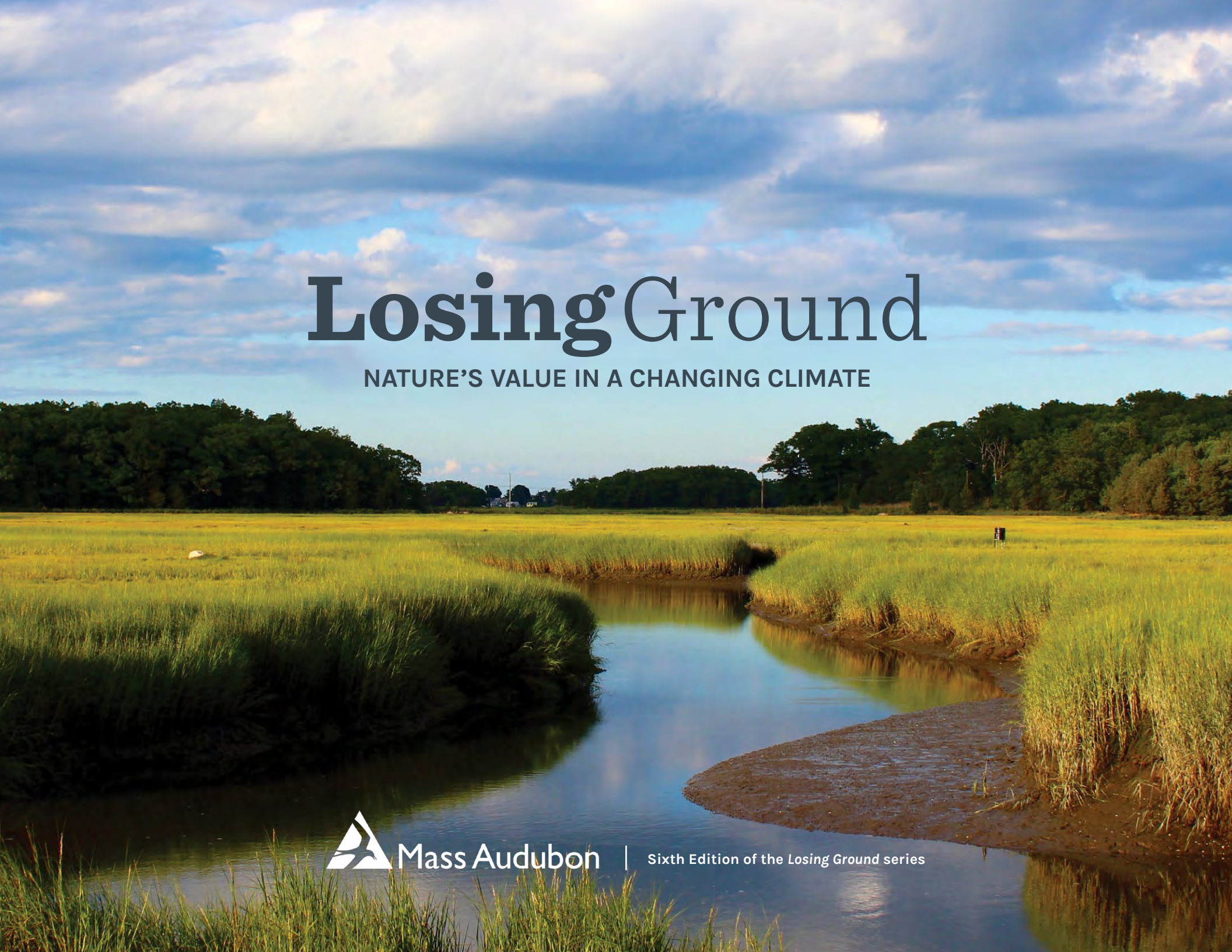

Losing Ground

NATURE'S VALUE IN A CHANGING CLIMATE

Mass Audubon | Sixth Edition of the *Losing Ground* series

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Mass Audubon calls for conservation of half of Massachusetts by 2050.

Photo of ovenbird by Asli Ertekin. Front cover photo by Julie Archibald

Introduction

As the effects of climate change become increasingly evident across Massachusetts and around the world, a sense of urgency has never been more apparent. A report by the UN's Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[1] in August 2019 and a September study on North American bird populations published in the journal *Science*[2] show that loss of natural land is not only worsening climate stressors, but also contributing to grave losses in biodiversity.

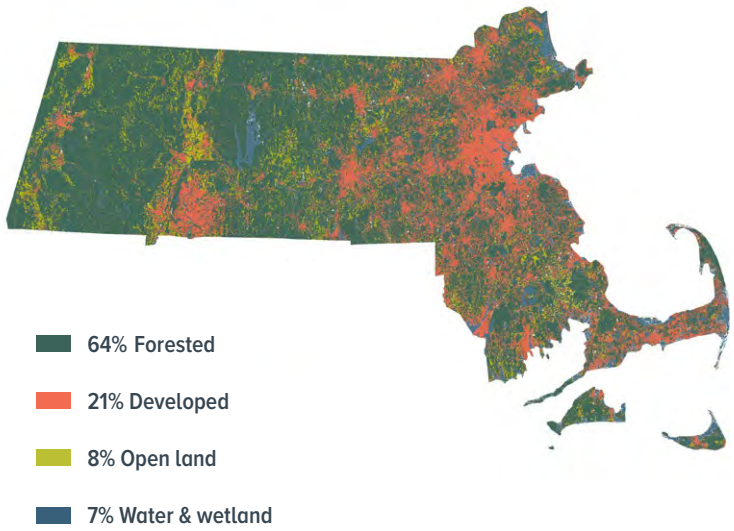
Given these harsh new realities, the value of undeveloped land has become even more crucial to both reducing greenhouse gas emissions and providing resilience in the face of growing environmental threats. This sixth iteration of *Losing Ground* reviews changes in the land at a moment when protection of natural lands and future development must align to promote healthy natural and human communities.

In this spirit of urgency, Mass Audubon calls for permanent conservation of 50% of all land in Massachusetts by 2050.

At the same time, we believe that socioeconomic priorities for Massachusetts residents, such as housing, transportation—even renewable energy—can be met through strategic and sustainable land use planning.

Reports such as this, presenting science-based alternatives and solutions, can serve both as a guide star for policy and as a broader resource for communities committed to meaningful climate action.

DISTRIBUTION OF LAND COVER IN 2017



WHAT THE NUMBERS TELL US

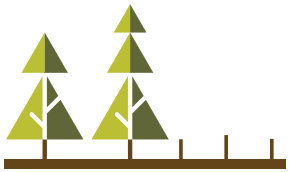
The average rate of development slightly increased from 13 acres/day in *Losing Ground 5* to 13.5 acres/day, with a new type of land development—ground-mounted solar photovoltaic arrays—contributing a significant proportion, as much as one-fourth of the total in recent years. However, in this same time period, the efforts of a dedicated conservation community have increased the rate of land being conserved from 40 acres/day to 54.8 acres/day.

01 | Changes to the Land

When *Losing Ground 5* was released in 2014, the state was still recovering economically from the effects of the Great Recession and the rate of development was down significantly from the previous installment of *Losing Ground*.[3] We hoped that this trend would continue as climate change resilience imperatives became more of a focus of the residents of the Commonwealth of Massachusetts.

In this installment of *Losing Ground* we analyzed a statewide land cover dataset created by Boston University's Department of Earth & Environment. We found that between June 2012 and June 2017 the average rate of land development had increased only slightly since our last report—from 13 to 13.5 acres per day—translating to approximately 24,700 acres of natural land converted to development in that five-year period. While this increase in the average rate of development is discouraging, we observed that a new category of land use makes up a significant portion of this new development: large-scale, ground-based solar photovoltaic (PV) arrays. We estimate that ground-based solar represents roughly 6,000 acres of land conversion between 2012 and 2017—or one quarter of all development. Without this new land use, the rate of development would have actually dropped to 10.2 acres per day. We must encourage the continued growth of the solar energy sector while emphasizing rooftop and parking lot canopy systems rather than ground-mounted arrays that degrade wildlife habitat and other important values of natural land.

LAND CHANGE & DISTRIBUTION (2012–2017)



↓ 29,929
ACRES OF FOREST LOST

↑ 24,699
ACRES DEVELOPED

↑ 2,221
ACRES WETLANDS

↑ 6,763
ACRES OPEN LAND

A NOTE ON OPEN LAND

The amount of open land in the state increased by nearly 6,800 acres between 2012 and 2017. Open land includes grasslands, agriculture, athletic fields and golf courses, beaches, and unvegetated land. Conversion to open land could represent expansion of one of these cover types as well as land that was being prepared for development toward the end of our window of analysis. Some of this increase in open land can also be attributed to rings of sandy beach seen around reservoirs that were relatively low during the extreme drought in 2017. At a statewide scale, the cumulative sum of this additional land area is meaningful.

A large solar photovoltaic canopy was installed over a parking lot in Framingham, MA.

Source: Map images from Google 2016 and 2018.

LET'S GET SOLAR OFF THE GROUND

A rapid transition to clean, renewable energy including solar photovoltaic (PV) systems is a crucial part of climate mitigation. But the choices we make in where to install these systems have a significant impact on other critical goals such as conservation of forests and farmlands. The Massachusetts Department of Energy Resources (DOER) offers financial incentives for solar PV development projects—a program that Mass Audubon wholeheartedly supports. However, the program has generated unanticipated, and quite unfortunate, land use outcomes thus far.

Since 2012, an estimated 6,000 acres or more of previously undeveloped land have been converted to large-scale, ground-mounted solar arrays.[4,5] If this trend continues, as much as 150,000 acres of land may be lost to meet the targets for renewable energy development—land that is needed to provide other important functions in responding to climate change.

This loss can be avoided by incentivizing solar installations within already developed sites and lands with lower resource values (e.g., parking lots, roofs, highway right-of-ways, and large turfgrass landscaped areas). Added benefits of this approach include distributed generation of power at locations where there is demand, avoiding expensive and environmentally damaging expansion of the electric grid, and support for decarbonization of the transportation and building sectors. It also avoids losses of functions provided by natural lands—including carbon sequestration, flood attenuation, clean air and water, cooling and wind breaks, and interconnected wildlife habitat—that are becoming more important due to climate change impacts.

According to the National Renewable Energy Laboratory, existing rooftops in Massachusetts have the potential to support up to 22.5 gigawatts of solar capacity, meeting up to 47% of the total electrical demand.[6] There are also vast expanses of parking lots where solar canopies could potentially be installed. The state's incentive program should be adjusted to ensure that the higher cost of these within-development installations are offset in order to make them cost-effective.

6,000 ACRES

CONVERTED TO SOLAR ARRAYS on previously undeveloped land since 2012

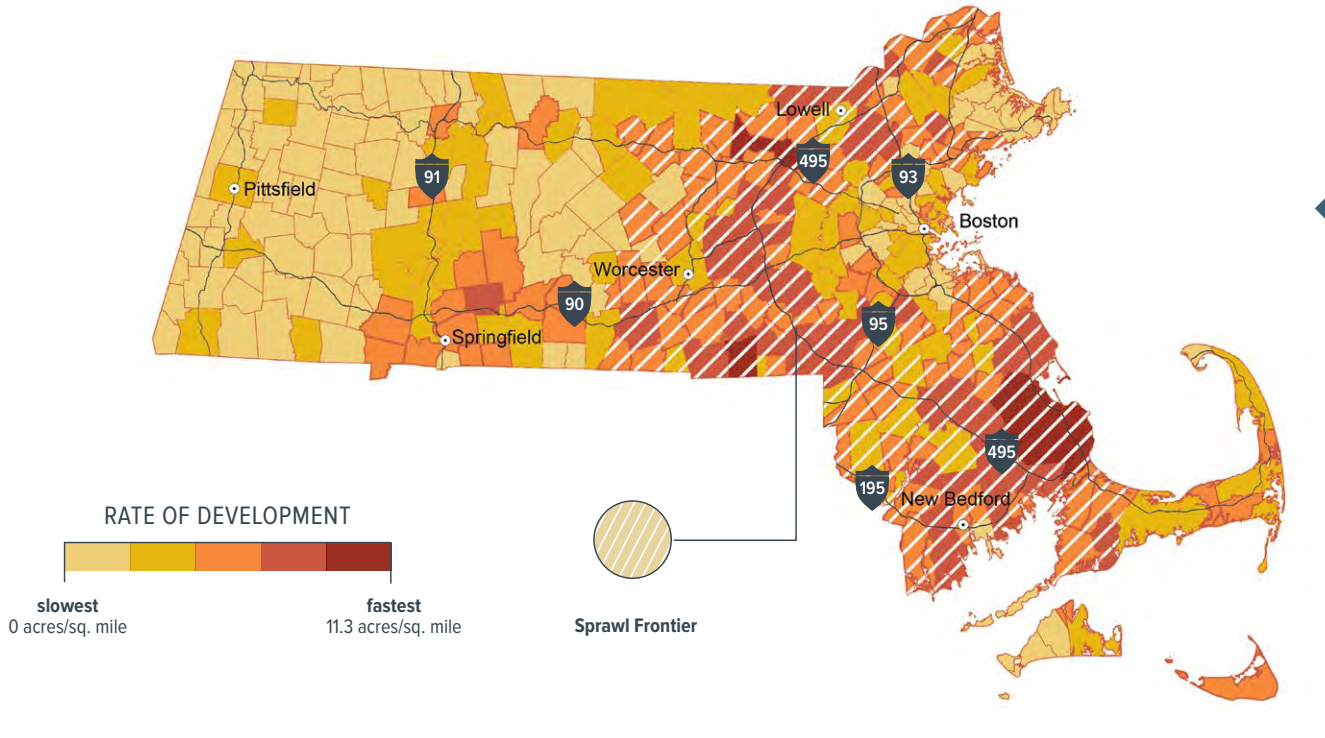
150,000 ACRES

OF LAND COULD BE LOST if current trends continue

47% OF ELECTRICAL DEMAND

COULD BE SUPPORTED BY solar capacity on existing rooftops

FIGURE 1.1 Recent development trends in Massachusetts.



COMPARING COMMUNITIES

Massachusetts' 351 municipalities vary greatly in size, from the smallest (Nahant, at 1 square mile of land) to the largest (Plymouth, at nearly 100 square miles of land), so it would not always be meaningful to compare the absolute acreage of development across towns. To provide a common basis for comparison in this report, the area of new development in each town between 2012 and 2017 has been normalized by the town's area, giving a development rate of acres per square mile.

FIGURE 1.1 illustrates the relative rate of new development by town between 2012 and 2017. The map shows that the most rapidly developing towns are largely found along the Interstate 495 belt, from the Merrimack River Valley through MetroWest and the Blackstone River Valley to Plymouth. Communities surrounding Springfield, along Interstate 91, and along Route 2 show slower but also notable new development.

Beginning in the fourth edition of *Losing Ground*, published in 2009, we labeled this belt of rapidly developing communities the Sprawl Frontier.[7] Rapid development within this area calls for proactive local and regional planning to ensure that development is focused in the most appropriate areas and the most important natural land is conserved. Since *Losing Ground 5*, some towns have taken action to develop better local planning that integrates protection of priority lands with economic needs. The Town of Ayer, for example, has gone from being the most rapidly developing town in the Sprawl Frontier to being a model of smart local planning (see Chapter 4 for more information).

FIGURE 1.2 Chart of annual acres developed versus new housing permits.

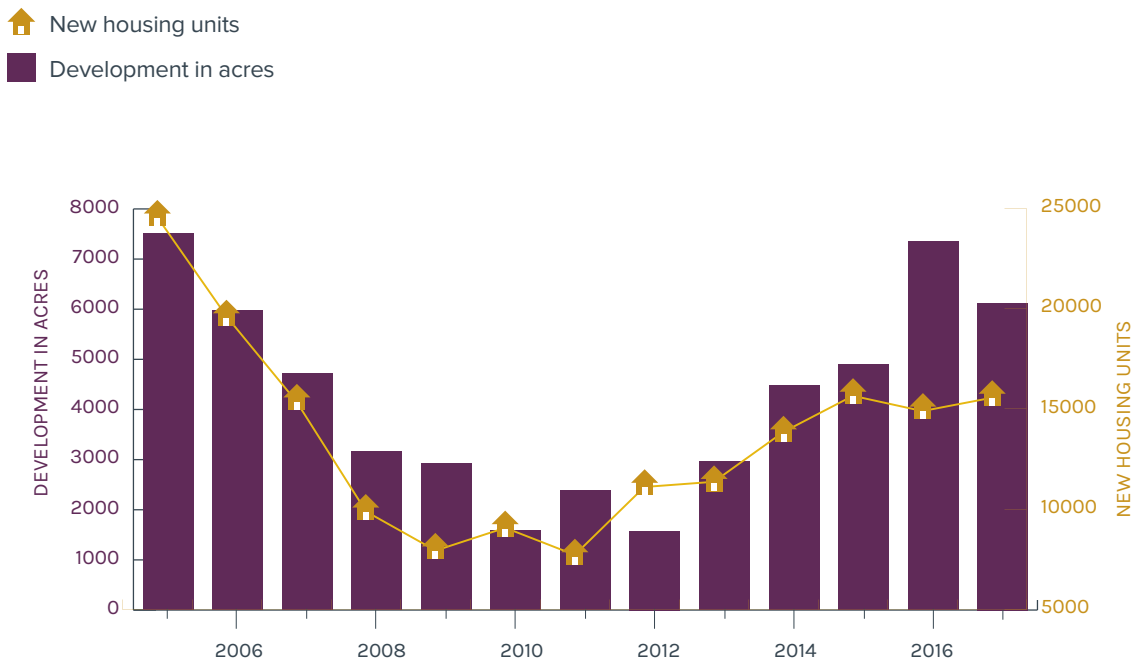


FIGURE 1.2 Data from Boston University and the U.S. Census Bureau shows annual changes in development and the number of new housing permits statewide. From 2005 to 2013, the fifth edition of *Losing Ground* found the annual rate of land conversion declined along with the annual rate of new residential building permits. These declines coincided with the housing bubble and Great Recession, and by 2013 had begun to show some recovery. We predicted that a rebounding housing market would lead again to rapid loss of natural land. This figure illustrates that both new housing development and land conversion indeed increased from 2012 to 2017, but the rate of land conversion in 2016 and 2017 increased faster than the number of new housing permits. This could be related to the boom in ground-mounted solar arrays. Housing production is far below demand and much less than in the 1980s.[8]

Photo by Karen Gardner

LAND USE DATA SOURCES

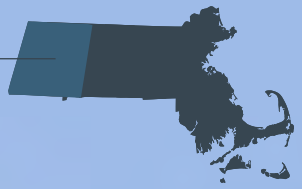
Mass Audubon partnered with the Boston University (BU) Department of Earth & Environment to develop our land cover change analysis. BU researchers use Landsat satellite imagery to map land cover and monitor land cover changes. Landsat Thematic Mapper and Enhanced Thematic Mapper Plus (TM/ETM+) imagery has a 30-meter resolution, resulting in a land use mosaic consisting of approximately 0.22-acre pixels.

The BU team has developed a change detection and classification approach that accurately determines the timing and location of land cover changes based on differences in the surface reflectance characteristics of individual pixels. This method utilizes all available Landsat TM/ETM+ data from 1985 to the present, and is relatively unaffected by clouds, shadows, satellite error, and other artifacts that challenge land cover analyses based on shorter observation periods.

02 | Saving Land

Through the efforts of many people, organizations, and agencies over many years, 1.353 million acres, or 27% of the land area of Massachusetts, is permanently conserved as of 2019. While many large tracts of permanently protected forest are found in central and western counties, conservation by communities and local land trusts is ensuring that open space is being protected throughout the state for people and wildlife.

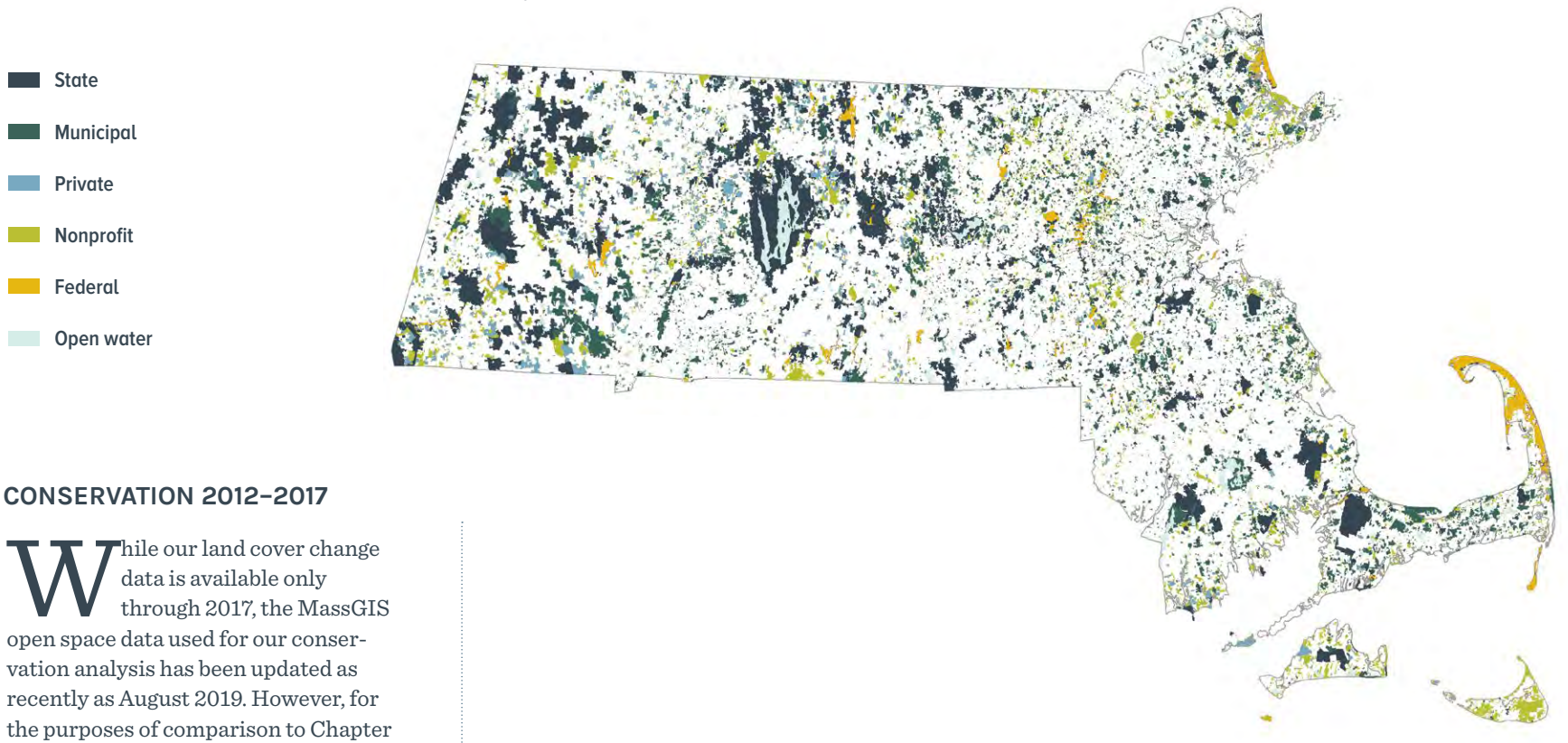
27%



of the land area of Massachusetts is now permanently conserved.

To protect 50% of the land in MA by 2050, we need to accelerate the pace to 100 acres/day.

FIGURE 2.1. Distribution and ownership of permanently conserved open space in 2019.



CONSERVATION 2012–2017

While our land cover change data is available only through 2017, the MassGIS open space data used for our conservation analysis has been updated as recently as August 2019. However, for the purposes of comparison to Chapter 1, we analyzed conservation activity between 2012 and 2017. In that time period just over 100,000 acres of land were permanently protected across the Commonwealth. This represents an average pace of 54.8 acres per day, a 37% increase from the 40-acre-per-day pace reported in the last edition of *Losing Ground*.

PERMANENTLY CONSERVED OPEN SPACE

2012–2017

100,000

ACRES WERE PERMANENTLY PROTECTED IN COMMONWEALTH

2008–2012

40 acres/day

2012–2017

54.8 acres/day

INCREASE 37%

Photo at left by Eric Luth

FIGURE 2.2

Rate of newly conserved land from 2012 to 2017 by town.

As open space holds so much value for wildlife, for the irreplaceable character of our communities, and for the ecosystem services provided, we call for a doubling of the pace of conservation with **the goal of protecting at least half of the Commonwealth by 2050 — 50% by '50.** To achieve that goal, we need to further accelerate the pace of land conservation to an average of 100 acres per day.

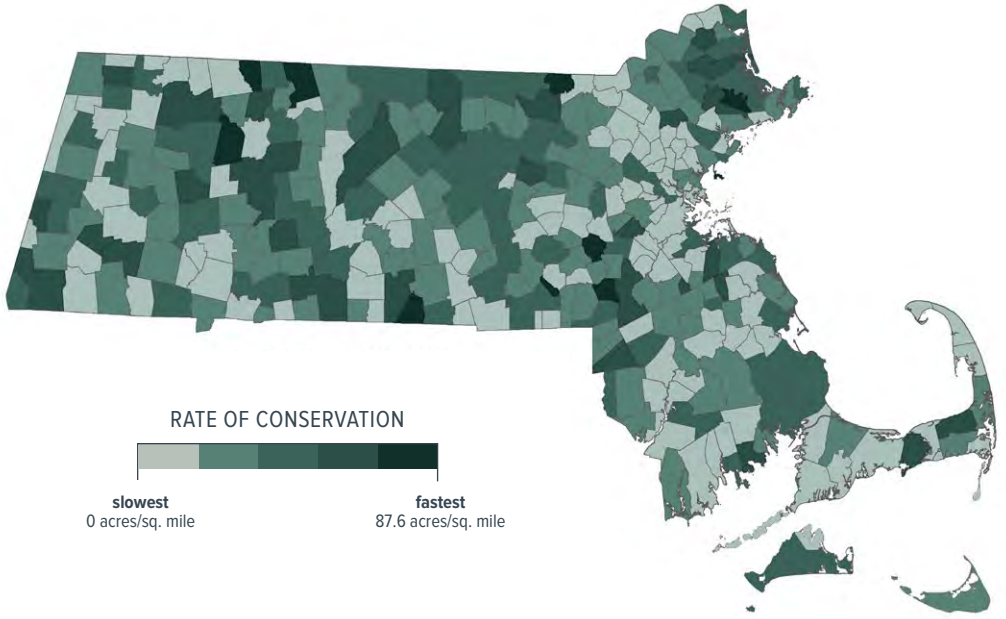
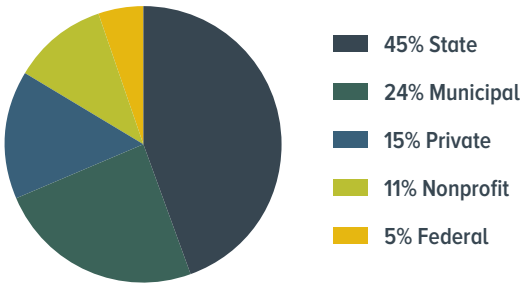


FIGURE 2.3

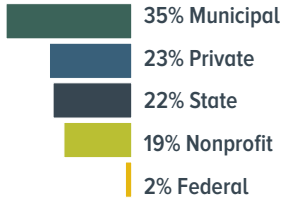
Ownership of permanently conserved land in Massachusetts as of 2017.



The Commonwealth of Massachusetts is the largest owner of permanently conserved open space, holding nearly 590,000 acres, largely in state forests, state parks, wildlife management areas, and the forests surrounding Quabbin and other reservoirs. Cities and towns own and manage about 321,000 acres of conserved lands, in town forests, parks, and other open spaces. Privately-owned protected land totals just over 196,000 acres, most often conserved with a Conservation Restriction or Agricultural Preservation Restriction held by the state, a municipality, or a land trust. Nonprofits such as land trusts own nearly 145,000 acres across the state, and the federal government protects just over 63,000 acres.

FIGURE 2.4

Who is protecting land recently?



Of the 100,000 acres conserved between 2012 and 2017, cities and towns conserved 34,637 acres. The role of municipalities in land protection has increased—from 23% of the land protected between 2008 and 2013 to 34% in this report period. The state protected an additional 22,100 acres, nonprofits such as land trusts added 18,600 acres, and the federal government acquired just shy of 2,000 acres. Private landowners remained very active participants in conservation, working with conservation entities to place restrictions on nearly 23,000 acres of land. Land trusts and the state each added roughly 9,500 acres of restrictions and municipalities protected 3,500 acres with restrictions.

Resilience for People & Nature

Based on the many values of natural systems (expanded on in Chapter 3), there is an increasing recognition of the role of "Green Infrastructure" (GI) in land use planning and development design. The last edition of *Losing Ground* focused on the role of land in providing resilience for the protection of biodiversity. A complete Green Infrastructure Network also provides resilience to human communities.

WHAT IS GREEN INFRASTRUCTURE?

For the purposes of this publication, we define Green Infrastructure as follows:

"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.[9]

As with built or gray infrastructure, Green Infrastructure performs a function, but with different mechanisms, little or no required financial investment, and in a self-sustaining manner. An example is vegetation along a river or shoreline: the roots hold soil in place and the soil filters out pollutants before they reach the river, thus avoiding the need for engineered water treatment systems.

Most Green Infrastructure performs multiple functions simultaneously, providing benefits of clean air, clean water, contiguous habitat, and carbon sequestration, among others. Sometimes where the natural system has been destroyed, financial investments may be needed to restore it, but the area is often then self-sustaining, and less costly to maintain than a gray engineering system.

GI plays important roles in the resilience of both natural and human communities. Consider a stream corridor, for example. Protecting and restoring forested areas along the stream provides habitat for both fish and wildlife and accommodates their movement through the landscape (ecological resilience), while also reducing flood risks to downstream communities. Upgrading an undersized culvert may improve this habitat connectivity while also removing a threat of a road washing out (infrastructure resilience). The overall result may provide for public recreation and improved water quality as well as maintenance or enhancement of flood storage capacity (societal resilience).

Photo by Ayla Fox for Narragansett Bay Estuary Program.

Green Infrastructure Network

In 2017 our conservation and research partners at Manomet, a nonprofit environmental organization based in Plymouth, developed a model called the Green Infrastructure Network (GIN) that identified the highest-priority unprotected and undeveloped natural areas of the Taunton Watershed.[10] Components of this model, combined in a Geographic Information System, include:

- **RESILIENT LAND**: Areas of "above average" resilience (≥ 0.5 standard deviation) according to The Nature Conservancy's Resilient Landscapes dataset (specifically, a higher-resolution 90m version generated by The Nature Conservancy for Mass Audubon).[11]
- **IMPORTANT HABITAT**: BioMap2 Core and Critical Natural Landscape areas.[12]
- **RIPARIAN BUFFERS**: Land within 100 feet of surface waters and wetlands (based on features in National Wetlands Inventory V2)[13] and areas within 100 feet of 100-year flood areas and high-risk coastal flood areas (as defined by the National Flood Hazard Layer).[14]
- **AREAS VULNERABLE TO SEA LEVEL RISE**: Land ≤ 4m elevation.

In this installment of *Losing Ground*, we have extended this approach to the entire state. The network allows us to see how well land protection efforts are being targeted at protecting the most important land for wildlife habitat and resilience. Likewise, it can inform decisions on where development would do the most harm.

FIGURE 2.5

The statewide Green Infrastructure Network in 2012 both protected and unprotected.

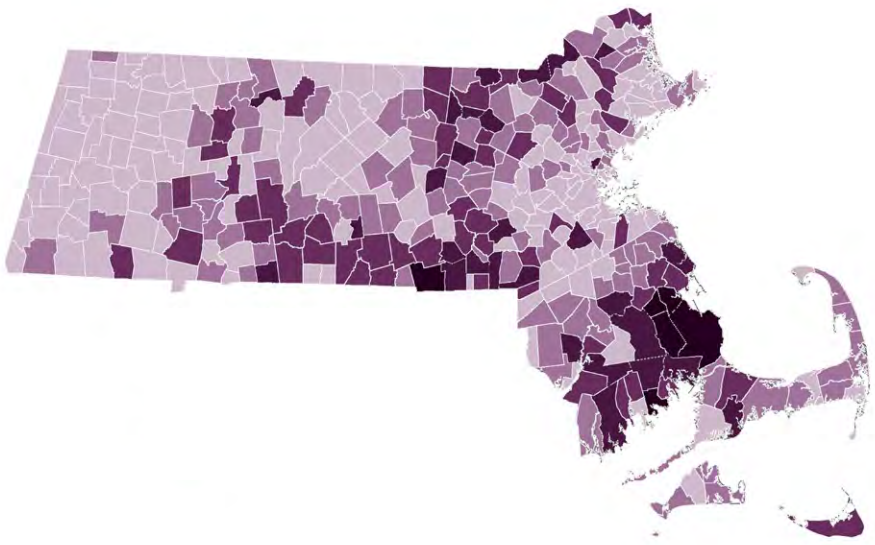
PROTECTION AND DEVELOPMENT OF THE GREEN INFRASTRUCTURE NETWORK

The statewide Green Infrastructure Network (GIN) encompasses 2.9 million acres. As of 2012, 1.037 million acres (36%) of the GIN had already been protected, leaving 1.8 million acres of high-priority land for conservation unprotected in Massachusetts.

Between 2012 and 2017, just over 9,300 acres of the GIN were lost to new development, largely within the Sprawl Frontier. This represents 38% of all new development, suggesting that there is an urgent need for improved development planning to avoid impacting our most valuable lands.

Just over 82,200 acres of GIN land were conserved between 2012 and 2017, or 76% of all newly protected land. Thanks to a strategic approach among agencies, municipalities, and land trusts, our investments in land conservation have been well-focused on protecting the GIN.

FIGURE 2.6
Newly Developed Green Infrastructure Network.



NEWLY DEVELOPED

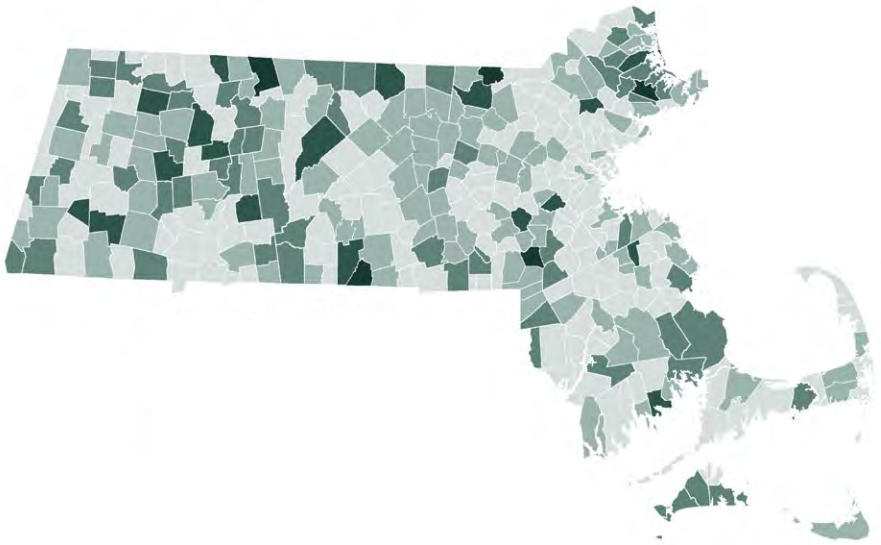
0 acres/sq. mile — 7.6 acres/sq. mile

9,300
ACRES OF GREEN INFRASTRUCTURE NETWORK LOST TO DEVELOPMENT

495

BIGGEST GIN LOSS LOCATED IN SPRAWL FRONTIER

FIGURE 2.7
Newly Protected Green Infrastructure Network.



NEWLY PROTECTED

0 acres/sq. mile — 84.6 acres/sq. mile

2012–2017

82,235
ACRES OF CONSERVED GIN

THAT'S **76%** OF ALL LAND PROTECTED

03 | Land Use, Ecosystem Services & Climate Resilience

Climate change is already having profound effects on both people and wildlife in Massachusetts. As we grapple with rapid, wide-ranging, and interconnected changes in our environment, the roles of land and development in responding to this threat become increasingly important. Undeveloped lands and urban green spaces contribute to both climate change mitigation (reducing greenhouse gases) and adaptation (increasing resilience in the face of unavoidable changes already underway).

Poorly planned or sprawling development reduces the capacity of the land to perform a wide range of valuable ecosystem services, while targeted land conservation coupled with green, sustainable development close to existing infrastructure can help minimize the impacts.

 Photo by Diane Germani

Vital Role of Land in Protecting Both People and Nature

Land use choices have significant impacts on both climate mitigation and adaptation.[15] Forests, wetlands, coastal areas, and well-managed farmlands can sequester large amounts of carbon while providing many other functions, including clean air and water, locally produced food and wood products, habitat for diverse native species of plants and animals, and recreational opportunities, along with a high quality of life for the people of Massachusetts. These lands also provide important adaptation and resilience functions, including buffering against floods and drought, reduction in local heat effects, and flexibility for plants and animals to meet their habitat needs as conditions change. Prioritizing land conservation and restoration within the Green Infrastructure Network maximizes these benefits.

In contrast, poor or unplanned land use increases the impacts of climate change in many ways—degrading the capacity of the land to store carbon or absorb heavy precipitation; increasing our reliance on remote sources of food and wood products transported great distances; increasing energy emissions from transportation and buildings; placing people, buildings, and infrastructure in harm's way in flood-prone areas; increasing air and water pollution, affecting human health; and reducing the ability of native plants and animals to survive in a changing climate. Choices in where development is located and how it is designed, as well as protection and restoration of naturally vegetated stream corridors, can minimize these impacts.

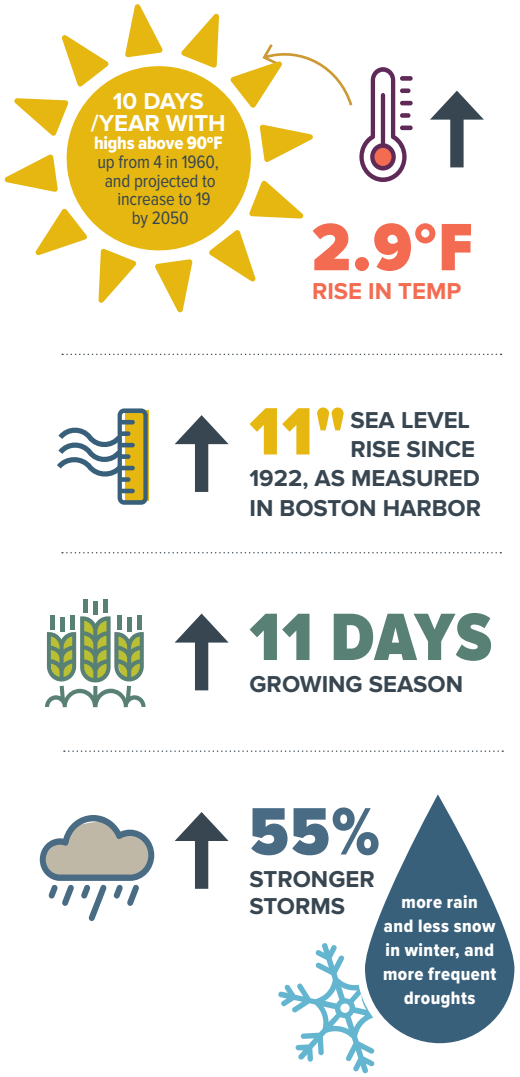
With careful planning and design, we can protect land and develop at the same time. By working with nature and incorporating it into our community development plans, we can retain the many services nature offers and reduce local infrastructure costs such as engineered solutions to flooding or water pollution.

OUR CHANGING CLIMATE AND LOCAL COMMUNITIES

Greenhouse gas emissions from human activity are the primary driver of climate change, and it is our collective responsibility to address both their causes and impacts. In Massachusetts, we are already seeing changes in temperature and precipitation patterns that are impacting natural and built environments. Key changes driven by increased temperatures include:

- ✓ **Shifting precipitation patterns** — more short-duration, intense storm events, more rain and less snow in winter, and more frequent droughts;
- ✓ **Changes in seasonality and growing patterns;**
- ✓ **Accelerated rise in sea level.**

CHANGES IN OUR STATE[16,17]



The Services Natural Land Provides

Our forests, farms, wetlands, and other natural areas provide a host of free ecosystem services. The following examples are just some of the many services that various habitats provide.

INLAND WETLANDS & WATERWAYS

Wetlands of the Eastern Mountains and Upper Midwest (includes Massachusetts/New England) store the most carbon, accounting for nearly half of the carbon stored in wetlands in the U.S.[18]

FOR EVERY

$1

SPENT ON SOURCE WATER PROTECTION

$27

SAVED IN WATER TREATMENT COSTS.[19]

GRASSLANDS & FARMLAND

1 of 3 bites

WE EAT DEPENDS ON POLLINATORS,[20] AND THEY CONTRIBUTE MORE THAN

$24 BILLION

TO THE U.S. ECONOMY.[21]

45%

of our agricultural commodities in Massachusetts rely on the rich diversity of pollinators for crop pollination.[22]

✓ **GRASSLANDS AND MEADOWS PROVIDE** unique habitat for a variety of species of birds, mammals, and insects. The native grasses and wildflowers found in these ecosystems are crucial for pollinators.

✓ **MASSACHUSETTS' ANNUAL TOTAL MARKET VALUE FOR AGRICULTURE** is $492 million, with the average 68-acre farm generating $64,000 annually (direct). Processing and support add additional value and jobs in this sector.[23]

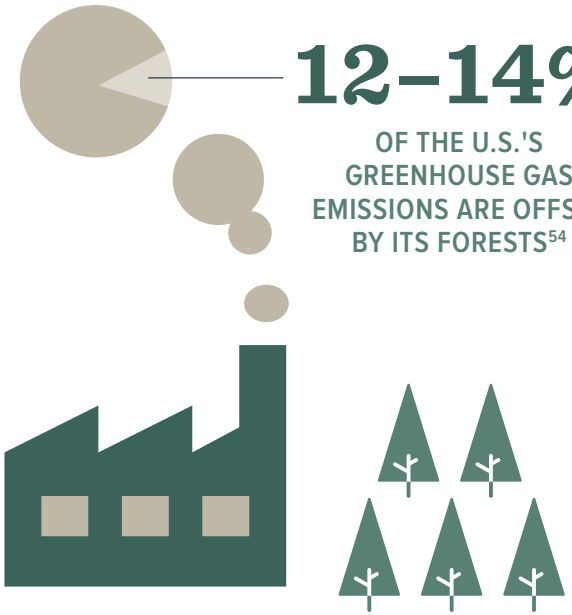
FORESTS

$3B
GROSS OUTPUT OF MA FOREST PRODUCTS/YR[24]

3 million acres (60% of state)
ARE FORESTED, STORING 85 TONS OF CARBON IN THE AVERAGE ACRE[25]

✓ **FORESTS ARE NATURAL WATER FILTRATION SYSTEMS.** Each forested acre that drains into a public water source filters 543,000 gallons of drinking water per year, meeting the needs of 19 people, with an annual value of $2,500 per acre.[26]

✓ MA's forest-based recreation economy generates approximately **$2.2 BILLION ANNUALLY AND SUPPORTS 9,000 JOBS.**[24]



12–14%
OF THE U.S.'S GREENHOUSE GAS EMISSIONS ARE OFFSET BY ITS FORESTS[54]

COASTAL

Coastal areas include diverse habitat types from salt marshes, seagrass beds, beaches and dunes, and forested or shrub upland buffers.

✓ **"BLUE CARBON ECOSYSTEMS,"** primarily salt marsh, mangroves, and seagrasses, annually sequester per area greater than 10 times the amount of carbon of most terrestrial forest systems.[27]

✓ **COASTAL WETLANDS** in the northeastern U.S. saved $625 million in flooding damages by Hurricane Sandy.[28]

22%
reduction of damages by Hurricane Sandy attributed to wetlands in over half of affected areas.[28]

✓ **THE SEAFOOD INDUSTRY SUPPORTED 87,000 JOBS** in Massachusetts in 2016, the second highest in the U.S., and it contributed $7.7 billion in sales, the third highest in the U.S.[29]

URBAN GREEN SPACE

The value of green space in cities should not be overlooked. Urban green space provides many ecosystem services, and it is especially important to provide marginalized and low-income urban communities with fair access to these benefits. Not only are these communities often farther away from open green space, but they are also more negatively impacted by the urban heat island effect and air pollution.

- ✓ **POOR AIR QUALITY** has been linked to asthma exacerbation and onset.[30] Trees' ability to absorb air pollution is preventing more than 670,000 instances of acute respiratory symptoms and more than 850 human deaths each year nationwide.[31]
- ✓ **NATURE-BASED SOLUTIONS TO URBAN STORMWATER** (e.g., rain gardens) can increase biodiversity in urban areas by mimicking lost habitat or serving as "stepping stones" that increase connectivity between fragmented habitats.[32] And the more biodiverse an ecosystem, the more resilient it is to climate change impacts like floods and increasing heat.[33]

30% reduction in air conditioning needs thanks to trees planted near buildings

20%–50% REDUCTION IN HEATING ENERGY

As estimated by the U.S. Forest Service[34]

Studies show a correlation between the proximity of communities to green space and lower levels of mental illness.[35]

- ✓ **URBAN TREES CAN REDUCE BUILDING ENERGY CONSUMPTION**, helping further mitigate climate change. Tree planting can result in up to $280 in per-house savings in the initial 15 years after planting in neighborhoods of two- and three-family homes.[34]

URBAN FORESTS IN THE 15 COMMUNITIES OF METRO BOSTON...

- ✓ **Store 962,000 tons of carbon**, worth $125 million, and capture an additional 23,000 tons of carbon per year, worth nearly $3 million.[36]
- ✓ **Help those communities** avoid 527 million gallons of stormwater runoff every year, worth $4.7 million.[36]
- ✓ **Remove 7.5 million pounds of air pollutants** per year.[36]

A VISION FOR FOOD SECURITY IN NEW ENGLAND

A NEW ENGLAND FOOD VISION, FOR 50 BY '60

Experts from universities around New England have created a plan to grow 50% of New Englanders' food locally by 2060. The 2 million acres of farmland in New England provide only 12% of our food, while 10 to 15% of households report not having enough to eat. New England has the capacity to expand its farmland from 2 million acres to 6 million acres, accomplishing the 50 by '60 goal while simultaneously reducing our "farm footprint," leaving 70% of the region forested, reconnecting people with the land, and enhancing wildlife habitat. There are trade-offs between forestland protection and increasing local food production, making it all the more imperative that conversion of prime soils to development is minimized.[37]

GOAL

50% OF NEW ENGLAND'S FOOD WILL BE GROWN LOCALLY BY 2060

GREEN CITY GROWERS

Green City Growers, an organization that converts unused spaces into urban farms, has grown more than 175,000 pounds of organic produce over less than 2 acres. Based on these production levels, it is estimated that just 1.6% of Boston's 57,363 acres of land would be needed to meet the needs of at-risk Bostonians.[38]

Photo by Nick SJ

ECOSYSTEM SERVICES FACT SHEETS

Mass Audubon has gathered information from dozens of technical articles on ecosystem services values relevant to New England. This research was used to develop a set of five fact sheets for the following ecosystems: Forests, Grasslands and Farmland, Coastal, Wetlands and Waterways, and Urban Areas. The fact sheets are available at massaudubon.org/losingground

Integrating Ecosystem Services into Development Planning

Choices about where and how development occurs directly impact the capacity of the land to support human and natural communities. Sprawling, poorly planned development with excessive amounts of habitat loss, fragmentation, and impervious surfaces will degrade land and water resources far more than the same amount of development focused away from Green Infrastructure and incorporating Low Impact Development design features. The latter approach can also increase resilience to the impacts of climate change and reduce costs such as flood control, water supply, and water purification by relying on natural systems to support these services (see Chapter 4 for more information).

NARRAGANSETT BAY WATERSHED

One example of a regional approach to valuing the natural landscape and considering options for the future is a project Mass Audubon undertook along with the University of Rhode Island and Stanford University's Natural Capital Project in the Narragansett Bay Watershed. This watershed covers more than 1,700 square miles of land, 60% in Massachusetts and 40% in Rhode Island, and 420 miles of coastline. Almost 2 million people reside within its borders, and the combined direct economic value of 13 industry sectors dependent on the Bay and its watershed is estimated at $14 billion annually.[39] In recent decades, successful investments in wastewater treatment facilities have cut nutrient pollution in the Bay in half. Now the challenges lie in addressing other pollution sources (primarily runoff from paved surfaces), protecting natural lands, and adapting to climate change.[40]

THE NARRAGANSETT BAY WATERSHED ECONOMY: THE EBB AND FLOW OF NATURAL CAPITAL

The University of Rhode Island's Coastal Institute quantified the benefits derived from the Narragansett Bay Watershed's natural capital through 13 key industries. The tourism industry provides the largest contribution to expenditure/revenue (73%) and employment (62%). Many of the industries rely on a healthy watershed ecosystem and its natural resources for continuing success, but these natural resources, and the ecosystem services they provide, are under threat from expanding development and climate change.

VALUATION OF WATER QUALITY FROM LAND USE CHANGE

The Natural Capital Project at Stanford University modeled the pollution retention benefits of lands in the Narragansett Bay Watershed. Under the Harvard Forest "Growing Global" scenario, the gains in water pollution reduction that have been achieved in the Narragansett Bay in recent years could be put at risk. The model predicted that without large investments in new wastewater treatment infrastructure, water quality would decline under this scenario due to a significant increase in bacteria levels caused by the increased conversion of forest to urban lands. Forest cover would be reduced to 22%, versus the Connected Communities scenario, which would retain 45% of the watershed as forest.

The Natural Capital Project also evaluated the willingness of people in the watershed to pay to retain the water quality level achieved by the recent wastewater treatment plant upgrades. It was estimated that on average, a household was willing to contribute between $44.76 and $59.60 per year, with total cumulative value ranging from $38 million to $51 million in the lower and upper bay, respectively.

The choices available to communities are further illustrated on Aquidneck, the largest island in the Narragansett Bay. If current sprawl trends continue, the island will run out of unprotected open space by 2050. However, by adopting smart growth development, the island can protect 70% more land, 87% of existing farmland, and achieve an 8% increase in tax revenue.[41]

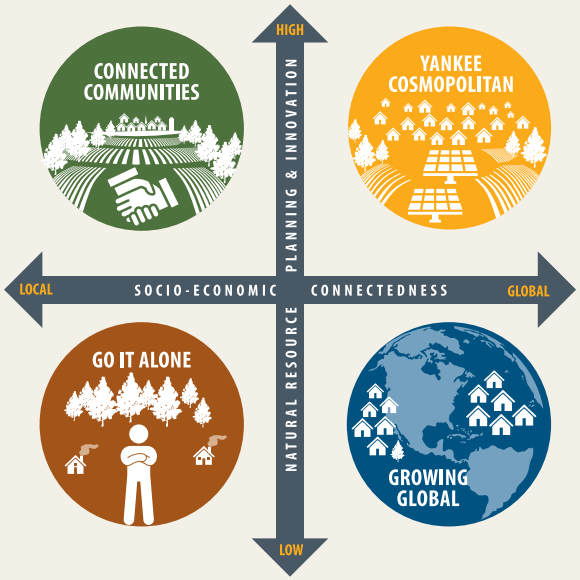
There are many potential future pathways for development and conservation across Massachusetts and the region. Decisions made today will influence the future in profound ways.

NARRAGANSETT BAY WATERSHED BENEFITS

13
KEY INDUSTRIES

+$14 billion
IN REVENUE & EXPENDITURES

+97,000 jobs
FULL & PART-TIME



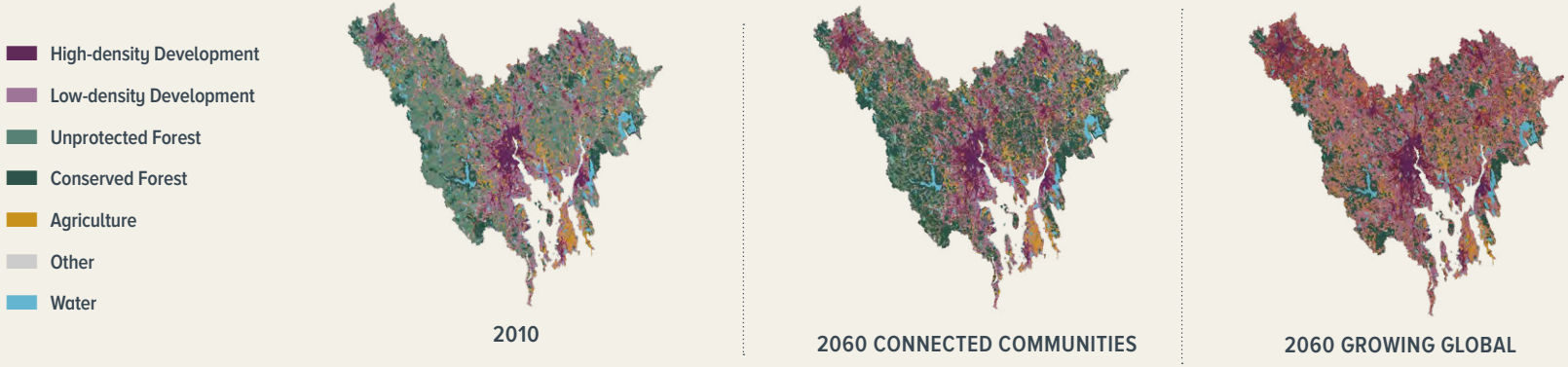
Four Potential Future Scenarios

To help envision the cumulative impacts of many small local land use and development decisions over time, researchers at Harvard Forest created a framework of scenarios based on four potential future trajectories. Developed with input from more than 160 stakeholders regarding social, economic, and environmental drivers of land use change through 2060, these scenarios are not predictions, but rather thought-provoking possible scenarios for the future of land use across the region.[42]

The four scenarios—Connected Communities, Go It Alone, Yankee Cosmopolitan, and Growing Global—are contrasted against current trends and a corresponding "business-as-usual" scenario. The scenarios construct future land use maps based on the degree to which development is focused on local community interests versus a global perspective on socioeconomic priorities, and on local planning and innovation versus low attention to local natural resources. This results in four scenarios. The Narragansett Bay example here contrasts the Connected Communities scenario with the Growing Global scenario:

- **The Connected Communities** scenario envisions a New England where communities have strengthened their local ties, becoming more self-reliant and focused on climate resilience. "Smart growth" strategies have been embraced, balancing development needs with the importance of protection of natural land.[42]
- **The Growing Global** scenario describes a very different New England in a globalized world with a much larger population, sprawling cities, inefficient energy use, degradation of open green spaces, and severely declining land protection.[42]

THE FUTURE OF NARRAGANSETT BAY WATERSHED



04 | Tools for Resilient Communities & Case Studies

Massachusetts has made much progress over the past several decades in reducing the rate of development from 44 acres per day in the mid-1980s to 13.5 acres today. We have seen that it is possible to reduce the rate of land lost to inefficient sprawl, and to increase the rate of conservation.

New challenges are emerging in response to the serious threat presented by climate change. Massachusetts is leading the way with the Global Warming Solutions Act, Green Communities Act, State Hazard Mitigation and Climate Adaptation Plan, and the Municipal Vulnerability Preparedness (MVP) Program. Yet we face many challenges in achieving optimal land use. There is a shortage of housing, and this gap is growing—nearly 500,000 new units are needed in the MetroBoston area by 2040.[43] Additionally, thousands of acres of forest and farmland are being lost to large-scale, ground-mounted solar arrays. The Commonwealth has the opportunity to coordinate the many programs and funds it provides for conservation and development to harmonize in support of targeted land conservation and smart, sustainable development.

Now is the time to act to chart a future for communities across the Commonwealth that will maximize the protection and restoration of nature for the free benefits it provides, while meeting the need to reach carbon neutrality by 2050, as well as myriad other needs including housing and jobs.

We must conserve the lands of highest natural value by using the Green Infrastructure Network to inform those decisions. Nature and the services it provides should then be integrated into new and existing developed areas. Further, restoration projects can enhance the functionality of areas that have been degraded, while providing many benefits to the communities where they are located.

Here we offer some positive examples of what is possible, as well as a framework for charting a more sustainable future for communities across the Commonwealth.

Conserve.

Strategic conservation is the best place to start for climate resilience. It is cost-effective and has multiple benefits:

- Climate mitigation and adaptation for both people and nature
- Cost savings from resilient infrastructure
- Healthy, vibrant communities (recreation, aesthetics)

We need to prioritize land conservation and stewardship, to maximize benefits for both people and nature and to focus development around existing infrastructure (water, sewer, transportation). The Green Infrastructure Network can help us identify the lands that are of highest priority.

A proactive approach based on valuing nature avoids costs of future degradation while supporting carbon sequestration, flood attenuation, water quality, air quality, and community character as well as habitat for native plants and animals.

CASE STUDY

Mass Audubon's Forest Carbon Offset Project

Carbon pricing policies, such as the California Air Resources Board's Cap-and-Trade Program, have proven effective in leveraging economic pressure to drive emissions reduction. Healthy forests are some of the Commonwealth's most invaluable assets, providing a vast array of benefits including carbon sequestration and storage. Covering more than 60% of Massachusetts' land area, forests sequester approximately 15% of annual emissions in the state.[25] Mass Audubon manages nearly all of its more than 32,000 acres of directly owned land for carbon storage, in addition to providing a diverse range of wildlife habitats.

Since 2015, Mass Audubon has been working to quantify the contributions of its managed lands, including large blocks of mature forest, to climate mitigation. A detailed inventory revealed that the forests in 10 of Mass Audubon's sanctuaries in Western Massachusetts store approximately 75% more carbon per acre than the regional average.[44] After careful planning and deliberation, Mass Audubon completed the certification process for carbon emissions offsets, and the California Air Resources Board issued nearly 800,000 offset credits under its Cap-and-Trade Program. To ensure that the sequestered carbon stays in place over the long term, Mass Audubon has formally committed to maintaining carbon stocks on the nearly 10,000 acres of forest enrolled in this project for a century, consistent with long-term ecological management goals. The sequestration estimate across the entire project area is 1.84 million metric tons of carbon dioxide equivalent, comparable to the total emissions from approximately 400,000 passenger vehicles driven for one year.[45]

This project also provides funding for monitoring, land stewardship, and other programs. Flexibility is maintained to manage other forests more intensively where appropriate for wildlife requiring young forest habitat. Through this effort and many others, Mass Audubon continues to lead by example, directly engaging with the policies, practices, and technologies that will help us adapt to and mitigate climate change over the next century.

Recently, Mass Audubon and partners have begun to explore opportunities for other landowners, particularly municipalities and smaller land trusts, to get involved in carbon offset projects.

Integrate.

Development is an essential part of our communities. There are many opportunities to improve project siting and design, as well as to retrofit existing development to reduce its impacts through the addition of trees and other natural features.

For example, local and regional planning that focuses development around existing infrastructure (e.g., transportation, water, and wastewater) can not only reduce sprawl, but also reduce emissions. Additionally attractive and walkable communities reduce transportation-related emissions. Urban trees and green spaces reduce the heat island effect while allowing areas to capture stormwater.

Natural Resource Protection Zoning and other land use tools can keep new development out of areas that are at risk of future flooding, such as coastal shorelines and inland buffers along wetlands and streams, while providing neighborhood parks and preserving critical wildlife habitats and corridors. Reducing the amount of pavement in new construction and redevelopment not only preserves water quality and reduces flooding, but it can also provide significant savings in avoidance of costly stormwater treatment systems.

Impervious Cover

0–7% 7–12% Over 12%

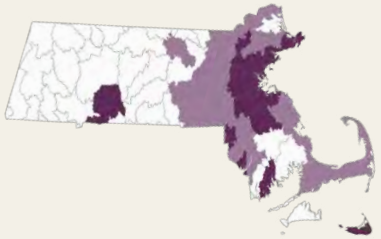
REDUCE IMPERVIOUS SURFACES

Communities' choices in how to plan for and regulate development will drive future outcomes, such as the degree to which forests and other lands can continue to absorb and filter rainwater, as depicted in these two potential futures generated from the Harvard Forest Landscape Futures Scenarios.[42] In addition to exacerbating stormwater and flooding issues, the amount of impervious cover present in the landscape has serious implications for wildlife.

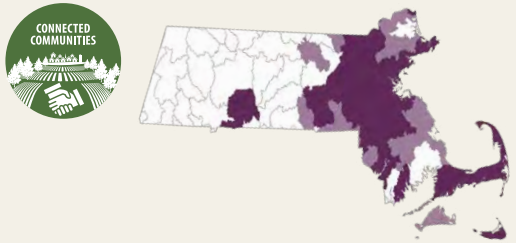
7% IMPERVIOUS COVER →
DECLINE OF RIVER FISH BY APPROXIMATELY 35%.[46]

12% IMPERVIOUS COVER →
FAILURE BY MOST STREAMS to meet water quality standards for aquatic life.[47]

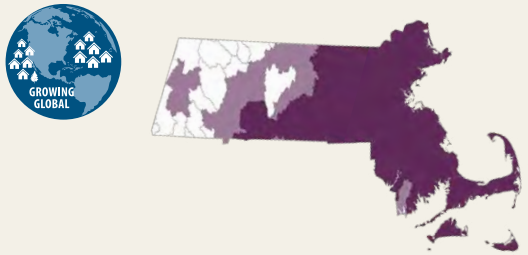
2010 Starting



2060 Connected Communities scenario



2060 Growing Global scenario



This Low Impact Development at Concord Riverwalk emphasizes less pavement and more green areas.

This rain garden at Mass Audubon's Broad Meadow Brook Wildlife Sanctuary is composed of native shrubs and flowers. It will temporarily hold stormwater runoff from the surrounding landscape and release it gradually.

LOW IMPACT DEVELOPMENT

Reducing the impact of development on the natural systems that support us is achieved not only by good site selection, but also by reducing impacts within the development design. A suite of techniques known as Low Impact Development (LID) can be applied to a wide variety of new development as well as redevelopment and retrofitting. These techniques include Open Space or Natural Resource Protection Zoning that protects much of the critical natural Green Infrastructure within a development site, at no cost, as well as development design standards that utilize plants and soils in capturing and filtering water while minimizing imperviousness. LID aims to use stormwater as a resource rather than a waste product, improving groundwater supplies and trapping pollutants before they reach our waterways. LID techniques also mitigate flooding and offer a host of additional free ecosystem services, including cleaner air, shade and energy savings, recreational opportunities, and enhanced property values and quality of life.

Utilizing LID is often cheaper than utilizing traditional built infrastructure, especially over the life span of a project. By reducing the amount of pavement, communities not only reduce their impervious surface and improve stormwater filtration, but also see a significant cost savings. For example, traditional paving costs about $6 per square foot. Reducing just a two-mile road from 28 feet wide to 20 feet wide equates to a savings of $500,000.[55] The EPA also found a cost savings of 15%-80% for 17 development sites that used Low Impact Development techniques like rain gardens and bioswales.[48]

TREE PLANTING & GREENING THE GATEWAY CITIES

Planting trees in urban areas has many benefits—from reducing heat islands and building-related energy consumption for heating and cooling, to improving health and quality of life, absorbing stormwater, and providing habitat for birds. The Massachusetts Greening the Gateway Cities program provides funding for tree planting in urban residential areas, focusing on environmental justice neighborhoods and locations with older housing stock, higher wind speeds, and large renter populations. The Greening the Gateway Cities team is planting 25,000 trees (all at least six feet tall) in 14 Gateway Cities, including Chelsea, Lawrence, New Bedford, and Pittsfield. Since its start, the program has created 100 jobs per year, and the $4 million spent has generated $8 million in revenue.[49] The program aspires to cover 5% of the target neighborhoods in new tree canopy cover.

Restore.

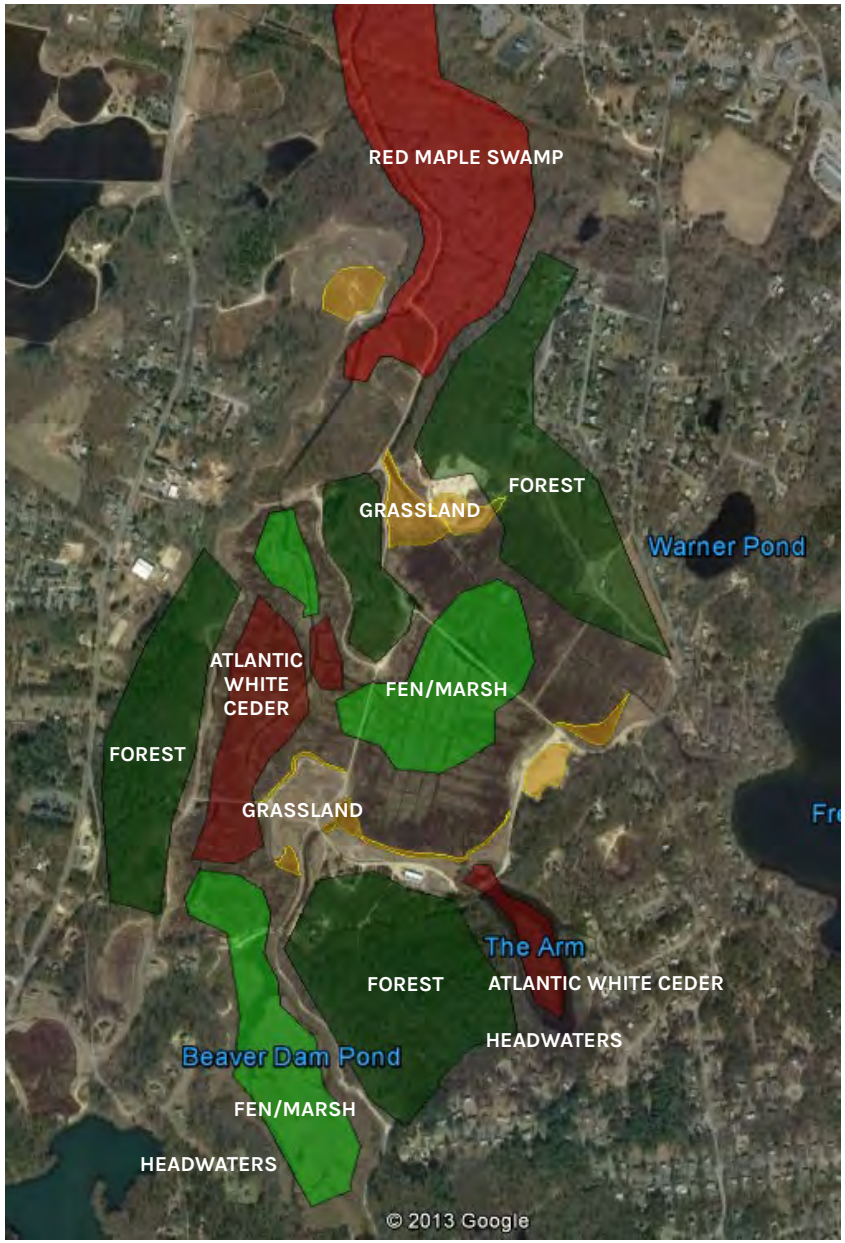
There are many opportunities to restore the natural capacity of land and water resources across the Commonwealth. Projects include converting abandoned or repeatedly flooded coastal shoreline and inland waterway buffers into reforested areas or parks; removing obsolete dams and upgrading undersized culverts; restoring abandoned cranberry bogs to natural wetlands; incorporating rain gardens, trees, and other green features into existing urban areas; and many others. A few examples are provided here.

CULVERTS

There are more than 25,000 culverts and small bridges across the state, averaging one every half mile of stream. Since the majority of these structures are significant or moderate barriers to passage of fish and wildlife, improving undersized crossings is essential to providing habitat connectivity. These upgrades will also reduce the threat of local floods and road washouts.

DAM REMOVALS IN THE MILL RIVER, TAUNTON RIVER

In 2005, downtown Taunton was evacuated due to concerns about the near failure of a dam during a flood event. Subsequently, the city worked with the state and nonprofit environmental groups to remove three dams that no longer had any useful function, and to install a fish ladder on an uppermost fourth dam. This project has not only greatly reduced the threat of flooding to the city, but it has restored more than 50 miles of habitat to anadromous fish and created new parkland along the river.[50]



◂ *Mass Audubon's Tidmarsh Wildlife Sanctuary was formerly a cranberry farm. It was recently restored to natural wetland so that water moves freely and there are diverse biological communities at the site.*

Original graphic provided by Alex Hackman, Massachusetts Division of Ecological Restoration, modified by Bob Wilber, Mass Audubon.

TIDMARSH – CONSERVATION AND REWILDING

Tidmarsh Wildlife Sanctuary in Plymouth is a 451-acre expanse of cold-water streams, ponds, forests, and woodlands within one of the most rapidly developing parts of the state. Once a working cranberry bog, this landscape underwent the largest freshwater ecological restoration ever completed in the Northeast. Its previous owners, the Schulman family, along with the Massachusetts Division of Ecological Restoration, U.S. Department of Agriculture's Natural Resources Conservation Service, and many other organizations, re-created nearly three and a half miles of meandering stream channel, sculpted the land's surface, and removed nine dams to reconnect the headwaters of Beaver Dam Brook to the ocean for the first time in more than a century.

As a result of this collaborative restoration effort, native plants and animals have returned to the area, and Tidmarsh now serves as a hub for research and education. With climate change projected to bring worsening storms and rising sea levels, this new sanctuary prevents further development on this part of the coast while also providing critical habitat for a variety of wildlife. And located just one mile from the ocean, the sanctuary serves as a critical conservation site that could enable salt marshes affected by rising sea levels to adapt by migrating here.

The state Division of Ecological Restoration has a program supporting the restoration of cranberry bogs, most of which were originally constructed within natural wetlands.

REWILDING GREAT NECK

In addition to protecting undeveloped land along the coast, the rewilding of lands in vulnerable areas is an option to consider. Mass Audubon recently acquired the 110-acre Sacred Hearts property in Wareham, thanks to the assistance of generous donors. Great Neck Wildlife Sanctuary now includes more than 200 acres of salt marsh and uplands, including a mile of coastline, in one of the most beautiful and ecologically vibrant areas of the South Coast. The wildlife sanctuary, which hosts a variety of species including egrets, ospreys, and Eastern box turtles, abuts an additional 130 acres protected privately through conservation restrictions. We are currently planning to return previously developed portions of this property back to natural conditions. This will increase the resilience of the land, enhance wildlife habitat, and provide visitors with a living example of diverse, functional coastal habitats.

SALT MARSH RESTORATION

Salt marshes are amazingly productive habitats, storing more carbon globally than tropical forests, despite their smaller geographic extent. They also provide many important functions, including providing essential habitat for young fish and buffering against storm impacts. Yet they are under grave threat from sea level rise, as the marshes are unable to keep up with the rapidly rising waters. Restoring and protecting salt marshes is critical for the state's climate resilience. Additionally, conserving the undeveloped, low-lying land adjacent to the coast is key for potentially providing space for salt marshes to migrate inland as sea levels rise.

Many salt marsh restoration projects are underway in Massachusetts. For example, the Herring River Restoration Project in Truro and Wellfleet will restore more than 1,000 acres of a salt marsh system by gradually removing tidal flow restrictions.[51]

▲ *The Saltmarsh Sparrow, which breeds only in salt marshes, is threatened with extinction. Mass Audubon recently supported its addition to the state list of rare and endangered species.*

PUTTING THE PIECES TOGETHER:

Community Resilience Building

Many tools are available to individuals and communities interested in protecting Green Infrastructure, enhancing climate resilience, and planning for vibrant and sustainable communities. Here are a few key examples for getting started.

1. Prioritize Land for Conservation: Mapping tools to identify priority areas or parcels include Mass Audubon's Mapping and Prioritizing Parcels for Resilience, The Nature Conservancy's Resilient Landscapes datalayer, and MassWildlife's BioMap2, which provides maps of core areas and supporting natural landscapes.

2. Utilize local land use controls and programs to incentivize protection of priority lands. These tools include Open Space Design or Natural Resource Protection Zoning, land disturbance and tree removal bylaws that minimize land clearing and grading within development, Transfer of Development Rights that concentrates development in preferred locations in exchange for protection in priority conservation areas, and other Low Impact Development techniques. Mass Audubon's LID bylaw review tool helps communities identify and prioritize improvements to local zoning and regulations.

3. Landowner incentive programs like Chapter 61 and the Working Lands Initiative provide funding for private land conservation and stewardship. Chapter 61 is a program that reduces local property taxes in exchange for landowners agreeing to keep land in forest, agriculture, or open space uses. Since 2009, the Working Forest Initiative has funded forest stewardship plans on 200,000 acres of private and municipal forests. Enrollment in Chapter 61 and stewardship plans has surpassed 500,000 acres.

4. State/local partnership programs including the Community Preservation Act and the Municipal Vulnerability Preparedness (MVP) Program provide funding for planning, conservation, affordable housing, nature-based resilience projects, and a host of other positive activities.

TOOLS FOR THE COMMUNITY

Municipal Vulnerability Preparedness (MVP)

What: State resource to identify vulnerabilities to hazards, solutions, and then fund the implementation of solutions

For Who: Teams of municipal officials in different departments plus community stakeholders

Resilientma.org

Community Preservation Act (CPA)

What: Tax program to generate funds for municipal open space, historical/cultural preservation, affordable housing, and outdoor recreation.

For Who: Municipal officials, namely planning, conservation, housing, recreation, selectmen/city council

Communitypreservation.org

Chapter 61

What: Property tax reduction to keep owner's property in forest, agriculture, or open space. Temporary protection only

For Who: Landowners. Municipalities should review Chapter 61 lands in their Open Space Plans and identify priorities for permanent protection

Mass.gov/service-details/forest-tax-program-chapter-61

Bylaw Review – Open Space, Natural Resources, and Low Impact Development in zoning and all local land use regulations

What: Protect priority lands for resilience using open space zoning; ensure all new development and redevelopment is designed for resilience

For Who: Municipalities

Massaudubon.org/shapingthefuture

TOWN OF AYER PROGRESS

From No. 1 sprawl community to a model of smart local planning

In the last edition of *Losing Ground*, the Town of Ayer had the dubious distinction of having the highest rate of development out of the 351 cities and towns across the state—primarily due to the construction of several large conventional subdivisions in once forested areas. Since then, the town has made remarkable progress, from the No. 1 sprawl community to a model of local planning.

Actions the town has taken since 2013:

- Hired professional planning, conservation, and economic development staff.
- Updated the town's zoning bylaw to require Open Space Residential Design as the preferred, by-right method for developing subdivisions.
- Conducted a study with the Montachusett Regional Planning Commission to identify Priority Preservation Areas using Mass Audubon's Mapping and Prioritizing Parcels for Resilience (MAPPR) tool and other conservation planning tools. Most of the parcels are within the state-designated Petapawag Area of Critical Environmental Concern.
- Updated its local Open Space and Recreation Plan with assistance from the Nashua River Watershed Association.
- Focused economic development on downtown revitalization, with expanded parking in a garage for the commuter rail.
- Adopted a form-based code bylaw for the downtown and commercial corridors to further spur smart, attractive development in these core areas.

05 | Conclusions & Recommendations

A number of international and regional reports lay out two major near-term challenges to land use and conservation in Massachusetts: climate change and the demand for additional housing.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) has stated emphatically that global greenhouse gas emissions need to be reduced by 45% from 2010 levels by 2030 in order to avoid catastrophic impacts to natural systems and people.[52] At the same time, the *Global Assessment on Biodiversity and Ecosystem Services*[1] by the UN's Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) emphasizes that natural lands will play a primary role in both mitigating carbon levels in the atmosphere and reducing the impacts of climate change on human and natural systems. Each country, state, municipality, and individual has a part to play in addressing this challenge. Another major challenge Massachusetts faces is a chronic and growing shortage in housing, and associated high costs and inequities. Residential and mixed-use developments are increasingly concentrated in urban areas, but the pace of housing development continues to fall far short of demand, and the types and locations of housing do not meet the needs.[8] The Commonwealth needs to produce more housing, and more affordable and diverse housing choices, in a way that will minimize climate change impacts to both people and nature.

With these overarching drivers in mind, we offer the following conclusions and recommendations regarding land use in Massachusetts.

 Photo by Kathy Sferra

Land Development

RECOMMENDATIONS

Promote compact, energy-efficient development concentrated around public transit and other existing infrastructure.

1. **Align state programs and regulations to ensure all new construction maximizes emissions reductions and resilience.**
   - Meet and exceed the targets of the **Global Warming Solutions Act,** including through efficiencies in land use, buildings, and transportation.
   - Fully engage all state agencies in implementation of the **State Hazard Mitigation and Climate Adaptation Plan.**
   - Ensure the **Municipal Vulnerability Preparedness (MVP)** Program incentivizes use of Nature-Based Solutions to climate change.
2. **Adopt state and local policies and regulations to "get solar off the ground," advancing rapid adoption of solar power while promoting use of roof-mounted and canopy arrays.**
   - Revise **Department of Energy Resources (DOER) solar incentives** to minimize conversion of fields and forests for solar sites.
   - Harmonize **state renewable energy programs** with land conservation and resilience goals.
   - Provide funding and a revised **model bylaw for communities** to update solar zoning consistent with these goals.
3. **Update local land use rules to ensure that new development employs low-impact standards.**
   - Make **Open Space Design/Natural Resource Protection Zoning** the by-right, preferred method for new development.
   - Prioritize **mixed-use neighborhoods** through redevelopment and infill in cities and town centers and along commercial corridors.
   - Allow **accessory units** in residential districts to promote density and diversity of housing options.
   - Promote use of **Transfer of Development Rights** from sensitive areas to locations where density is desirable.
4. **Provide state assistance to municipalities to pursue these recommendations.**
   - Provide funding through **MVP action grants** and state planning grants.
   - Align **state agency funding and infrastructure improvement programs** to support smart, walkable, energy efficient communities and restoration projects for resilience (e.g., culvert upgrades).

CONCLUSIONS

The average rate of development of 13.5 acres/day is similar to the pace reported between 2005 and 2013. This rate remains much slower than the rate of 40 acres/day reported in *Losing Ground 4* for the period 1999 to 2005. This recent period of relatively modest development includes the Great Recession and slowdowns in the housing market. Previous periods of modest development proved to be opportunities for significant land conservation progress, provided that adequate funding was available.

Patterns of development remain similar to those of past study periods, with continued concentrations of construction activity extending from urban cores and along major transportation corridors. The Sprawl Frontier, a band of towns seeing relatively rapid development, remains prominent along and outside of Interstate 495.

The rate of land conversion closely tracked the rate of new residential housing development between 2005 and 2015, suggesting that encouraging more compact development patterns could contribute directly to reducing loss of natural land. However, this connection between housing permits and land development appeared to decouple in 2016, suggesting other land uses are contributing more directly to habitat loss.

Between 2012 and 2017, large-scale, ground-mounted solar panel arrays accounted for one quarter of all new development, converting thousands of acres of forest and farmland to development. If not for this activity, the rate of development would have dropped to below 11 acres/day during this study period.

Land Conservation

RECOMMENDATIONS

1. **Increase the pace of land protection across Massachusetts to 100 acres per day to achieve 50% of the state protected by 2050 – 50 by '50.** Focus conservation, stewardship, and restoration to maximize the role of land for both mitigation of and adaptation to climate change.

2. Complete and implement the **Resilient Lands Initiative,** a public-private blueprint for land conservation in Massachusetts.

3. Prioritize protection of critical natural **Green Infrastructure Network** land.

   - **Connect large blocks of land** and provide landscape complexity and habitat diversity.
   - **Protect and restore floodplains and buffers** to wetlands and coastal and inland waterways. Remove obsolete dams and upgrade culverts.
   - **Prioritize lands** identified in BioMap2 or future updates, The Nature Conservancy's Terrestrial Resilience model, and other scientific analyses.

4. Provide funds to increase the pace of land conservation.

   - Continue and increase state funding for land conservation, at a minimum of **$60 million/year and increasing over time.**
   - **Expand the Massachusetts Land Conservation Tax Credit.**
   - **Increase funding for ecological restoration** — coastal and inland resilience programs and projects, including dam removals, culvert upgrades, and wetlands restoration.
   - **Promote the use of carbon offsets** on municipal and land trust lands to support long-term protection and stewardship of forested lands.

5. Create innovative new funding mechanisms for state and local land protection.

   - **Pass the Natural Lands Solutions Act** to incentivize land protection for carbon storage and resilience.
   - **Monetize the valuable ecosystem services** generated by natural lands — particularly in relation to climate change — with payments flowing both to landowners and host municipalities.
   - **Create a new source of funding** for land conservation and recreation outside of the traditional state environmental bond mechanism.
   - **Establish a buyback program** for properties that are repeatedly and substantially damaged by storms.
   - **Attract investment of private and corporate dollars** in land conservation.
   - **Include fee interest (actual land ownership)** conservation gifts in existing Enhanced Federal Tax Incentives for Conservation.

CONCLUSIONS

Twenty-seven percent of the land area of Massachusetts is permanently conserved as of 2019.

Between 2012 and 2017, land was protected at a pace of 55 acres/day, an increase of nearly 40% over the pace from 2005 to 2013.

Seventy-six percent of newly protected land was within the Green Infrastructure Network, indicating that conservation efforts are largely focused on the most important lands.

Conservation by cities and towns has increased dramatically, possibly reflecting investment of funds from the Community Preservation Act (CPA) and land set aside through Open Space Design projects.

MASS AUDUBON'S ROLE

Mass Audubon will continue to lead in conserving land and managing that land to maximize resilience for the benefit of wildlife and people in a changing climate. We plan to annually conserve at least an additional 1,000 acres of high-priority lands, providing valuable climate change response services. We will continue to assess the climate change vulnerability of our 32,000-plus acres of fee lands and model climate-smart ecological stewardship.

Mass Audubon will also advance our recommended conservation and smart development initiatives at the state level by supporting funding, planning, and interagency coordination, and at the regional and local levels through our *Shaping the Future of Your Community* program and partnerships such as the Citizen Planner Training Collaborative.

We will continue to engage with the communities we serve, educate people about actions they can take, share examples of what we and our partners are doing, and support local and regional initiatives that advance these goals. We will educate communities about nature-based climate solutions and the important roles that targeted land protection and Low Impact Development practices can play.

Massachusetts Leads the Way

The Commonwealth of Massachusetts has been an innovation leader since its founding. It was where the land trust movement began in the 1890s, and it was the first state to adopt a wetlands protection law in the 1960s. The new century has brought new challenges, and once again Massachusetts is leading the way through the passage of laws like the Global Warming Solutions Act, Green Communities Act, and other bold initiatives. In 2018, a $2.4 billion Environmental Bond funded conservation and restoration of lands for resilience and formalized the state's commitment to the Municipal Vulnerability Preparedness (MVP) Program and the Statewide Hazard Mitigation and Climate Adaptation Plan (SHMCAP).[53] Massachusetts is the first state to adopt a SHMCAP, which will be updated periodically and mandates coordination across all sectors of state government. The plan calls for integration of programs to reduce natural hazards and climate change impacts, both through an understanding of vulnerabilities and risks and through solutions that increase resilience of natural systems, the built environment, and the economy. It is being implemented through education and incentives across government, industry, nonprofits, and the public, with an emphasis on Nature-based Solutions.

"The conservation, enhancement, and restoration of nature to reduce emissions, adaptation, and enhance resiliency. These types of solutions use natural systems, mimic natural processes, or work in tandem with traditional engineering approaches to address natural hazards like flooding, erosion, drought, and heat islands."[53]

Photo by Eric Luth

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Mass Audubon works to protect the nature of Massachusetts for people and wildlife.

Mass Audubon protects more than 38,000 acres of land throughout Massachusetts, saving birds and other wildlife, and making nature accessible to all. As Massachusetts' largest nature conservation nonprofit, we welcome more than a half million visitors a year to our wildlife sanctuaries and 20 nature centers. From inspiring hilltop views to breathtaking coastal landscapes, serene woods, and working farms, we believe in protecting our state's natural treasures for wildlife and for all people—a vision shared in 1896 by our founders, two extraordinary Boston women.

Today, Mass Audubon is a nationally recognized environmental education leader, offering thousands of camp, school, and adult programs that get over 225,000 kids and adults outdoors every year. With more than 135,000 members and supporters, we advocate on Beacon Hill and beyond, and conduct conservation research to preserve the natural heritage of our beautiful state for today's and future generations. We welcome you to explore a nearby sanctuary, find inspiration, and get involved. Learn how at www.massaudubon.org

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Mass Audubon's Advocacy Department works to educate and motivate Mass Audubon members, citizens, and state, federal, and local elected and appointed officials to make decisions that protect the nature of Massachusetts.

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