LOSING GROUND

BEYOND THE FOOTPRINT

Patterns of development and their impact on the nature of Massachusetts

Fourth Edition of the Losing Ground *Series*

James DeNormandie

Claire Corcoran, Editor and Writer

John J. Clarke,
Director of Public Policy and
Governmental Relations

May 2009

Mass Audubon
Protecting the Nature of Massachusetts

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

We thank the director and staff of MassGIS, particularly Philip John and Dan Marrier. They made 2005 Land Use/Land Cover data available to us as soon as they got it themselves and worked closely with us to explain how the data were created and how they differed from previous land use data. This collaboration was extremely valuable and contributed to a stronger document. MassGIS also provided an analysis of Warren Group housing data from 1999-2005. This source of new residential development in this time period was invaluable as a companion to the Land Use/Land Cover data. Finally, thanks especially to MassGIS Director Christian Jacqz for advice on valuable analyses that were informed by his bird's-eye view of the state's data infrastructure.

The Nature Conservancy (TNC) provided a portion of the funding for the Conservation Assessment and Prioritization System (CAPS) analysis conducted by the University of Massachusetts, which allowed us to examine the ecological impacts of development. A special thanks to Andy Finton, who spent significant time discussing various aspects of this analysis.

We are particularly grateful to Hector Galbraith and the Manomet Center for Conservation Sciences for sharing with us the preliminary results of ongoing research as well as to Olivia LeDee, also of the Manomet Center for Conservation Sciences.

Several outside organizations and donors provided funding for *Losing Ground* and deserve our thanks. We are very grateful to the foundations and individuals who generously provided financial support to this edition of *Losing Ground* including the Alces Foundation, The Boston Foundation, Thaddeus R. Gillespie, Merloyd Ludington, and the family and friends of Meghan and Michael Lytton.

We thank all of the CAPS research team, Kevin McGarigal, Scott Jackson, and Kasey Rolih, and we are particularly indebted to Brad Compton for both many hours of analysis running the CAPS model and for his help grappling with the differences between the 1999 and the 2005 Land Use/Land Cover data sets. Brad made major technical contributions to the estimates of new development and the CAPS analysis, and for those we are very grateful.

A number of individuals provided input at the initial planning stages of the document: Vin Antil, Andy Finton, Bernie McHugh, Bob O'Connor, Chris Rodstrom, Loring Schwarz, Wes Ward, and Bob Wilber.

John Scanlon of the MassWildlife Forestry Program provided hardware support during the peak of the analysis and gave valuable advice and understanding throughout.

The following Mass Audubon employees provided extensive feedback during various phases of the document: Robert Buchsbaum, Jeff Collins, and Tom Lautzenheiser. We extend a special thanks to Matthew Smith of the Mass Audubon IT Department for help in all stages of developing the *Losing Ground* interactive website, and to Ann Prince of the Publications Department for her editorial guidance.

We made extensive use of the Massachusetts Department of Fish & Game, Natural Heritage and Endangered Species Program's BioMap and Living Waters data, which allowed us to analyze the protection and threats to the biodiversity of Massachusetts. We are grateful for these invaluable tools.

The following individuals reviewed drafts of the document and their comments were extremely helpful in forming the final document: Taber Allison, Vin Antil, Robert Buchsbaum, Jack Clarke, Gary Clayton, Jeff Collins, Andy Finton, Christian Jacqz, Laura Johnson, Tom Lautzenheiser, Kathy Leahy, Susannah Lund, Bernie McHugh, Bob OConnor, Banks Poor, Ann Prince, Heidi Ricci, Jennifer Ryan, Kathy Sferra, Lou Wagner, Wes Ward, Donna Williams, Henry Woolsey, and Gail Yeo.

EXECUTIVE SUMMARY/CALL TO ACTION

Over the past 40 years, the landscape of Massachusetts has been transformed by new residential and commercial development. Eastern and southeastern Massachusetts have undergone the most change, but virtually every community in the Commonwealth has experienced rapid growth driven by economic and demographic factors. Starting in 1991, Mass Audubon's *Losing Ground* series has analyzed these changes every 5 years using the most up-to-date technology and methods, providing conservationists, town planners, and agencies with information for planning and advocacy. This edition of *Losing Ground* examines recent changes in land use based on data from 1999 through 2005 (Chapters 1 and 2). It also examines the ecological impacts of development over a longer period of time, from 1971-2005 (Chapter 3). These analyses capture change in the Commonwealth of Massachusetts prior to the current, severe economic downturn. Although data are not available on the rate of development at present, it is a safe assumption that development has stalled significantly in the current economic climate. While the troubled economy is a serious challenge for our state and its people, it provides an opportunity for those concerned with land conservation to assess our progress thus far, enhance our communication and coordination, and strategically plan to continue to protect the most important land, so that we can sustain our supply of clean water, our biodiversity and wildlife habitat, and the recreational and psychological services provided by land in its natural—or nearly natural—condition.

Goals of this Report

This edition of *Losing Ground* assesses the progress that has been made in conservation of natural and agricultural lands, as well as how well these efforts are protecting the terrestrial and freshwater aquatic biodiversity of Massachusetts. Through our analyses, we seek to better understand the rate of transformation of the landscape, both agricultural and naturally vegetated, resulting from development. We identify areas in the state where development is rampant, and we also highlight areas where unchecked development is most likely to have impact in the future. We identify lands that are high priorities for conservation using a new metric of ecological integrity, the Conservation Assessment and Prioritization System (CAPS). We advocate for public policy changes that will provide communities, organizations, and individuals with the tools necessary to guide future development in Massachusetts in a more sustainable direction.

For a glossary of terms and frequently asked questions, please visit www.massaudubon.org/losingground.

Our findings are encouraging in that we are making significant progress in protecting our biodiversity, but they also highlight continuing threats to the nature of Massachusetts. The rate of development has declined considerably since the late 1980s and the 1990s. While the rate has slowed, development is still threatening our most sensitive rare species habitat and important natural communities. The trend toward larger, more dispersed homes continues as well—driving up energy use in the Commonwealth and using more land to house fewer people.

Key Findings

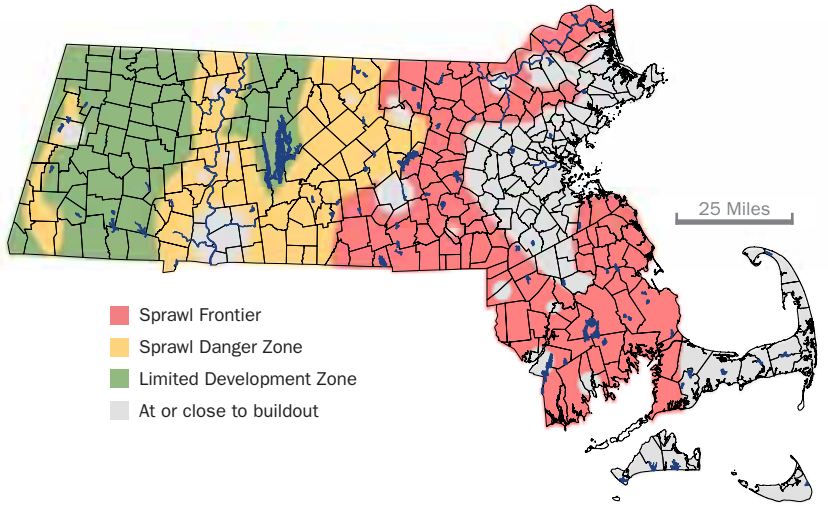
- Between 1999 and 2005, we lost 22 acres of land to development each day. Residential housing remains the key driver of land development in the Commonwealth, accounting for nearly 87% of land use change. Over 40,000 acres were converted to residential development in those six years—30,000 acres from forest and 10,000 acres from agricultural land.
- According to a new measure of ecological impact that allows us to look beyond the footprint of development, its indirect impacts on ecological function are three times higher than the direct impacts of development. More importantly, we found that in towns that are less developed, the indirect ecological impacts can be as much as eight times higher than the direct impacts.
- The Sprawl Frontier identified in the 2003 edition of *Losing Ground* has continued to push west and southeast from Boston. Unprotected natural land remaining in the affected towns must continue to be a focus of conservation efforts. Development pressure remains high in the southeast, where many towns have globally significant and highly imperiled biodiversity.
- We have identified the Sprawl Danger Zone, where communities beyond the Sprawl Frontiers are already experiencing increased development pressure as the towns eastward or northward approach buildout. Municipalities in this zone are not the fastest growing in the state, but they are experiencing increased growth rates that warrant attention. At the same time, they still have significant ecological integrity that urgently needs protection.

- Beyond the Sprawl Frontier west to the Quabbin Reservoir and all along the Connecticut River, the ecological impacts of development are significant. In addition, demand for municipal services in these towns—roads, schools, waste disposal/treatment, and energy use—is straining resources. Many of these municipalities have large areas of suburban-style zoning, which will further fragment the landscape and degrade ecosystem function.
- From 1999 to 2005, a total of 109,863 additional acres of land were protected in Massachusetts. This represents an additional 2.2% of the state's total land area.
- Between 1999 and 2005, conservation agencies and organizations protected twice the land that was developed. This is largely thanks to three banner years from 2000 to 2002.
- The current economic downturn presents a unique window of opportunity—gains in land protection can be made while development pressure has dropped off. The Patrick Adminstration pledge to spend $50 million each year from the Environmental Bond on land protection will significantly advance the state's efforts to secure important land while there is a lull in development.
- Meaningful zoning reform is crucial to providing municipalities with better tools for planning and managing future growth. Sustainable development patterns put higher density zoning in places where infrastructure is in place, or can be readily expanded.
- Despite the large lot zoning prevalent in many towns within the Interstate 495 corridor, ecological function has been severely degraded by landscape fragmentation. The areas with the greatest loss in their ecological integrity mirror the Sprawl Frontier precisely. However, great opportunities to protect intact ecosystem processes persist in the western half of Massachusetts.
- We are building larger houses, farther from metropolitan centers, and using more energy to heat and power these bigger homes. This trend encourages increased reliance on automobiles, increased consumption of fossil fuels, and increased carbon release into the atmosphere, exacerbating global climate change.
- Agricultural land is also highly threatened by development in many of Massachusetts' communities at the edge of the Sprawl Frontier—statewide, 215 towns had less than 5% of their land in agriculture in 2005, compared to 153 and 184 in 1985 and 1999 respectively.
- 55% of BioMap areas still lack permanent protection. Of the areas identified as Supporting Natural Landscape in the BioMap, 73% are unprotected. Aquatic rare species habitat is in dire need of protection. Only 16% of the Living Waters Core Habitat areas, and only 26% of the Living Waters Critical Supporting Watersheds areas, are protected.
- At the same time, remaining ecological integrity in cities and more developed towns must be protected. Urban open space and forests help cool urban heat islands, reducing energy use in cities. Access to protected lands helps urban residents understand why tax dollars are being spent on land protection elsewhere in the state, while providing cultural, recreational, and psychological benefits.

THE ECOLOGICAL FUNCTION OF THE MASSACHUSETTS LANDSCAPE

Using a new computer model, we analyzed the ecological impacts of development in Massachusetts. The map of Development Impact Zones delineates the new Sprawl Frontier. It also shifts focus farther west to the towns in the Sprawl Danger Zone. Although development is not occurring at the highest rates in these towns, it has had significant ecological impact (Figure 3.5). Important ecological resources remain in these municipalities, and attention must be paid to their protection. Many of these communities have large lot zoning (Figure 2.3) and have had a significant increase in their housing stock in recent years (Figure 2.1), underscoring their urgent need for both planning resources and protection dollars. Finally, the towns shown in green still have high levels of ecological integrity because of relatively low rates of development. However, in these less developed areas, the indirect impacts of development are magnified the most (Figure 3.7).

Development Impact Zones



CHAPTER 1: LAND USE CHANGES IN MASSACHUSETTS

Massachusetts has a large, hardworking conservation community consisting of activists, philanthropists, nonprofit organizations, state and federal government agencies, towns, and cities. During the past 40 years, development has transformed the landscape of Massachusetts. At the same time, land protection efforts by conservation agencies and organizations have accelerated in the face of the sprawling patterns of land use change. This edition of *Losing Ground* will analyze and quantify recent land use change by examining data from 1999 through 2005.

Massachusetts' greatest environmental challenges are caused by land use change. In transforming our landscape, development has degraded ecological functions and reduced our ecosystems' inherent resilience to change. With climate change now expected to significantly impact our region, we need to be strategic in our land protection efforts to protect the resilience of our ecosystem as well as its functional components, i.e., individual species. Through this analysis, we seek a better understanding of land use change in Massachusetts, to inform local, regional, and statewide planning. Thoughtful planning that preserves the traditional character of our towns, while protecting our biodiversity and natural resources, is possible, but it requires an understanding of how development pressures have shaped our land use to date, as well as of current trends in land protection.

International Connections

Massachusetts is home to a great diversity of species of regional, national, and global significance. Not only do we have resident populations of rare and endangered species, but our state also provides habitat for migratory birds that fly thousands of miles to feed or breed here. Our biodiversity is of global significance: the sandplains of southeastern Massachusetts and the Cape and Islands support globally rare natural communities such as pine barrens, coastal plain pondshores, grasslands, heathlands, and oak savannah—home to myriad rare and endangered plants and animals.

Are We Getting the Job Done?

How are we using our land base in Massachusetts? Where is the most rapid development taking place? How efficiently are we using our resource to provide housing for people? What types of land are being converted from one use to another? In order to answer these and other questions, we used the spring 2005 Land Use/Land Cover data layer created by MassGIS and compared it with the previous version from 1999.

COMPARING DATA SETS

The 2005 Land Use/Land Cover data was created using a computer model that sorts the aerial images into various cover types. The previous 1999 version of the Land Use/Land Cover data layer was created through manual digitization of aerial images. Combining the two data sets allowed us to isolate new development between 1999 and 2005. Since the two data sets were produced using different methods, the results had to be checked manually and corrections were applied to the raw data in order to increase the accuracy of our estimates of land use change. For a more detailed discussion of these methods, please see the *Losing Ground Technical Report*, available online at www.massaudubon.org/losingground.

Figure 1.1: Land converted to development in Massachusetts 1999-2005

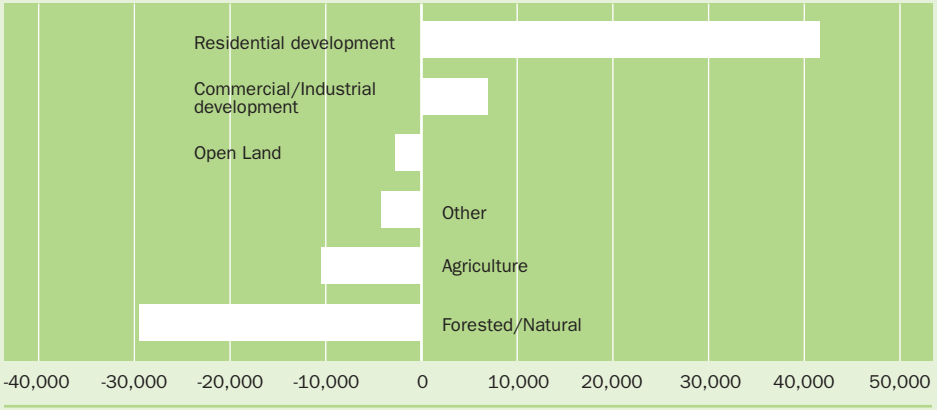


Figure 1.1 shows the change in land use in acres from 1999-2005, giving a complete picture of overall land use change during those six years. Between 1999 and 2005, we estimate that 47,600 acres of development took place. Over 40,000 acres of residential development were added to the Massachusetts landscape during those six years. The majority of the land developed was originally forested land, at nearly 30,000 acres, with an additional 10,000 acres of agricultural land converted into development.

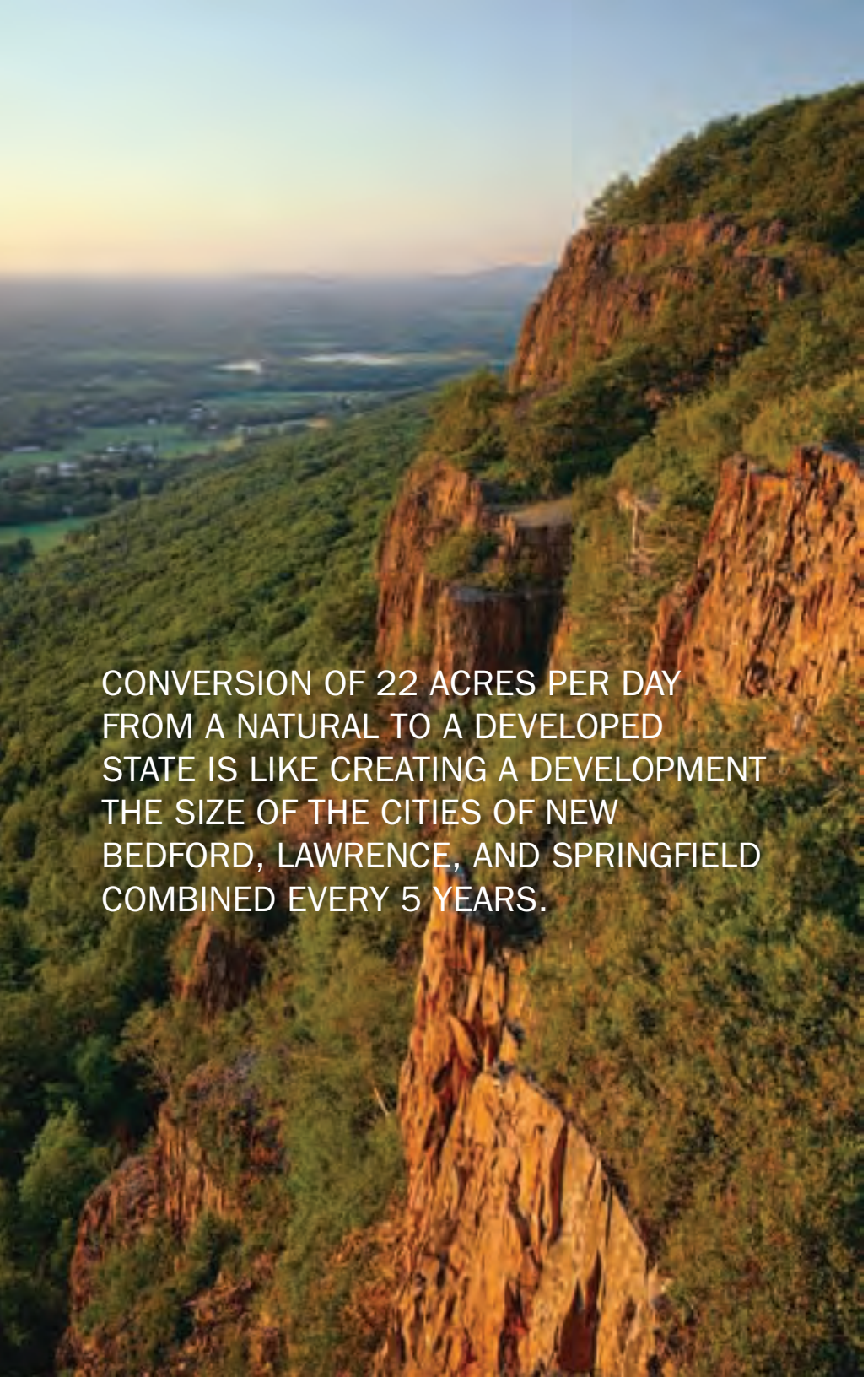
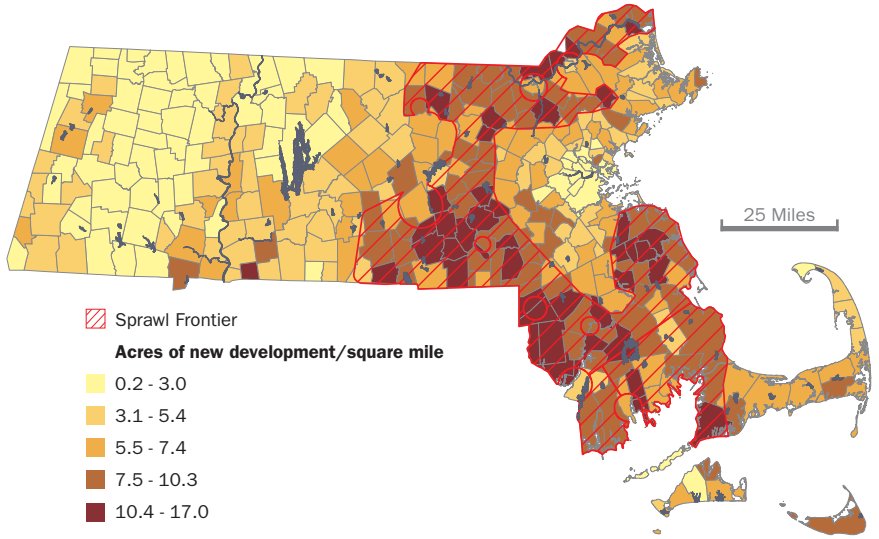


Figure 1.2: Recent development trends in Massachusetts (1999-2005)



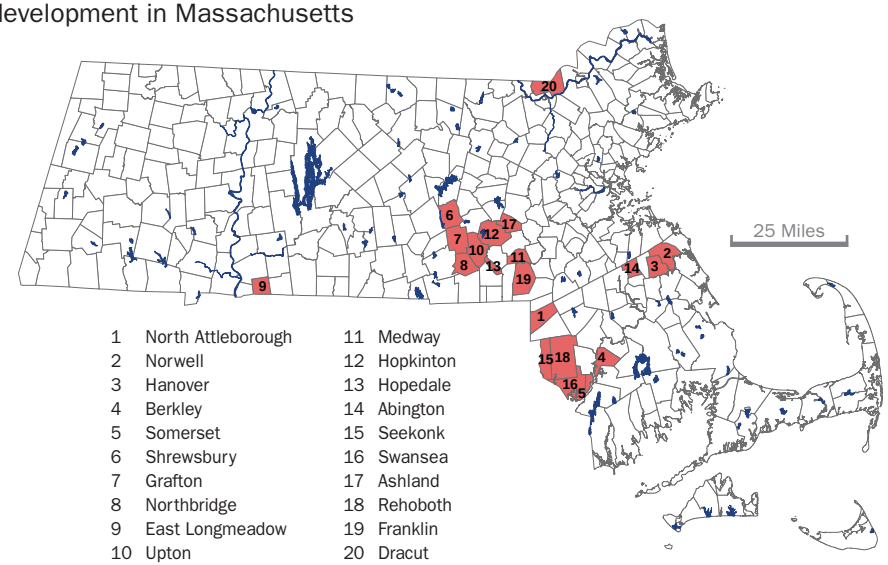
From 1999-2005, Massachusetts lost an estimated 22 acres per day to all forms of development. Conversion of 22 acres per day from a natural to a developed state is like creating a development the size of the cities of New Bedford, Lawrence, and Springfield combined every 5 years. This represents a decrease from the period 1985-1999, during which the rate of development in Massachusetts was estimated at 40 acres a day. Figure 1.2 shows acres of new development per square mile, with the darker towns undergoing the highest rates of land conversion.

The Sprawl Frontier: How far has it spread?

The last edition of *Losing Ground* highlighted the Sprawl Frontier, the area where development was the most rapid. In these communities, the remaining land is being converted to residential and commercial uses at the greatest rates. A new Sprawl Frontier was identified by delineating the towns with the highest rates of development (Figure 1.2). The Sprawl Frontier is an area that radiates out from the metropolitan centers of Boston, Providence, and Worcester and has crept farther west and south since the last edition of *Losing Ground*.

Two significant clusters of high-growth communities are apparent (Figure 1.3): one concentrated in the Blackstone River watershed (formed by the towns of Shrewsbury, Grafton, Northbridge, Upton, Hopedale, Hopkinton, Ashland, Medway, and Franklin) and one primarily in the Ten Mile and Narragansett Bay watersheds (made up of the towns of North Attleboro, Seekonk, Rehoboth, Swansea, Somerset, and Berkley). While parcels of unprotected natural land tend to be smaller in the Sprawl Frontier, their protection is nevertheless crucial.

Figure 1.3: Hot spots of development: 20 Towns with the highest rate of development in Massachusetts



In addition to the Sprawl Frontier, this edition of *Losing Ground* identifies the Sprawl Danger Zone: areas where development pressure is increasing and significant ecological impacts have already occurred, yet significant regional conservation opportunities still exist. Many of these towns are still rural in character. We delineated the Sprawl Danger Zone using information on land use change (Figure 1.2), recent housing growth (Figure 2.1), as well as consideration of ecological impacts (Figure 3.5). Further discussion of the Sprawl Danger Zone follows in Chapters 2 and 3.

NORMALIZED DATA

It is important to "normalize" spatial data when comparing cities and towns with each other. Municipalities in Massachusetts vary greatly in size. As a result, it is not always accurate to compare absolute rates of change. For instance, Plymouth (66,800 acres) is far larger than North Attleboro (12,400 acres). The absolute amount of development in Plymouth from 1999-2005 was 790 acres, while in North Attleboro it was 330 acres. However, the rate of development, when normalized, highlights that development is occurring far more rapidly in North Attleboro (17 acres per square mile) than in Plymouth (7.7 acres per square mile). Presenting the information this way is intended to give the reader the ability to look at land use change as it impacts each individual community. In some cases, however, it is instructive to examine *both* normalized data and absolute acres of conversion because different patterns will emerge from the data (e.g., Figure 1.4).

What Types of Land Are We Losing in Massachusetts?

This section examines the forest and agricultural resources that have been lost to development between 1999 and 2005.

Figure 1.4: Forest conversion in Massachusetts, 1999-2005

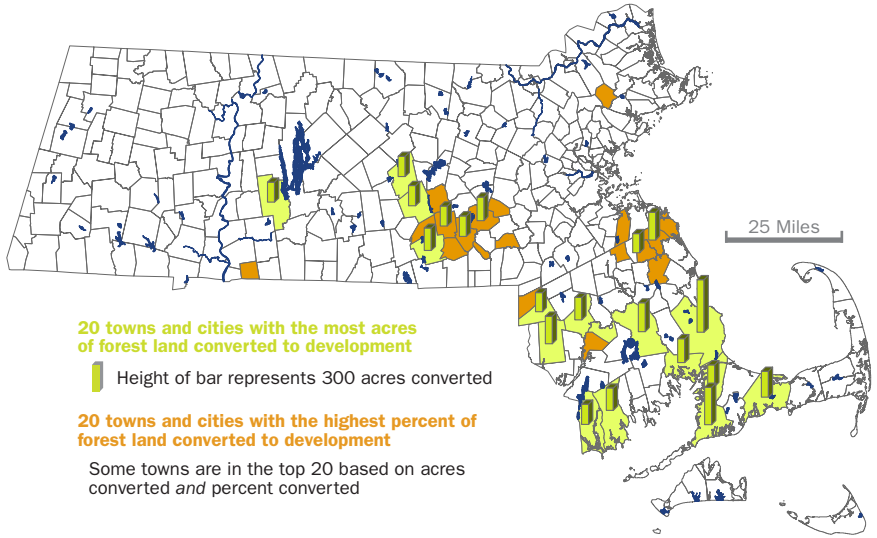
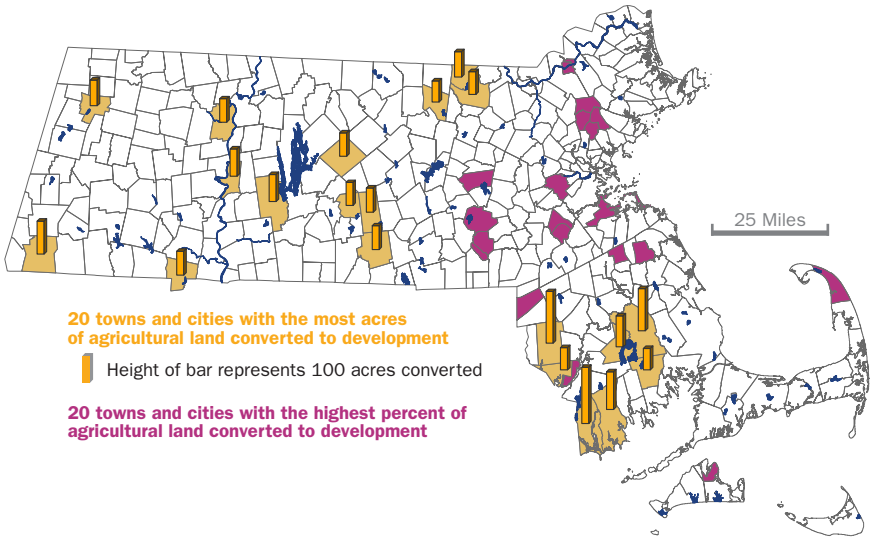


Figure 1.4 shows a ranking of the 20 municipalities with the greatest amount of forest loss between 1999 and 2005. The towns with the green bars are those with the highest amount of forest lost in acres, while the orange towns are those with the highest percent of the town's forest converted. Southeastern Massachusetts continues to lose forest at an alarming rate. This land use conversion threatens some of the most vulnerable rare species and significant natural communities in the state. A cluster of towns around Worcester, primarily in the Blackstone River watershed, has undergone an explosion of forest loss since 1999.

Forested and natural lands provide important habitat for the full range of our native biodiversity, supporting both common species and rare species, but they also provide other crucial environmental services to our state. One of the most critical is water supply protection—forested lands keep our water supplies clean and reduce the need for costly filtration and treatment facilities for drinking water. The value of these "ecosystem services" provided by undeveloped land was calculated in the last edition of *Losing Ground* at over 6.3 billion dollars annually.

Figure 1.5: Agriculture conversion in Massachusetts, 1999-2005



Agricultural lands can be particularly vulnerable to development pressures because they have already been cleared and leveled. Financial pressures on farmers also contribute to loss of agricultural land, particularly during the transfer of family farms through generations. Figure 1.5 shows that many of the smaller communities closer to Boston are losing the highest *percentages* of their last remaining agricultural land to development. The percentage loss is high in communities close to Boston because they have small acreages of agricultural land to begin with. Hot spots, where large acreages of agriculture have been converted, are more broadly distributed, with small clusters of towns in the southeastern and central regions, and with some outlying municipalities also experiencing high levels of agricultural loss. Agricultural land use conversion must be confronted as a statewide issue and is not localized within the Sprawl Frontier.

The loss of agricultural land has ramifications beyond changing the aesthetics of the landscape and increasing the demand for services in formerly rural towns. It also removes land from food production, while the increased interest in and demand for locally grown fresh produce, meat, and dairy products reflects a growing desire by consumers to reduce their carbon footprints by eating locally whenever possible.

SPOTLIGHT YOUR TOWN!

The new *Losing Ground* interactive website (www.massaudubon.org/losingground) allows you to take a closer look at development trends in your community, as well as protection of forestland and agricultural land. *Losing Ground* generates a variety of statistics, many of them at a statewide level. Conservation agencies and organizations in Massachusetts direct their activities on many different levels. Local land trusts most frequently focus protection efforts in their municipality while the Commonwealth's many watershed associations have a broader perspective.

The *Losing Ground* website makes available key statistics and maps at *all* of the following levels: town, watershed, ecoregion, county, and regional planning agency. For example, Rehoboth:

- has more than 20,000 acres of unprotected forest
- has more than 50% of the town zoned in over 2-acre lots
- is among the top 20 fastest developing towns
- is one of the top 20 towns in acres of forest developed between 1999 and 2005
- is only 4% protected
- is number 2 in the state for acres of agriculture developed between 1999 and 2005
- is number 2 in change in the town Index of Ecological Integrity between 1999 and 2005

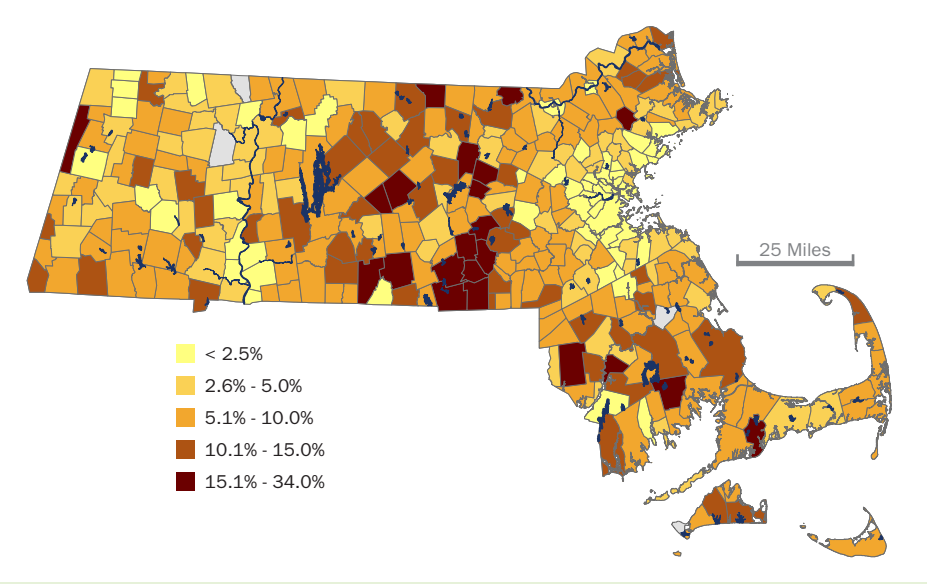
In addition to accessing this tabular data, the user will be able to view maps of the town's development pattern in 2005, as well as the location of important forest, agricultural, and other ecological resources. We anticipate that this additional resource will greatly increase the utility of *Losing Ground* for municipalities, conservation agencies, and organizations.

CHAPTER 2: HOUSING AS A DRIVER OF LAND USE

Demographics

In comparison with other states, Massachusetts' population growth has been mostly flat over the past six years, and actually declined between 2003 and 2005. In fact, Massachusetts 2.3% growth rate this decade is 43rd in the country. Despite this slow growth, Massachusetts is still the third most densely populated state after Rhode Island and New Jersey, and new homes continue to be built far from existing cities.

Figure 2.1: New homes in Massachusetts cities and towns (1999-2005), as a percentage of existing housing units in 2000 (US Census Bureau)



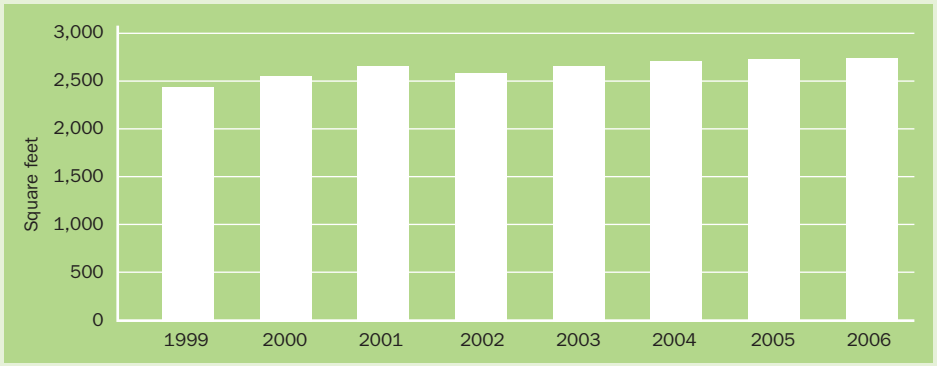
High-Vulnerability Areas: Sprawl Danger Zones

Figure 2.1 shows the relative growth of housing in each municipality. The darkest areas are towns where the housing stock has increased by between 15 and 34% in only six years. In a band of towns running north to south just east of the Quabbin Reservoir, there have been surprising increases in the housing stock. The rate of land use change is not the fastest in these towns, but the relative changes are significant and represent the Sprawl Danger Zone that has already arrived in this part of Massachusetts. Many of these towns have added 10 to 15% to their housing stock during the six years in question, are experiencing rapid growth, and until recently were facing increasing development pressure. Such rapid development leads to drastic increases in demand for services such as road maintenance, schools, and waste treatment and disposal, and these municipalities will need to increase their infrastructure and spending to meet those demands. At the moment, the opportunity still exists to engage in thoughtful planning to shape the future growth of these communities.

Trends in Housing

Figure 2.2: Home sizes continue to increase

Average living area of new homes in Massachusetts (1999-2006)



Bigger Houses, More Sprawl

The average size of new homes constructed in Massachusetts continues to rise steadily to a peak of over 2,700 square feet in 2006. These larger homes not only have a larger footprint but also bring more secondary impact to the environment of Massachusetts, creating larger driveways and more impermeable surfaces, more edge effect into surrounding forestland, and more hydrological disruption above and below ground.

Since the 1980s, many communities in Massachusetts increased their minimum lot sizes in their zoning regulations, often to comply with Title 5, the state's regulations for siting septic systems. Larger lot sizes were seen as desirable, and many communities now require a one- or two-acre minimum lot size in the hope they will retain the traditional character of their communities by discouraging density. However, the resulting suburban development pattern, combined with the many loopholes in current zoning laws, encourages sprawling development, using more land to house a smaller population and impacting a larger area with land use change.

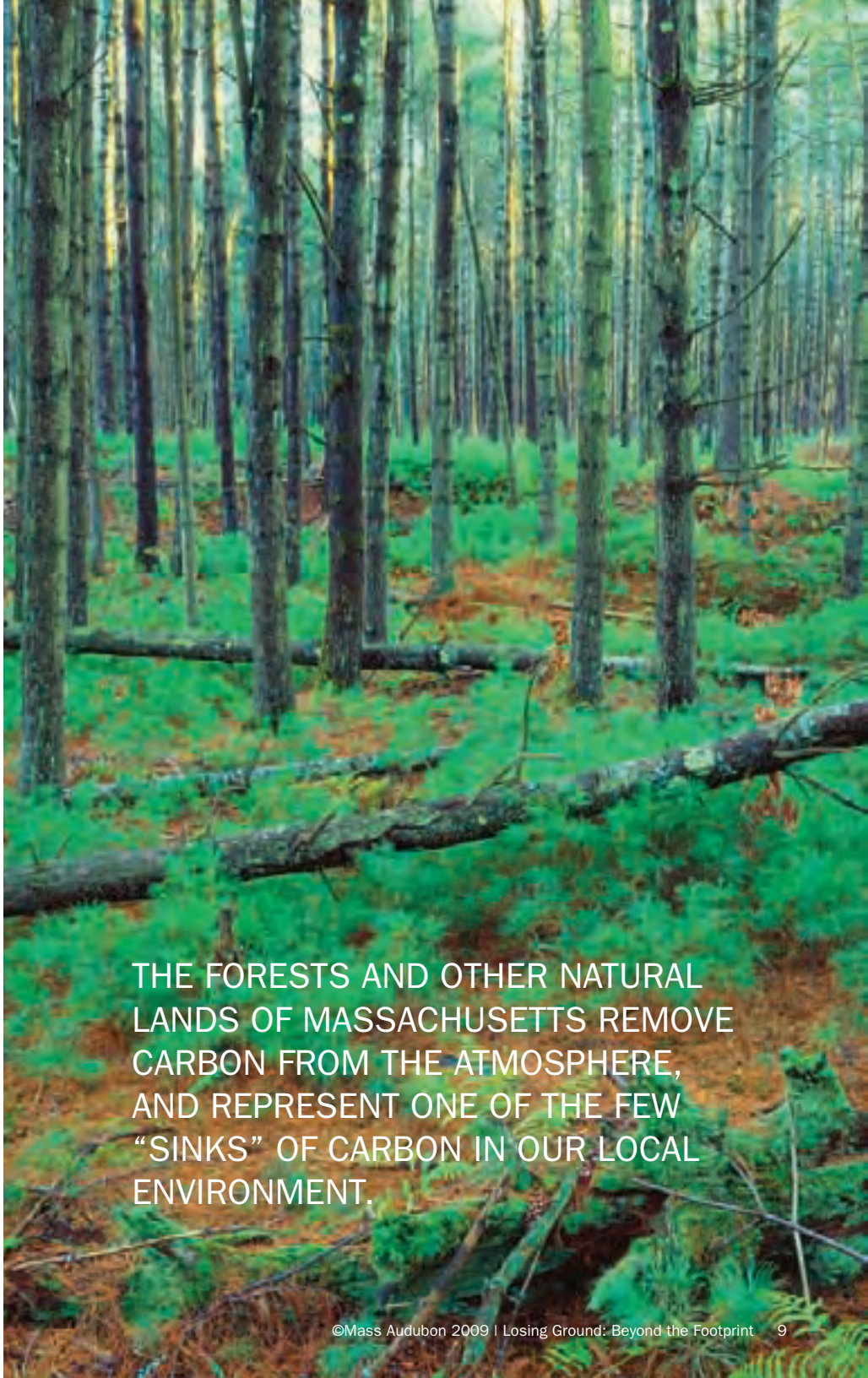
Figure 2.2 illustrates the trend in new house size from 1999 to 2006. It shows that for most of our recent housing boom, developers were building larger houses. As we will show in Chapter 3, the lower density of population has a greater ecological impact, fragmenting the landscape further and using more energy and natural resources to construct and maintain.

Climate Connection

The importance of curbing our appetite for land becomes more urgent in the face of climate change. The forests and other natural lands of Massachusetts remove carbon from the atmosphere, and represent one of the few "sinks" of carbon in our local environment. Meanwhile, the continued proliferation of large houses means that we are consuming more land to house fewer people, in larger houses that consume more energy—creating more "sources" of carbon in the atmosphere, and further exacerbating the global problem of climate change. Sprawling development encourages increased reliance on automobiles, contributing still more carbon to the atmosphere.

Table 2.1: Zoning for density consumes less land

	Predominantly zoned for 2-acre lots	Predominantly zoned for 1- to 2-acre lots	Predominantly zoned for less than 1-acre lot
New residential units	20,617	32,937	28,283
Total parcel-acres	53,790	48,136	15,503
New units/parcel-acre	0.38	0.68	1.95



THE FORESTS AND OTHER NATURAL LANDS OF MASSACHUSETTS REMOVE CARBON FROM THE ATMOSPHERE, AND REPRESENT ONE OF THE FEW "SINKS" OF CARBON IN OUR LOCAL ENVIRONMENT.

Zoning regulations are complex, but to enable our analysis, we considered three categories of zoning—two acres or larger, one to two acres, and less than one acre. Table 2.1 looks at the amount of land used by these three different types of zoning. In towns where more than 50% of the town is zoned for density, with less than one-acre lots, over 28,000 units of housing were created, spread over 14,500 parcel-acres. In contrast, in towns with primarily greater than 2-acre zoning, 20,600 housing units were created, spread over almost 54,000 parcel-acres. When the number of housing units per parcel-acre is calculated, the primarily denser zoning creates almost 2 units of housing per parcel-acre, whereas the least dense zoning is distributed over much more land, creating only 0.38 units of housing per parcel-acre. In general, we advocate for flexibility that would allow the placement of more units on each lot, which, in concert with a strong land conservation program, would allow for development of housing stock and protection of open space in towns that need both.

Figure 2.3: Zoning in Massachusetts—Towns with greater than 50% of area in low-, medium-, or high-density zoning

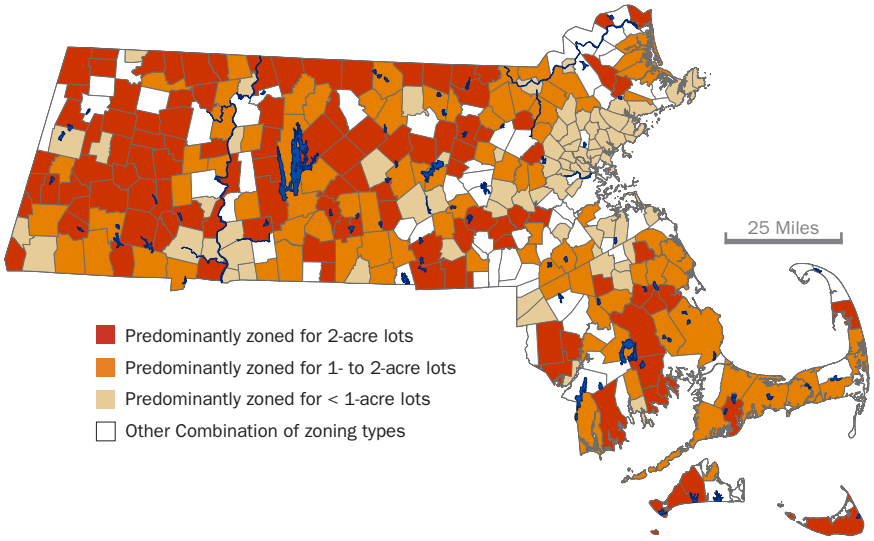


Figure 2.3 highlights the towns in Massachusetts with greater than 50% of their area zoned for 2-acre lots or larger. There are large clusters of towns within the Sprawl Frontier and Sprawl Danger Zone that are dominated by large-lot zoning. Much of the northern edge and western half of Massachusetts remains dominated by large-lot zoning, which if left unchanged could lead to a great loss in ecological integrity in the future. Meaningful reform of Massachusetts' outdated zoning ordinance could give those communities new flexibility and new tools to guide both development and conservation as their populations continue to grow.

IMPROVING THE COMMUNITY PRESERVATION ACT

Mass Audubon advocates improving the Community Preservation Act (CPA) by broadening municipal participation to promote sustainable communities. Legislation has been filed to advance and strengthen these goals to accomplish the following.

Ensure lasting success. One of the most important amendments in this bill would increase the annual minimum CPA trust fund match to 75%. The trust fund derives its revenue from fees collected at the Registries of Deeds statewide. This legislation seeks to stabilize the statewide trust fund by guaranteeing that CPA communities receive a minimum 75 percent annual match. In 2008, for the first time in the CPA's eight-year history, CPA communities received an average match of 74 percent, rather than the dollar-for-dollar match seen in previous years. The state Department of Revenue projects that the match will fall dramatically this year, likely as low as 35 percent for many communities, due in part to the popularity of the program as well as the decline in real estate activity.

Broaden CPA participation. The second component of the bill would help cities and less affluent communities, many of which have yet to adopt the CPA. It would allow communities to combine a traditional 1% CPA property tax surcharge with up to 2% of other municipal revenue in order to fund their local Community Preservation account. This alternate method of adoption relies less on the local property tax surcharge to raise revenue and provides a higher level of matching funds from the statewide CPA Trust, which will spur more CPA adoption in urban communities. Furthermore, the bill adds a new optional commercial exemption for the first $100,000 of property value for commercial and industrial properties to mirror the current $100,000 residential exemption. This new exemption is especially beneficial to small businesses. These two important changes are designed to broaden CPA adoption.

Clarify allowable uses to promote sustainable communities. Another important amendment would clarify the allowable uses for CPA funds so that communities can rehabilitate existing outdoor parks and other recreational resources. Currently, rehabilitation projects are restricted to recreational resources that were acquired or created with CPA funds. This has been extremely limiting in many communities, including larger urban communities with less open space to protect but with many older parks in need of capital rehabilitation. In addition, it may force some communities to create needed playing fields on land used for passive open space instead of rehabilitating existing fields. This change would mirror a legislative amendment made in 2002 allowing CPA funds to be devoted to rehabilitation of historic assets not acquired under CPA.

PLANNING FOR FUTURE GROWTH: THE LAND USE PARTNERSHIP ACT

Mass Audubon advocates reforming our outdated zoning regulations that for many years have allowed for sprawling, unplanned development. For the past several years, a Patrick Administration task force of conservationists, planners, developers, and state officials has been working toward a new framework for developing land in Massachusetts while providing open space protection and affordable housing opportunities, by recommending to the state legislature amendments to the outdated Massachusetts General Laws Chapter 40A—the state's zoning act. The Land Use Partnership Act (LUPA) would provide communities with new flexibility to implement land use regulations that reflect their common vision for growth. It would increase flexibility in zoning and permitting, foster housing affordability and open-space protection, and close loopholes that undermine planning efforts. It would also improve local regulatory procedures, streamline reviews, and promote mediation of appeals. In addition, it would allow municipalities to opt-in to a higher performance standard and thereby receive new tools for directing development.

If enacted, this legislation would allow all municipalities in the Commonwealth to:

- Curb "McMansions;"
- Allow a majority vote for adopting zoning changes, as opposed to the 2/3 vote required now;
- Limit "zoning freezes" to project plans, and not the underlying land itself;
- Establish a framework for site plan review;
- Authorize municipalities to institute the Transfer of Development Rights to protect important landscapes;
- Expand the use of "cluster development" to protect open space within residential developments;
- Empower municipalities to charge impact fees to offset the costs of increased public services.

For those municipalities that choose to go a step further and locally adopt certain provisions of LUPA, benefits are extended to include authority to:

- Create a plan and enact local zoning consistent with the plan;
- Provide for prompt and predictable permitting;
- Mandate Open Space Residential Design to protect open space;
- Mandate low-impact development techniques to help replenish groundwater;
- Eliminate the approval-not-required exemption for residential projects;
- Reduce the subdivision zoning freeze from eight to three years;
- Impose reasonable rate-of-growth programs within growth areas;
- Permit natural resource protection;
- Receive technical and financial assistance from the Commonwealth.

Mass Audubon advocates for tools to help Massachusetts communities plan future development, siting areas of density where appropriate, to preserve the traditional character of our landscapes; to protect biodiversity and open space; and to provide more affordable housing. The Land Use Partnership Act, with refinements, would provide valuable tools for communities to meet these goals.

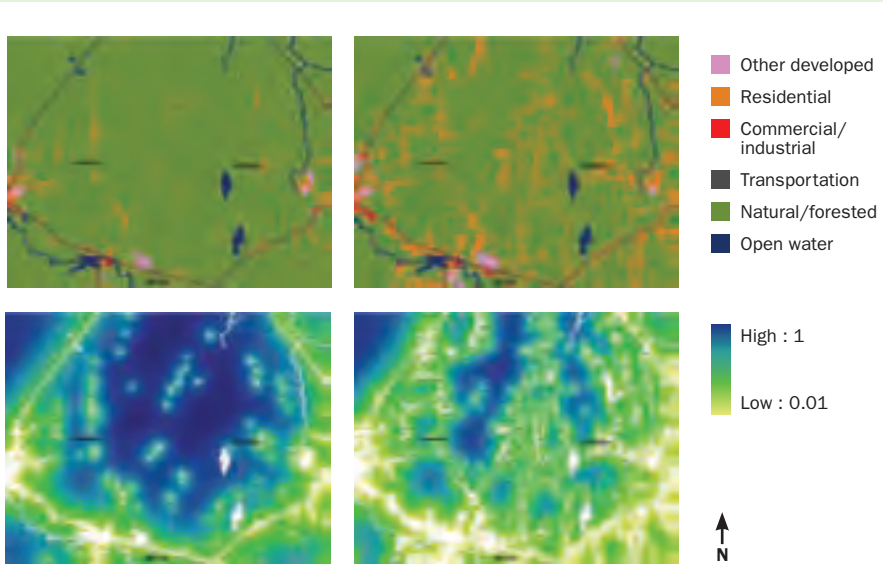
CHAPTER 3: QUANTIFYING ECOLOGICAL IMPACT

Goal of Analysis

Quantifying the footprint of development is an important first step in identifying its impact on the nature of Massachusetts. However, ecological impacts to habitat and wildlife extend beyond the lawns, roads, and buildings that make up the residential, commercial, and industrial footprint. We know that the ecosystem surrounding a home or building will be impacted by increased edge effects, disruption of ecological processes, changes in microclimate, and hydrology. Using an exciting new analytical tool, we investigated impacts that extend beyond the footprint of development into the larger ecosystem and examined how they vary across the state.

The CAPS model was run for 1971, 1985, 1999, and 2005 using the MassGIS Land Use/ Land Cover data sets. This made it possible to investigate changes in the ecological integrity of the Massachusetts landscape over the past 35 years.

Figure 3.1: Land Use/Land Cover data for 1971 and 2005 and also the IEI results for 1971 and 2005 for a portion of the towns of Townsend and Pepperell.



WHAT IS CAPS?

In order to investigate the ecological impacts of development in Massachusetts, Mass Audubon partnered with researchers at the Department of Natural Resources Conservation at the University of Massachusetts, Amherst. Kevin McGarigal, Scott Jackson, Brad Compton, and Kasey Rolih have developed the Conservation Assessment and Prioritization System (CAPS) model. CAPS is a spatial model designed to assess the ecological integrity of lands and waters across relatively large geographic extents (e.g., all of Massachusetts). Ecological integrity can be thought of as the ability of an area to support plants and animals and the natural processes necessary to sustain them over the long term. The CAPS model presumes that by conserving intact areas of high ecological integrity, we can conserve most (but not necessarily all) species and ecological processes.

The CAPS model creates a grid over the state of Massachusetts, and calculates the "index of ecological integrity" (IEI) for each cell of the grid based on eight different ecological factors. These factors include habitat loss; microclimate alterations; impacts from domestic predators such as cats and dogs; impacts from edge predators such as raccoons, blue jays, and cowbirds; non-native invasive plants; non-native invasive earthworms; connectedness of the landscape; and similarity of each point to the surrounding landscape. The resulting map is a computer model of the ecological function of the landscape. Like all computer models, it has its limitations, but it also speaks powerfully to very real impacts in landscape-level ecological function and integrity.

One limitation of CAPS is that it does not consider explicitly rare and endangered species that are essential components of the biodiversity of Massachusetts. The great biodiversity value of southeastern Massachusetts and the importance of coastal ecosystems to migratory shorebirds are critical to conservation in Massachusetts, yet not reflected in the CAPS maps. In addition, land conservation of smaller parcels and in more densely developed areas continues to be an important component of community-focused conservation in Massachusetts, yet the CAPS analysis does not highlight the need for urban ecology and recreation, stormwater mitigation, and water supply protection.

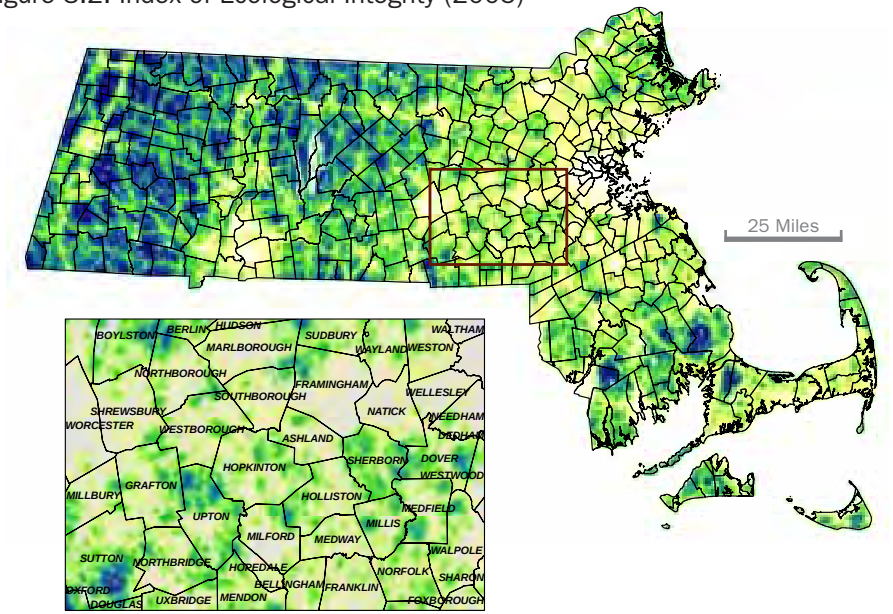
Nonetheless, the CAPS analysis provides an important tool for land conservation prioritization in Massachusetts. The CAPS maps highlight less fragmented areas of high ecological function and show us areas where ecological processes are most intact across the landscape. They also highlight the impact of development on ecosystem function, by graphically showing the effects of fragmentation on large blocks of naturally vegetated land.

In the case of a block of lightly developed land along the Townsend-Pepperell border, development present in 1971 is sufficiently scattered that a large contiguous block of high-integrity natural land persists, as shown in darkest blue in the 1971 CAPS map. Between 1971 and 2005, many individual homes were built along secondary roads within this block. The result is that the one mostly connected block of natural land has now been split into two much smaller strips, and it is evident that both of these blocks do not contain the dark blue areas of high IEI scores. The above information was generated for the entire state and for four years, 1971, 1985, 1999, and 2005. It allows for a detailed look at the changes in ecological integrity that have taken place statewide, across large areas such as watersheds, and down to smaller units of analysis such as towns.

The Patterns of Ecological Integrity

Figure 3.2 represents the 2005 IEI scores for the entire state. This map shows the value of each 30 by 30 meter grid cell. At the statewide scale, intact natural lands can be seen, primarily in western Massachusetts and surrounding the Quabbin Reservoir, but also in southeastern Massachusetts, just south of Worcester, and in some North Shore communities. The power of the CAPS model is that it can be used for analysis at a statewide, regional, or townwide scale.

Figure 3.2: Index of Ecological Integrity (2005)



Between 1971 and 2005, Massachusetts suffered a 23% reduction in its overall ecological integrity. Over the same period, only 8% of the state's land area, or roughly 400,000 acres, was developed. In 1971, the total IEI-acres score for Massachusetts was 2,093,500 IEI-acres while in 2005, it stands at 1,618,000 IEI-acres. Between 1999 and 2005, the statewide total fell by 9%.

The Patterns of Loss

The following section looks at the pattern of loss in ecological integrity in several different ways. Figure 3.3 shows the loss of ecological integrity in a transect running through the state, and then zooms into three clusters of towns. The transect shows that significant reductions in IEI (shown in black, red, orange and yellow) are occurring both in the Sprawl Frontier and beyond. In the east, loss is not as widespread because land is, for the most part, already developed, or protected. In the west, smaller clusters of loss are evident amidst much larger blocks of intact natural land. It is in central Massachusetts, in towns such as Barre, Oakham, Brookfield, and Belchertown, where the impacts of development are visible and widespread, and thus fall in the new Sprawl Danger Zone. While IEI scores in western Massachusetts remain high, the pattern of loss is striking because it is already evident in all towns as scattered impacts that closely follow the existing roads.

IEI-ACRES DEFINED

The Index of Ecological Integrity (IEI) depicts the value of a given point on the landscape relative to others based on its ability to support plants, animals, and the natural processes that sustain them. To facilitate this comparison of one area with another, units called IEI-acres are used throughout CAPS analysis. One IEI-acre is equivalent to an acre of cells—roughly five cells—with a perfect score of 1. One IEI-acre can also be made up of 2 acres of cells each with a score of 0.5.

For example, consider the town of Townsend with a total land area of 21,100 acres. In 1971, Townsend had an IEI score of 12,000, i.e., the sum of the cells in the town's 21,100 acres added up to 12,000 IEI-acres. By 2005, Townsend's score had dropped to 8,700 IEI-acres, which can be thought of as a loss of 3,300 acres of land with high ecological integrity. This loss occurred throughout the entire acreage of the town rather than on just 3,300 acres; but it enables comparison of Townsend with other towns and allows calculation of the change in IEI over time.

Figure 3.3: Loss of ecological integrity between 1971 and 2005, a transect through Massachusetts

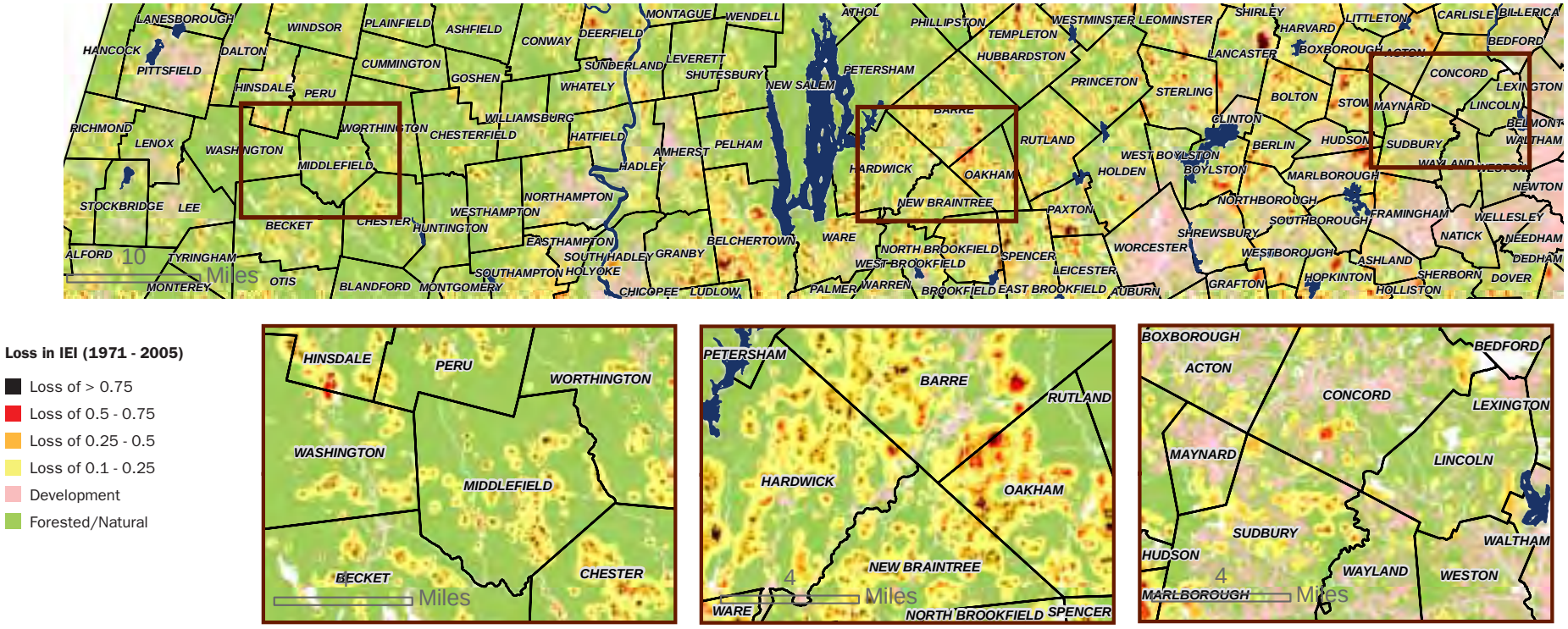
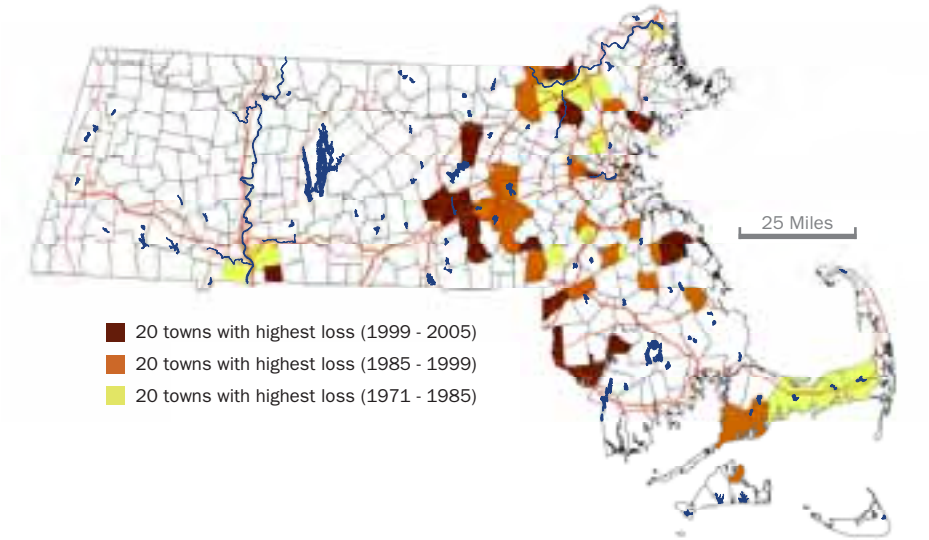


Figure 3.4 shows the 20 communities with the largest loss in IEI values from 1971-1985, 1985-1999, and 1999-2005. This figure mirrors the impact of the Sprawl Frontier very closely. In the 1970s and early 1980s, the highest impacts were seen close to existing urban centers of Boston, Springfield, Lowell/Lawrence, and on Cape Cod. From 1985 to 1999, development along I-495 was clearly having an impact on the ecological integrity of natural lands in these cities and towns. During the most recent time step, the impacts extend beyond I-495 in all directions, toward Nashua, New Hampshire, in the north; toward Worcester in the west; and toward Providence, Rhode Island, in the south. This figure affirms one focus of conservation efforts on the Sprawl Frontier.

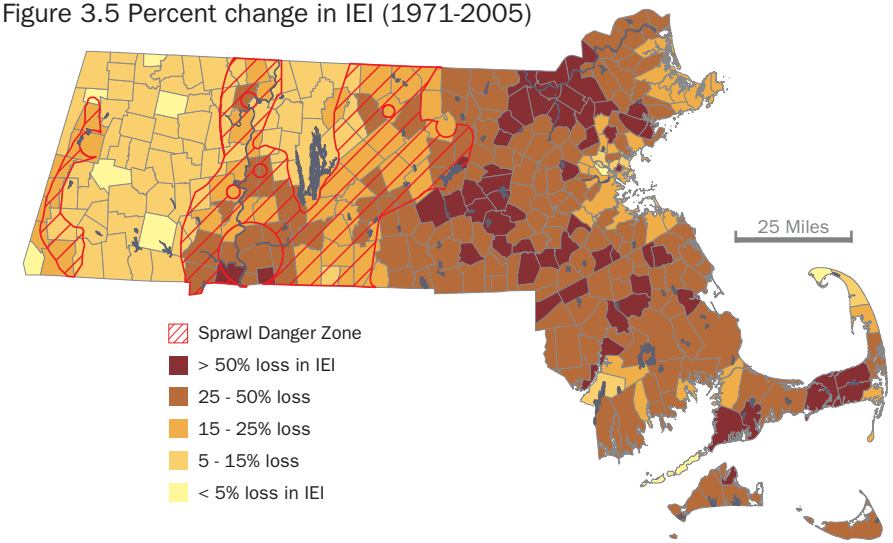
Figure 3.4: Towns with highest loss (percent change) in IEI through time



Historically, *Losing Ground* has focused on recent growth, attempting to highlight the location of the Sprawl Frontier, where the *fastest* development is occurring. However, the next figure shows how the impacts to the natural resources of Massachusetts have begun to accumulate in the towns that lie *beyond* the Sprawl Frontier. Figure 3.5 shows the loss in IEI from 1971 to 2005, and is one of the key figures that spurred the delineation of the Sprawl Danger Zone. More than half of the towns in the state (209) have undergone at least a 25% reduction in their IEI score since 1971; this high impact extends beyond I-495 to I-190, which lies 45 miles inland of Boston. With the exception of a small band of towns southeast of the Quabbin Reservoir, this band of 25 to 50% reduction extends all the way to Springfield, and extends up the Connecticut River valley and into the agricultural towns of Massachusetts. The next lowest range of IEI loss (15 to 25%) creates a solid wall of towns all the way to the Quabbin, and extends from north to south up the entire Connecticut River valley.

The Sprawl Frontier is the *crest* of a wave of development. This analysis shows that the development that occurs *before* the crest, the Sprawl Danger Zone, has already had a significant impact on the ecological integrity of the landscape. There is a band of towns running north-south to the east of the Quabbin Reservoir that has been spared the highest impacts, and these towns deserve attention and resources. In addition, the block of towns west of the Connecticut River, transitioning into the Berkshires, have had the smallest reductions in IEI. As CAPS measures it, these towns contain the lands with the highest ecological value in the state.

Figure 3.5 Percent change in IEI (1971-2005)



LOCAL VS REGIONAL LAND PROTECTION EFFORTS

The CAPS analysis identifies large blocks of land of high ecological value. However, land in much of the state falls in the lower categories of ecological value. In some of these areas, there is not much land left to protect. In towns that have low IEI scores, the ecological value of the land to the town is still high. The ecological services and benefits provided by natural lands in densely developed areas are of great value to individual communities, and additional natural land should be protected. The CAPS model is useful because it suggests ways that local IEI scores could be increased through management of both protected and unprotected land. Activities such as removing invasive plants or minimizing domestic animal/wildlife interactions can improve habitat quality locally. Individual management activities, in addition to focusing on larger reserves and outright land protection, should be part of the overall conservation strategy.

Direct vs Indirect Impacts of Developments

The CAPS analysis provides the opportunity to compare the direct impacts of recent development with the indirect impacts of recent development. Direct impact is the loss in ecological integrity that happens immediately under the footprint of development. Cells that were previously natural and are converted to a home or commercial/industrial building, for instance, will change to a zero value. The direct impacts are calculated by summing up the loss in IEI for all cells of new development. The indirect impacts of development are determined by looking at all of the cells that remain undeveloped. While they remain in a natural state, their values have been altered as a result of their proximity to new development. Figure 3.6 shows the impact of two subdivisions that were recently built. The zones in reddish brown, penetrating significantly into the surrounding forest, had a decrease in the IEI value of at least 50%. The ecological impacts of development extend far *beyond the footprint* of our homes and buildings.

Figure 3.6: Decrease in ecological integrity surrounding new development

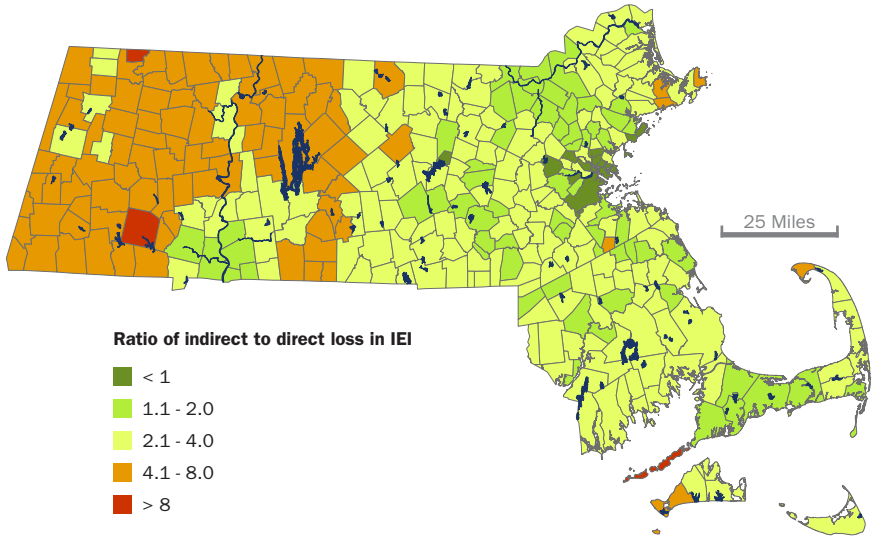
Table 3.1 compares the direct and indirect impacts of development. The indirect impacts of development are three to four times greater than the direct impacts of development. From 1971-2005, the indirect impacts were three times greater than the direct impacts of development.

Table 3.1: Direct and indirect loss in ecological value over time (statewide)

	1971-1985	1985-1999	1999-2005	1971-2005
Direct loss in IEI-acres	29,760	37,065	31,115	119,459
Indirect loss in IEI-acres	115,197	132,855	129,477	356,005
Overall loss in IEI-acres	144,957	169,920	160,592	475,464
Ratio of indirect loss to direct loss	**3.9**	**3.6**	**4.2**	**3.0**

Furthermore, examination of individual towns between 1971 and 2005 shows that in a few towns the indirect impacts can be as much as 8 times greater than the direct impacts. The towns that see the greatest indirect impacts to development are precisely the towns that have the largest intact blocks of habitat remaining in the state.

Figure 3.7: Effects of development—beyond the footprint (1971-2005)



In all past editions of *Losing Ground*, Mass Audubon has used the best available data to estimate the acres of *direct* impact due to development. The CAPS analysis shows that the *indirect* impacts of development have an even larger negative impact on the ecological integrity of our natural lands. Faced with these conclusions, the challenge to conservation agencies and organizations is twofold: 1) to protect as much of the high-quality habitat that remains at local, regional, and statewide scales; and 2) to find ways to change the pattern of dispersed residential development that is so prevalent. The CAPS analysis clearly shows that it is exactly this type of development that will most quickly degrade the ecological integrity of the landscape.

CHAPTER 4: THE STATE OF LAND PROTECTION IN MASSACHUSETTS—FORESTS, WETLANDS, AND AGRICULTURE

Massachusetts' land area is currently more than one-fifth (20.6%) permanently protected wildlife habitat. This is up from 18.8 percent in 2003 and 17.3 percent in 1997. We have protected one million acres of wildlife habitat: 404,000 acres for conservation only; 418,500 acres for conservation and recreation; and 206,900 acres for water supply protection.

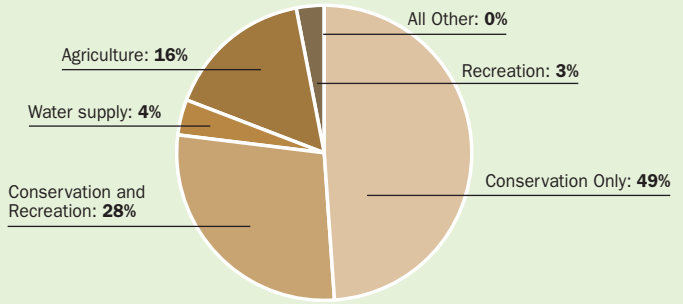
The best source of information on the state of land protection in Massachusetts continues to be the Protected Recreation and Open Space data available from MassGIS. This is a Geographic Information Systems (GIS) database, allowing both spatial and statistical analysis of protection levels.

Table 4.1: Type of ownership and primary purpose of protection, December 2008

	State	Municipal/ County	Nonprofit org	Private w/ restriction	Federal	Other	Total
All Polygons from Open Space Layer	570,141	351,009	133,162	227,216	65,872	12,316	**1,359,716**
Permanently Protected Land only	559,017	272,423	112,342	148,808	61,938	8,497	**1,163,025**
Conservation only	130,511	112,662	84,243	63,608	12,739	252	**404,015**
Conservation and Recreation	317,716	29,218	20,542	14,462	36,490	80	**418,508**
Water Supply Protection	98,452	95,778	44	3,565	2,931	6,176	**206,946**
Agriculture	860	1,156	3,128	62,376	–	1,858	**69,378**
Recreation only	6,732	26,704	1,464	2,018	794	50	**37,762**
Historical/Cultural/ Scenic	38	5,052	2,240	1,820	1,636	79	**10,865**
Other	4,707	1,854	681	958	7,347	1	**15,548**

Table 4.1 presents this acreage by type of ownership and primary purpose of protection. Since the last edition of *Losing Ground*, the land categorized as having a "conservation only" purpose has increased from 33% to 35% of all permanently protected lands. This is a significant increase given such a large protected land area. The shift can be explained by the greater amounts of land being protected with the sole purpose of conservation. Between 1999 and 2005, 49% of land protected was for the sole purpose of conservation.

Figure 4.1: Primary purpose of protection between 1999 and 2005



Who Owns Our Protected Lands?

Table 4.2 shows how the purpose of protection varies based on the type of ownership. Overall, nearly 50% of permanently protected land is state owned. Almost all state-owned land is managed by the Department of Fish & Game and the Department of Conservation and Recreation. Municipal land is protected primarily for conservation or for water supply protection. Within the nonprofit category, 75% of the land is protected for conservation purposes. Private land that is permanently protected is dominated and equally split between conservation and agricultural purposes. The relatively small amount of Federal land has a breakdown very similar to state land.

Table 4.2: Percentage breakdown of primary purpose by ownership type

	State	Municipal/ County	Nonprofit org	Private w/ restriction	Federal	Other	Total
Permanently protected land only	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	**100.0%**
Conservation only	23.3%	41.4%	75.0%	42.7%	20.6%	3.0%	**34.7%**
Conservation and Recreation	56.8%	10.7%	18.3%	9.7%	58.9%	0.9%	**36.1%**
Water Supply Protection	17.6%	35.2%	0.0%	2.4%	4.7%	72.7%	**17.8%**
Agriculture	0.2%	0.4%	2.8%	41.9%	0.0%	21.9%	**6.0%**
Recreation only	1.2%	9.8%	1.3%	1.4%	1.3%	0.6%	**3.2%**
Historical/Cultural/ Scenic	0.0%	1.9%	2.0%	1.2%	2.6%	0.9%	**0.9%**
Other	0.8%	0.7%	0.6%	0.6%	11.9%	0.0%	**1.3%**

The Good News

Between 1999 and 2005, the open space database reported 109,863 acres of land that was permanently protected (Table 4.3) This represents a protection rate of 43 acres per day. Between 1999 and 2005, the rate of land protection was double the rate of development in Massachusetts. However, only 50% of this protection had the sole purpose of conservation. The rate of land protection was highest in 2000, 2001, and 2002, with more than 20,000 acres being protected in each of those years. The rate of land protection between 2003 and 2005 was much less.

The Executive Office of Energy and Environmental Affairs (EEA) recently announced that 24,100 acres were protected in Fiscal Year 2008 through EEA action, almost double that protected in FY2007. Roughly 13,800 acres were protected via expenditure and 10,300 acres through conservation restrictions. This is exciting news and, with the help of the Environmental Bond, it is likely the first of several years with high levels of land protection.

Table 4.3: Acres protected between 1999 and 2005 by primary purpose

Primary Purpose of Conservation	1999	2000	2001	2002	2003	2004	2005	Total
Conservation only	6,434	11,865	13,483	12,470	3,139	2,236	4,500	**54,127**
Conservation and Recreation	2,343	5,110	4,851	9,385	3,286	4,302	1,537	**30,814**
Water Supply	821	172	1,529	1,362	14	433	119	**4,450**
Agriculture	2,313	3,613	3,272	2,185	1,531	2,384	1,746	**17,044**
Recreation	6	127	17	2,767	99	–	303	**3,319**
All Other	–	5	1	2	45	39	17	**109**
TOTAL (All permanently protected lands)	**11,917**	**20,892**	**23,153**	**28,171**	**8,114**	**9,394**	**8,222**	**109,863**

The Bad News

Two other statewide conservation plans used as benchmarks show that although we have made significant progress in land protection, there is still much work to do. The Statewide Conservation Plan, endorsed in 2003 by then EOEA Secretary Herzfelder and summarized in the last edition of *Losing Ground*, called for 50,000 acres of protection each year in order to meet its goals. The year with the highest rate of protection, 2002, fell more than 20,000 acres short of this goal, and since then protection rates have fallen. Unfortunately, this plan was not implemented in any substantive manner during the Romney Administration. The Wildlands and Woodlands vision of the Harvard Forest calls for protection of half of the state, or 2.5 million acres. At the 1999-2005 rate of land protection, it would take roughly 85 years to reach the 2.5-million-acre goal. Given the indirect impacts of development described in Chapter 3, this rate of protection will not be adequate to fulfill the vision of wildland reserves with surrounding managed woodlands.

IMPROVEMENTS TO THE MASSGIS PROTECTED LAND DATABASE

MassGIS Protected Recreation and Open Space data is one of the most useful sources of information on land protection in Massachusetts. In recent months, MassGIS has taken steps that will lead to many improvements. The result will be a more up-to-date data set on the protection of open space in the Commonwealth.

A past hurdle of this dataset was the inability of individuals and organizations to provide spatial data to MassGIS without purchase and knowledge of GIS software. MassGIS is currently developing an online "Open Space Wiki" where local officials and land trusts can submit parcel data into the open space data set electronically.

Another improvement that will yield more up-to-date information is the submission of map (spatial) information to MassGIS for all conservation restrictions and all Executive Office of Energy and Environmental Affairs grant programs.

A final important improvement is that the rate of entry of state data into the database has greatly improved. We should expect to see state acquisitions of parcels in any fiscal year be reflected in the database within several months of June 30th. If the data in the open space data set is current, conservation agencies and organizations can ask the basic question, "What have we protected in the past year?" Previously, we have not been able to reliably answer this important question.

Some challenges remain when it comes to open space data. Parcels privately held by small nonprofit organizations may still not be reflected in the open space data set for a variety of reasons. While the Massachusetts Conservation Mapping Assistance Partnership Program of MassGIS provides inexpensive GIS software, training, and data viewers to land trusts and conservation commissions, it has not yet reached everyone it could.

Protection of Natural Lands

Massachusetts currently has 3.5 million acres of land in a natural state. Overall, 28.4% of the natural landscape is protected. Table 4.4 shows the breakdown of each natural land use type. According to the 2005 Land Use/Land Cover data, approximately 3,187,100 acres (91%) is forested. Much of the brushland/successional habitat that is protected is on Martha's Vineyard where 82% of its 4,270 acres is protected and on Nantucket where 55% of its 11,680 acres is protected. On the mainland, 28% of the remaining 15,720 acres is protected. This habitat will often be host to a unique suite of early successional species and represents potential land that can be actively managed to promote these species. While powerlines are built by humans and continue to be managed, they are also host to species found only in early successional habitats. For this reason, they were included as a natural land use type.

BETWEEN 1999 AND 2005, THE RATE OF LAND PROTECTION WAS DOUBLE THE RATE OF DEVELOPMENT.

Table 4.4: Breakdown of natural land in Massachusetts (2005)

Land Use	Acres in Forested/Natural	Acres Protected	Percent Protected
Forested	2,899,417	813,565	28.1%
Nonforested wetland	165,625	50,543	30.5%
Salt wetland	43,711	18,999	43.5%
Powerlines	27,911	5,268	18.9%
Saltwater sandy beach	50,774	14,204	28.0%
Forested wetland	287,701	78,138	27.2%
Brushland/successional	31,676	14,276	45.1%
TOTAL	**3,506,815**	**994,993**	**28.4%**

To identify the natural portions of the state that are under the highest threat from development, we used the town-specific rates of development between 1999 and 2005 (acres of development per square mile) as an indicator of threat to the remaining habitat. We then calculated the acres of unprotected natural land that remains in each town. Since the distribution of natural land varies widely by municipality, we grouped the towns into four categories based on acres of unprotected forest/natural, > 10,000 acres, 5,000-10,000 acres, 1,000-5,000 acres, and < 1,000 acres. As the acreage of natural land in towns decreases, the amount of protection generally increases from 25% to just under 60% in the category with the smallest amounts of natural land.

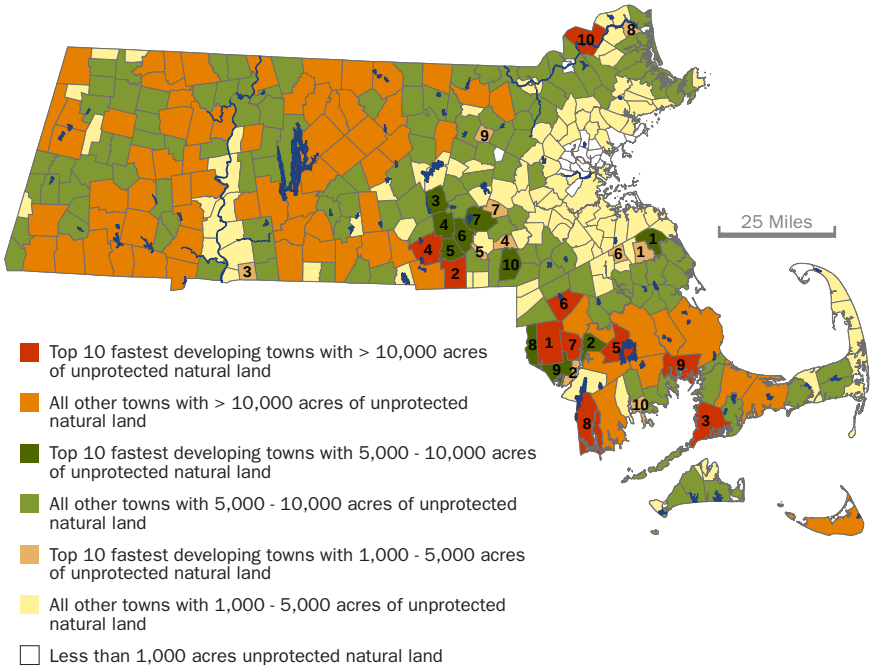
Table 4.5: Amount and Protection of natural land in Massachusetts

Unprotected natural category	Number of towns	Land in natural	Percent protected
> 10,000 acres	83	1,568,981	25.1%
5,000-10,000 acres	136	1,388,344	30.3%
1,000-5,000 acres	109	509,279	33.0%
< 1,000 acres	23	19,788	59.5%

We identified the top 10 communities in each category that are most under threat of development. Seven of the top 10 threatened towns with more than 10,000 acres of natural land are clustered in southeastern Massachusetts, with the remaining towns in the Blackstone River watershed and in Haverhill (Figure 4.2). Rehoboth, for instance, has more than 20,000 acres of natural lands that remain unprotected, and 12 acres of every square

mile have been developed since 1999. The towns shown in dark green identify a cluster of towns to the east and southeast of Worcester that have between 5,000 and 10,000 acres of unprotected natural land and high rates of development. This analysis reinforces the conclusion from the previous edition of *Losing Ground* that sprawl continues to impact towns in southeastern Massachusetts. Detailed examination of the towns with the highest rates of development shows that the sprawl has moved to even farther flung portions of southeastern Massachusetts. In addition, it highlights the Blackstone River watershed as a hot spot where development is having, and will continue to have, a significant impact on the remaining natural resources.

Figure 4.2: Natural lands and development in Massachusetts



Protection of Agricultural Lands

According to the 2005 Land Use/Land Cover data, Massachusetts has roughly 285,800 acres of agricultural land, or 5.5% of the state. Table 4.6 shows how this acreage is distributed in various types of agriculture.

Table 4.6: Breakdown of agricultural land in Massachusetts (2005)

Land use	Acres in agriculture	Acres protected	Percent protected
Cropland	159,011	33,119	20.8%
Pasture	87,899	12,808	14.6%
Cranberry bogs	24,203	1,551	6.4%
Orchard	8,759	2,803	32.0%
Nursery	5,948	891	15.0%
TOTAL	**285,820**	**51,172**	**17.9%**

The majority of agriculture is in cropland (56%), with pasture (31%) and cranberry bogs (8%) also making significant contributions to the agricultural land base. Roughly 21% of the state's cropland is protected, as is 15% of the state's pasture. The cranberry bogs, primarily located in southeastern Massachusetts, suffer from a low level of protection (6%). However, these bogs represent wetlands that were converted to cranberry production long ago, and as such are not readily developable. A thorough investigation of threats to commercial cranberry bogs would take into account the quality of protection afforded adjacent upland areas as well as the bogs themselves. This type of analysis should be completed for this important cultural and agricultural resource.

To identify the agricultural portions of the state that are under the highest threat from development, we used the town-specific rates of development between 1999 and 2005 (acres of development per square mile) as an indicator of the threat to remaining habitat. We then calculated the acres of unprotected agricultural land that remain in each town. The distribution of agricultural land varies widely by town, so we grouped the towns into four categories based on acres of unprotected agriculture: > 2,500 acres, 1,000-2,500 acres, 250-1,000 acres, and < 250 acres.

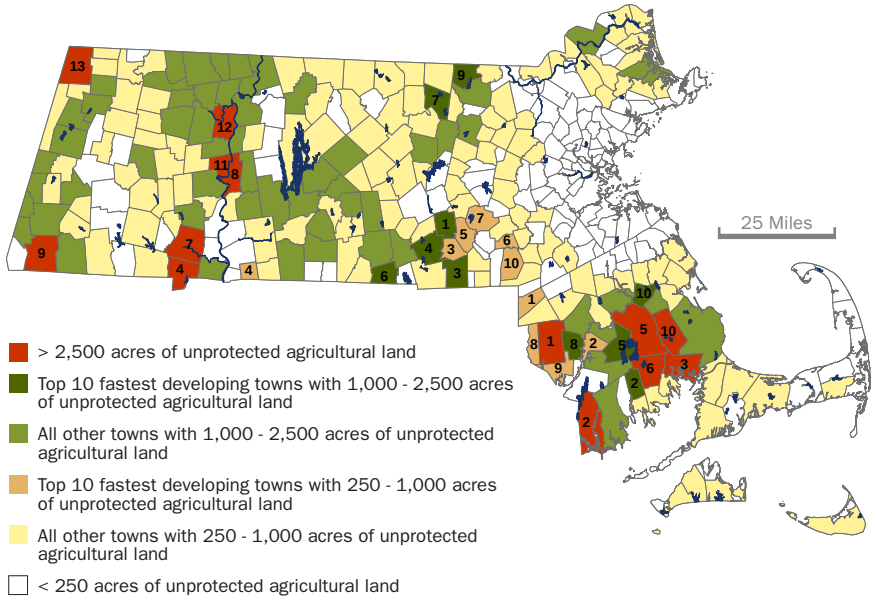
Table 4.7: Amount and protection of agricultural land in Massachusetts

Unprotected agriculture category	Number of towns	Land in agriculture	Percent protected
> 2,500 acres	12	49,922	14.5%
1,000-2,500 acres	68	125,799	17.6%
250-1,000 acres	136	94,123	19.0%
100-250 acres	54	12,529	22.0%
< 100 acres	81	3,447	32.9%

Towns with small amounts of agriculture remaining (< 100 acres) provide much higher levels of protection to this scarce resource, almost 33%. In contrast, those towns with large acreages that remain in agriculture protect less than 15% of the agricultural land.

We identified the top 10 towns in each category that are most under threat of development. The pattern of threatened towns that emerges is interesting. If we focus on towns with large amounts of agricultural land remaining (> 2,500 acres shown in red on Figure 4.3), six out of the ten most threatened towns are in the southeast, arguing for increased protection of agricultural lands in this region. The remaining most threatened towns are clustered in the Connecticut River valley and in the river valleys in the northwest and southwest of the state. This pattern is significant because it shows that in order to protect the state's agricultural land, we must focus on growth in the Connecticut River valley as well as in the far western corners of the state. The nature of the protection must also vary. In southeastern Massachusetts, the uplands surrounding cranberry bogs must be protected while in other parts of the state outright protection of the upland agricultural land is more appropriate.

Figure 4.3: Agriculture and development in Massachusetts



CHAPTER 5: BIODIVERSITY IN MASSACHUSETTS—PROTECTION AND THREATS

Terrestrial Biodiversity

In 2001, the Massachusetts Natural Heritage and Endangered Species Program (NHESP) created the BioMap, which delineated habitat for the full complement of native species in Massachusetts. Based on their comprehensive database of rare and endangered species occurrences, the BioMap also used a sophisticated analysis to capture nonendangered species habitat as well. Almost 1.2 million acres of Massachusetts was delineated as BioMap Core Habitat—that is, habitat for a viable population of an important element of biodiversity. Overall, 45% of the BioMap Cores are permanently protected (544,400 acres). This includes the Quabbin Reservoir. Table 5.1 divides these protected acres by their primary purpose. Roughly 14% of Core Habitat is protected with the sole purpose of conservation.

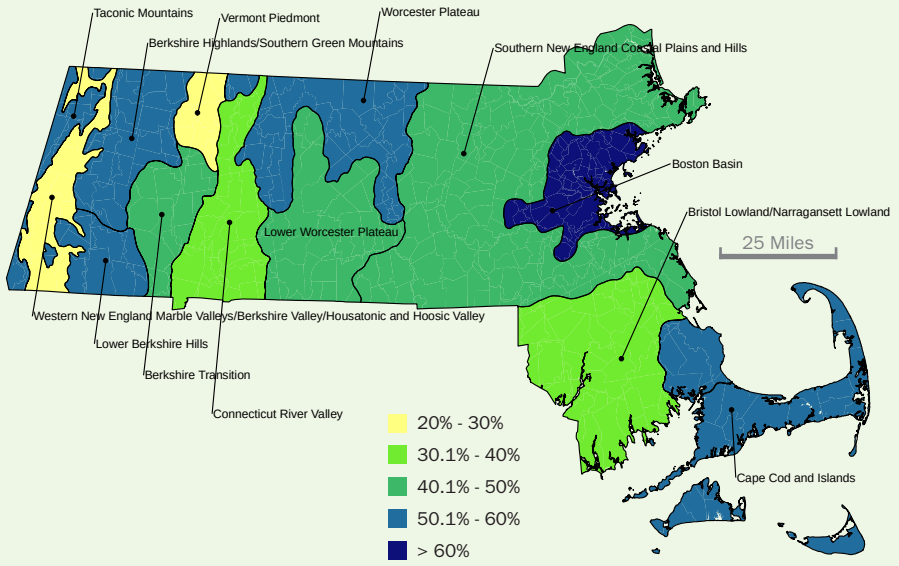
As part of the BioMap project, the NHESP team identified 963,600 acres overall of Supporting Natural Landscape: areas of high ecological value that provide habitat for nonendangered elements of biodiversity, that buffer populations of rare or endangered species, or that connect large roadless blocks of intact natural vegetation. Of those areas delineated as Supporting Natural Landscape, only 260,000 acres, or 27%, are protected.

Table 5.1: Protection of BioMap Cores by primary purpose

Primary Purpose of Protection	Acres protected	Percent of Bio Map Cores
All permanently protected lands	544,375	44.6%
Recreation and Conservation only	214,356	17.6%
Conservation only	170,200	14.0%
Water supply only	138,700	11.4%
Other	21,119	1.7%

Figure 5.1 shows the protection of BioMap Cores by ecoregion. BioMap Core Habitat in many of the ecoregions is more than 50% protected. The Western New England Marble Valleys (12,100 out of 55,200 acres protected) and the Vermont Piedmont (2,400 out of 12,300 acres protected) ecoregions have the smallest amounts of protected Core Habitat.

Figure 5.1 Percent of BioMap Core Habitat protected in each ecoregion



In order to further investigate threats to BioMap Core areas, we identified the portions of each Core that were unprotected, and then measured how much new development was present in 2005. As delineated in 2001, the BioMap Cores could contain development *inside* their boundaries. Large clusters of development were segregated into separate areas that were inholdings within the Core Habitat. These interior polygons were removed for this analysis. As a result, the development considered here is mostly new development. The amount of recent development in the Core is an indicator of development pressure on the

THE WESTERN NEW ENGLAND MARBLE VALLEYS AND THE VERMONT PIEDMONT ECOREGIONS HAVE THE SMALLEST AMOUNTS OF PROTECTED BIOMAP CORE HABITAT.

remaining Core Habitat. Figure 5.2 shows the unprotected Cores in yellow, orange, and red that are at least 5% developed. Overall, 4.5% of the unprotected Core polygons are already developed. The majority of the Core Habitats under higher levels of threat are found east of the Wachusett Reservoir. Several Cores within the Connecticut River valley also fall in the higher levels of threat.

Figure 5.2: Threat of development in each BioMap Core

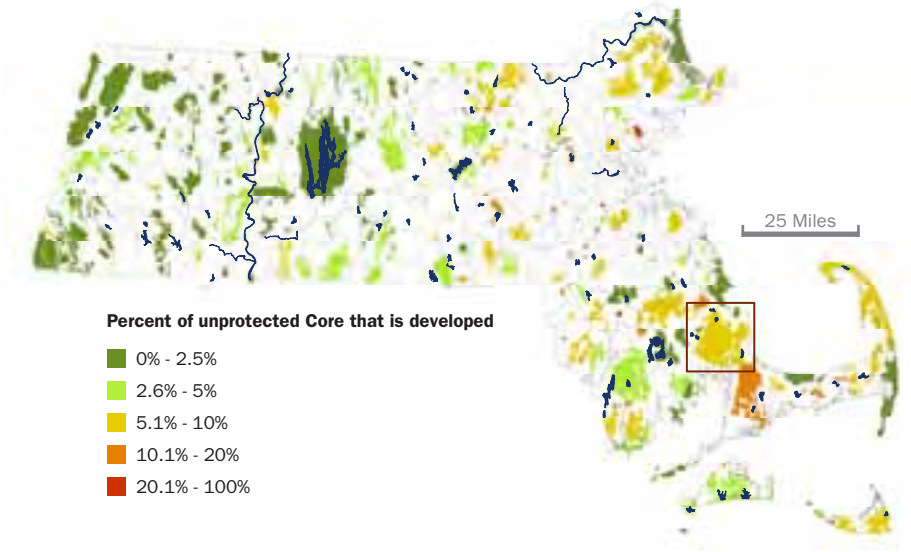
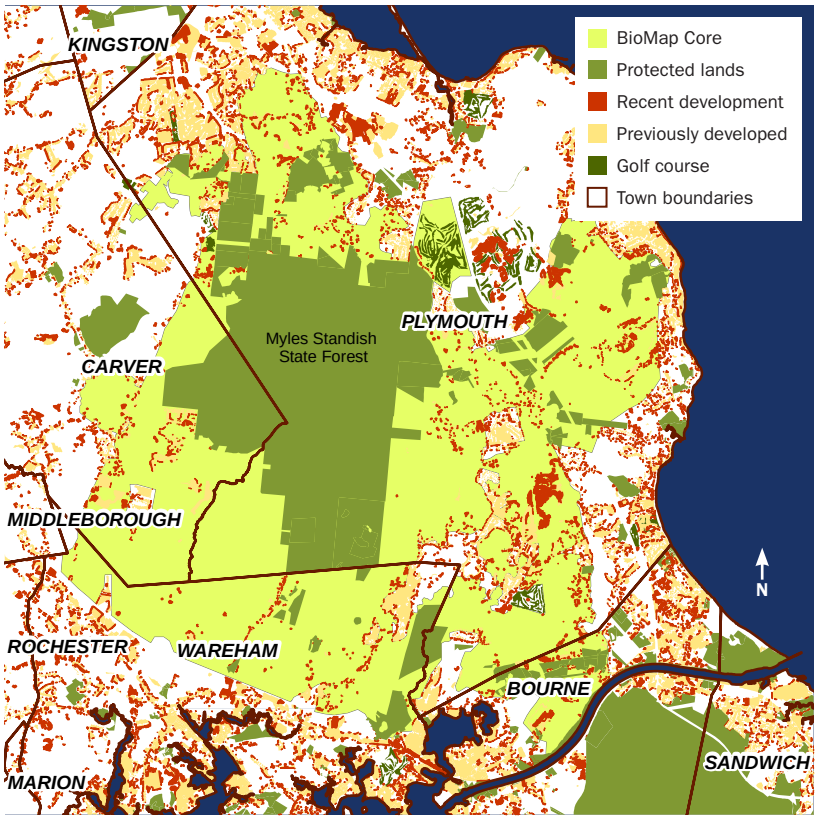


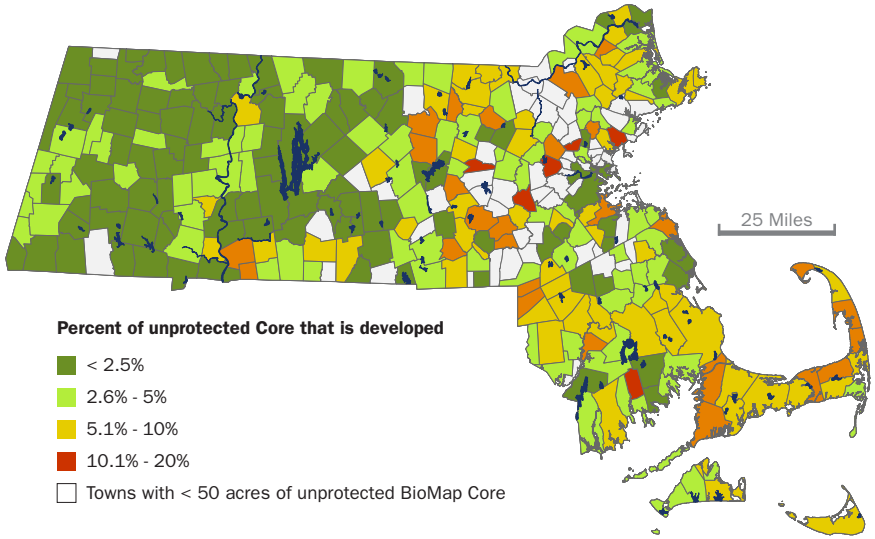
Figure 5.2 assigns to each Core a color based on the percent of development present in the unprotected portion of the Core. Individual consideration of each Core will reveal the much more complex interplay among protected lands, unprotected lands, and development. Figure 5.3 zooms into the yellow (5-10%) Core Habitat surrounding Myles Standish State Forest. Additional protected lands could clearly coalesce around the state land in the middle of this Core. However, such protection is not materializing quickly enough to stop fragmentation of the remaining Core. Significant amounts of recent development (shown in red) can be seen in the northern and eastern parts of the Core.

Figure 5.3: Recent development in a BioMap Core polygon



The results of this analysis have been converted into other levels—town/city, watershed, ecoregion, county, and regional planning agency—so that results can be used at different scales. Figure 5.4 shows these results at the town/city level. There are 33 towns in which the undeveloped BioMap Core is more than 10% developed and 63 in which between 5 and 10% of the Core is developed. For more details of these results, see the *Losing Ground* website found at www.massaudubon.org/losingground.

Figure 5.4: Encroachment of development into BioMap Cores by town/city



CLIMATE CHANGE AND BIODIVERSITY IN MASSACHUSETTS

The Massachusetts climate is changing rapidly as indicated by the increases in southern bird, dragonfly, and butterfly species. The rapidly warming Massachusetts climate threatens to disrupt natural communities and exacerbate the stresses of development. Conservation organizations are considering their missions with respect to climate change, and the dual strategies of "mitigation" and "adaptation" are being advanced. Mitigation strategies reduce the emissions of greenhouse gases to avoid the unmanageable effects of climate change, and adaptation strategies increase the resilience of natural communities as they respond to the unavoidable effects of climate change. The Manomet Center for Conservation Sciences, The Nature Conservancy, and MassWildlife are collaborating on an effort to include the impacts of climate change into the State Wildlife Action Plan, with particular focus on the relative vulnerability of Massachusetts' natural communities to the stresses of climate change. Mass Audubon will be working with these partners to better understand the interaction between land use and development. See www.manomet.org for more information on the current status of this research.

Aquatic Biodiversity

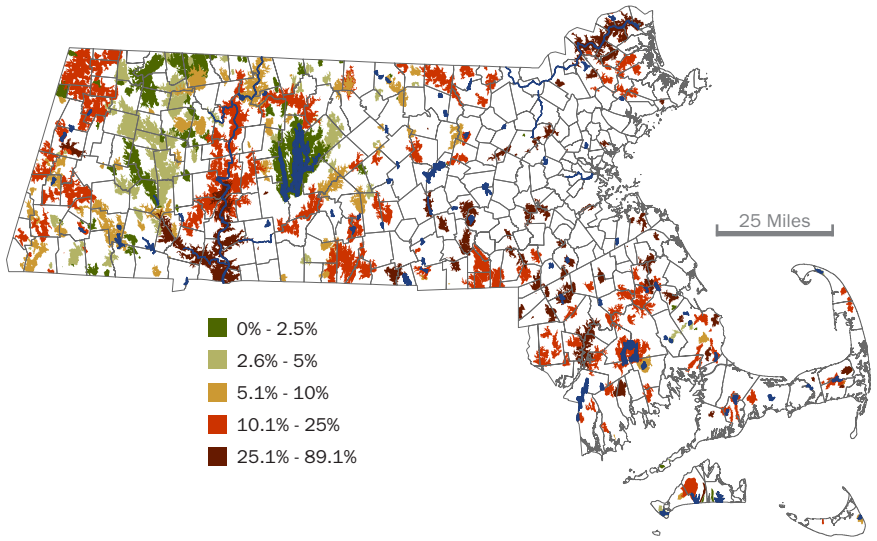
In 2003, the Natural Heritage and Endangered Species Program created the Living Waters map, which delineates habitat for aquatic biodiversity in Massachusetts. Living Waters Core Habitats represent lakes, ponds, rivers, and streams that are important for the protection of freshwater biodiversity in Massachusetts. According to the Open Space datalayer from MassGIS, of the 65,500 acres of Living Waters Core Habitat in the state, 47% is protected. However, if you remove the 24,300 acres of the Quabbin Reservoir, only 15.7% is protected. Only 2.5% of this habitat is protected with the primary purpose of conservation.

Table 5.2: Protection of Living Waters Core by primary purpose (Quabbin Reservoir removed from analysis)

Primary Purpose of Protection	Acres protected	Percent of Living Waters Core
All permanently protected lands	6,465	15.7%
Conservation, Recreation and Conservation, and Water supply	6,235	15.2%
Recreation and Conservation only	4,490	10.9%
Conservation only	1,020	2.5%
Water supply only	726	1.8%

The Living Waters project also identified Critical Supporting Watersheds, which are the terrestrial areas that have immediate hydrologic connections to the Living Waters Core Habitat. Because of the difficulty in assessing protection levels of dynamic hydrologic systems, we looked at the level of protection in the surrounding Critical Supporting Watersheds. To identify threatened Living Waters Core Habitats, we calculated for each Critical Supporting Watershed (CSW) the amount of the watershed protected and the amount of development present in the remaining unprotected portion of the watershed.

Figure 5.5: Threat of development in each Living Waters Critical Supporting Watershed



Of the 1,380,700 acres of CSW, roughly 364,300 acres have been protected (including the Quabbin Reservoir), or 26.4%. This level of protection is far less than the 45% protection of the BioMap Core Habitat. These watersheds are more threatened by development. Roughly 16% of the CSW that is unprotected is already developed, or 159,800 acres. Figure 5.5 shows that many of eastern Massachusetts' supporting watersheds are more than 25% developed already (shown in dark red). The southern portion of the Connecticut River in Massachusetts and the Westfield River are similarly threatened and rightly deserve the attention they are receiving from the conservation agencies and organizations.

CLIMATE CONNECTION

As Massachusetts develops renewable energy sources—through the Green Communities Act and otherwise—they must be sited appropriately so as not to impact aquatic resources identified by the Living Waters project. New hydroelectric projects should be sited on waterways without intact flow regimes, ones that have been previously diverted, so as to minimize the impact on freshwater biodiversity. Dam removal projects are also especially important in light of climate change, since restored flow would allow fish and other river organisms to seek out cooler upstream waters.

Figure 5.6: Encroachment of development into Living Waters CSWs by town/city

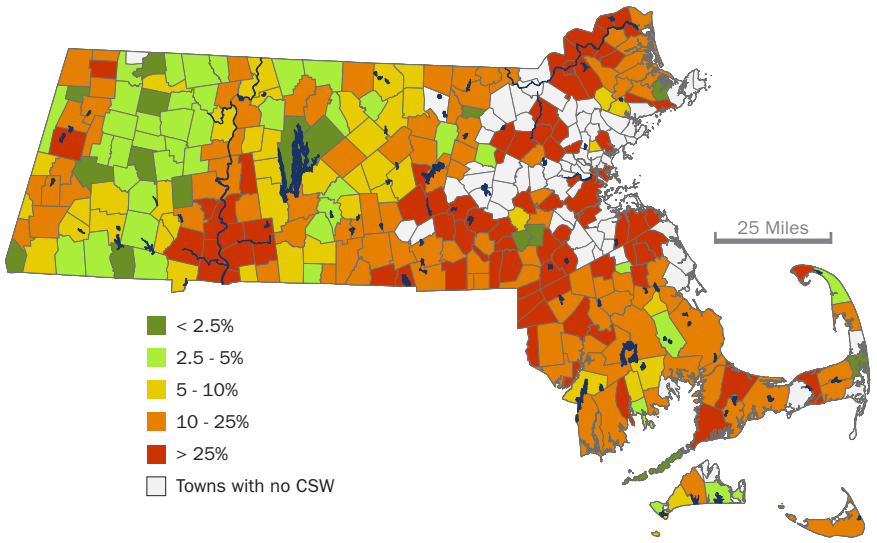


Figure 5.6 highlights the 78 cities and towns where more than 25% (shown in red) of the CSW is already developed. The location of remaining *unprotected* CSW must be evaluated by land trusts and in municipal documents such as open space plans and master plans. An additional 145 towns and cities have between 5 and 25% (orange and yellow) of their CSW already developed.

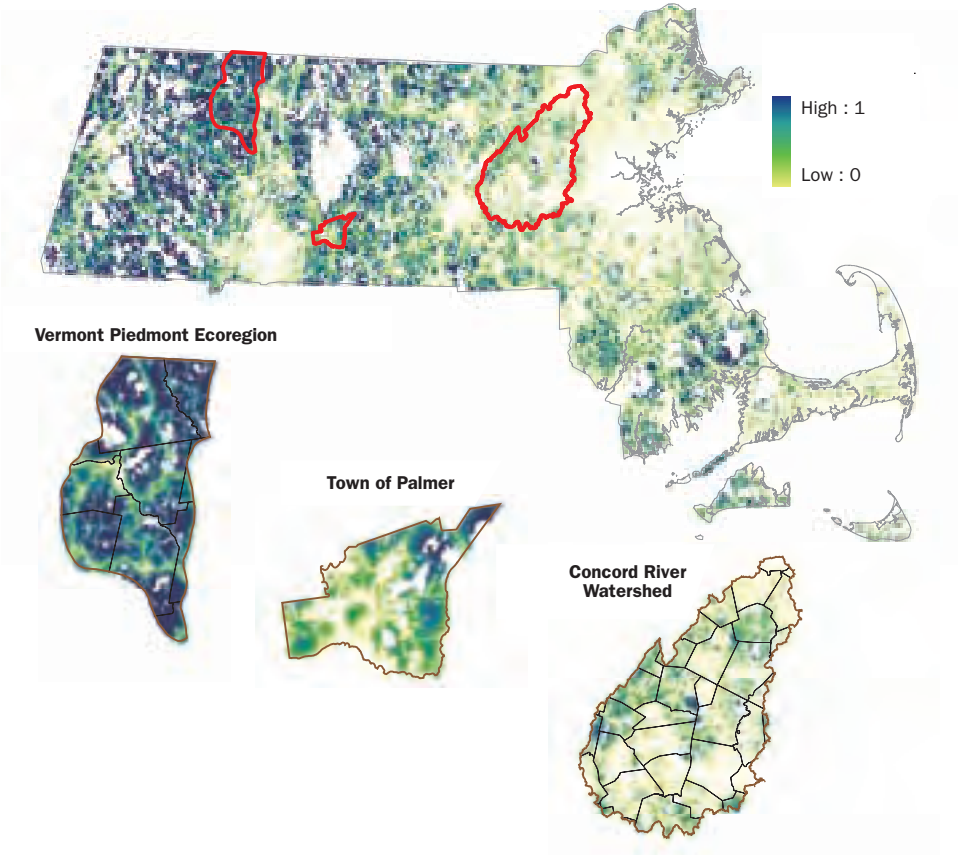
It is important to realize that a wide spectrum of acreages lie behind the summary depicted in Figure 5.6. Ayer has only 0.1 acres of CSW, hardly meaningful, while Petersham contains 35,400 acres of CSW. For detailed information from this analysis summarized by town or city, visit the *Losing Ground* website at www.massaudubon.org/losingground.

Quality of Unprotected Land as Evaluated by the CAPS Model

If we view the 2005 IEI map through the window of *unprotected* lands, it helps us to prioritize our future efforts. Figure 5.7 shows the results of the 2005 CAPS model, but with the protected lands removed so they are not visible. One is immediately aware of the high value of lands that are adjacent to the areas of existing protection. Displaying the results in this way illustrates how the CAPS model can help us to prioritize conservation efforts no matter what the scale at which we are operating. We can look at the results of the model statewide, within the Vermont Piedmont ecoregion, in the Concord River watershed, or for an individual town such as Palmer. The information used to prioritize conservation efforts must regularly be updated. For instance, the CAPS research team is currently working with The Nature Conservancy, the Executive Office of Transportation, and the Massachusetts Department of Environmental Protection to generate a statewide model that incorporates more information than was possible when considering ecological integrity between 1971 and 2005. When the model is complete in the coming months, it will represent a new source of information that can be used to prioritize conservation efforts.

Figure 5.7: Ecological value of unprotected land in Massachusetts (2005)

The CAPS analysis has shown that the greatest loss in ecological value takes place during the initial stages of development. This finding suggests that significant attention needs to be given to towns that lie far beyond the Sprawl Frontier in western Massachusetts, in the Connecticut River valley, and in towns surrounding the Quabbin Reservoir.



CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

The third edition of *Losing Ground* recommended a variety of policy changes, and progress has been made since 2003. Currently, 140 towns have passed the Community Preservation Act, protecting 10,270 acres of open space in the last eight years. A new Environmental Bond recently has been passed with an administration promise to spend no less than $50 million per year over the next five years for open space protection.

Conservation agencies and organizations in Massachusetts, both public and private, have made great progress in land protection since 1971. The current economic downturn is akin to the eye of a storm. This is an important opportunity to make changes in how we develop, conserve, and manage land. As the economy recovers, the pressures of sprawling development will likely continue to move across the landscape. While our estimate of the rate of development has decreased, the patterns of change continue to spread farther west and southeast. We have shown that the indirect impacts of development on ecological integrity are far greater than the direct impacts of development. To attain our goal of protecting habitat for our full suite of biodiversity—and therefore the nature of Massachusetts—more land must be permanently protected.

Protection of Biodiversity and Other Resources

Between 1999 and 2005, twice as much land was protected than was developed. This is largely due to three banner years in 2000, 2001, and 2002. While it is significant that the rate of protection is outpacing the rate of development, the indirect impacts of development remain three to eight times higher than the direct impacts of development. For this reason, Mass Audubon recommends the following actions to meet this goal.

- "One percent for nature"—spend at least 1% of the state's total budget on operating support for environmental programs, including administration, enforcement, and implementation of environmental statutes.
- Ensure that $50 million per year in capital funding from Environmental Bond funds continues to be appropriated for land protection.
- Focus resources and land protection efforts by conservation agencies and organizations on towns in the Sprawl Frontier, particularly in southeastern Massachusetts. Unprotected natural land remaining in these towns must be placed beyond the reach of development, for the benefit of both wildlife and people.

THE LOSING GROUND INTERACTIVE WEBSITE

This edition of *Losing Ground* is designed to aid in local and regional, as well as statewide, planning. The analysis presented in this document has been scaled to many different practical levels, including by town, county, watershed, ecoregion, and regional planning agency. Please visit www.massaudubon.org/losingground to view both *statistics and maps* that explore how land use change has affected your corner of the Commonwealth.

The results of the CAPS analysis demonstrate that significant ecological impacts have taken place beyond the Sprawl Frontier, in the Sprawl Danger Zone. While less land is being developed in these towns, the initial development has far greater negative ecological impact than subsequent development. Mass Audubon recommends the following.

- The creation of a robust and coordinated land protection strategy among state agencies and conservation nonprofits in western Massachusetts, in the Connecticut River valley, and in towns surrounding the Quabbin Reservoir, as well as sufficient resources to implement the strategy.
- The extension of planning resources to these towns in the form of circuit riders, funding for town planning and resource manager positions, or funding for education of town board members, so that the true impacts of zoning and development decisions can be understood. Small towns with largely volunteer boards can be overwhelmed by the number and complexity of land use decisions that must be made, and they require increased financial and technical support to help them do their jobs.
- Protection of remaining agricultural lands throughout Massachusetts. The amount of agriculture that remains in towns varies widely; in some towns just a few acres remain, and outright protection by a local organization might be an appropriate option, while in other towns thousands of acres remain, and outright protection may not be easily accomplished. A coalition of federal, state, and local, and nonprofit stakeholders is needed to protect these lands. Because of farmland's habitat value to a number of native bird species, as well as its value as a resource for locally grown food and a more diverse landscape, Mass Audubon supports the protection of agricultural land in Massachusetts.

- The prioritization of protection efforts, regionally and locally, using the analyses of threat levels summarized in this edition of *Losing Ground* and available on the *Losing Ground* website (www.massaudubon.org/losinground). We analyzed threats to natural land, agricultural land, BioMap Core Habitat, and Living Waters Core Habitat.
- The creation of a coordinated restoration strategy for riverine and wetlands habitat within the Executive Office of Energy and Environmental Affairs, which would include significant resources for removal of obsolete dams and old culverts, restoring riverine connectivity. Significant investment in stream and river restoration would be an adaptative strategy for climate change. Aquatic rare species habitat is more difficult to protect, and as a result receives far less protection than important terrestrial biological resources. Although it is a challenge to protect these species, focusing on this habitat continues to be critical to the survival of freshwater aquatic biodiversity.
- The systematic analysis of how climate change will impact biodiversity when coupled with land use conversion and landscape fragmentation, disruption of ecological processes, invasive species, and incompatible human uses, would provide valuable insights for land use planning.

Zoning and Legislative Reform

Communities must engage in thoughtful planning to shape their future.

- We urge the Massachusetts legislature to act now to reform the Commonwealth's zoning laws by taking up the administration's Land Use Partnership Act (LUPA).
- We need to ensure the lasting success of the Community Preservation Act by broadening municipal participation and clarifying allowable uses to promote sustainable communities. We support the legislation that has been filed to advance and strengthen the CPA.

The Importance of Our Spatial Data Infrastructure

The foundation of each edition of *Losing Ground* is an updated Land Use/Land Cover derived from statewide aerial imagery. This data provides the ability to determine what opportunities have been missed as well as where we must focus our conservation efforts. The complement to this layer is up-to-date information on the protected lands in our Commonwealth. Mass Audubon recommends the following.

- Land Use/Land Cover data be regularly updated. The funding for this important resource should be incorporated into operating budgets, ensuring regular acquisition.
- Conservation agencies and organizations make a concerted effort to fully populate the open space data layer.

Conclusion

According to the best available data and analysis, the rate of land use change in Massachusetts has slowed from a high of 40 acres a day during the years 1985 through 1999, to 22 acres a day from 1999 to 2005. During the same time, the rate of land protection was double the rate of land use change. We commend the Commonwealth's Executive and Legislative branches of government along with municipalities and private conservation organizations that have collaborated over those six years to protect an additional 109,863 acres of land.

At the same time, there is much more to be done. Twenty-two acres a day is the equivalent of creating a new development the size of the cities of New Bedford, Lawrence, and Springfield combined every five years.

Furthermore, the ecological impacts of development multiply the scope of impact far beyond the immediate 22 acres of land developed. Our analysis found that for each acre developed, an additional three acres loses significant ecological integrity from such factors as fragmentation, edge effects, increased predation by domestic animals, encroachment of invasive species, and other secondary impacts of land use conversion from a natural to a developed state.

The Sprawl Frontier continues to extend farther from large cities like Boston and Providence. This type of unplanned development is not sustainable, and communities within the Sprawl Frontier are facing increased costs in infrastructure and services. Those communities on the leading edge of the Sprawl Frontier, the Sprawl Danger Zone, need better planning and zoning tools to address the pressures they face. Amending the Community Preservation Act and enacting meaningful zoning reform such as the Land Use Partnership Act will give municipalities new tools to guide growth and development in a sustainable direction.

In all past editions of *Losing Ground*, Mass Audubon has used the best available data to estimate the acres of direct impact due to development. In this edition of *Losing Ground*, we have used the CAPS analysis to show that the indirect impacts of development have an even larger negative impact on the ecological integrity of our natural lands. Faced with these conclusions, the challenge to conservation agencies and organizations is twofold: 1) protect as much of the high-quality habitat that remains at local, regional, and statewide scales; and 2) find ways to change the pattern of dispersed residential development that is currently so prevalent. The CAPS analysis clearly shows that it is exactly this type of development that will most quickly degrade the ecological integrity of the landscape. We have an opportunity that must be taken now to save the most important aspects of our treasured Commonwealth—biodiversity, wildlife habitat, clean water, agricultural resources—for the benefit of future generations.

REFERENCES

Berdik, Chris, "Give me land, lots of land," *The Boston Globe*, June 12, 2005.

Blanton, Kimberly, "Home costs are called a drag on state growth," *The Boston Globe*, May 22, 2006.

Breunig, Kevin, Losing Ground: At What Cost? Changes in Land Use and Their Impact on Habitat, Biodiversity, and Ecosystem Services in Massachusetts. Mass Audubon, November 2003.

Brown, Larissa, and Nancy Goodman, Massachusetts Smart Growth Alliance, Shared Destinies: A Smart Growth Agenda for Massachusetts, Boston, Massachusetts. 2005.

Caffrey, Andrew, and Charlie Russo, "Smaller homes are nonstarters," *The Boston Globe*, November 5, 2006.

Compton, Bradley W., Kevin McGarigal, Samuel A. Cushman, and Lloyd R. Gamble. A resistant-kernel model of connectivity for amphibians that breed in vernal pools. Conservation Biology 21:788-799 (2007).

Foster, David R., David B. Kittredge, Brian Donahue, Glenn Motzkin, David Orwig, Aaron Ellison, Brian Hall, Betsy Colburn, and Anthony D'Amato. Wildlands and Woodlands: A Vision for the Forests of Massachusetts. Harvard Forest Paper # 26. 2005.

Goodman, Michael D., "A state of decline: Why Massachusetts is losing people," *The Boston Globe*, October 23, 2005.

Greenbaum, Daniel S., and Arleen O'Donnell, Losing Ground: The Case for Land Conservation in Massachusetts. Mass Audubon, October 1987.

Karr, James R. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1(1):66-84 (1991).

Levenson, Michael, "Most who left state don't plan to return," *The Boston Globe*, May 14, 2006.

MassGIS data sets: Protected and Recreational Open Space, Zoning, 1999 Land Use/Land Cover, 2005 Land Use/Land Cover, BioMap, Living Waters, Political boundaries, Water bodies, Priority Habitats.

Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, BioMap: Guiding Land Conservation for Biodiversity in Massachusetts, 2001.

Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Living Waters: Guiding the Protection of Freshwater Biodiversity in Massachusetts. 2003

Palmer, Thomas C. Jr., "Study: Massachusetts' high costs erode workforce," *The Boston Globe*, October 30, 2006.

Steel, Jennifer, Losing Ground: An Analysis of Recent Rates and Patterns of Development and Their Effects on Open Space in Massachusetts. Mass Audubon, May 1999.

Trombulak, Stephen C., and Christopher A. Frissell. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14(1):18-30 (2000).

United States Census Bureau (2008, December 6). Population Estimates. Retrieved December 6, 2008, from http://www.census.gov/popest/estimates.html.

The Warren Group real property listing. Data from 1999-2005 were summarized by the Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs. 2008.

PRODUCTION CREDITS

Authors

James DeNormandie is a bioregional conservation planner and GIS specialist with Mass Audubon's Ecological Extension Service.

Claire Corcoran is an ecologist and writer consulting for Mass Audubon.

Photography

Cover (top right): Kathy Sferra
Cover (bottom right): ©Paul Rezendes
Inside front cover: Bob Speare
Page 1: Kathy Sferra
Page 5: ©Paul Rezendes
Page 9: ©Paul Rezendes
Page 13: ©Paul Rezendes
Page 19: ©Eduardo del Solar
Page 23: ©Paul Rezendes
Back cover: Tom Lautzenheiser

Design and Layout

Levine Design
Cambridge, Massachusetts

Printing

MacDonald & Evans
Braintree, Massachusetts

Mass Audubon

Protecting the Nature of Massachusetts

Massachusetts Audubon Society
208 South Great Road
Lincoln, Massachusetts 01773

781-259-9500
800-AUDUBON
www.massaudubon.org

Mass Audubon works to protect the nature of Massachusetts for people and wildlife. Together with more than 100,000 members, we care for 33,000 acres of conservation land, provide educational programs for 200,000 children and adults annually, and advocate for sound environmental policies at local, state, and federal levels. Mass Audubon's mission and actions have expanded since our beginning in 1896 when our founders set out to stop the slaughter of birds for use on women's fashions. Today we are the largest conservation organization in New England. Our statewide network of 45 wildlife sanctuaries welcomes visitors of all ages and serves as the base for our conservation, education, and advocacy work. To support these important efforts, call 800-AUDUBON (283-8266) or visit www.massaudubon.org

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.

Printed on Recycled Paper