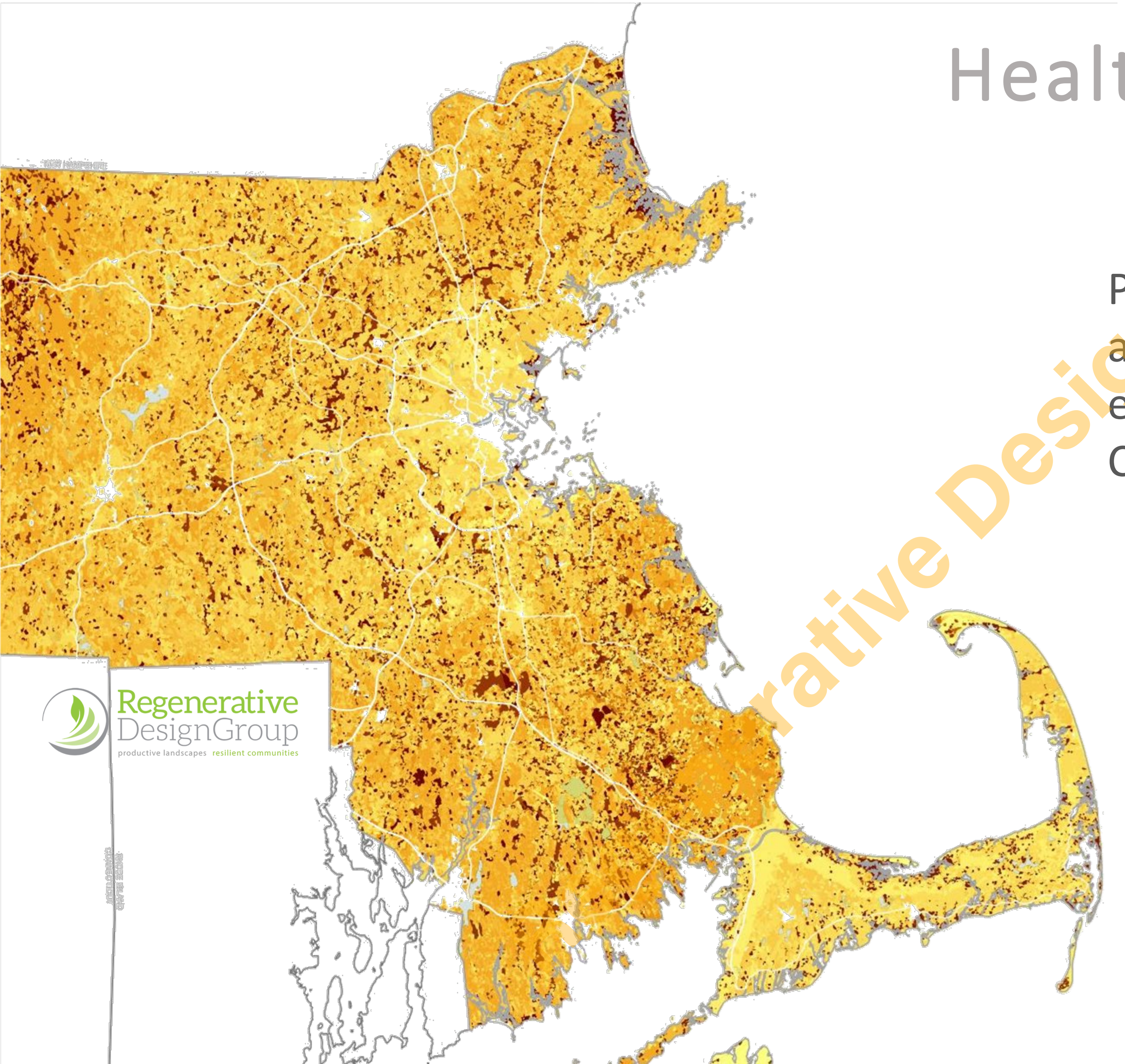
LINNEAN SOLUTIONS

The Perennial Agriculture Institute

NOFA MASS

Northeast Organic Farming Association

Healthy Soils Action Plan
Purpose



Protect and enhance the soil resources across all land types to support thriving ecosystems and communities of the Commonwealth.

- Improve Policies and Programs
- Guide Land Use Planning
- Support Land Managers
- Identify Research Needs

Map of Soil Organic Carbon
Data Source: NRCS SSURGO Data

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Functions of a Complete Action Plan

REGENERATION
Repair + build capacity of living soils to support healthy ecosystems + production

MITIGATION + CONSERVATION
Reduce the activities + events that degrade soil health

Healthy Soils Action Plan

ADAPTATION
Proactive change to management of soils for anticipated conditions

RESISTANCE + RESILIENCE
Increase ability of soil to resist disturbances and restore functions after

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Massachusetts Healthy Soils Action Plan

Draft Goals

> Limit the conversion of natural and working lands

> Increase adoption of soil-smart management practices across all land types

> Proactively use soil-based solutions to mitigate and adapt to Climate Change

> Improve access to technical expertise, financial, and other resources for land managers

> Incorporate soil-based criteria + performance standards into government land use and land management policy and programs

> Develop + promote soil health certifications and trainings for land-based professionals

> Enhance Massachusetts-based capacity to analyze and assess soil health

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What is Soil Health?

Soil health is defined as the continued capacity of soil to function as a vital **living ecosystem** that sustains plants, animals, and humans.

- Natural Resource Conservation Service (NRCS)

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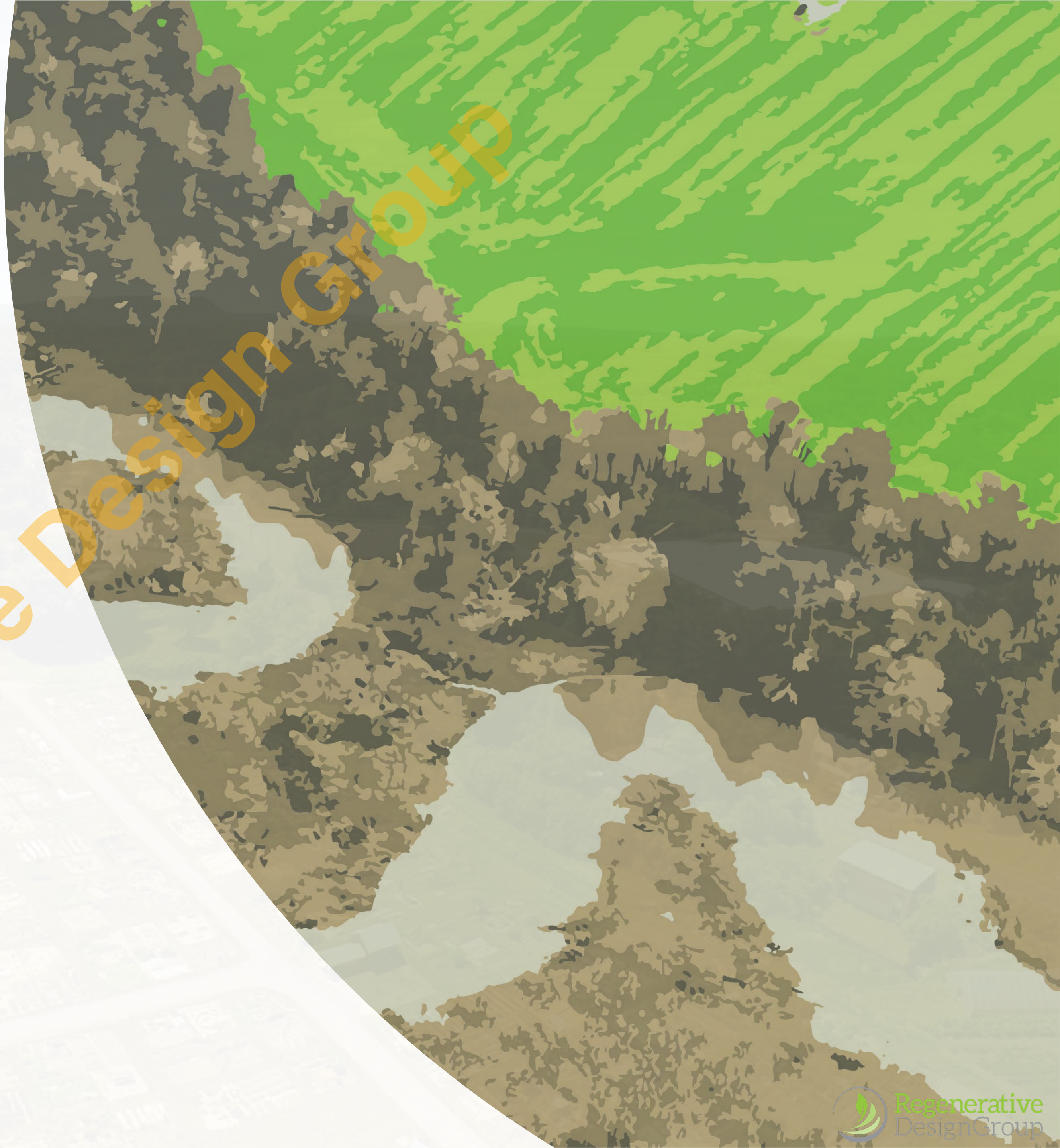


Healthy Soils Functions Support Ecosystems
Productive Capacity
Water Storage + Filtration
Biological Activity + Diversity
Carbon Capture + Storage
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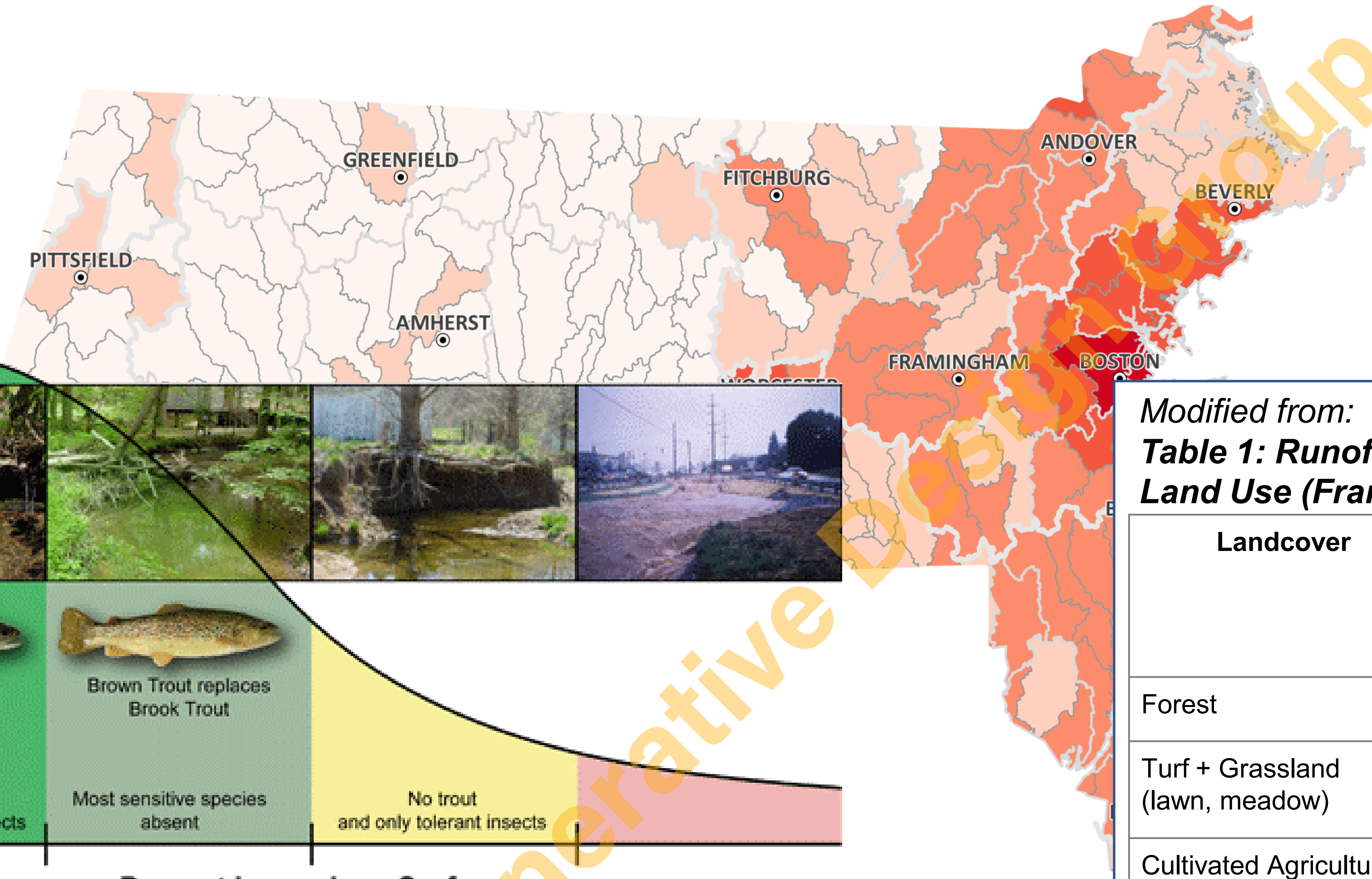
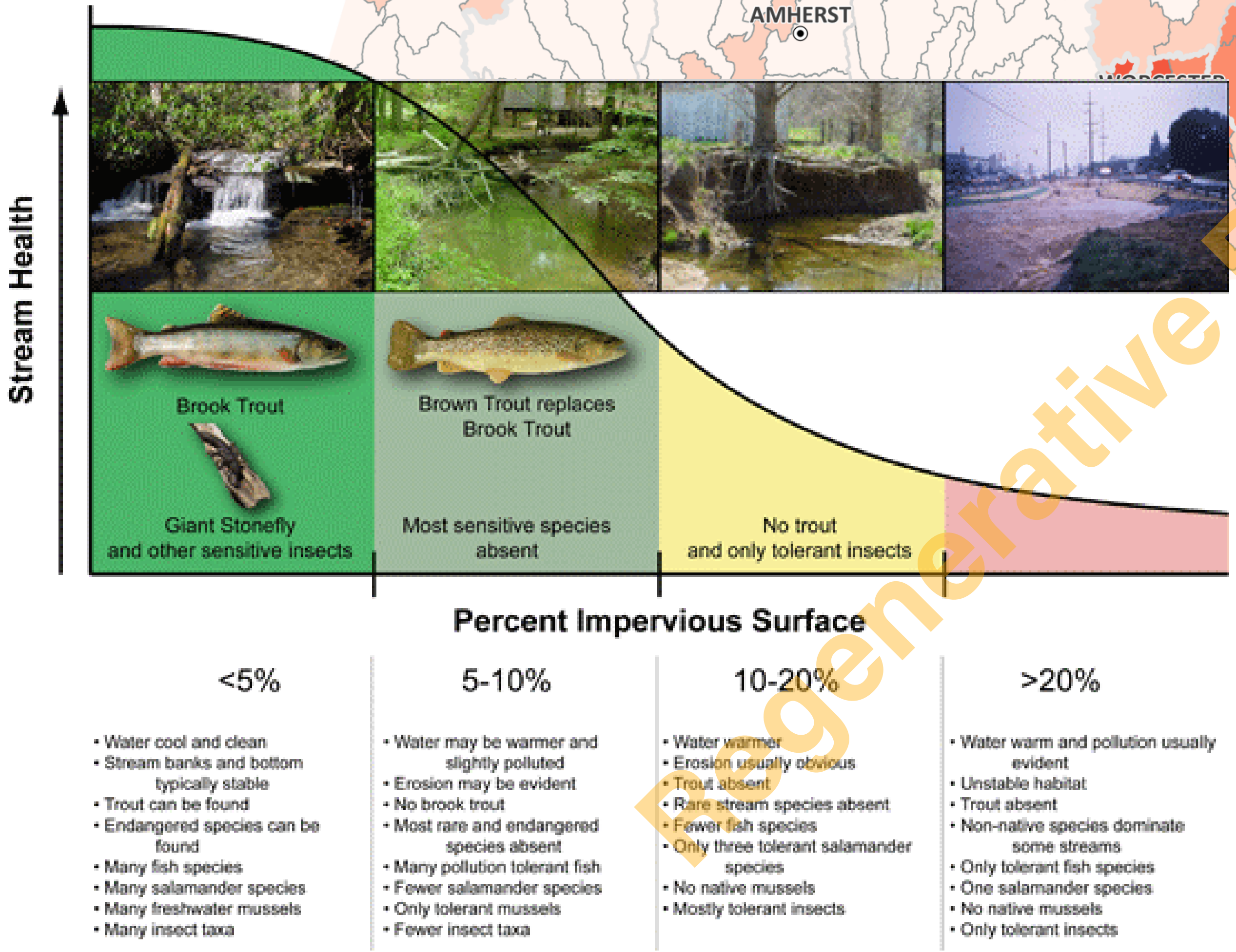
Existing Impervious Area as Percentage of Subwatersheds (2016)





Modified from:

Table 1: Runoff Expected from Four Types of Land Use (Frankenberger, NRCS)

Landcover	Runoff from a 4-inch rainfall (inches) 24-hr	Runoff volume from 4-inch rainfall on 1 acre (gallons)
Forest	0.5 inch	13,600
Turf + Grassland (lawn, meadow)	0.8 inches	21,700
Cultivated Agriculture (Corn + Soy)	2.0 inches	54,300
Developed Impervious (Roofs/pavement)	3.9 inches	105,900

Note: NRCS "Curve Number" method of estimation; Hydrologic soil group B; Corn/soybeans have 30% residue coverage; Curve numbers are 55 (forest), 61 (grass), 75 (corn/soybeans), and 98 (roofs/pavement). Soil moisture before storm is average.

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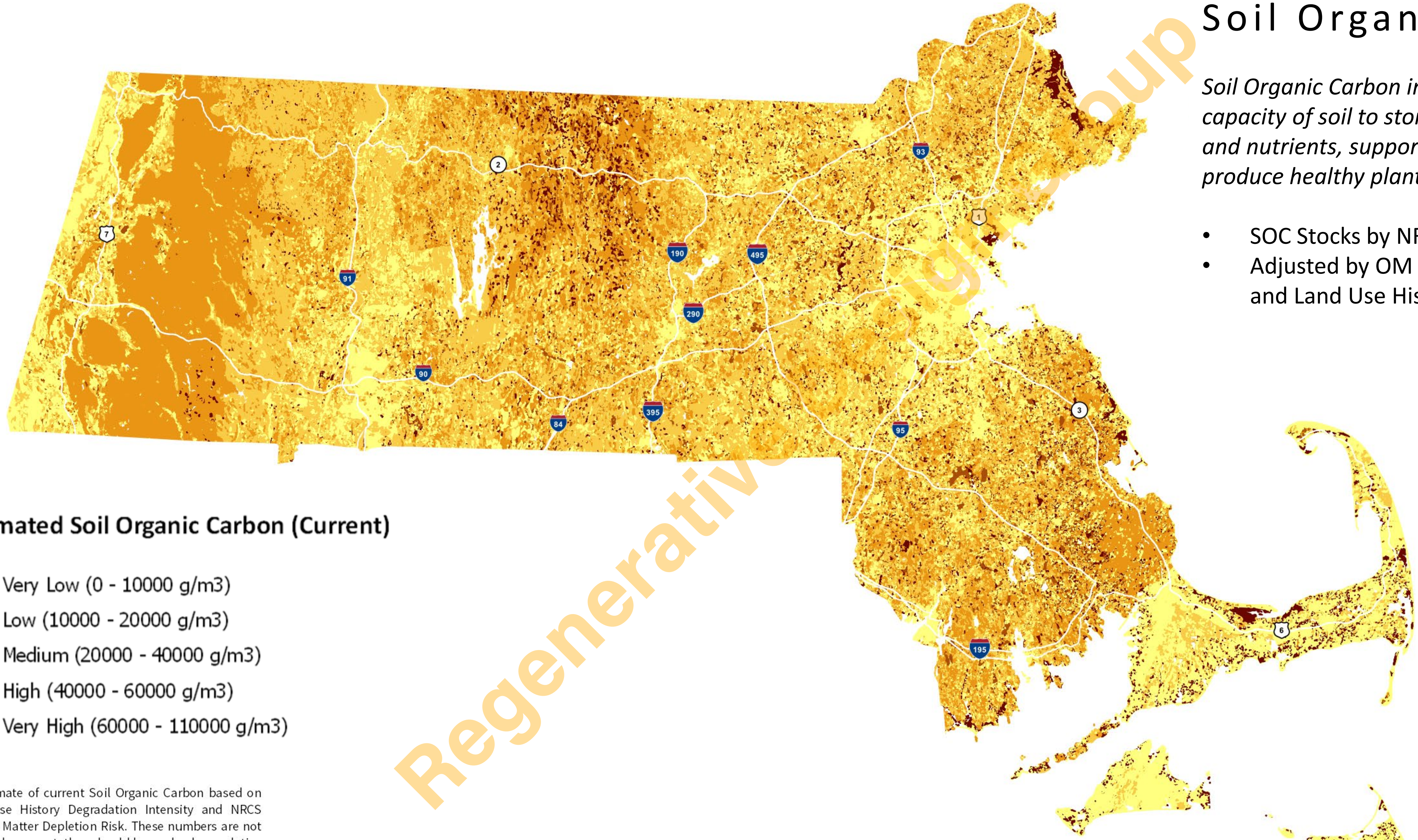
Estimated Stocks of Soil Organic Carbon

Soil Organic Carbon influences the capacity of soil to store and filter water and nutrients, support soil life, and produce healthy plants.

- SOC Stocks by NRCS Soil Map Unit
- Adjusted by OM Depletion Risk Index and Land Use History



Estimated Soil Organic Carbon (Current)

- Very Low (0 - 10000 g/m3)
- Low (10000 - 20000 g/m3)
- Medium (20000 - 40000 g/m3)
- High (40000 - 60000 g/m3)
- Very High (60000 - 110000 g/m3)

An estimate of current Soil Organic Carbon based on Land Use History Degradation Intensity and NRCS Organic Matter Depletion Risk. These numbers are not likely to be correct, thus should be read only as relative to the original values and each other not g/m3.

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Soil Function, Land Cover, Land Management

Land cover and management strongly influence
dynamic soil properties

- Water Storage Capacity + Availability
- Nutrient Storage + Availability
- Bulk Density + Compaction
- Biological Activity, Diversity, + Composition
- Soil Organic Matter + Organic Carbon

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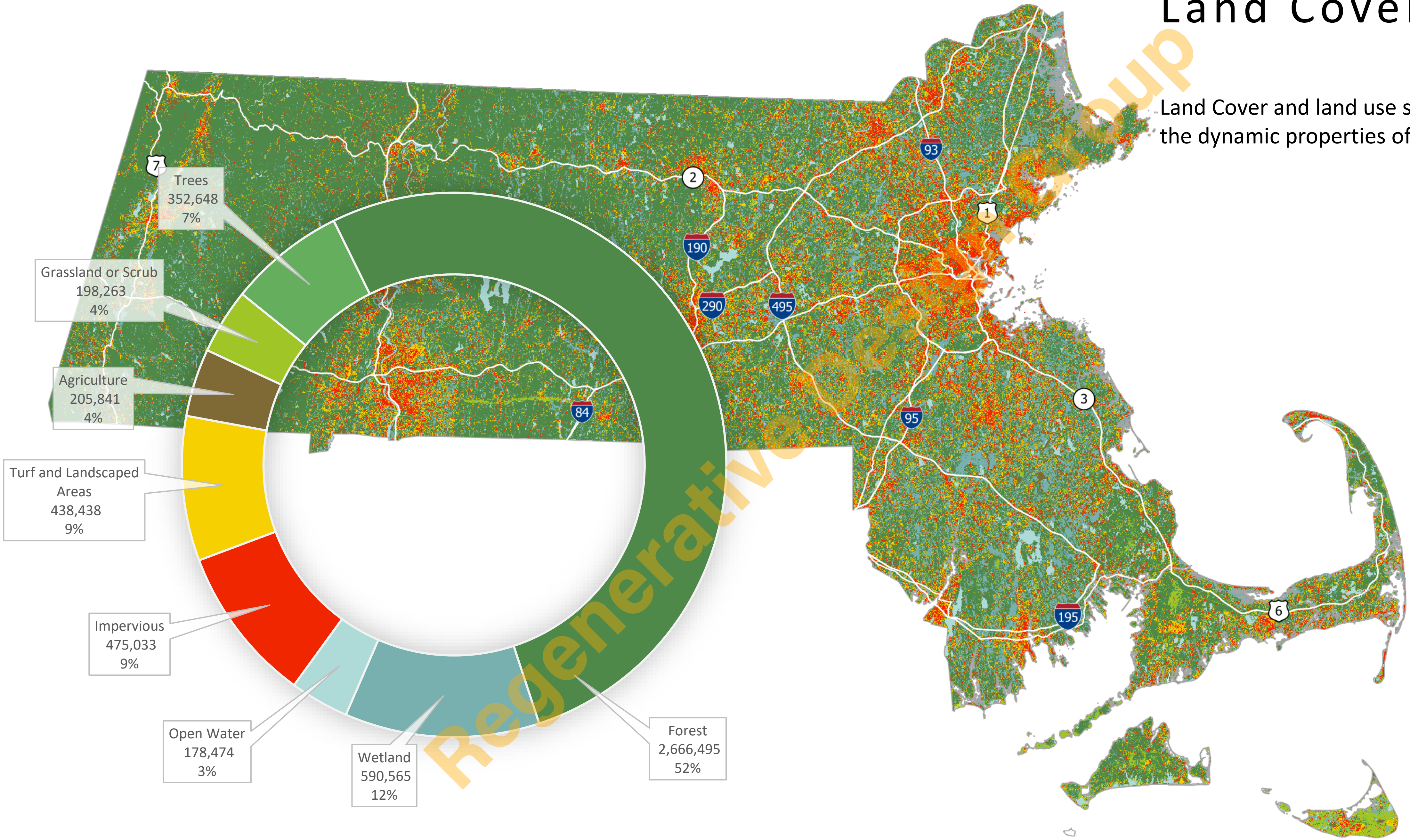
Land Cover Types

Land Cover and land use strongly influence the dynamic properties of soil



Data: Reclassified 2016 Land Cover Layer, NOAA + MassGIS

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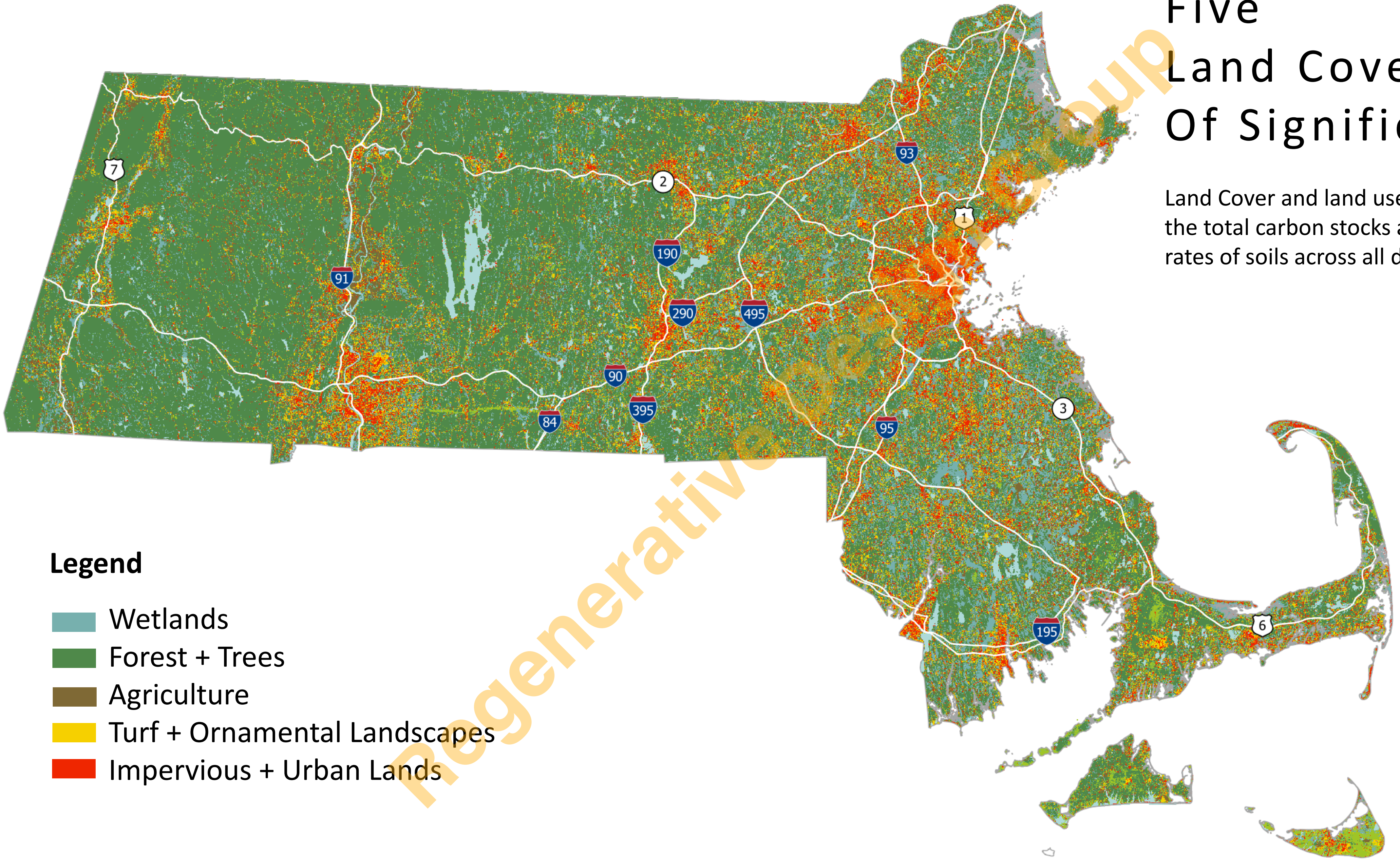
Five Land Cover Types Of Significance

Land Cover and land use strongly influence the total carbon stocks and sequestration rates of soils across all drainage classes.



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Data: Reclassified 2016 Land Cover Layer, NOAA + MassGIS

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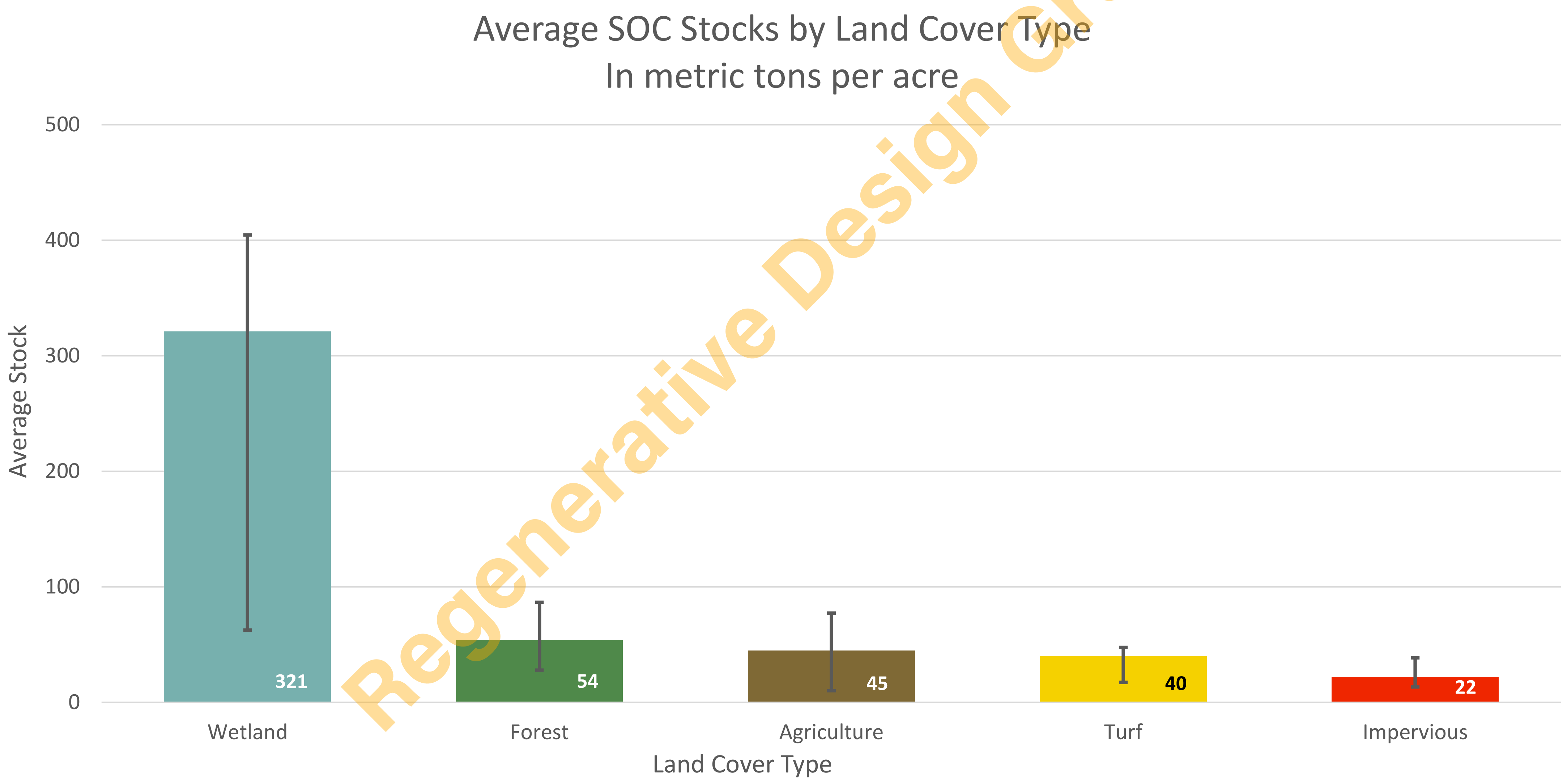
Massachusetts Soil Organic Carbon Density

Excluding carbon in biomass



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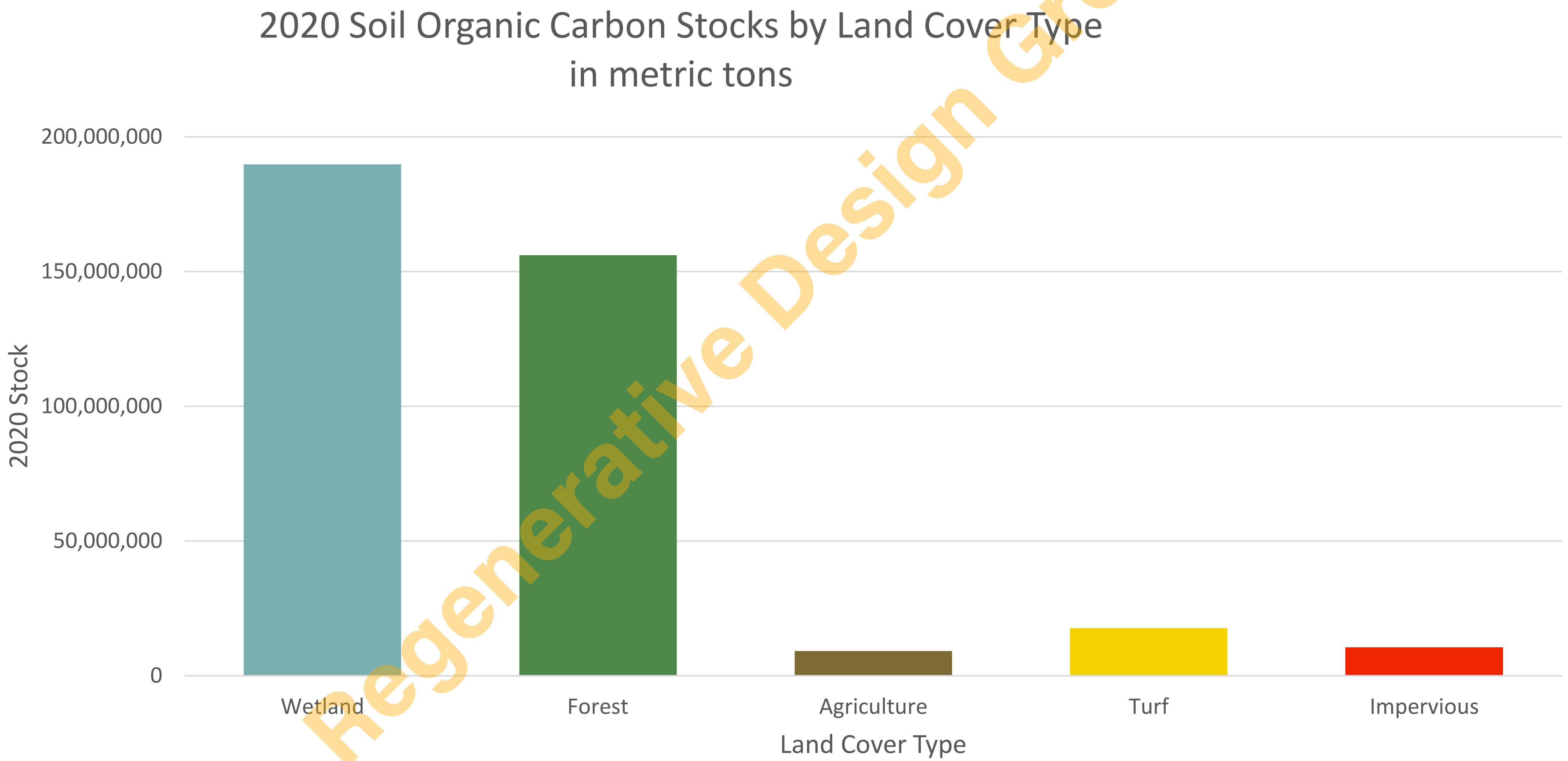
Massachusetts Soil Carbon Stocks, Existing

Excluding carbon in biomass



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The Commonwealth's current SOC stocks are estimated at **401 million tons, equal to 1.5 billion tons** of carbon dioxide.

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Climate Change + Natural Hazards

Climate change is projected to produce profound impacts on soil health.

Warming Soils Impact Biology + Ecology
- Shifts in plant and ag ecology
- Loss of soil organic carbon

Flooding + Sea Level Rise
- More frequent riverine flooding and catastrophic erosion.
- Permanent inundation of coastal areas

Indirect Impacts
- Climate migration + changes in development patterns

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Soil plume from Connecticut River Valley entering Long Island Sound after Hurricane Irene.

Source: NASA Earth Observatory image by Robert Simmon, using [Landsat 5] data from the U.S. Geological Survey [Global Visualization Viewer.]

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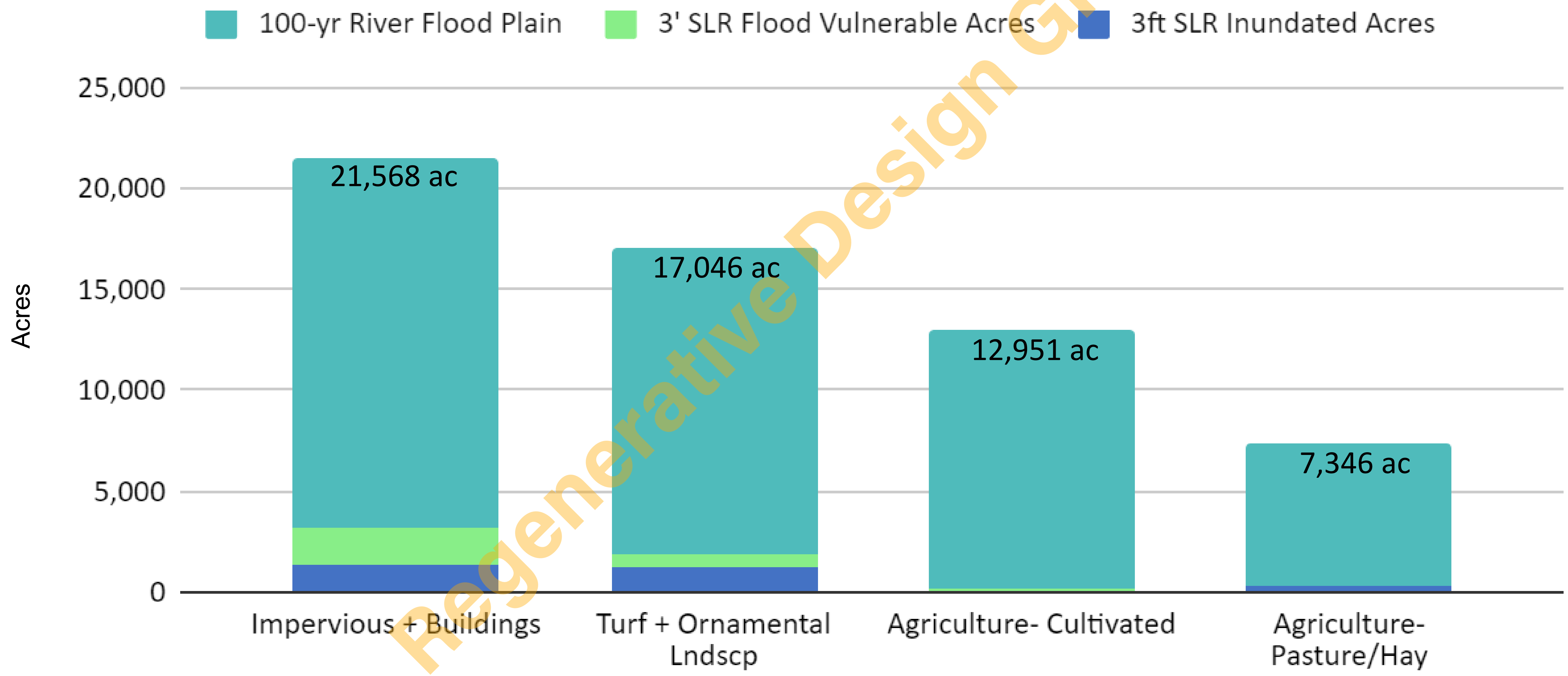
Developed + Farmland at Risk of Sea Level Rise + Frequent Flooding



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100-yr River Flood Plain acreage excludes Franklin County due to a lack of data.

Land Conversion

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

Conversion of forest, farms, and other open space to residential, commercial, transportation, and solar energy installations significantly degrades all functions provided by soil and is the greatest risk to soil health in Massachusetts.

Between 2012 and 2017

- 30,000 acres of forest lost
- 24,700 acres of land developed, mostly low-density residential
- **6,000+ acres** to large scale **ground mounted solar arrays**. This is 25% of all development during that time.

Source: Losing Ground 2020, MA Audubon

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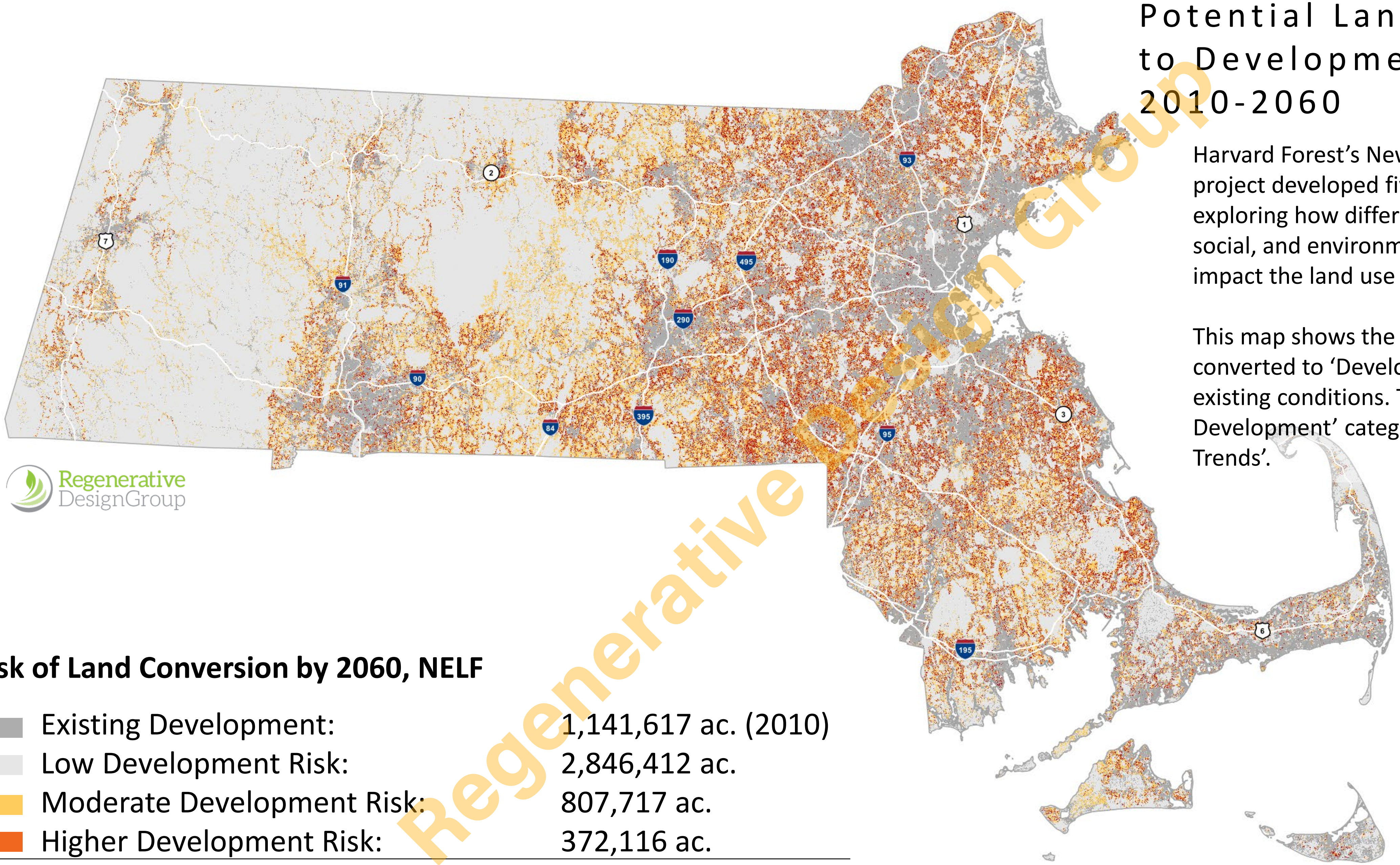
Potential Land Conversion to Development 2010-2060

Harvard Forest's New England Land Futures project developed five different scenarios exploring how different policy, economic, social, and environmental changes would impact the land use of the region.

This map shows the aggregate of lands converted to 'Developed' as compared to existing conditions. The 'Likely Development' category represents 'Recent Trends'.



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Risk of Land Conversion by 2060, NELF

Existing Development:	1,141,617 ac. (2010)
Low Development Risk:	2,846,412 ac.
Moderate Development Risk:	807,717 ac.
Higher Development Risk:	372,116 ac.
2050 Likely Development:	***299,547 ac.***

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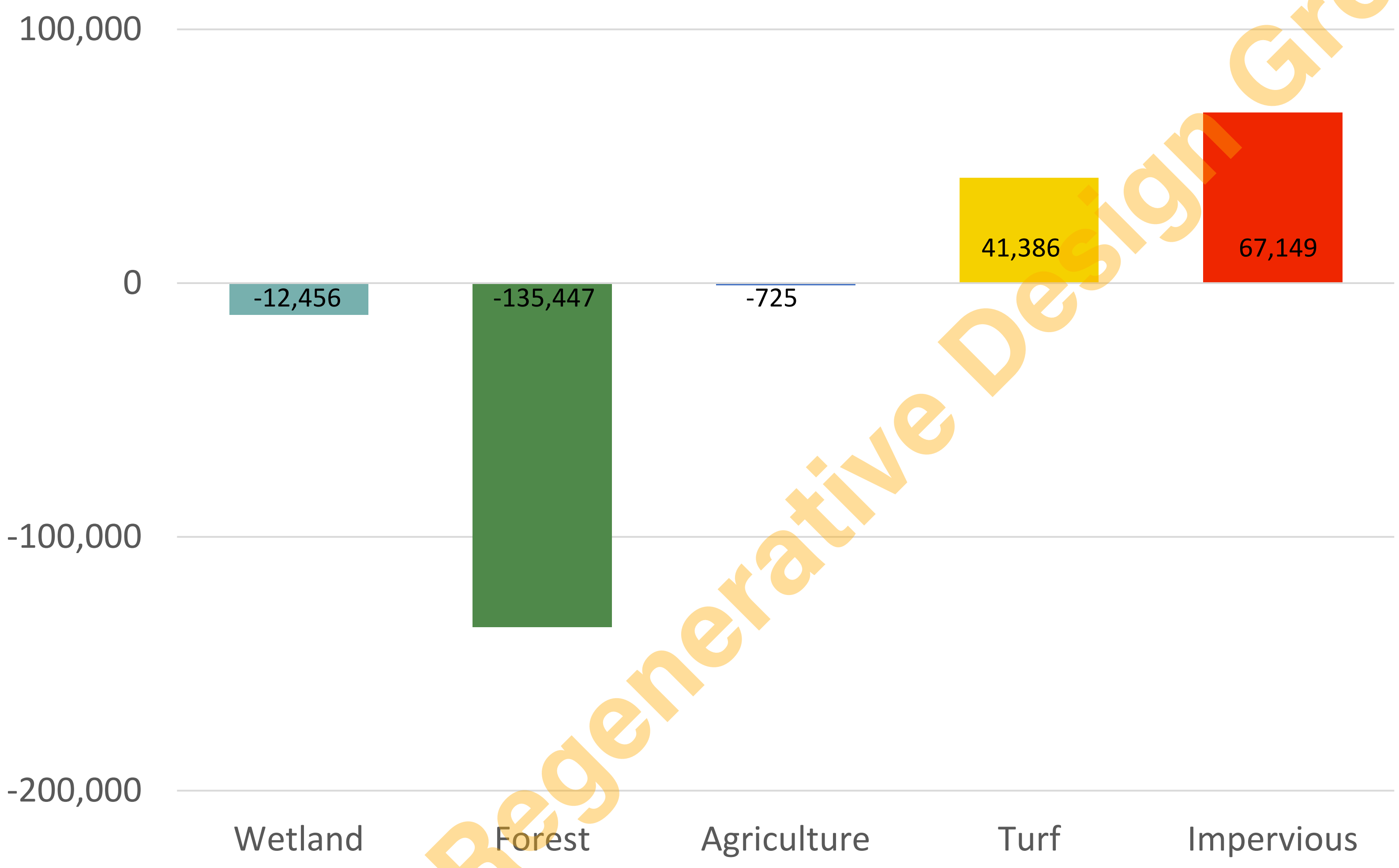
Data: *New England Land Futures*

Projected Development Impact on Land Cover Types

Cumulative change between 2016 and 2050, NELF Recent Trends



Comparison of Development Scenarios	Acres of New Development in 2050
NELF: Recent Trends	289,046
NELF: Connected Communities	93,369
NELF: Growing Global	902,279
GWSA: Baseline	123,623

The figure above represents land cover change from 2016 MassGIS Landcover layer to areas of new Low-Density or High-Density Development as shown in the Recent Trends projection of Harvard Forest's New England Land Futures project.

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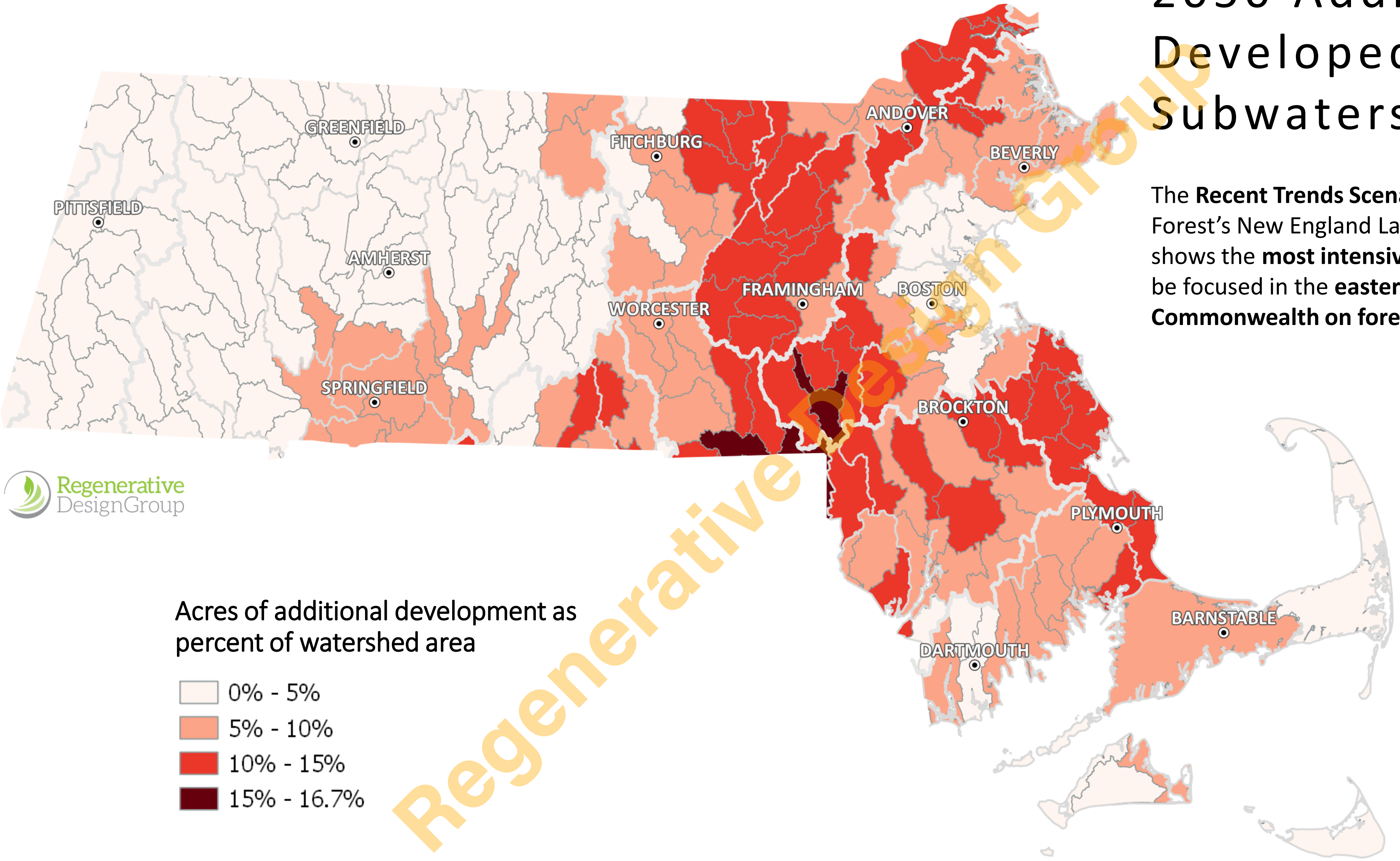
2050 Additional Developed Acres by Subwatersheds

The **Recent Trends Scenario** from Harvard Forest's New England Land Futures Project shows the **most intensive development** will be focused in the **eastern third of the Commonwealth on forested land**.



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Data: *New England Land Futures*

	Land Use Change	Forest BMPs	Wetland BMPs	Turf BMPs	Agriculture BMPs
Scenario 1: ***Business as Usual***	• 100% of projected land use change occurs	• No increase	• No increase	• No increase	• No increase
Scenario 2: ***Modest***	• 25% of projected land use change is avoided	• No increase (forest BMPs are required in MA and adoption is all or nothing)	• High-priority cranberry restoration at DER levels • Coastal wetlands restored at cranberry rate • Other freshwater wetlands restored at half cranberry levels	• Turf BMPs grow from 5% to 10% • Trees planted on 10% of treeless turf	• Conservation agriculture grows at Drawdown 1.5˚C rate • Organic grows at current rate • Managed grazing grows at Drawdown 1.5˚C rate
Scenario 3: ***Ambitious***	• 50% of projected land use change is avoided	• Shift high-intensity to medium and low intensity harvest • End high-grade harvesting	• High- and medium-priority cranberry restoration at DER levels • Coastal wetlands restored at cranberry rate • Other freshwater wetlands restored at half cranberry levels	• Turf BMPs grow from 5% to 25% • Trees planted on 25% of treeless turf	• Conservation agriculture grows at existing MA no-till rate • Organic grows at 1.5x current rate • Managed grazing grows at national growth rate • Agroforestry grows to 2017 scale of organic

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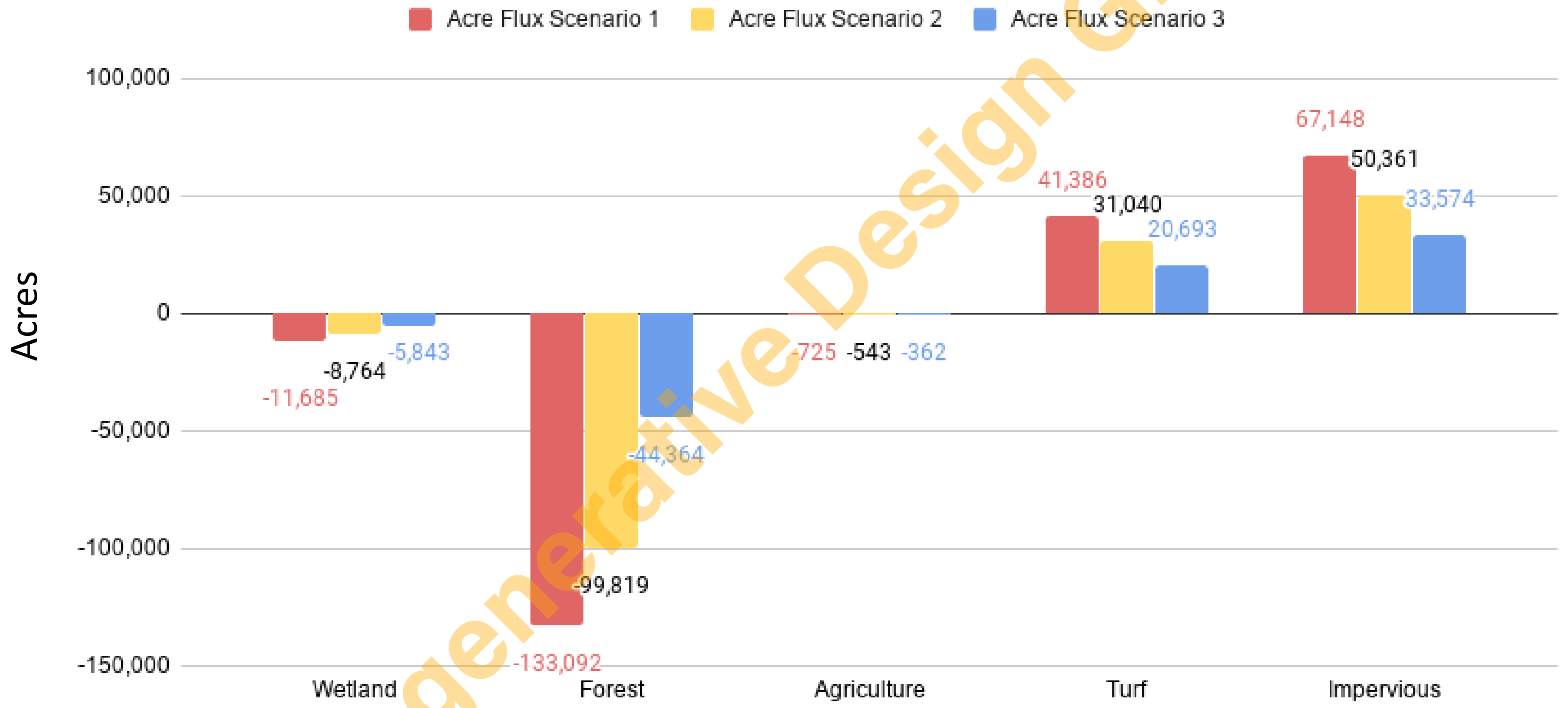
Three Scenarios for Land Cover Change

Cumulative change between 2020 and 2050 in acres



Scenario 1 = 100% 'Likely Developed' **Scenario 2** = 75% 'Likely Developed' **Scenario 3** = 50% 'Likely Developed'

The land cover change scenarios are based on the 'Recent Trends' projection of Harvard Forest's New England Land Futures project. If this projection showed conversion to developed, it was designated as 'developed' in the HSAP study. The land cover change illustrated in the 2050 Scenarios above simply modifications to that percent conversion.

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Management Practices

Current and past management are the greatest influencers of dynamic soil properties.

Management that disturbs soils or reduces the amount of living cover and roots can negatively impact soil health.

Four general management principles that support soil health have been identified by the NRCS

1. Minimize soil disturbance
2. Maximize soil cover
3. Maximize biodiversity
4. Maximize presence of living roots

Ward's Berry Farm, Sharon MA – Photo Courtesy of NRCS

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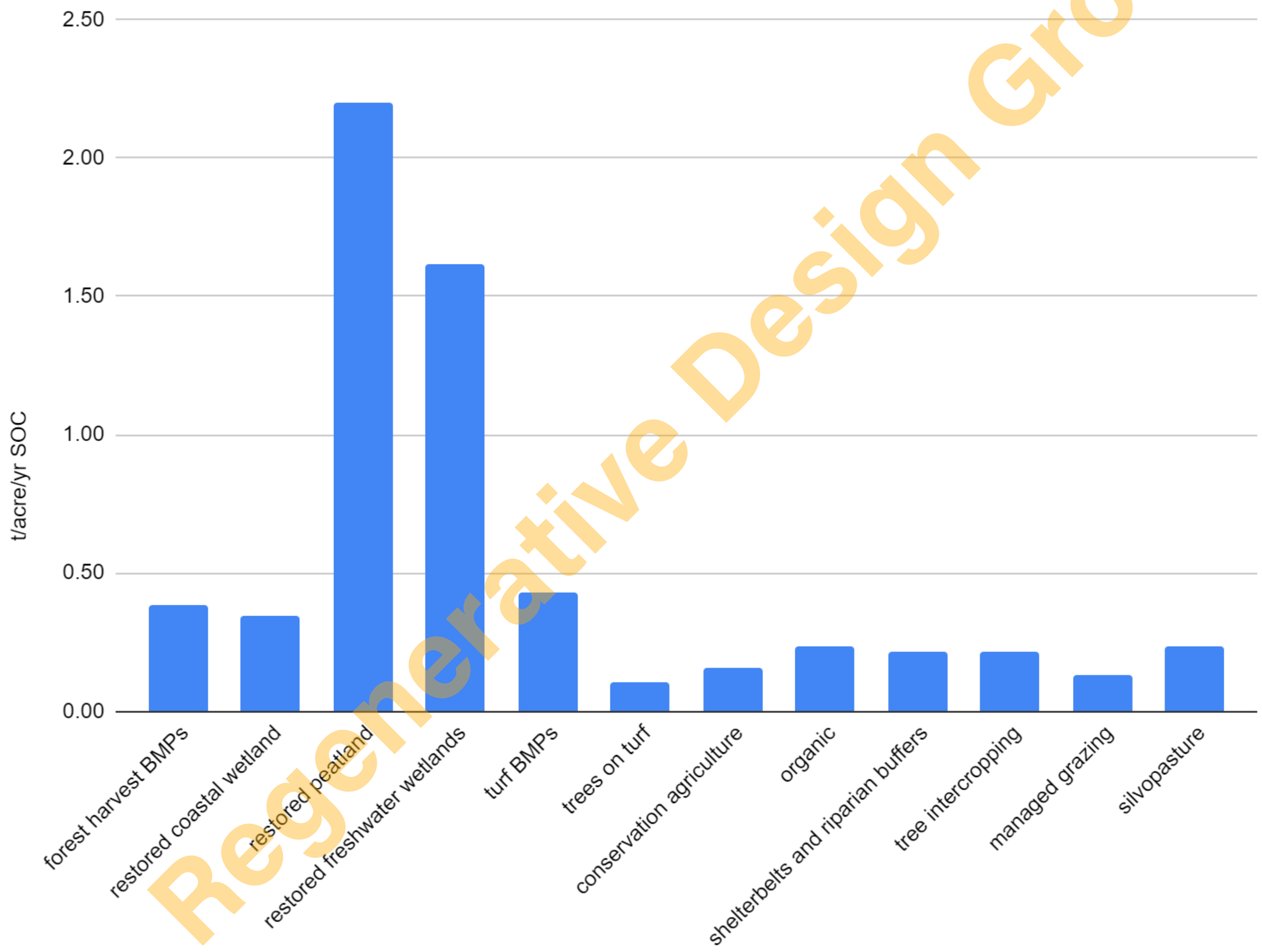
Technical Potential of Best Management Practice

Annual contribution of soil organic carbon in tons per acre per year



Best Management Practices by Land Cover/Management Group

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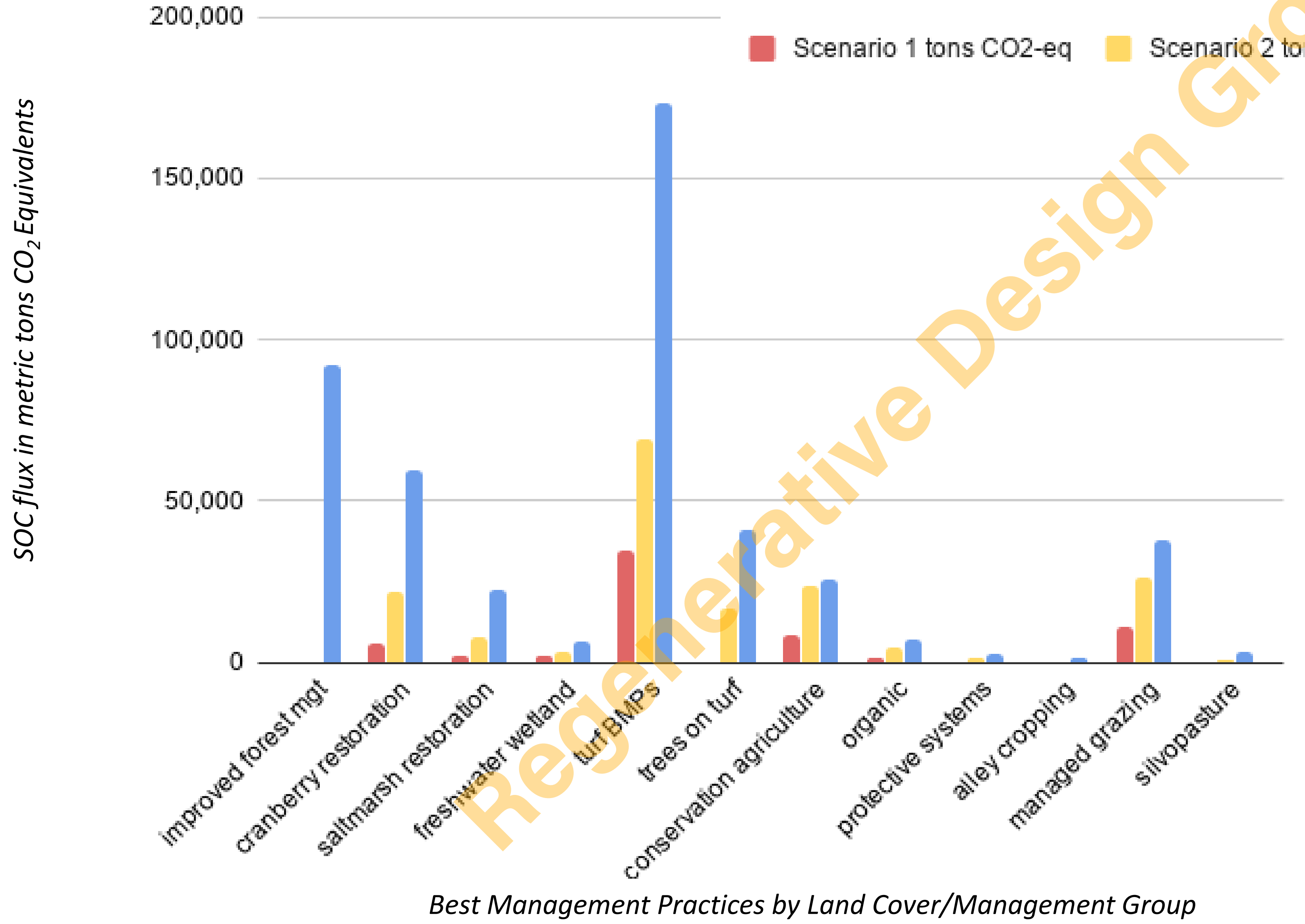
Comparison of Impacts of Soil-Smart Practices across Three Scenarios

2050 Annual contribution of soil organic carbon in tons per acre per year



Potential SOC gains from BMPs in 2050 are estimated at 18 to 128 thousand tons.

This is equal to 67 to 473 thousand tons of carbon dioxide, or 0.3% to 0.8% of 2017 Massachusetts emissions.

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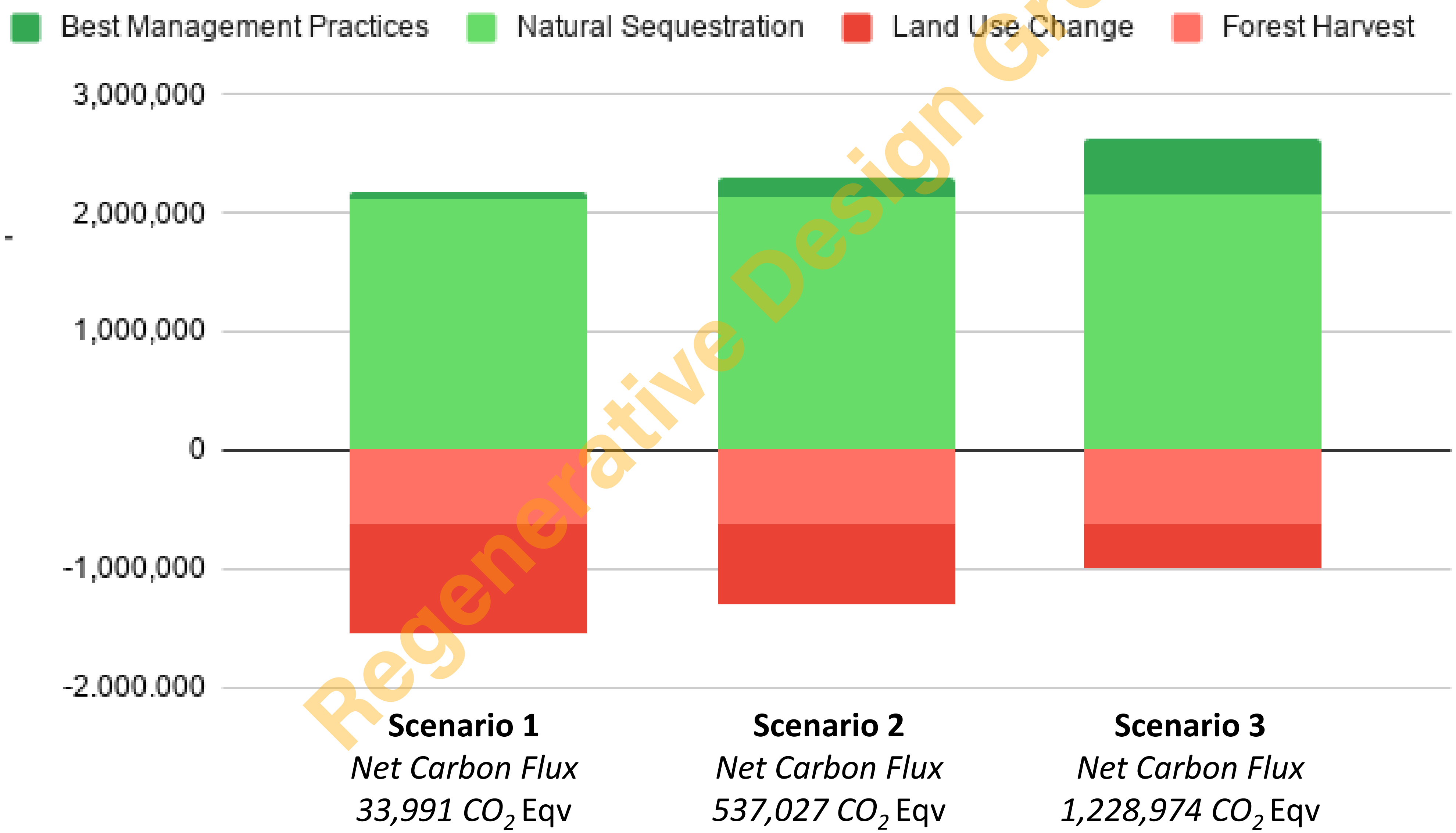
Comparison of Annual Soil Organic Carbon Fluxes in 2050

Under three scenarios



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Land Cover Types + Soil Health Potential

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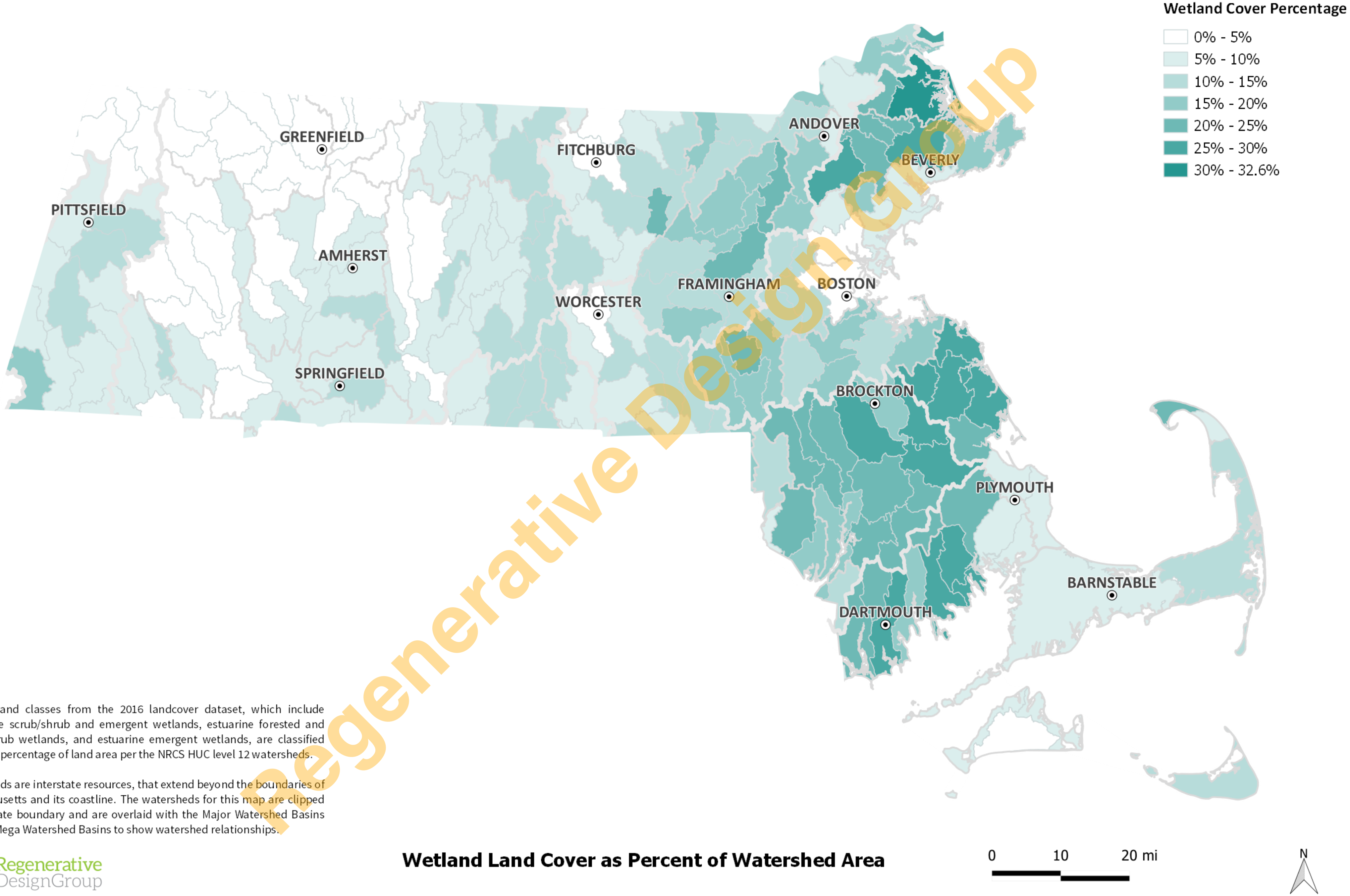

The wetland classes from the 2016 landcover dataset, which include palustrine scrub/shrub and emergent wetlands, estuarine forested and scrub/shrub wetlands, and estuarine emergent wetlands, are classified here as a percentage of land area per the NRCS HUC level 12 watersheds.

Watersheds are interstate resources, that extend beyond the boundaries of Massachusetts and its coastline. The watersheds for this map are clipped to the state boundary and are overlaid with the Major Watershed Basins and the Mega Watershed Basins to show watershed relationships.

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Wetland Land Cover as Percent of Watershed Area

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Wetlands: Soil Health Vulnerabilities

Climate Change + Natural Hazards

- The outsized role of Wetlands in climate adaptation + mitigation isn't recognized as such by the WPA.

Land Conversion

- Conversion of wetlands + intact uplands to other uses permanently degrades ecosystem function; it is estimated that replications, if successful, store 53% less soil C than natural wetlands.

Land Management

- Replication requirements do not specify soils-related performance standards.
- Contractors tasked with constructing wetlands aren't required to have special knowledge of wetland function or ecological restoration.
- Restoration of former + degraded wetlands is necessary to restore ecosystem function, but expensive (currently 20k per acre for cranberry bogs).

Source: USFWS, Kelly Fike

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Wetlands: Key Recommendations

- Add a Ninth Interest to the Wetlands Protection Act that recognizes the ecosystem services and carbon storage/sequestration capabilities of wetlands as they relate to climate resiliency.
- Integrate likely emissions from conversion of wetland into the Global Warming Solutions Act Implementation Plan (NetZero by 2050).
- Improve practices, policies, + certification requirements to ensure replication and restoration efforts are successful at creating/regenerating functioning wetlands.
- Increase funding for wetland restoration.

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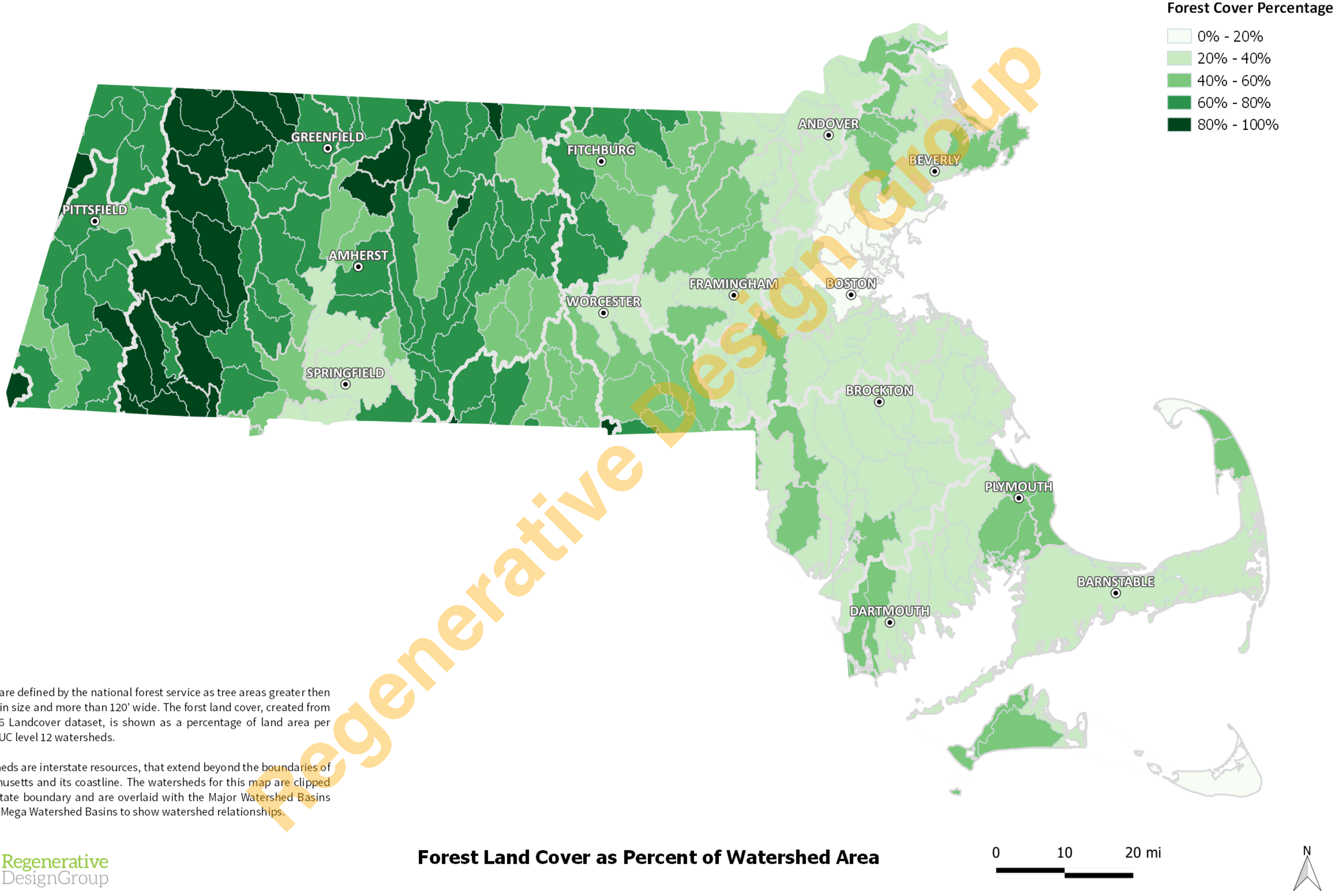
Source: USFWS, Kelly Fike



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Forests are defined by the national forest service as tree areas greater then an acre in size and more than 120' wide. The forst land cover, created from the 2016 Landcover dataset, is shown as a percentage of land area per NRCS HUC level 12 watersheds.

Watersheds are interstate resources, that extend beyond the boundaries of Massachusetts and its coastline. The watersheds for this map are clipped to the state boundary and are overlaid with the Major Watershed Basins and the Mega Watershed Basins to show watershed relationships.

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Forest Land Cover as Percent of Watershed Area

Forests: Soil Health Vulnerabilities

Climate Change + Natural Hazards

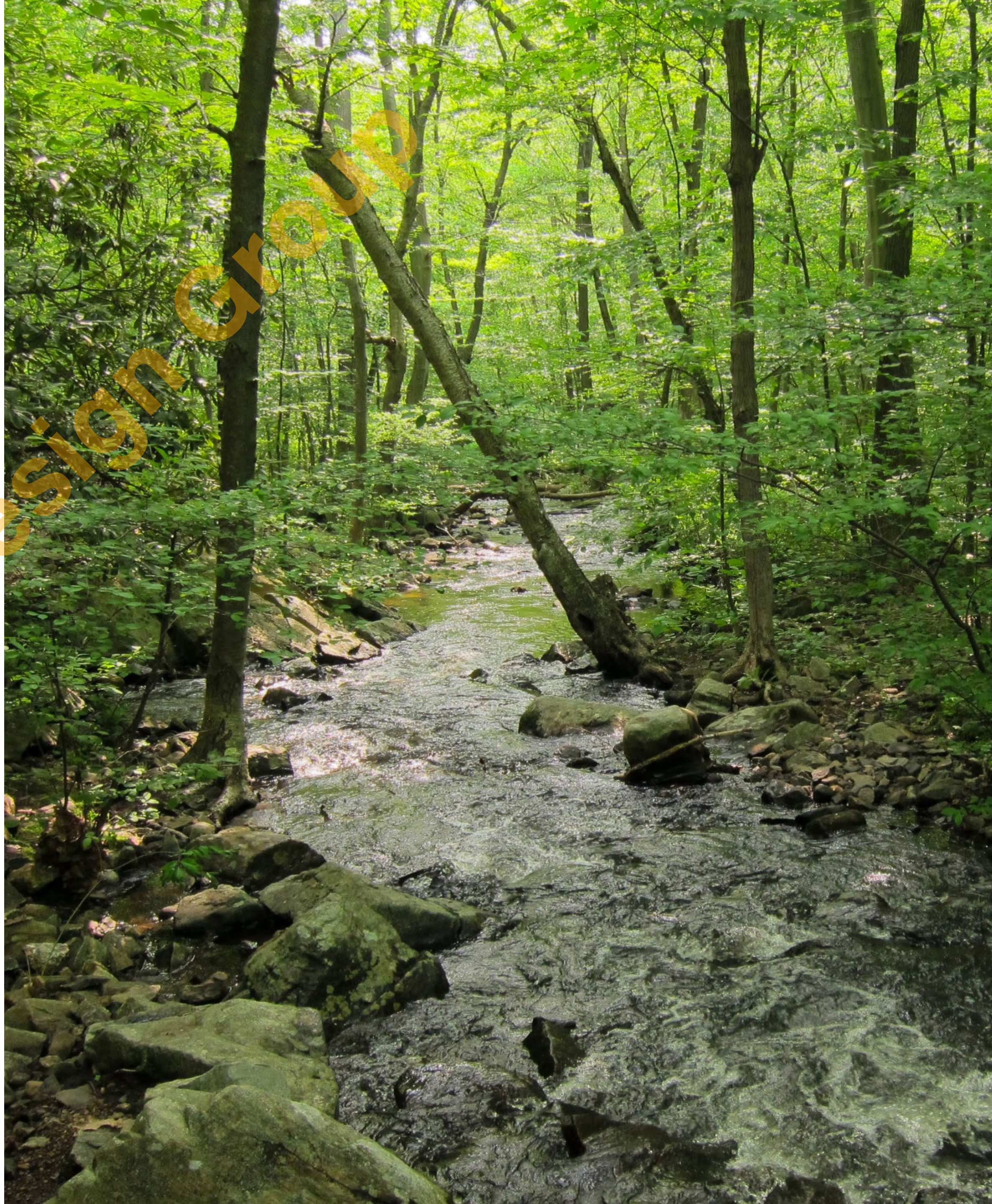
- Potential impacts of warmer temperatures include reduction in suitable habitat for more northerly species; altered soil moisture patterns; increased tree mortality related to insects and disease.
- Floods brought on by increased frequency and magnitude of precipitation threaten 86,465 acres of forest in 100-year flood zones.

Land Conversion

- Between 2012-2017, over 29,929 acres of MA forests were converted to other land uses. Of natural + working lands, forests are considered most at risk of development.

Land Management

- Lack of agreement among stakeholders, WG, + other participants regarding the priority vulnerabilities to forest soils from management practices.
- Lack of consistent + cohesive support for landowners that need guidance in protecting and managing their forests.



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Forests: Key Recommendations

- Create an Advisory Group to research the effectiveness and feasibility of BMPs that protect + enhance SOC in MA Forests.
- Increase funding for consultants and outreach materials that assist landowners and communities in protecting and managing forests for soil health in a changing climate.
- Integrate likely emissions from conversion of forests to non-forest uses into the Global Warming Solutions Act Implementation Plan (NetZero by 2050). Include live below ground biomass and soil organic carbon.
- Update state legislation and renewable energy programs to incentivize solar development towards already developed lands where co-benefits are high such as parking lots, flat roofs, roadsides, and brownfields.
- Incentivize strategic reforestation where forests may provide increased resilience to climate change induced disturbance.
- Identify + increase protection for floodplain forests and forested wetlands as critical climate resiliency resource areas.

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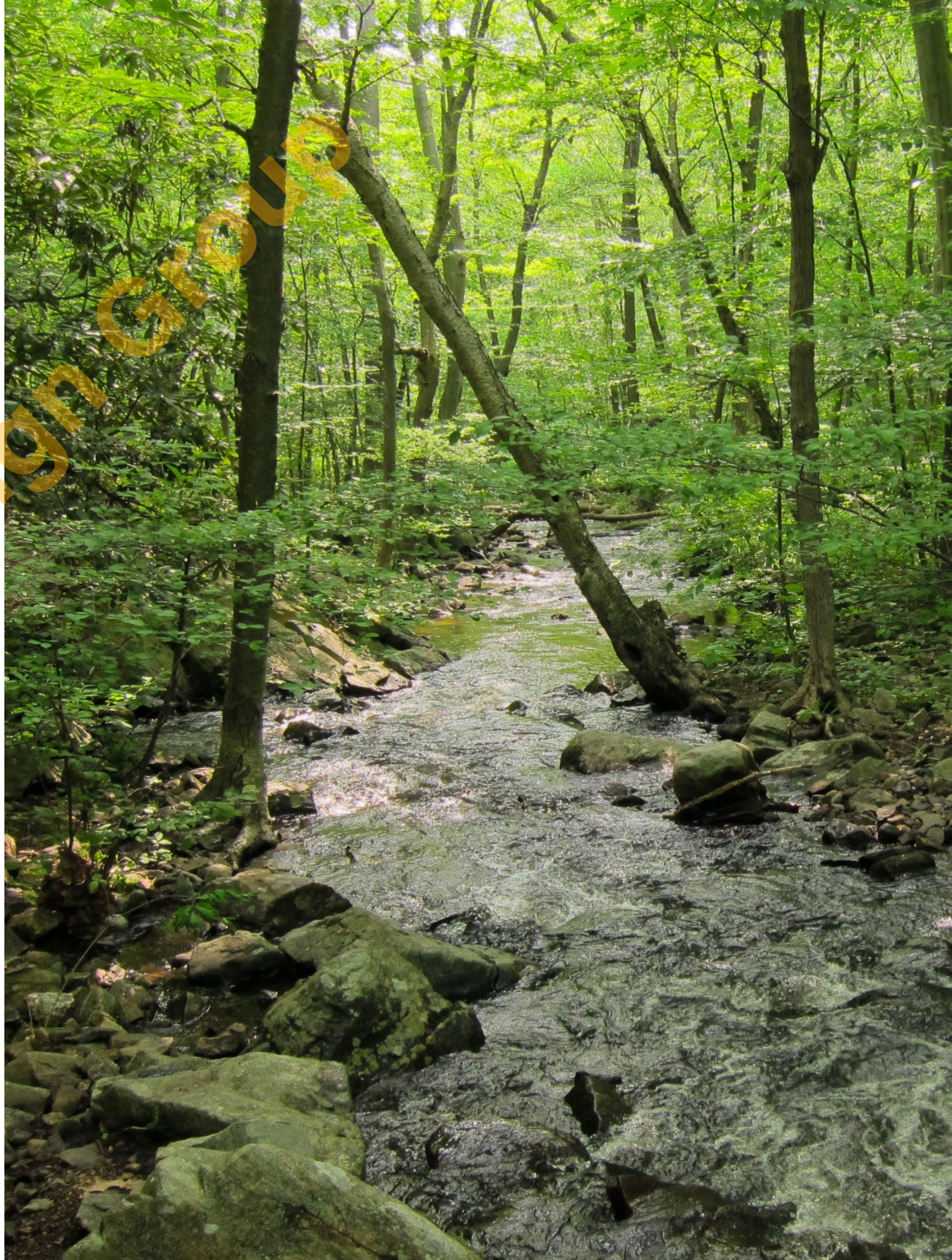

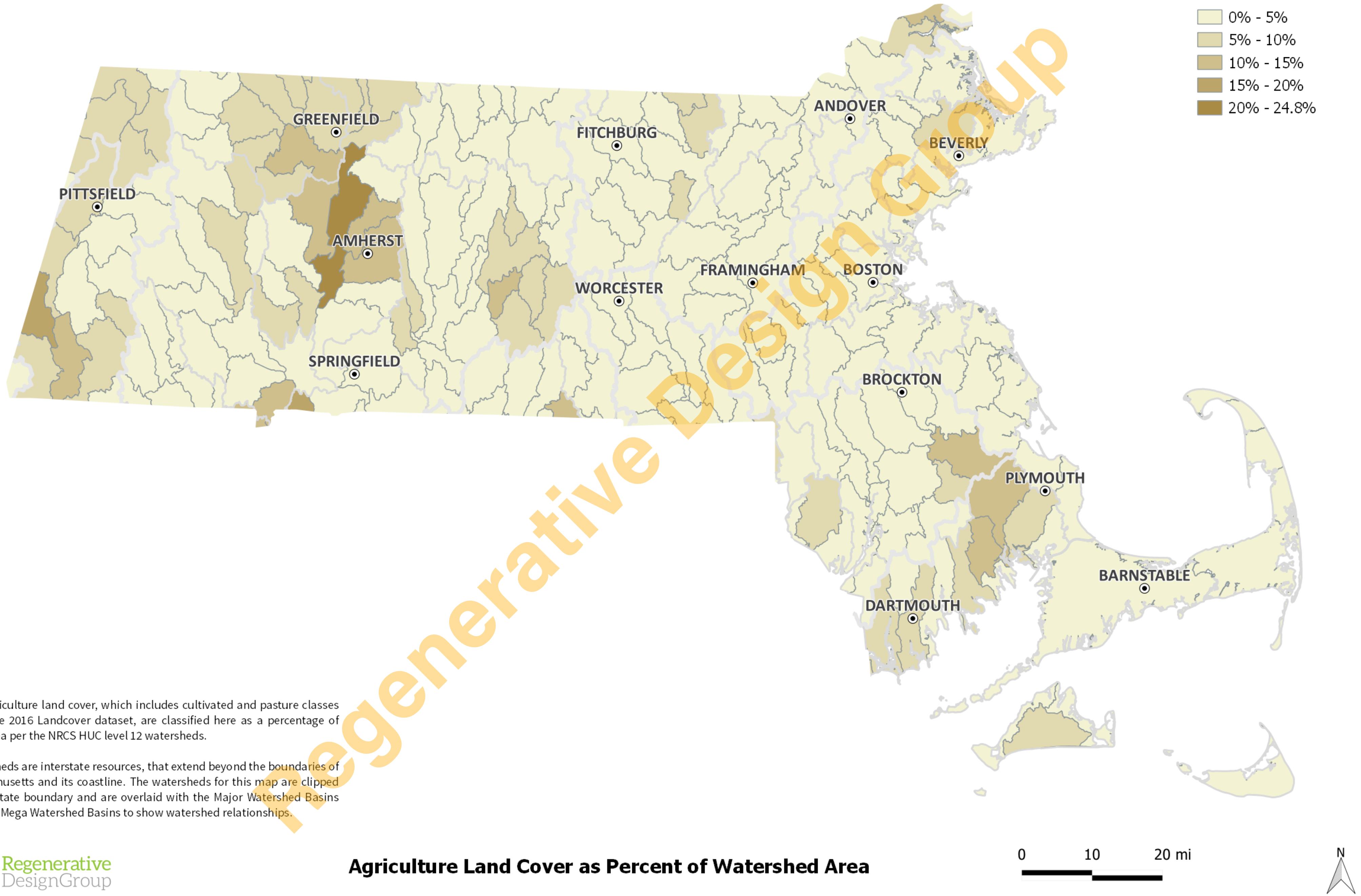

The agriculture land cover, which includes cultivated and pasture classes from the 2016 Landcover dataset, are classified here as a percentage of land area per the NRCS HUC level 12 watersheds.

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Agriculture Land Cover as Percent of Watershed Area

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Agriculture: Soil Health Vulnerabilities

Climate Change + Natural Hazards

- Floods brought on by increased frequency and magnitude of precipitation threaten approximately 20,000 acres of cultivated + pastured farmland in the 100-year flood zone.

Land Conversion

- Although projections for threatened acres varies widely by source, all unprotected farmland is at risk of residential, commercial, and ground-mounted solar development.

Land Management

- Lack of consistent + cohesive support for farmers that want to learn about, implement, and monitor the effectiveness of soil health practices.
- Slim profit margins make it economically challenging for farmers to implement soil health practices.

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Source: Massachusetts Dairy Farmers, massdairy.com

Agriculture: Key Recommendations

- Incentivize integration of trees and other perennial crops on farmland vulnerable to flooding and sea level rise.
- Increase monitoring + research of changes to agricultural soils from climate change.
- Update state legislation and renewable energy programs to incentivize solar development towards already developed lands where co-benefits are high such as parking lots, flat roofs, roadsides, and brownfields.
- Incentivize multi-use solar development on agricultural lands when it has clear benefits for farm viability and soil health.
- Increase funding for and farmer enrollment in existing programs that provide technical assistance, educational opportunities, and material support.
- Research feasibility of using a fertilizer fee as a funding source for Healthy Soils Programs.
- Research feasibility of a Payment for Ecosystem Services program to compensate farmers for producing measurable benefits like reduced nutrient runoff, stormwater management, and OM or SOC gains.

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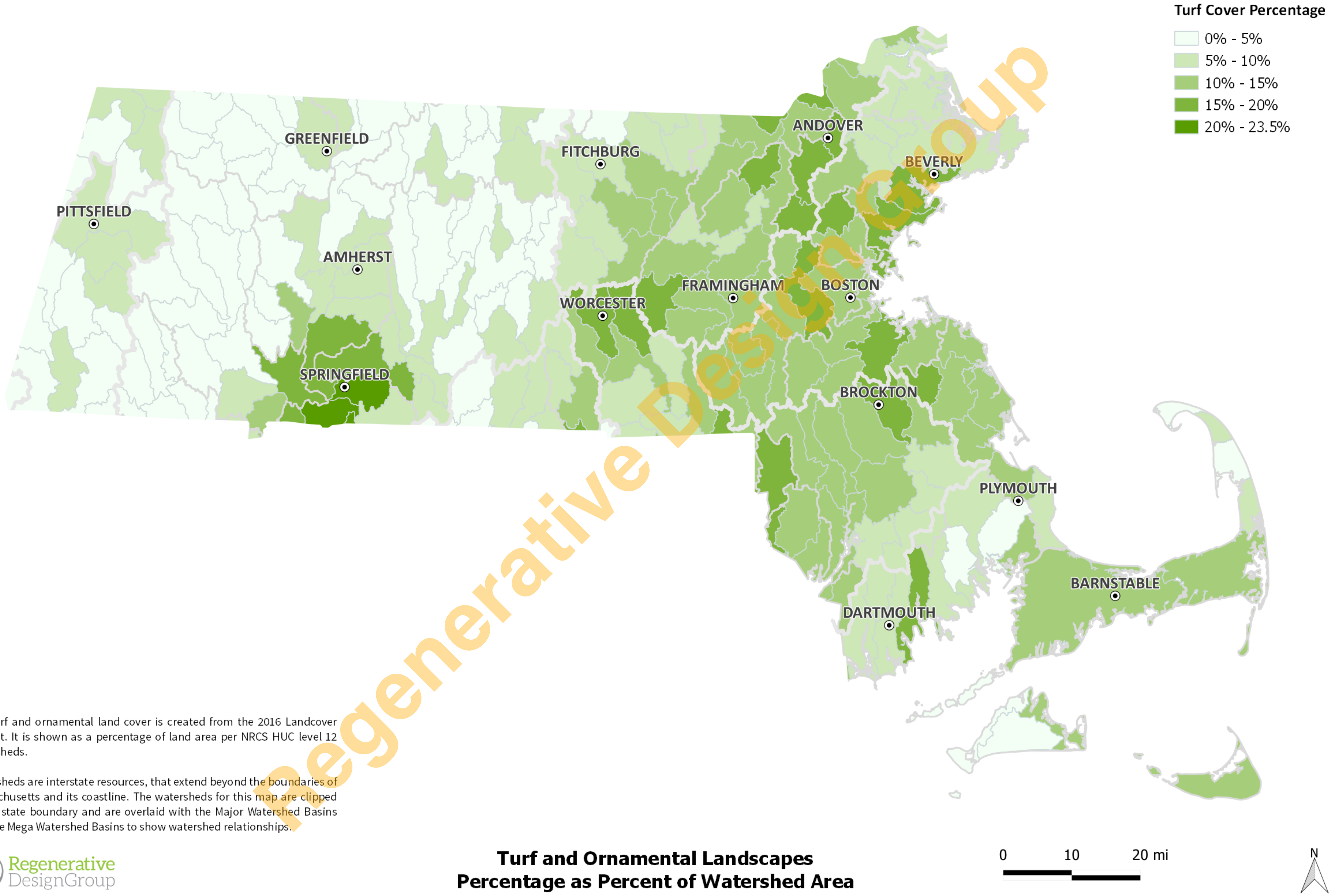
Source: Massachusetts Dairy Farmers, massdairy.com



The turf and ornamental land cover is created from the 2016 Landcover dataset. It is shown as a percentage of land area per NRCS HUC level 12 watersheds.

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Turf and Ornamental Landscapes
Percentage as Percent of Watershed Area

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Turf: Soil Health Vulnerabilities

Climate Change + Natural Hazards

- Increasing intensity and frequency of drought and heatwaves require more inputs to maintain function

Land Conversion

- Standard development practices drastically alter soil function and create conditions that limit the performance of this land cover; it is estimated that MA could have up to 123,000 acres of new turf and ornamental landscapes by 2050.

Land Management

- Turf and landscape professionals repeatedly cited the management challenges of ‘inheriting’ poor soil post-development.
- Turf and landscape professionals cited a perceived lack of consumer knowledge about the many benefits of healthy soils as common hurdles to better practice.

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Turf: Soil Health Recommendations

- Encourage practices that increase resilience to drought and heat.
- Encourage municipal bylaws that prevent and repair compaction by documenting existing conditions prior to site clearance to establish a soil health baseline. Aim to maintain or increase stormwater infiltration and SOC.
- Establish stockpiling, soil movement, and tree protection requirements as part of the planning, conservation commission, and building permitting processes.
- Increase soil health education and outreach strategies for all professionals that play a role in the creation and maintenance of turf and ornamental landscapes.
- Develop or update statewide programs that celebrate, educate, and incentivize soil health practices in the developed landscape.

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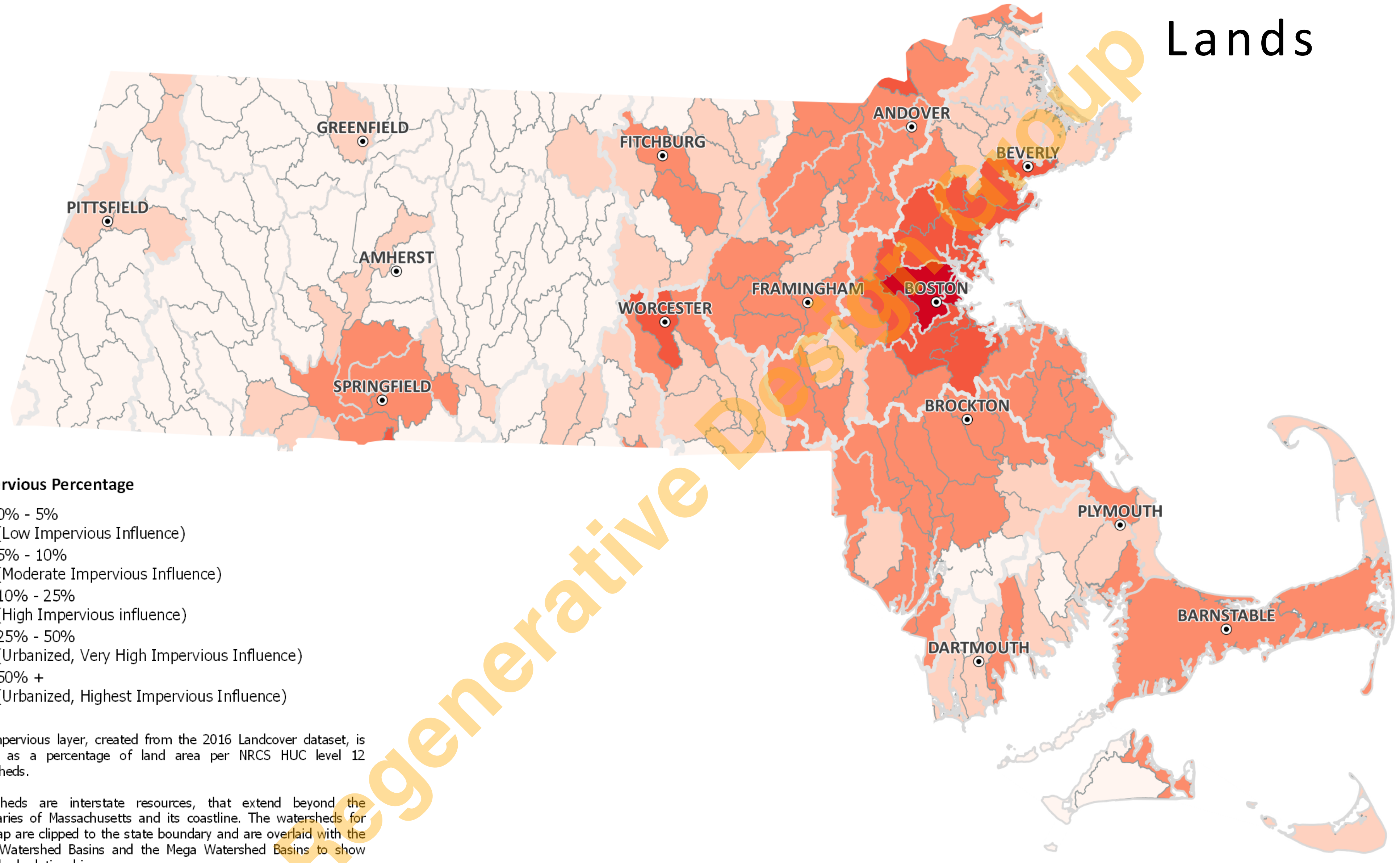
Impervious Lands



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Impervious Percentage

- 0% - 5% (Low Impervious Influence)
- 5% - 10% (Moderate Impervious Influence)
- 10% - 25% (High Impervious influence)
- 25% - 50% (Urbanized, Very High Impervious Influence)
- 50% + (Urbanized, Highest Impervious Influence)

The impervious layer, created from the 2016 Landcover dataset, is shown as a percentage of land area per NRCS HUC level 12 watersheds.

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Impervious as Percent of Watershed Area

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Impervious: Soil Health Vulnerabilities

Climate Change + Natural Hazards

- 18,370-acres of this land cover is in the 100-year flood zone. With 3-feet of sea level rise roughly 1,400-acres will be permanently inundated and almost 1,800-acres will below this new sea-level.
- Bears the burden of contamination from industrial land uses and remediation is costly; however the costs of not addressing these legacy issues are often borne most heavily by the black, brown, poor and other vulnerable populations of the Commonwealth.

Land Conversion

- The requirements for the construction of durable paved areas and stable buildings often necessitate the removal of native soils and ecosystems they support in favor of engineered soil and simplified vegetative communities.
- This land use is projected to increase to between 550 to 625 thousand acres by 2050.

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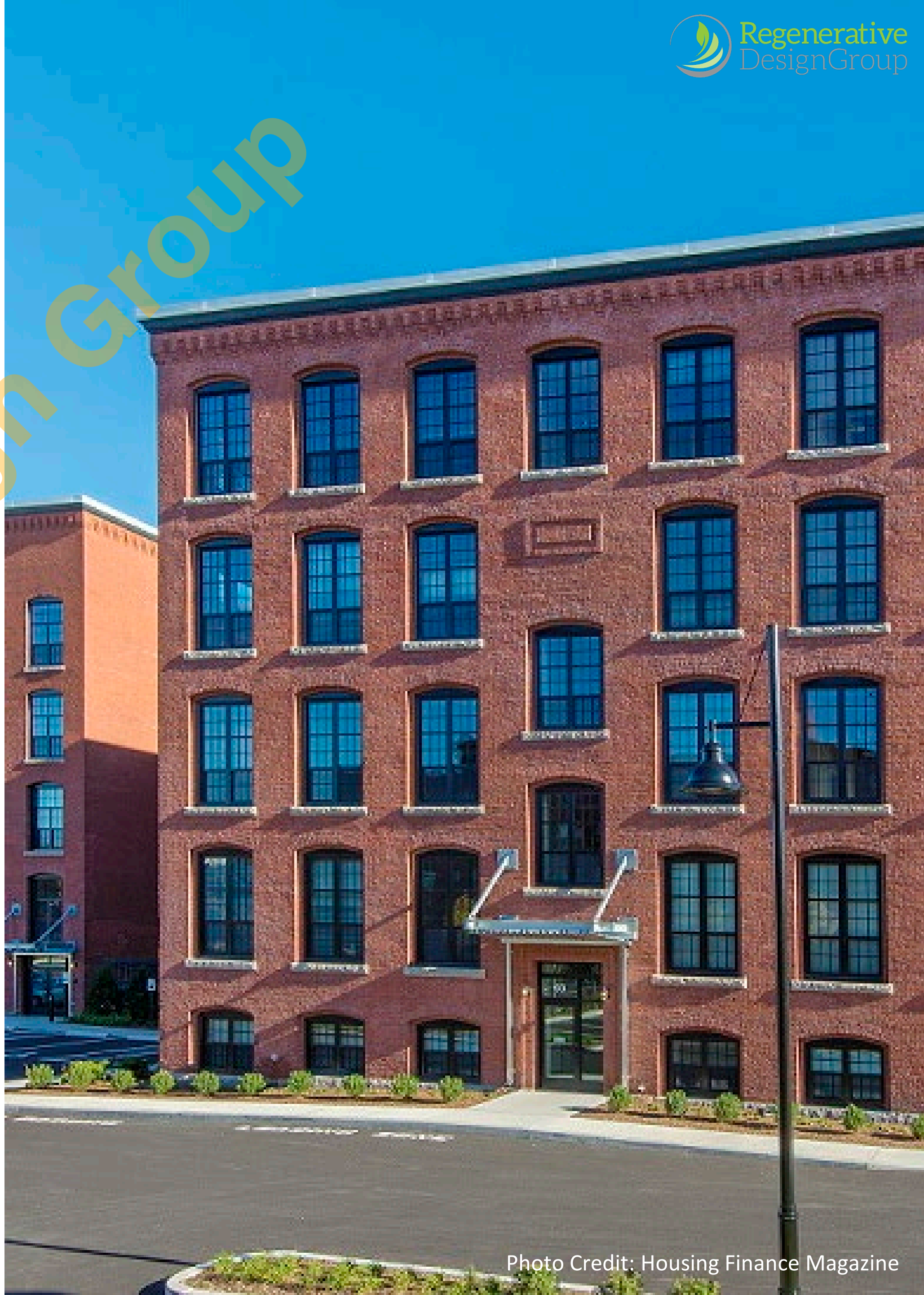

Photo Credit: Housing Finance Magazine

Impervious: Key Recommendations

- Encourage higher-density in-fill development and redevelopment on already impacted soils.
- Develop and adopt Post-Construction Soil Performance Standard for development/re-development projects
- Improve performance specifications for engineered soils that increase the stormwater infiltration and storage capacity in and around impervious surfaces.
- Develop watershed resilience plans for subwatersheds already significantly impacted by impervious cover or at high risk of future development to protect or regenerate soil function.
- Require green infrastructure and other nature-based solutions be integrated into development and redevelopment projects to mitigate or regenerate loss of soil function due to development process and increase in impervious surfaces.

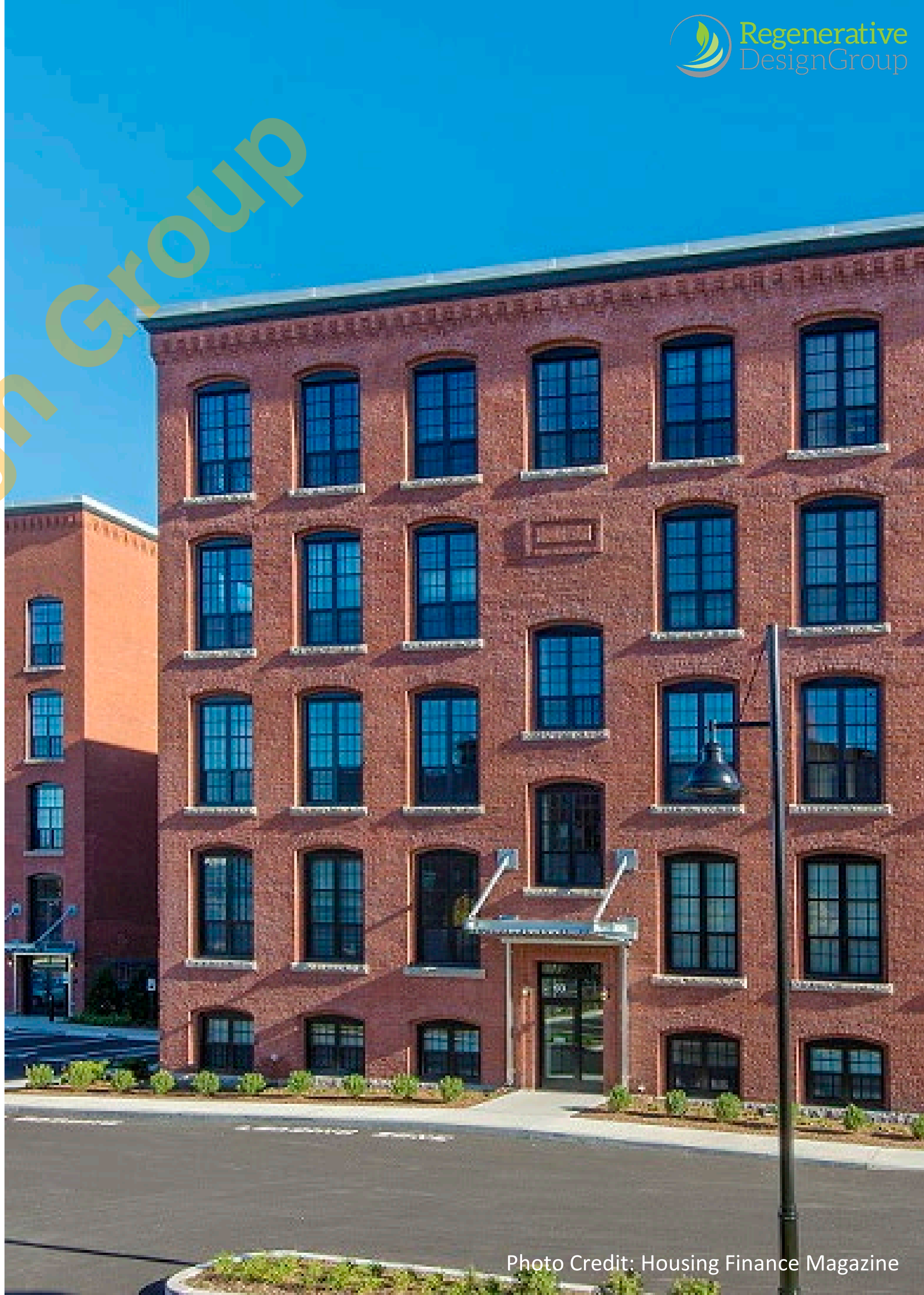

Photo Credit: Housing Finance Magazine

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Massachusetts Healthy Soils Action Plan

Draft Goals

- > Limit the conversion of natural and working lands
- > Increase adoption of soil-smart management practices across all land types
- > Proactively use soil-based solutions to mitigate and adapt to Climate Change
- > Improve access to technical expertise, financial, and other resources for land managers
- > Incorporate soil-based criteria + performance standards into government land use and land management policy and programs
- > Develop + promote soil health certifications and trainings for land-based professionals
- > Enhance Massachusetts-based capacity to analyze and assess soil health

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