Summary Report

Losing Ground: At What Cost?

Third Edition of the Losing Ground Series

Changes in Land Use and Their Impact on Habitat, Biodiversity, and Ecosystem Services in Massachusetts

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November 2003

Mass Audubon
Protecting the Nature of Massachusetts

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ABOUT MASS AUDUBON

The Massachusetts Audubon Society is the largest conservation organization in New England, concentrating its efforts on protecting the nature of Massachusetts for people and wildlife. Mass Audubon protects more than 30,000 acres of conservation land, conducts educational programs for 250,000 children and adults annually, and advocates for sound environmental policies at the local, state, and federal levels. Established in 1896 and supported by 68,000 member households, Mass Audubon maintains 42 wildlife sanctuaries that are open to the public and serve as the base for its conservation, education, and advocacy work across the state. For more information or to become a member, call 800-AUDUBON (283-8266) or visit www.massaudubon.org.

ADDITIONAL COPIES AND TECHNICAL NOTES

Accompanying technical notes provide more detailed data tables and an expanded description of the methodology used for this report. Copies of the technical notes, or additional copies of this summary report, can be obtained by contacting Mass Audubon's Advocacy Department at 781-259-2171, sending email to advocacy@massaudubon.org, or writing to Mass Audubon, Advocacy Department Publications, 208 South Great Road, Lincoln, MA 01773.

ACKNOWLEDGEMENTS

This report draws heavily from Geographic Information Systems data and tools provided by MassGIS, an agency of the Massachusetts Executive Office of Environmental Affairs (EOEA). The level of analysis in this edition would have been impossible without this public data source. We also make use of several sources of data on rare species and natural communities developed by the Natural Heritage and Endangered Species Program (NHESP) of the Department of Fish and Game within EOEA. The Warren Group provided a custom version of its real estate database for use in this report.

All maps for this report were created in ESRI ArcView at Mass Audubon. Technical assistance and development of intermediate datalayers were provided by Dominique Pahlavan and Dan Marrier of MassGIS.

The chapter on Ecosystem Services Valuation was developed in conjunction with Dr. Matthew Wilson of the School of Business Administration and Gund Institute for Ecological Economics and Dr. Austin Troy of the School of Natural Resources and Gund Institute at the University of Vermont.

The Appalachian Mountain Club, Environmental League of Massachusetts, The Nature Conservancy, The Trust for Public Land, and The Trustees of Reservations all have provided ongoing support of the Losing Ground series.

Merloyd Luddington and Ginny Welles were instrumental in securing funding for this project.

A number of individuals provided invaluable feedback on this report, either during its development or by reviewing draft versions. Reviewers included Susan Arnold of the Appalachian Mountain Club, Mark Robinson of The Compact of Cape Cod Land Trusts, Bob O'Connor and Kristin Foord of EOEA, Ed Becker of the Essex County Greenbelt Association, Christian Jacqz of MassGIS, Bernie McHugh of the Massachusetts Land Trust Coalition, Chloe Stuart, David Szczebak and Henry Woolsey of NHESP, Loring Schwarz, Andy Finton, and Rob Warren of The Nature Conservancy, Wes Ward, Peg Wheeler, and Chris Rodstrom of The Trustees of Reservations, Whitney Hatch of The Trust for Public Land, Mark Racicot and Alan Bishop of the Metropolitan Area Planning Council. Reviewers and contributors at Mass Audubon include Taber Allison, Susannah Caffry, Jeff Collins, Jack Clarke, Gary Clayton, Chris Hardy, Nick Holland, Maura Kelly, Laura Johnson, Ann Prince, Heidi Ricci, Kathy Sferra, and Bob Wilber.

Graphic design for this report by Rob Levine, Levine Design, Cambridge, Massachusetts.

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EXECUTIVE SUMMARY

Despite progress in protecting land and a growing appreciation for the natural resources of the Commonwealth, Massachusetts continues to lose ground each day to development. While the rate of loss may be moderating, the impact of development is being felt in regions of the state containing some of our most sensitive rare species habitat and natural communities. And what is being built is becoming less and less sustainable, in terms of larger average house and lot sizes supporting fewer people. The findings are sobering and should be a call to action for citizens and public officials to work together to protect the nature of Massachusetts.

- Massachusetts continued to lose 40 acres per day to "visible" development between 1985 and 1999, as interpreted from aerial photography. Nearly nine out of ten acres lost were used for residential development; 65 percent of this land was used for low-density, large-lot construction. Twenty-four percent of the state's land area was developed as of 1999, compared to 17 percent in 1971.
- When the "hidden" impact of development is taken into account, including most roads and portions of building lots that appear undeveloped in aerial photography, the full level of human impact was closer to 78 acres per day.
- A review of more recent development between 2000 and 2002 shows that new residential and commercial construction continues to consume forest and agricultural land. We estimate that an additional 40,000 acres were impacted by both visible and hidden development during that period.
- Average residential building lot sizes have increased 47 percent statewide since 1970, and have more than doubled in some counties, suggesting that when an economic recovery occurs we may see even higher levels of land consumption.
- Forest loss to development, and therefore habitat loss, was particularly pronounced on Cape Cod and in southeastern Massachusetts. Loss of agricultural land to development was distributed through the I-495 corridor and Connecticut River valley.
- Just under one million acres of wildlife habitat were permanently protected as of May 2003, or 19 percent of the state's land area. Seventy-one percent of wildlife habitat statewide lacks permanent protection and is at risk of development.
- While progress has been made in land protection statewide, many rare species habitat areas, and riparian areas surrounding aquatic species habitat, have little or no permanent protection. Fragmentation threatens most rare species habitat areas. Only 39 percent of terrestrial rare species habitat and 23 percent of riparian areas near aquatic rare species habitat is permanently protected. Two-thirds of what is permanently protected supports multiple uses, including water supply, forestry, and recreation, which may be in conflict with habitat conservation goals.
- Much of the remaining forest in the state is highly fragmented, but certain areas offer opportunities for protecting the large roadless forest blocks needed for natural system functions and for broad biodiversity conservation.
- Undeveloped and recreational land in Massachusetts generates more than $6 billion annually in nonmarket ecosystem services—85 percent of this value is provided by forests, wetlands, lakes, and rivers left largely in their natural state. Loss of these "free" services would result in an increased burden on taxpayers due to the need for additional water treatment, climate regulation, and flood control, as well as reduced property values and tourism revenues.
- Over $200 million in annual ecosystem service value was lost between 1985 and 1999 due to loss of forest and agricultural land to development.

At the current rate of development, Massachusetts faces a closing window of opportunity to protect critical habitat areas and address sprawling development before it is too late. We recommend that state and local officials take immediate action on the following fronts.

- **Open Space Protection:** We call for the state government to restore past land acquisition spending levels through allocation of funds from the Environmental Bond of 2002 as a step toward meeting the goals of the Statewide Land Conservation Plan. The plan has identified one million acres as priorities for protection. We recommend further prioritization to focus short-term efforts on protecting critical habitat areas and natural communities from further development.
- **Land Use and Development:** We call for meaningful zoning and subdivision regulatory reform that removes loopholes that bypass local review of development. We encourage municipalities to adopt cluster and conservation subdivision bylaws to simultaneously achieve goals of increased open space protection and affordable housing.
- **Biodiversity:** The state should demonstrate its commitment to endangered species protection and recovery by adding permanent matching funds to the voluntary contributions currently supporting the Natural Heritage and Endangered Species Program. We recommend improved protection of rare species habitat both through land acquisition and identification of areas where recreational and water supply uses may be in conflict with conservation.
- **Additional Monitoring and Research:** Much of this report is based on digitized land use data funded by state agencies. However, much more frequent and complete updates of both land use and open space data are needed to adequately track progress in land conservation. We also recommend additional ecosystem services research in Massachusetts to encourage a better economic understanding of the "free" services being provided by natural ecosystems.

CHAPTER 1: INTRODUCTION

Why Land Use Matters in Massachusetts

Mass Audubon has chosen to make changes in land use the focal point of its current assessment of the environmental health of the Commonwealth. Understanding trends in development is particularly important in Massachusetts, which possesses a number of natural communities and rare species of regional and global significance. Examples include the following.

- Southeastern Massachusetts and Cape Cod support several globally rare pine barrens and coastal plain pond communities. This region also includes some of the Northeast's largest remaining coastal forests.
- Southeastern Massachusetts is the location of the largest wetland system in southern New England, Hockomock Swamp.
- Martha's Vineyard, Nantucket, and other Massachusetts islands support globally rare coastal sandplain ecosystems, including rare coastal grassland, heathland, pitch pine/scrub oak barrens, and oak savannahs, which in turn support a number of rare and endangered species.
- The North Shore is the site of the Great Marsh, the largest contiguous salt marsh in New England.
- Southwestern Massachusetts includes the Berkshire/Taconic region. Here large tracts of forest support great biodiversity, including 120 rare or endangered species.

Land use also directly impacts environmental health and quality of life in a number of ways.

- Land use that results in loss of habitat is the number one determinant of loss of biodiversity, more so than climate change, release of nitrogen, biotic change (such as introduction of invasive species), and atmospheric change.[1]
- Poorly planned land use that results in fragmentation both threatens species and makes other land uses, such as forestry and agriculture, less economically viable.
- When compared to compact development near city centers, sprawling "greenfield" development results in higher vehicle miles and public infrastructure costs, as well as increased auto emissions.[2]
- Land use that is inefficient and sprawling relative to the population it supports, often influenced by local zoning and permitting, can exacerbate the affordable housing shortage in Massachusetts, a major quality-of-life concern for citizens of the state.

What we lose to development each year not only diminishes the natural richness and quality of life that Massachusetts citizens enjoy but also has impact on a broader regional, national, and international scale. We are truly stewards of an irreplaceable natural landscape.

Goals of This Report

This is the third edition of the Massachusetts Audubon Society's landmark *Losing Ground* report, first published in 1987.[3] As part of its mission of protecting the nature of Massachusetts, Mass Audubon has published this series to educate policymakers and the public about the impact of continued development in the Commonwealth and to advocate for changes in land protection policy and land use planning. Sixteen years ago, the first edition of *Losing Ground* observed "with unprecedented economic growth has come unprecedented pressure on the open spaces of the Commonwealth—its farmlands, forests, wetlands, water supplies, and habitat." These pressures remain today. Our objective in 2003 is to see if we are gaining, or losing, ground in protecting open space in Massachusetts through an examination of land use, housing, protection of wildlife habitat and biodiversity, and the economic value of nature-based services such as water filtration and climate control.

CHAPTER 2
Changes in Statewide Land Use

The Massachusetts landscape ranges from pitch pine and scrub oak habitat in the southeast to fertile lowlands of the Connecticut River valley to the ridgetops of the Berkshire Highlands. Shaped by glaciers during the last ice age, this diverse landscape has historically supported a broad range of species requiring wetlands, grasslands, beaches, saltwater estuaries, and interior forest. Protecting the nature of Massachusetts requires an understanding of changes in the underlying landscape and its use.

Past development has been particularly damaging to wildlife habitat. Much of the pitch pine/scrub oak barrens present in the Connecticut River valley have been permanently lost. At least 15,000 acres of Atlantic White Cedar swamp have been destroyed due to logging, draining, and clearing through 1970. Large areas of coastal heathlands have disappeared and been replaced with housing and commercial development.[4] This chapter will focus on recent land use trends in the state, the impact of those changes on Massachusetts wildlife, and the need to move quickly to protect the remaining portions of our unique natural landscape.

Land Lost to Development in Massachusetts through 1999

Visible Impact of Development

Our examination of visible land use changes between 1971, 1985, and 1999 utilizes digitized land use data from MassGIS, an agency of the Executive Office of Environmental Affairs. The data is based on interpretation of statewide aerial photography by the Resource Mapping Project at the University of Massachusetts, Amherst.[5] Photographic images were converted to a series of land use blocks with a minimum mapping unit of one acre, using a 21-category land use classification system created by William MacConnell.

The digitized land use data allows us to compare different snapshots of land use, each 14 years apart, and measure visible changes. Land was considered developed if it was used for residential, commercial, or industrial purposes; transportation, mining, or waste disposal; participation recreation such as golf courses; or playing fields or spectator recreation such as stadiums. Detailed definitions of each land use category and changes by category can be found in the technical notes.

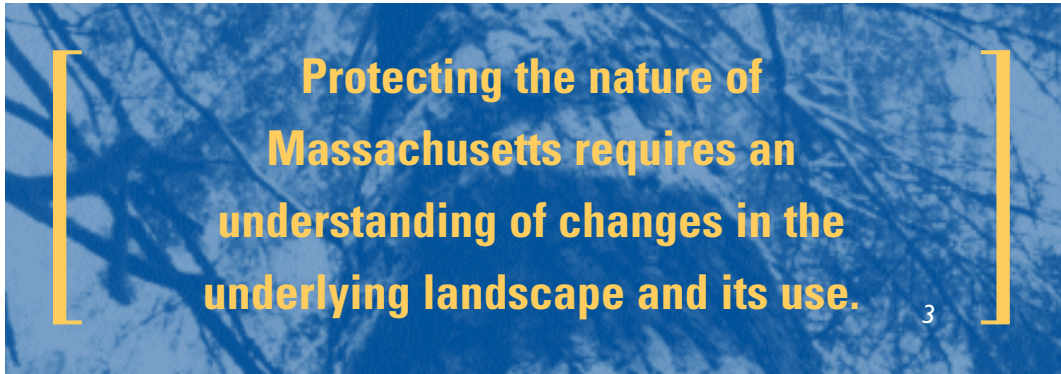
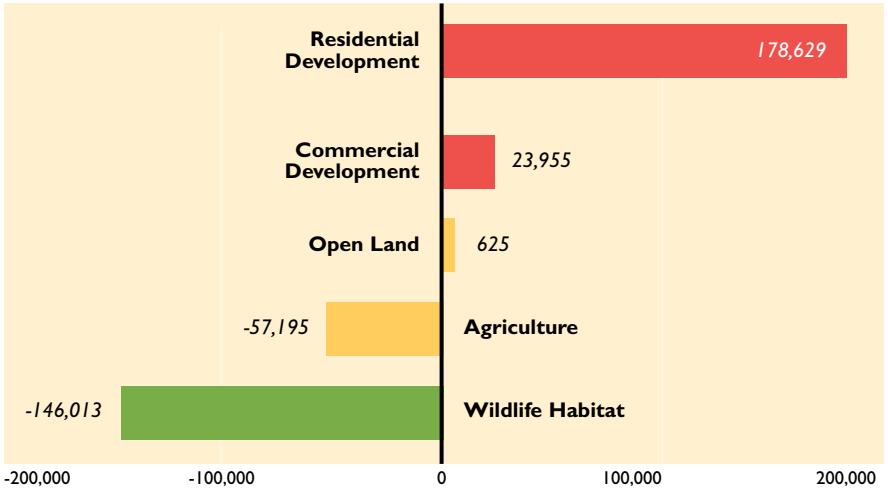


Figure 1

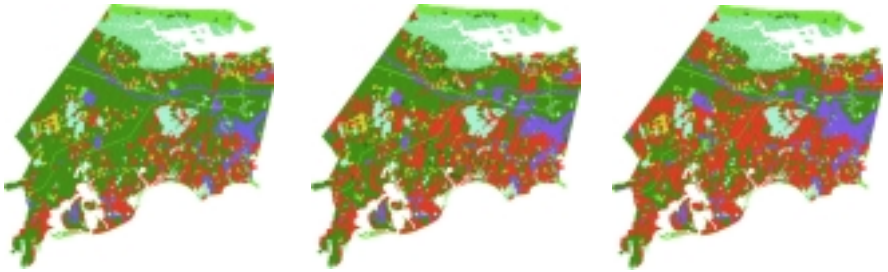
Change in Land Use, 1985-1999 *(in acres)*



Source: MassGIS land use data

Figure 2

The Changing Face of Barnstable, 1971, 1985, and 1999



Source: MassGIS land use data

- Residential development
- Commercial development
- Agriculture
- Open land and beaches
- Forest
- Water and saltwater wetlands

Our findings include the following.

- Between 1985 and 1999, 202,583 acres, or 40 acres of land per day, were visibly converted to development in Massachusetts. This was an increase from the conversion rate of 33 acres per day seen between 1971 and 1985. The area lost to development during this period is equivalent to the size of the 30 cities and towns on or within Routes 128 and 95, north to Lynn and south to Quincy.
- Of the 40 acres per day lost to development, 31 acres were wildlife habitat, 7 acres were agricultural land, and 2 acres were open land. Because of regulatory protection of wetlands in Massachusetts, virtually all of the habitat lost in the period was forest.
- Eighty-eight percent of land lost to development, or 35 acres per day, went to new residential construction. Of this, 65 percent went to low-density development on lots of a half-acre or more.
- As of 1999, over 24 percent of the land area in the state was used for commercial, industrial, or residential development, while 7 percent continued to be used for agriculture and 5 percent remained as open land. Sixty-four percent remained as wildlife habitat in the form of forest, wetlands, and open water. In contrast, only 17 percent of the state's land area was developed in 1971.

When all causes of land use change are factored in, including development as well as conversion of former agricultural land into open land and open land into forest, we get a complete picture of land use changes in Massachusetts. **Figure 1** shows overall visible changes in acreage by land use group between 1985 and 1999.

Forest and Agricultural Land Loss Hot Spots

During the 1985 to 1999 period, 157,037 acres of wildlife habitat were lost statewide to all forms of development. Virtually all that was lost was forest cover. Forest declined from 60 percent of all land in Massachusetts in 1985 to 57 percent in 1999.

The impact of land use changes was fairly concentrated, with the greatest changes occurring in eastern Massachusetts. Because of its impact on overall land consumption, we looked at residential development and the resulting "hot spots" of deforestation around the state.

Barnstable had the greatest loss of forest to residential development, and shows the pattern of development typical of many of these forest loss hot spots. As seen in **Figure 2**, forest land is fragmented by roadside commercial

development and residential development near coastal areas. Eventually, these fragmented areas become filled in with additional roads and development.

Figure 3 shows a ranking of the 20 municipalities with the greatest conversion of forest land to residential development. Losses are most pronounced not only on Mid- and Upper Cape Cod and in southeastern Massachusetts, but also into the I-495 region, western Worcester county, and Hampshire county. Twenty-three percent of all forest land loss to residential development during the period occurred in these 20 cities and towns.

Loss of forest cover has negative effects on wildlife in general. Virtually all of the top 20 cities and towns consist of some amount of terrestrial and rare species habitat (to be covered in Chapter 5), and other important natural communities such as vernal pools. Additionally, the high level of forest loss and development in southeastern Massachusetts and Cape Cod puts pressure on some of the most vulnerable natural communities in the state. This region includes rare natural communities that support Endangered and Threatened plant and animal species, including coastal natural communities such as barrier beaches and coastal salt ponds, maritime sandplain communities such as sandplain grasslands and heathlands, coastal plain ponds, pitch pine/scrub oak barrens, and riverine natural communities.[6] Five of the municipalities with the highest levels of forest loss, West Tisbury, Brewster, Plymouth, Sandwich, and Barnstable, are in the top 25 for rare species density, defined as number of recorded rare species incidences, confirmed in the last 25 years, per square mile. Falmouth and Mashpee are in the top 50.[7] The natural communities threatened by deforestation and development are indicated in the detail table accompanying Figure 3.

A total of 33,577 acres of agricultural land were converted to all forms of development during the 1985 to 1999 period. Because cropland in particular has already been cleared and leveled, it is a prime target for commercial and residential development. Agricultural lands were also converted to recreational use and open land, for an even greater net decline of 57,195 acres.

Figure 4 shows a ranking of the top 20 municipalities with the greatest conversions of agricultural land to residential development. Hot spots here were more broadly distributed, and include portions of northern Middlesex, Bristol, and Hampden counties. These 20 cities and towns represent 24 percent of all agricultural land lost to residential development during the period. Again, agricultural land loss and development put pressure on some of our most sensitive natural communities. Communities falling into the top 20 list for both forest and agricultural land loss include: Franklin, Taunton, Westford, Charlton, Belchertown, Dartmouth, Groton, and Bridgewater.

Hot Spots of Forest Loss to Residential Development *1985-1999*

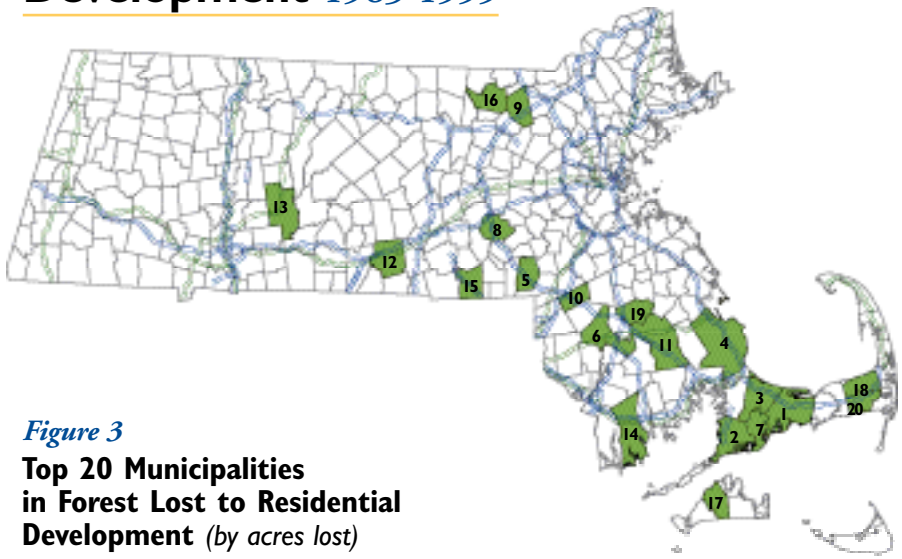


Figure 3

Top 20 Municipalities in Forest Lost to Residential Development *(by acres lost)*

Rank	Municipality	Forest Land Converted (Acres)	Municipal Acres	Converted as % of Municipal Land	Critical Natural Communities Present
1	Barnstable	3,131	40,086	7.8%	CSP, CPP, CNC
2	Falmouth	2,329	29,395	7.9%	CNC
3	Sandwich	2,233	28,168	7.9%	CNC
4	Plymouth	2,106	65,733	3.2%	PB, CNC, CSP, CPP
5	**Franklin**	1,711	17,288	9.9%	
6	**Taunton**	1,668	30,649	5.4%	PEAT, RIV
7	Mashpee	1,577	16,509	9.6%	CPP, PEAT, CNC
8	Hopkinton	1,545	18,024	8.6%	
9	**Westford**	1,526	20,050	7.6%	
10	Mansfield	1,314	13,263	9.9%	RIV
11	Middleborough	1,293	46,271	2.8%	PEAT, CPP
12	**Charlton**	1,232	28,014	4.4%	
13	**Belchertown**	1,232	35,430	3.5%	
14	**Dartmouth**	1,230	39,866	3.1%	PEAT, CSP, RIV
15	Uxbridge	1,178	19,437	6.1%	
16	**Groton**	1,171	21,576	5.4%	
17	West Tisbury	1,132	16,880	6.7%	CSP, CNC
18	Brewster	1,125	16,275	6.9%	CPP, CNC
19	**Bridgewater**	1,112	18,068	6.2%	PEAT, RIV
20	Harwich	1,103	14,450	7.6%	CPP, CNC

City and town names in **bold** are also in the top 20 for agricultural land lost to residential development. CSP=Coastal Sandplain, CPP=Coastal Plain Pond, CNC=Coastal Natural Community, PB=Pine Barrens, PEAT=Peatlands, RIV=Riverine Community.

Source: MassGIS land use data

Hot Spots of Agricultural Land Loss to Residential Development *1985-1999*

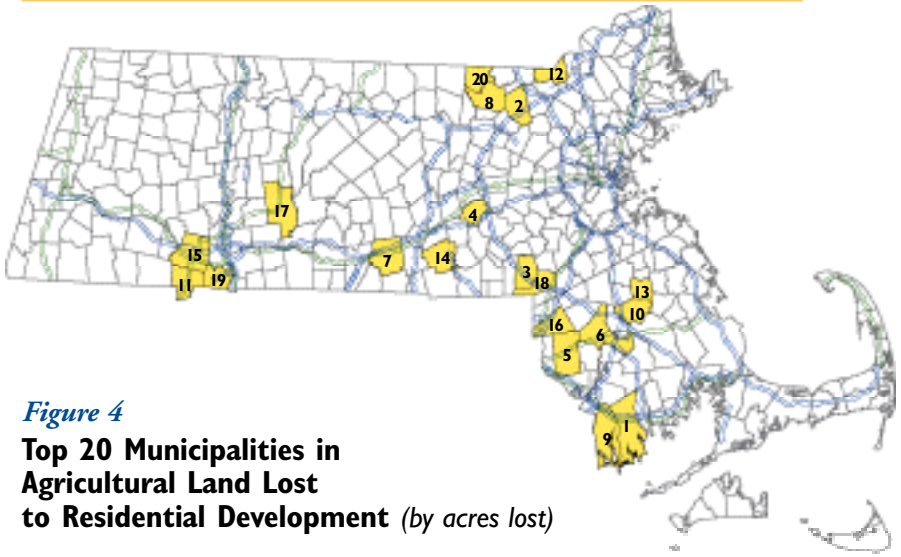


Figure 4

Top 20 Municipalities in Agricultural Land Lost to Residential Development *(by acres lost)*

Rank	Municipality	Agricultural Land Converted (Acres)	Municipal Acres	Converted as % of Municipal Land	Critical Natural Communities Present
1	**Dartmouth**	513	39,866	1.3%	PEAT, CSP, RIV
2	**Westford**	478	20,050	2.4%	
3	**Franklin**	445	17,288	2.6%	
4	Westborough	443	13,842	3.2%	
5	Rehoboth	443	29,934	1.5%	PEAT, RIV
6	**Taunton**	418	30,649	1.4%	PEAT, RIV
7	**Charlton**	377	28,014	1.3%	
8	**Groton**	344	21,576	1.6%	
9	Westport	337	32,941	1.0%	CNC
10	**Bridgewater**	337	18,068	1.9%	PEAT, RIV
11	Southwick	333	20,288	1.6%	
12	Dracut	325	13,671	2.4%	
13	East Bridgewater	306	11,203	2.7%	CPP, RIV
14	Sutton	302	21,715	1.4%	
15	Westfield	301	30,280	1.0%	
16	Attleboro	298	18,099	1.6%	PEAT, RIV
17	**Belchertown**	295	35,430	0.8%	
18	Wrentham	292	14,669	2.0%	RIV
19	Agawam	284	15,506	1.8%	
20	Pepperell	281	14,831	1.9%	

City and town names in **bold** are also in the top 20 for forest land lost to residential development. CSP=Coastal Sandplain, CPP=Coastal Plain Pond, CNC=Coastal Natural Community, PB=Pine Barrens, PEAT=Peatlands, RIV=Riverine Community.

Source: MassGIS land use data

"Hidden" Impacts of Development

The statewide land use data we have used so far has certain limitations. Aerial photography cannot distinguish between intact forest and trees in the rear portion of a developed lot. It also cannot account for subdivision and changes in land ownership, which can lead to additional fragmentation of forest and open land. The interpretation and classification system used also accounts only for transportation corridors near multilane highways, and does not include other roads in the developed land category.

Development often has effects beyond the visible footprint of an office park, housing subdivision, or strip mall. Paved surfaces produce runoff that may be contaminated with road salt, oil, and other pollutants. Use of fertilizer on lawns and the resulting runoff adds excess nutrients to ponds and rivers. Domestic pets can harass or kill wildlife. Roads divide forests and introduce edge effects such as the proliferation of invasive species and increased predation. **Figure 5** shows the differences between land use measured by aerial photography and by parcel boundaries. Current land use data classifies as undeveloped forest many areas of a parcel impacted by development and road building.

To better understand the differences between visible development and the total size of recently developed lots, we reviewed a statewide tax assessor's parcel database developed by The Warren Group. Assessor records during the period showed new single-family, residential construction between 1985 and 1999 (excluding condominiums) on lots representing almost 323,000 acres statewide, or new construction on lots representing 63 acres per day. This is 80 percent greater than visible residential development of 35 acres per day. All residential construction, including multifamily housing, during the period affected almost 365,000 acres, or 71 acres per day. All commercial and industrial development impacted 36,800 acres, or 7 acres per day. Therefore, land use changes due to development, from a land ownership and total parcel perspective, impacted 78 acres per day between 1985 and 1999, almost double the visible impact.

Recent Changes in Land Use 2000-2002

Since the most recent GIS land use data is from 1999, we needed to look at other sources to determine whether the rate of land lost to development was increasing or decreasing through 2002. We again reviewed parcel level data from The Warren Group for the years 2000 and 2002. All lot-size data was converted to acres.

Reporting by cities and towns tends to lag actual construction and sale of new buildings. Despite this, we found that, based on *reported* construction of taxable properties, during 2000 through 2002 an additional 36,039 acres were impacted by residential development, and 4,341 acres were impacted by commercial development.

Because not all municipalities had fully reported new construction for 2002, we adjusted the data by multiplying average reported land use per housing unit by housing permit data provided by the US Census Bureau. Based on housing permits during the period, we estimate that the total land area impacted by all forms of residential development, including visible and "hidden" development impact, was 64,000 acres, or 59 parcel acres per day. We estimate that an additional 4,341 parcel acres were impacted by new commercial development, or 4 acres per day. Total parcel acreage impacted by development is therefore estimated as over 68,000 acres, or 63 acres per day, versus 78 acres per day in the 1985 through 1999 period.

Figure 5

Two Views of Land Use in Mendon

Source: MassGIS land use data, aerial photography: town of Mendon parcel boundaries

Residential development
Agricultural land
Forest

The picture to the left shows parcel boundaries overlaid on an aerial photograph of residential development. The picture to the right shows how the aerial photograph is interpreted, and what "hidden" areas are missed. (1) Subdivision: interior lots completely included in "developed" acreage, but parts of back lots on outer parcels missing; (2) Cul-de-sac subdivision: up to half of lot missing from "developed" category; (3) Large parcel: house and lawn included in "developed," but road cutting through forest parcel not shown.

CHAPTER 3
Housing as a Driver of Land Use

As noted in the previous section, loss of land in Massachusetts to development, particularly loss of wildlife habitat, is driven primarily by residential development. As we also saw in the previous section, almost half of the land going to residential development went to low-density, single-family housing with lot sizes of one-half acre or more. Since housing is such an important factor in land use, we need to look at what is driving the overall level of housing construction as well as the characteristics of new construction in the Commonwealth.

Housing and Demographics

The population of Massachusetts grew from 6,022,639 to an estimated 6,427,801 between 1990 and 2002 according to the US Census Bureau, an increase of 6.7 percent. Total housing units grew from 2.47 million to 2.66 million during the same period, or 7.4 percent.

We fit those people and housing units in a relatively small land area: Massachusetts ranks third nationwide in population density at 810 people per square mile, behind New Jersey and Rhode Island, according to the 2000 US Census. Our housing density, at 334 units per square mile, is also the third highest in the US.

The number of households statewide (a household represents all the people who live in a given housing unit) increased at a faster rate, 9.2 percent, than population or housing, between 1990 and 2001. Smaller families, higher divorce rates, and younger people brought into home ownership by low interest rates all are driving the average household size down. Massachusetts saw a 20 percent decline in average household size between 1970 and 2000, from 3.12 people per household to 2.51.

Why does household size matter? Even if house and lot sizes are fixed, a smaller number of people per household drives up per-capita resource consumption. In developing countries, declining household size, and resulting demand for land, fuel, and construction materials, is seen as a greater threat to biodiversity than population growth.[8] In Massachusetts, it demonstrates an additional source of pressure on land resources beyond simple population growth.

Changes in Housing Characteristics: Why Bigger is Not Better

While household sizes are shrinking in Massachusetts, homes are getting bigger and, on average, are being built on larger and larger lots—meaning more and more resources are being consumed per person. The affordability of housing in the Commonwealth has received much media coverage, and is a major concern of the average citizen.[9] Certainly, market forces are at work in driving at least some of the growth in house size. As demand for housing increases, so does the demand for land; and, as land prices increase, there is

pressure on developers to build larger homes in order to generate the same return on investment. Personal taste also is part of the equation because people increasingly want home offices and larger family areas in their homes. Statewide, the average living space for newly constructed single-family homes increased 44 percent between 1970 and 2001 from 1,572 to 2,260 square feet (living area was not available for Nantucket).

One would also expect developers to respond to increasing land prices by increasing housing density—building more units per acre of land. But the opposite has happened. From 1970 through 2002, average lot sizes statewide increased 47 percent. There were wide differences in lot-size growth across counties. While more built-out counties such as Suffolk, Norfolk, Middlesex, Worcester, and Nantucket exhibited relatively little change, Plymouth and Bristol counties in the southeast, Essex in the northeast, and Franklin and Hampshire counties in the west more than doubled, with average lot sizes far in excess of any minimum lot-size requirements.

Drivers of Sprawl: Transportation, Economics, and Zoning

Clearly, something is amiss if average lot sizes are increasing at a time when the market is demanding more affordable housing. Land prices, along with transportation improvements, are driving more and more development into suburban and exurban areas. And often, state and local zoning laws limit the ability to build denser housing in these regions, resulting in sprawl and rapid growth in per-capita land consumption.

Development Hot Spots 2000-2002

Land availability and price play an important role in determining where development occurs. As urban areas and surrounding suburbs are built out, development continues to radiate out in larger and larger circles.

Figure 6 shows hot spots of new housing activity—the 20 communities with the highest number of single-family housing permits, and the 20 with the highest level of multifamily units permitted. Multifamily housing activity tends to be clustered in the inner suburbs and Boston and in some areas with recent extensions to commuter rail lines. New single-family activity is highest in Plymouth, Bristol, Barnstable, and Worcester counties.

Why are we seeing development pressure in these particular communities? The answer lies in a combination of land availability, zoning and permitting, and transportation investments.

Hot Spots of New Housing Construction

2000-2002

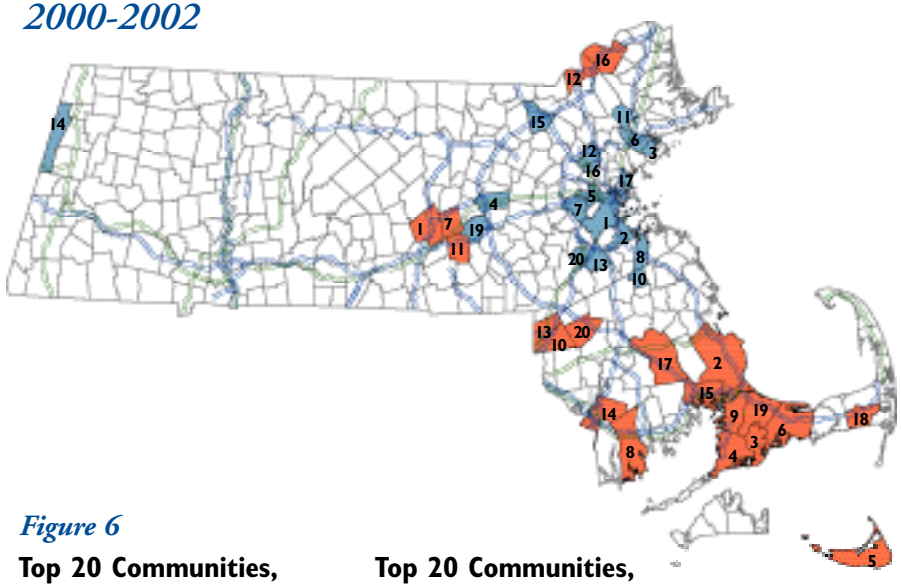


Figure 6

Top 20 Communities, Single-Family Housing Unit Permits, 2000-2002

Rank	Municipality	Single-Family Unit Permits
1	Worcester	957
2	Plymouth	840
3	Mashpee	765
4	Falmouth	688
5	Nantucket	601
6	Barnstable	530
7	Shrewsbury	450
8	Dartmouth	426
9	Bourne	417
10	Attleboro	382
11	Grafton	357
12	Methuen	345
13	North Attleborough	343
14	Fall River	331
15	Wareham	327
16	Haverhill+	326
17	Middleborough	323
18	Harwich	321
19	Sandwich	304
20	Norton	294

Top 20 Communities, Multifamily Housing Unit Permits, 2000-2002

Rank	Municipality	Multi Family Unit Permits
1	Boston	1,977
2	Quincy	673
3	Salem	618
4	Marlborough	572
5	Cambridge	488
6	Peabody	487
7	Newton	469
8	Weymouth	340
9	Haverhill+	266
10	Abington	228
11	Middleton	228
12	Woburn	209
13	Canton	198
14	Hancock	197
15	Chelmsford	184
16	Winchester	170
17	Revere	164
18	Watertown	159
19	Westborough*	156
20	Norwood	147

Hot spots of new single-family housing construction (shown in red) and multi-family housing construction (shown in blue) based on building permits.

+Haverhill was a hot spot for both single-family and multifamily housing permits (shown in red only).

**2000 data missing, 2001 data used. Source: US Census Bureau*

Development Hot Spots and Commuter Rail *2000-2002*

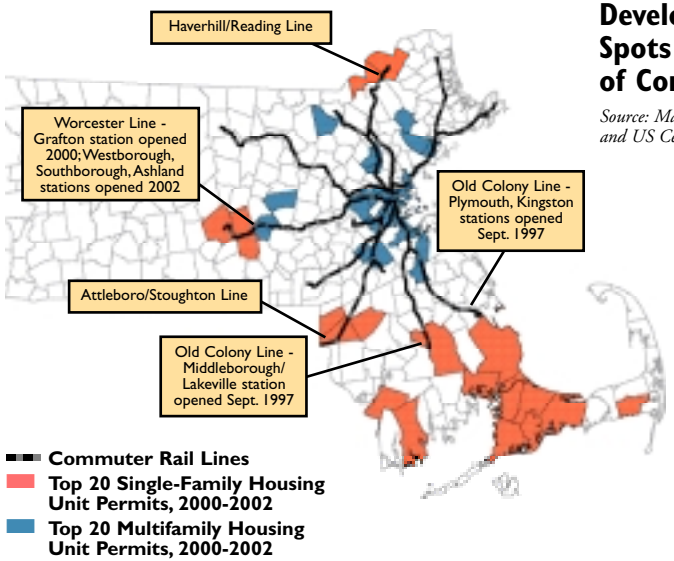


Figure 7

Development Hot Spots and Expansion of Commuter Rail

Source: MassGIS MBTA Rail data and US Census Bureau

Buildout and Sprawl Frontier *2000-2002*

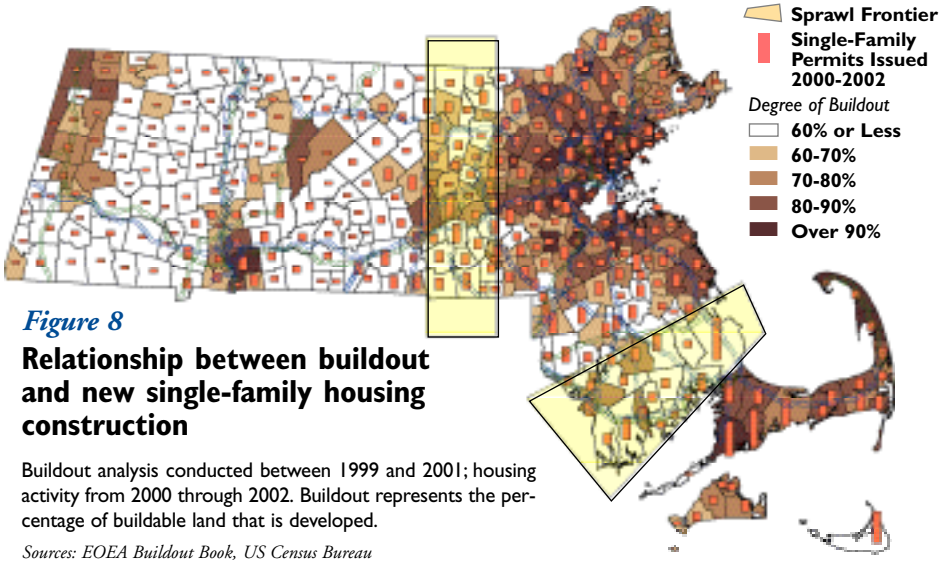


Figure 8

Relationship between buildout and new single-family housing construction

Buildout analysis conducted between 1999 and 2001; housing activity from 2000 through 2002. Buildout represents the percentage of buildable land that is developed.

Sources: EOEA Buildout Book, US Census Bureau

Transportation

The growth of cities and towns in the Interstate 495 corridor has been well publicized, and over half of the top 20 municipalities in single-family housing growth lie within the I-495 or I-190 corridors. **Figure 7** also shows vividly the relationship between new Massachusetts Bay Transportation Authority (MBTA) commuter rail stations and housing growth. Ten of the top 20 cities and towns in new single-family housing growth lie at the terminus of commuter rail lines.

While it is difficult to determine cause and effect here, it is clear that an opportunity was lost to combine regional transportation and development planning. For example, Plymouth approved a mix of housing between 2000 and 2002, including 564 new single-family houses with average lot sizes of 1.27 acres, along with over 100 units of multifamily housing. In contrast, during the same period Middleborough permitted 100 single-family homes with an average lot size of over 2 acres, and only six units of multifamily housing.

Buildout and Land Availability

To understand where the current development pressures are, we looked at single-family housing activity, measured by building permits issued between 2000 and 2002, by municipality. Housing permit data for the period was taken from the US Census. We also looked at the capacity of each city or town to take on more housing, or the degree to which it was "built out" as of 2001. Buildout data was provided for each municipality by the EOEA in 2001 as part of the Community Preservation Initiative, and estimates both current development as well as "buildable" land that may be developed as of right based on current zoning.[10] Buildable land excludes land with constraints to development such as wetlands, conservation lands, and water-supply areas.

Figure 8 shows the relationship between level of buildout by municipality and the number of new single-family residential housing permits issued in the 2000-2002 period. While construction levels remained high on Cape Cod despite high levels of buildout (suggesting ongoing infill and teardown development), high levels of development took place in areas of relatively low buildout west of I-495 and in a band of communities in the lower part of southeastern Massachusetts. This combination of high rates of construction with relatively unbuilt land sets up a "sprawl frontier" pushing its way west and southeast across the state.

Zoning

As we have seen, land economics and state and federal infrastructure investments have their influence on where development in Massachusetts takes place. A third major factor—zoning—also alters the nature of development and is largely in the control of local governments. Zoning and land use affect the types of housing and land consumption that take place at the municipal level. Zoning bylaws and lot-size requirements vary widely across the state, reflecting the varying character and goals of different communities. As of 2000, 96 municipalities had at least some land zoned with two-acre minimum lot-size requirements.

While many rural communities in western Massachusetts require larger minimum lot sizes, land availability in the eastern part of the state has pushed development into our sprawl frontier, which includes many municipalities with large minimum lot-size requirements. Many of these municipalities permit low-density housing exclusively. Several cities and towns with high levels of single-family housing construction between 2000 and 2002, including Dartmouth, Middleborough, Wareham, and Mashpee, had high levels of construction *and* large two-acre zoning districts. Townsend, Pepperell, and Groton had high levels of construction and relied almost exclusively on two-acre zoning.

Where is Sprawl Occurring?

Land supply and demand, public infrastructure, and zoning all play a role in directing growth and determining which municipalities experience high levels of development. Development is needed for the economic vitality of the state and to support a growing population. But not all development is appropriate or well executed.

Figures 9 and 10 show the top 20 communities for each measure of our "sprawl index." In creating the index we compared land consumption between 1991 and 1999 to 80% of the housing or population growth between 1990 and 2000. These cities and towns generally do not have the highest levels of housing construction but are leading indicators of areas of high per-capita land consumption. Our analysis shows "sprawl" clustering in several distinct groups.

- As predicted, high rates of land consumption per new housing unit fell along the "sprawl frontier" running north-south from Pepperell to Uxbridge, with the highest rates of land consumption per housing unit being in the eastern half of Worcester County. Uxbridge,

Sprawl Hot Spots—Acres Per New Housing Unit *1991-1999*

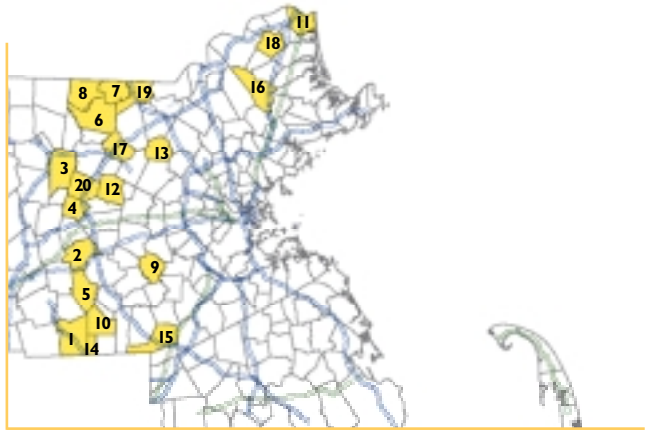


Figure 9

Top 20 Communities Ranked by Acres Consumed Per New Housing Unit

Rank	Municipality	Acres Consumed For Res. Dev. 1991-1999	New Housing Units 1990-2000	Acres Per New Unit	Critical Natural Communities Present
1	Uxbridge	736	127	7.74	
2	Westborough	695	145	6.00	
3	Lancaster	200	46	5.43	
4	Berlin	156	64	3.05	
5	Upton	437	189	2.89	
6	Groton	985	619	1.99	
7	Dunstable	316	207	1.91	
8	Pepperell	627	412	1.90	
9	Sherborn	111	77	1.80	
10	Mendon	612	432	1.77	
11	Salisbury	149	116	1.61	CNC, CSP, RIV
12	Stow	345	275	1.57	
13	Carlisle	192	160	1.50	
14	Millville	147	126	1.46	
15	Wrentham	615	532	1.45	
16	Boxford	588	523	1.41	CSP, PEAT, RIV
17	Littleton	404	364	1.39	
18	West Newbury	295	276	1.34	CSP, RIV
19	Tyngsborough	824	773	1.33	
20	Bolton	399	379	1.32	

CSP=Coastal Sandplain, CNC=Coastal Natural Community, PEAT=Peatlands, RIV=Riverine Community.

Source: MassGIS land use data and US Census Bureau

Sprawl Hot Spots — Acres Per New Permanent Resident *1991-1999*

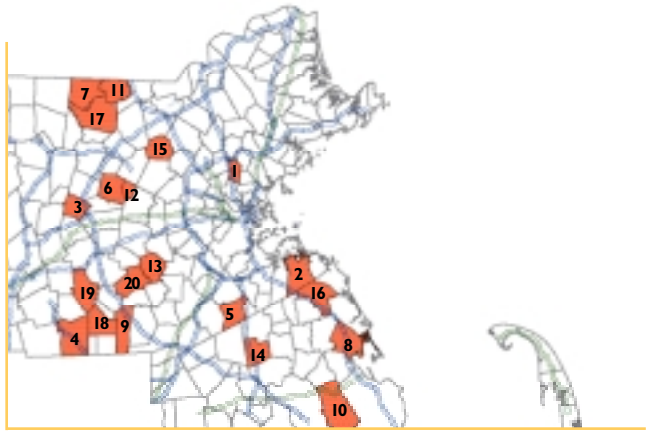


Figure 10

Top 20 Communities Ranked by Land Consumed Per New Permanent Resident

Rank	Municipality	Acres Consumed For Res. Dev. 1991-1999	Population Change 1990-2000	Acres Per New Resident	Critical Natural Communities Present
1	Stoneham	58	16	4.56	
2	Hingham	172	61	3.53	
3	Berlin	156	87	2.25	
4	Uxbridge	736	741	1.24	
5	Stoughton	362	372	1.22	
6	Stow	345	574	0.75	
7	Pepperell	627	1,044	0.75	
8	Duxbury	201	353	0.71	CNC
9	Bellingham	241	437	0.69	
10	Carver	315	587	0.67	PB, CSP
11	Dunstable	316	593	0.67	
12	Maynard	57	108	0.66	
13	Sherborn	111	211	0.66	
14	West Bridgewater	127	245	0.65	
15	Carlisle	192	384	0.62	
16	Norwell	238	486	0.61	RIV
17	Groton	985	2,036	0.60	
18	Mendon	612	1,276	0.60	
19	Upton	437	965	0.57	
20	Holliston	366	875	0.52	

CSP=Coastal Sandplain, CNC=Coastal Natural Community, PB=Pine Barrens, RIV=Riverine Community.

Source: MassGIS land use data and US Census Bureau

Westborough, and Lancaster had the highest rates of land use per new housing unit during the period.

- High rates of land consumption per new permanent resident occurred on the northern and southern portions of the sprawl frontier, as well as on parts of the North Shore and South Shore. Stoneham, Hingham, and Berlin had the highest rates of land consumption per new permanent resident.
- Ten municipalities were in the top 20 for *both* land consumed per housing unit and per new resident: Pepperell, Dunstable, Groton, Carlisle, Stow, Berlin, Upton, Uxbridge, Mendon, and Sherborn.

We continue to lose ground to development in ways that are increasingly unsustainable and inefficient from a land use perspective. As development pushes farther west and southeast, it is increasingly in conflict with some of our most vulnerable natural communities and species. In the next chapter, we will explore whether our land conservation efforts are keeping pace with development.

CHAPTER 4

The State of Land Protection in Massachusetts

In previous sections, we examined changes taking place in land use in the state, and how development in particular is impacting wildlife areas such as forest. In this section, we will explore whether we are gaining ground in protecting wildlife habitat in the state, how this protected land is managed, and what risks remain for protected land, particularly land with only temporary protection.

Land Protection and Management

To understand the state of land protection in the Commonwealth, we reviewed the Protected Recreation and Open Space data available through MassGIS, which provides both a statistical view of protected acreage and a spatial view of where protected lands are located.

Data available from MassGIS shows that as of June 2003, over 1.5 million acres had been set aside for recreation and open space in the state. Of this, two-thirds, or just over 1 million acres, was permanently protected through fee ownership by a federal, state, or municipal agency or nonprofit conservation organization, or through a conservation restriction.

Land protection is only one factor in preserving habitat. How the land is managed is also important. As seen in **Figure 11**, 90 percent of permanently protected land in the state is managed for water supply, conservation, or combined conservation and recreation, and thus has substantial habitat value. Fifty-seven percent is managed for water supply or for dual conservation and recreation use, creating the potential for conflict between water drawdowns, timber harvesting and recreation, and habitat conservation. Twenty-three percent was protected primarily for conservation. Timber harvesting may also occur on state-owned Department of Fish and Game and Department of Conservation and Recreation lands. Some dual-use conservation/recreation lands such as state parks may have specific areas designated for conservation.

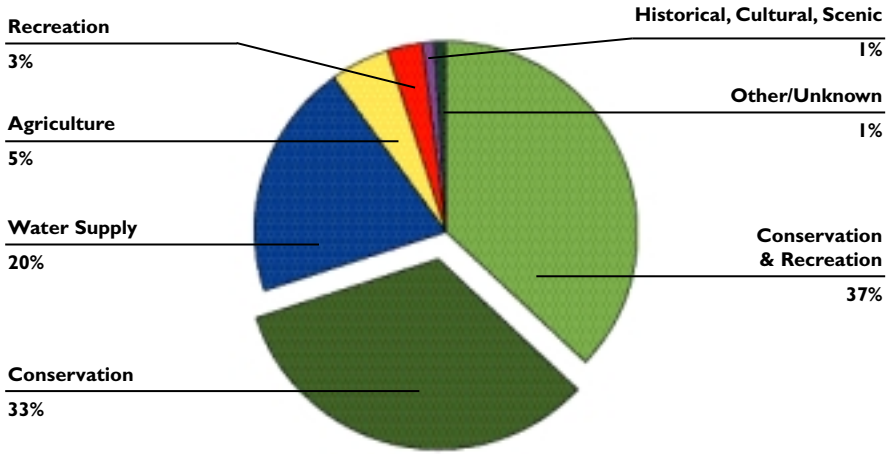
Conservation Land Ownership in Massachusetts

Over half of all permanently protected land is owned directly by the state and managed by agencies within the EOEA. Another one-quarter is owned by cities and towns.

The pattern of ownership changes when one considers only permanently protected land managed primarily for conservation. Land protected for conservation may also include lands with managed forestry. Here, nonprofits such as conservation organizations and land trusts, and private owners, play a greater role, directly owning about one-third of this permanently protected land.[11] Virtually all of the privately owned land listed here is covered by conservation restrictions. **Figure 12** summarizes ownership patterns by type of land management.

Figure 11

Primary Purpose of Permanently Protected Land, June 2003



Source: MassGIS protected recreation and open space data, June 2003

Figure 12

Ownership by Level of Protection and Type of Land Management, June 2003

	Owner						
	State	Country/ Town	Nonprofit Org.	Private Ownership	Federal	Other	Total
All Protected Recreational and Open Space (acres)	542,154	329,981	129,299	475,909	62,700	22,741	1,562,784
%	34.7%	21.1%	8.3%	30.5%	4.0%	1.5%	100.0%
Permanently Protected Land (acres)	531,943	251,418	97,696	95,974	59,164	12,462	1,048,656
%	50.7%	24.0%	9.3%	9.2%	5.6%	1.2%	100.0%
Permanently Protected Conservation or Conservation & Recreation Land (acres)	425,720	120,664	92,336	47,180	46,179	670	732,750
%	58.1%	16.5%	12.6%	6.4%	6.3%	0.1%	100.0%
Permanently Protected Conservation Land (acres)	119,643	98,571	76,165	42,517	12,761	383	350,040
%	34.2%	28.2%	21.8%	12.1%	3.6%	0.1%	100.0%

Source: MassGIS protected recreation and open space data

Is Wildlife Habitat Being Protected?

The data provided previously gives us an overall snapshot of the level of land protection in the Commonwealth in terms of raw acreage and management objectives. We also need to consider how successful these efforts have been in protecting wildlife habitat specifically, and how much habitat remains at risk.

To measure the amount of wildlife habitat permanently protected, we used a taxonomy similar to that in the second edition of *Losing Ground*, and compared 1999 land use and May 2003 protected recreational and open space data from MassGIS. MassGIS data was adjusted to reflect missing CR acreage and an estimate of missing nonprofit land ownership. Open water is generally not included in the MassGIS open space data. We do not attempt in this study to determine which open water bodies should be considered permanently protected based on the status of surrounding land. To be considered permanently protected, land needed to be owned directly by a conservation-oriented agency or nonprofit, or be covered by a perpetual conservation restriction. Because 1999 is the most recent year for which land use data is available, it will by definition underestimate the amount of land developed today and overestimate the amount of remaining habitat.

The results of this analysis show that while strides have been made in land protection, a large amount of wildlife habitat remains at risk.

- Of the undeveloped land in Massachusetts, 3.4 million acres represented extended wildlife habitat in 1999, including forest, wetlands, ponds, and streams, as well as open land and urban open land protected for water supply, conservation, or dual conservation and recreation use. Of this, 985,000 acres, or 29 percent, is permanently protected.
- In Massachusetts, 564,000 acres of land is agricultural or other open land. Of this, 55,000 acres, or just under 10 percent, is permanently protected by our definition. (In some cases an APR may be protecting forested acres we would otherwise consider as wildlife habitat.)
- Permanently protected wildlife habitat covered almost 19 percent of the state's land area; 46 percent of the state represents extended wildlife habitat—forests, wetlands, lakes, ponds, streams, sandplains, and heathlands—that lacks permanent protection and is at risk of development.

Are We Gaining or Losing Ground?

Because historical data on land protection is incomplete, it is difficult to track statewide changes in land protection by federal, state, municipal, and nonprofit organizations. Our snapshot of land protection in the second edition of *Losing Ground* showed that 17.3 percent of the land area in the state was permanently protected wildlife habitat in 1997, versus our estimate of 18.8 percent in 2003, a change of 78,000 acres over five years.

The EOEA has reported on its own direct land acquisitions, and areas where it has assisted in funding land purchases and conservation restrictions in partnership with other organizations. The agency's reporting indicates the following.

- One hundred thousand acres were protected statewide between 1991 and 1998 for all purposes, including recreation and water supply.
- An additional 100,000 acres were protected from October 1998 through July 2001 for all purposes. Eighty five percent of this land would end up in the *BioMap* Core Habitat and Supporting Natural Landscape areas later delineated by NHESP. This faster pace of protection reflects the increased use of conservation restrictions, public/private partnerships, as well as increased state funding for land acquisition. This includes 15,000 acres protected within the Massachusetts Military Reservation (MMR) in Bourne and Sandwich by state law and agreement with the federal government
- Over 50,000 acres were protected from August 2001 to January 2003 for all purposes.

This progress is encouraging. However, an additional one million acres have been identified for protection over the next 20 years through the Statewide Land Conservation Plan, a collaborative effort between EOEA and a number of conservation, recreation, and watershed groups in the state. Successful implementation of this plan will require a sustained level of protection averaging 50,000 acres per year to protect the best remaining priority lands from development. As we will see in the next chapter, there is a closing window of opportunity to protect these lands, particularly those supporting the rare species and natural communities critical to preserving biodiversity in our state.

CHAPTER 5

Land Use Threats to Biodiversity in Massachusetts

The previous chapter demonstrated that progress is being made in protecting potential wildlife habitat based on overall acreage. But are we being successful at protecting the lands most critical to preserving the broadest diversity of animal and plant communities in the state? Are we protecting our most vulnerable natural communities? In other words, are we investing limited land conservation resources wisely from a biodiversity perspective?

Level of Protection by EPA Ecoregion

One indication of our success or failure in protecting a variety of ecosystems and, by definition, biodiversity is to look at the level of protection within ecoregions. Ecoregions, defined by the US Environmental Protection Agency, identify areas with a similar type,

Loss of land in Massachusetts to development, particularly loss of wildlife habitat, is driven primarily by residential development.

quality, and quantity of environmental resources. We took the statewide analysis of permanently protected wildlife habitat and applied it to the ecoregions. This visual overview, seen in **Figure 13**, shows some ecoregions, particularly the Berkshire Highlands, Lower Berkshire Hills, and Worcester Plateau, having large protected areas, while the Vermont Piedmont, Connecticut River Valley, and Western New England Marble Valleys, Housatonic Valley, and Hoosic Valley have relatively little protection. To the extent that specific species are dependent on specific natural communities, having a good mix of protected ecoregions is important. Some of the highest rare species densities, based on records documented by the NHESP, can be found in the Marble, Housatonic, and Hoosic valleys, Connecticut River Valley, and Bristol Lowland ecoregions, which are among the least well protected.[12]

Level of Permanently Protected Wildlife Habitat by Ecoregion *May 2003*

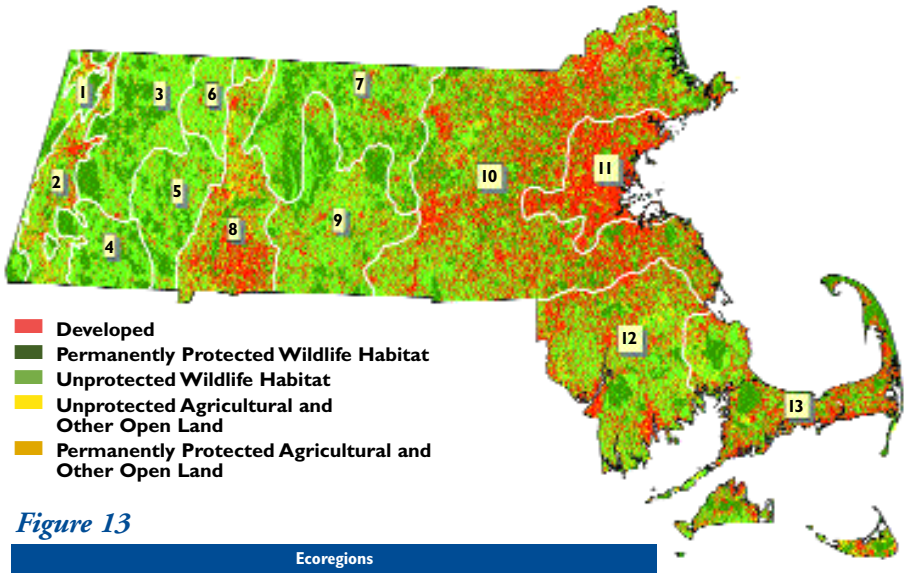


Figure 13

Ecoregions			
1	Taconic Mountains	8	Connecticut River Valley
2	W. New England Marble, Housatonic, Hoosic Valleys	9	Lower Worcester Plateau
3	Berkshire Highlands	10	S. New England Coastal Plains and Hills
4	Lower Berkshire Hills	11	Boston Basin
5	Berkshire Transition	12	Bristol Lowland
6	Vermont Piedmont	13	Cape Cod and Islands
7	Worcester Plateau		

Source: MassGIS land use and protected recreational and open space data, May 2003

Identifying Critical Habitat Areas

We also wanted to measure our success in protecting those lands in Massachusetts known to support the richest biodiversity. (Other areas remain to be inventoried.) We chose three sources of data for this study.

- **Terrestrial Rare Species Habitat and Exemplary Natural Communities:** based on the *BioMap* report created in 2001 by the Natural Heritage and Endangered Species Program of the Division of Fisheries and Wildlife.[13] A total of 1,160,000 acres of land in Massachusetts was identified as Core Habitat.
- **Aquatic Rare Species Habitat and Exemplary Freshwater Systems:** based on the *Living Waters* report published in September 2003 by NHESP.[14] This aquatic complement to *BioMap* identified 1,000 miles of rivers and streams and 247 lakes and ponds deemed most critical to preserving aquatic biodiversity.
- **Critical Ecological Communities:** based on an ecoregion conservation "portfolio" created by the Northeast and Eastern Divisions of The Nature Conservancy (TNC).[15] This portfolio attempts to identify the highest quality set of matrix, or large intact forests, natural communities, large patch communities, large and small patch communities, and rare species populations.

How Well Protected Are Critical Habitat Areas?

For each set of priority habitats and natural communities, we looked at the degree to which they are permanently protected and how they are managed, based on the MassGIS protected recreation and open space datalayer as of June 2003. For *BioMap* Core Habitat and TNC portfolio areas, we looked at protection within the delineated area. For *Living Waters* Core Habitat areas, we focused on the riparian area 100 meters from a riverbank or shoreline as the portion of a Critical Supporting Watershed most likely to contribute to the survival of rare aquatic species.

The results are troubling, particularly for areas where NHESP has identified the minimum land area required for protecting the remaining viable populations of rare plant and animal species. As discussed earlier, these results will not reflect state, municipal, nonprofit, and CR lands missing from the MassGIS data.

- Our analysis shows 39 percent of Core Habitat acreage is permanently protected. (If we use the methodology used in the original *BioMap* report, and consider the surface area of the Quabbin and Wachusett Reservoirs and Assawompset Pond as permanently protected, 42 percent of Core Habitat acreage is permanently protected, a gain of approximately 50,000 acres since the end of 2000.)
- Twenty-three percent of the riparian area acreage surrounding *Living Waters* Core Habitats is permanently protected.
- The TNC portfolio areas are somewhat less protected than *BioMap* Core Habitats, with 34% of land permanently protected. The focus on contiguous natural communities by definition may include more public lands.
- The potential exists for conflicting uses within land permanently protected for these sensitive habitats. Of all the permanently protected land in *BioMap* Core Habitats, only one-third is protected exclusively for conservation, with the remaining lands protected in part for water supply and recreation. Thirty-one percent of the permanently protected lands within the *Living Waters* riparian areas are protected exclusively for conservation.

The overall level of protection is one measure of success or failure in protecting biodiversity. Another measure is whether we are applying resources to protecting a good mix of habitat and natural community types across the state. Land protection in eastern Massachusetts is particularly challenging because of high land prices. **Figure 14** shows the level of protection within each *BioMap* Core Habitat area and ecoregion, providing an overview of which areas are most at risk of development and regional differences.

A review of Core Habitat protection shows good progress in protecting many of the largest areas. Core Habitats can include water bodies and extend into ocean waters and across state boundaries. Since water bodies and areas outside of Massachusetts do not show up as protected in the MassGIS open space data, some coastal, water protection, and border areas may appear to be less protected than they actually are. Based on the land protection data available to us, a number of Core Habitats in southeastern Massachusetts and Cape Cod; the Nashua, SuAsCo, and Blackstone watersheds; and the Connecticut River Valley and Vermont Piedmont ecoregions are less than one-third protected.

BioMap Core Habitats Level of Permanent Protection *June 2003*

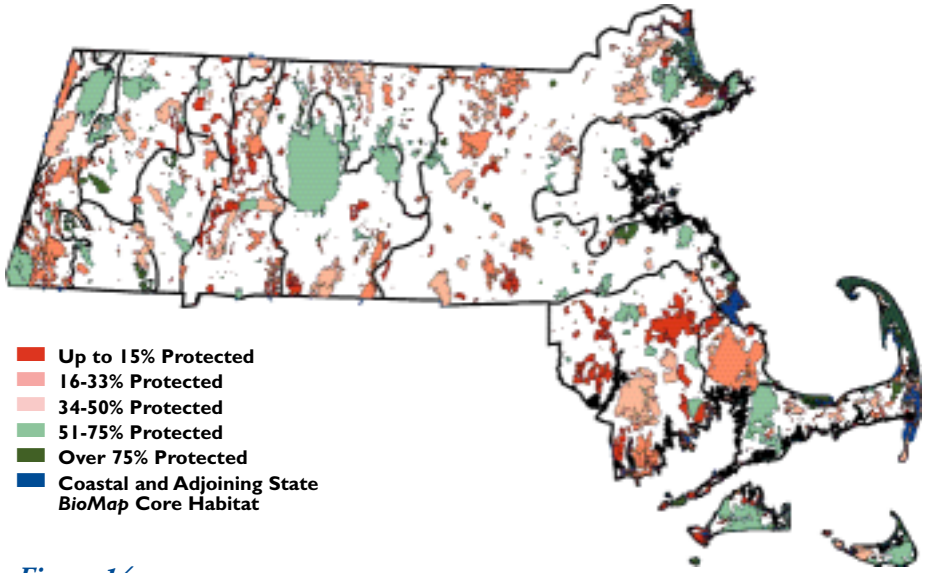


Figure 14

Level of Permanent Protection of Individual *BioMap* Core Habitats

To qualify, land needed to be permanently protected for water supply, conservation, or dual conservation and recreation purposes. Red shows the lowest level of protection on a percentage of acres basis.

Sources: MassGIS NHESP BioMap *Core Habitat and protected recreation and open space data*

Impact of Development In or Near Critical Habitat Areas

Our most vulnerable species and natural communities are not only threatened by a lack of permanent land protection and potentially inappropriate use, but also by development both in and around critical habitat areas. As we noted in Chapter 2, human presence in or near habitat can have a number of adverse impacts due to fertilizers and pesticides used on lawns, poorly maintained septic systems, pets, noise and exterior lighting, and the introduction of non-native plant species.

BioMap Core Habitat Area in the Plymouth Region

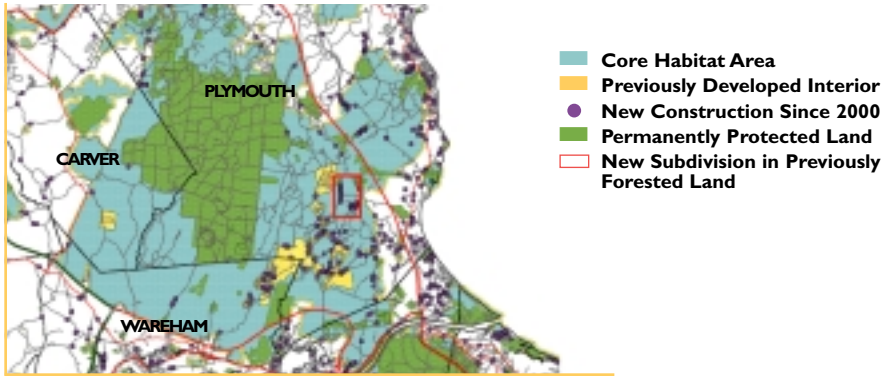


Figure 15

New construction within *BioMap* Core Habitat area in Plymouth, Carver, and Wareham. Roughly a third of the total habitat area is permanently protected.

Figure 16

Current Degree of Fragmentation by EPA Ecoregion

EPA Ecoregion	Road Density (km roads/km² area)	Number of Forest Blocks	Average Forest Block Size (acres)	Number of Forest Core Areas	Average Forest Core Size (acres)	Forest Core Area % of Forest Block Area
Taconic Mountains	0.5	233	354	90	741	81%
Western N.E. Marble Valleys/Berkshire Valley/Housatonic and Hoosic Valley	1.5	1,525	179	548	355	71%
Berksire Highlands/ Southern Green Mts.	0.5	511	286	293	352	71%
Lower Berkshire Hills	0.5	1,308	146	420	311	69%
Berkshire Transition	2.9	3,687	101	1,337	170	61%
Vermont Piedmont	1.4	903	83	283	157	60%
Worcester Plateau	1.6	5,043	62	1,624	99	52%
Connecticut River Valley	1.3	2,564	46	917	55	43%
Lower Worcester Plateau	3.8	8,181	37	2,289	52	39%
Southern N.E. Coastal Plains and Hills	3.3	23,399	30	5,896	41	34%
Boston Basin	5.1	5,652	26	1,239	39	33%
Bristol Lowlands/ Narragansett Lowland	2.4	11,210	19	2,040	29	29%
Cape Cod and Islands	4.9	3,640	12	421	15	15%

Fragmentation metrics by EPA ecoregion in Massachusetts.

Source: MassGIS 1999 land use and 2002 Massachusetts Highway Department roads data

An examination of an individual *BioMap* Core Habitat area in the Plymouth region, in **Figure 15**, shows the promise and challenges of land protection within rare species habitats. Myles Standish State Forest provides protection to a large section of Core Habitat. However, new development continues, both through extensions of previously developed areas within the habitat, and new subdivisions within previously forested areas.

Fragmentation in Critical Habitat Areas

Development has an immediate effect of destroying habitat and disrupting ecological processes. Habitat fragmentation by roads and the clearing of land can also degrade what habitat remains by limiting the ability of plants and animals to migrate and reproduce undisturbed. While natural disturbances such as fire and hurricanes can also fragment forest, in Massachusetts most fragmentation is caused by human activity and leaves a more permanent impact on the landscape.

The table in **Figure 16** summarizes the current degree of fragmentation by EPA ecoregion in the Commonwealth. We looked at the size of remaining forest blocks as well as the "core" area of each forest block, after 90 meters of edge effects were factored in. We believe this data establishes a benchmark that should be tracked over time.

Not surprisingly, the areas of the state with the largest intact forest blocks, and most undisturbed core areas, are in the less populated Taconic Mountains and Berkshire Valley and Highlands areas of western Massachusetts. Conversely, many ecoregions in eastern Massachusetts are highly fragmented. On Cape Cod and the Islands, the average remaining forest block is 12 acres, and edge effects make only 15 percent of those blocks useful as interior habitat.

The Taconic Mountain and Berkshire Highlands also had the lowest road densities within existing forest blocks. Generally, a road density higher than 0.6 km roads per square kilometer of area is considered a barrier to large mammal movement. Despite having large interior forest blocks, the Marble Valleys/Housatonic Valley ecoregion had a relatively high road density of 1.5 kilometers per square kilometer.

The vulnerability of rare species habitats, and relatively low level of protection, should instill a renewed commitment to saving these areas before they are lost forever. We will now consider one way to build an economic case for land protection, based on the value of ecosystem services.

CHAPTER 6

Accounting for the Economic Value of Ecosystem Services in Massachusetts

Thus far, we have laid out the costs of unchecked development in the Commonwealth in traditional conservation terms. Deforestation destroys wildlife habitat, fragmentation threatens biodiversity, and sprawling development affects quality of life. Protecting land is important for ecological as well as aesthetic and cultural reasons. As important as these factors are, however, most day-to-day land use decisions are based on market economics. Landowners are influenced by land prices as well as property tax assessments that value land based on its "fair market value." Similarly, local and state governments must often weigh the economic costs and benefits of infrastructure development while policy makers evaluate the tradeoffs between competing stakeholder demands in the marketplace.

The forests, rivers, wetlands, estuaries, and beaches throughout Massachusetts provide many different goods and services to the people of the Commonwealth. An ecosystem service, by definition, contains "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life."[16] While these natural processes have been well understood from a scientific perspective for some time, only recently has there been an effort to quantify the economic value of these services.

Estimating the Value of Ecosystem Services in Massachusetts

For this chapter, Mass Audubon worked with Dr. Matthew A. Wilson and Dr. Austin Troy, professors associated with the Gund Institute for Ecological Economics at the University of Vermont, to create a spatially explicit economic model of ecosystem service values for the Massachusetts landscape.

Our primary interest is to shed light on the nonmarket economic benefits of ecosystem services associated with habitat and open land when it is left in its natural state, as opposed to direct or extractive uses such as forestry, fishing, and agriculture. To estimate the economic value of ecosystem services in Massachusetts, we relied on secondary analysis of published results drawn from the peer-reviewed economic literature. When analyzed carefully, information from studies published in the economic literature can form a meaningful basis for directing environmental policy and management.[17]

The forests, rivers, wetlands, estuaries, and beaches throughout Massachusetts provide many different goods and services to the people of the Commonwealth.

The research team reviewed the best available economic literature and selected valuation studies that were:

- Peer reviewed and published in recognized journals,
- Focused on temperate regions in either North America or Europe, and
- Focused primarily on nonconsumptive use.

The search yielded 42 viable studies that were then inputted into a relational database. The results of each study were then standardized to 2001 US dollar equivalents to provide a consistent basis for comparison.[18] The end result was a database containing 65 valuation data points.[19] Given the selection criteria used, we believe this approach yields conservative, baseline, economic values. It also means that some land cover types in Massachusetts for which no applicable peer-reviewed research exists, such as sandplains and heathlands, received no economic value estimate, even though these areas are widely recognized as having high ecological and aesthetic value.

The ecosystem services used in our analysis include the following.[20]

- **Climate Regulation:** Capture and storage of carbon dioxide by forest and other plant cover, reducing global warming.
- **Freshwater Regulation and Supply:** Storage, control, and release of water by forests and wetlands, providing local supply of water.
- **Waste Assimilation:** Filtering of pathogens and nutrients from runoff by forests and wetlands, reducing the need for water-treatment systems.
- **Nutrient Regulation:** Cycling of nutrients, such as nitrogen, through ecosystem for usage by plants, reducing need to apply fertilizers.
- **Habitat Refugium:** Value of contiguous patches of forest and wetland in supporting a diversity of plant and animal life.
- **Soil Retention and Formation:** Creation of new soils and prevention of erosion, reducing need for dredging and mitigation of damage due to siltation of rivers and streams.
- **Disturbance Prevention:** Mitigation of flooding and coastal damage by natural wetlands and floodplains.
- **Pollination:** Services provided by natural pollinators such as bees, moths, butterflies, and birds, avoiding need for farmers to import bees for crop pollination.
- **Recreation and Aesthetics:** Recreational value of natural places as well as positive impact on nearby property values.

How Ecosystem Services Save Massachusetts Taxpayers Money

A few examples of how "free" services provided by nature have allowed the state and municipalities to save money on infrastructure.

- Wetlands in the Charles River Basin reduce peak river flows during storms and delay storm surges, preventing $18 million in flood damage each year. The Army Corps of Engineers concluded that protecting these wetlands was more cost-effective than building new flood-control infrastructure. Surrounding property values are also higher thanks to the flood-protection services provided by these wetlands.[21]
- The Massachusetts Water Resources Authority (MWRA) avoided the cost of a new $180 million filtration plant because of natural waste treatment provided by protected watershed lands around the Quabbin and Wachusett reservoirs.[22]
- The US Forest Service estimates that urban forests in Massachusetts store 16 million metric tons of carbon, and capture an additional 523,000 metric tons per year, with a social value due to migration of global warming effects of over $300 million.[23]

Modeling Ecosystem Services in Massachusetts

In selecting land cover for our analysis, we returned to the land cover data introduced in Chapter 2, and eliminated land cover types such as mining, transportation, and municipal waste disposal that provide no measurable ecosystem service value. We then consolidated the remaining 18 land cover classes into 11 simplified categories. A summary of the ecosystem services provided by different simplified land cover types is shown in **Figure 17**, as well as whether there was sufficient data for valuation in Massachusetts.

Several ecosystem service values can be associated with each land cover type, although current knowledge for all possible land cover and ecosystem service

relationships is incomplete. Yellow triangles shown in Figure 17 represent where the best available scientific information suggests ecosystem goods and services provided by landscape features and habitats might exist, but have yet to be empirically studied in the peer-reviewed literature. Blue triangles, on the other hand, represent ecosystem goods and services that have been empirically measured in the economic valuation literature.

Within each land cover type, we took the mean per-acre value across all studies for mapping values. We also calculated the average minimum and maximum values based on the selected research. Data sources and detailed per-acre values by land cover type can be found in the technical notes.

When these per-acre values are applied to the total acreage in Massachusetts for each land cover type, the resulting annual *nonmarket* ecosystem service value is over $6.3 billion annually. (This figure is *in addition* to the market value of timber and crops. Farms, agricultural services, forestry, lumber and wood products, and fishing contributed $1.9 billion to the state's Gross State Product in 2001.[24]) Given the lack of available research for many service and land cover combinations in Massachusetts, we consider our nonmarket value estimate to be conservative. *Eighty-five percent of the nonmarket ecosystem value created in Massachusetts comes from wildlife habitat*—water, wetlands, and forest—as opposed to land that has been altered by agricultural or recreational use. Forest cover provided the greatest annual ecosystem service value at $2.9 billion, with freshwater wetlands providing $1.8 billion and saltwater wetlands providing $573 million.

As we discussed in Chapter 2, most development in Massachusetts has come at the expense of forest and agricultural land. Based on the net forest and agricultural land lost to all forms of development between 1985 and 1999, the state lost over $200 million *annually* in ecosystem service value during the period, based on 2001 dollars. Had the same amount of development occurred in a way that impacted less forest and agricultural land, through denser and more brownfield development, the state could have enjoyed the economic benefits of both development and ecosystem services.

Figure 18 shows ecosystem service values per acre. The highest values were in areas rich in saltwater wetlands, such as the coastal portions of the Backwater, Parker, and Essex river watersheds, including Plum Island Sound and the Lower Ipswich, Little, and Essex river basins. The eastern half of the Miller and Chicopee watersheds, and Housatonic watershed, also have high per-acre values, driven again by the level of forest and freshwater wetlands in those regions.

Figure 17

Ecosystem Services and Available Research

Simplified Land Use Category	Cropland	Pasture	Forest	Wetland-Fresh	Wetland-Salt	Open Land	Urban Green Space*	Woody Perennial	Water and Coastal Embayment	Water-based Recreation	Highly Impacted+
Climate Regulation	▲	▲	▲	▲	▲	▲	▲	▲			
Freshwater Regulation and Supply			▲	▲	▲	▲			▲		
Waste Assimilation and Water Quality			▲	▲	▲	▲	▲		▲		
Nutrient Regulation	▲	▲	▲	▲	▲	▲	▲	▲	▲		
Habitat Refugium	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
Soil Retention and Formation	▲	▲	▲	▲	▲	▲	▲	▲			
Disturbance Prevention	▲	▲	▲	▲	▲	▲					
Pollination	▲	▲	▲	▲	▲	▲	▲	▲			
Recreation and Aesthetics	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	

Mapping of ecosystem services to Massachusetts land cover types.

▲ **Service provided by land cover type, with sufficient peer-reviewed research for valuation in MA**

▲ **Service provided by land cover type, but insufficient peer-reviewed research for valuation in MA**

* **Includes urban open space and participation recreation**

\+ **Includes commercial, industrial, and residential development**

Ecosystem Service Value Per Acre by Watershed *(2001 dollars)*

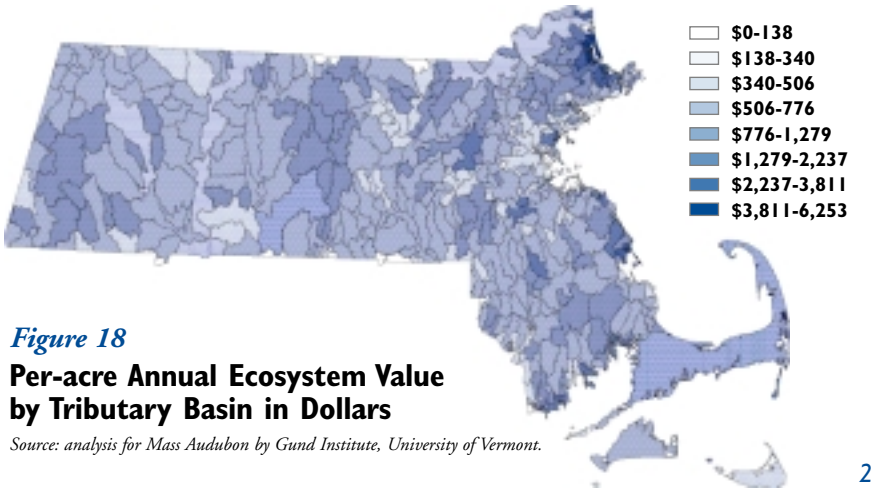


Figure 18

Per-acre Annual Ecosystem Value by Tributary Basin in Dollars

Source: analysis for Mass Audubon by Gund Institute, University of Vermont.

CHAPTER 7
Conclusion and Recommendations

The second edition of *Losing Ground* recommended a number of policy changes, and progress has been made over the last four years. The passage of the Environmental Bond of 2002 and the Community Preservation Act have provided new potential resources for land protection. Executive Order 418 gave municipalities additional resources for examining what their community could become under current zoning, and to look at better ways of planning growth. New reports that identify potential rare species habitat and exemplary natural communities in the state—the *BioMap* and *Living Waters* reports from the Natural Heritage and Endangered Species Program—provide an additional tool for setting land conservation priorities. An unprecedented public and private partnership has been formed to develop a Statewide Land Conservation Plan for the next 20 years.

Despite these gains, we continue to lose ground in 2003. Today, 2.4 million acres of wildlife habitat remain unprotected in Massachusetts, of which one million acres have been agreed upon at the state, local, and nonprofit organization levels as priorities for protection under the Statewide Land Conservation Plan. Other areas may be significant locally and regionally. Given ongoing forest fragmentation, and development in and around rare species habitats, we call for further refinement of the plan to focus on short-term opportunities for protecting intact forest blocks as well as rare land-based and aquatic species habitats. While continuing targeted land protection efforts, we must simultaneously reduce the rate of land consumption by development through improved zoning and denser development in areas that are not conservation priorities and are appropriate for new development.

We encourage readers to take action and work with their state and local representatives to address the problems of sprawl and habitat loss in the Commonwealth.

Today,
2.4 million acres of wildlife habitat remain unprotected in Massachusetts.

Open Space Protection

Land, including forest protecting our rare species and water supplies, is being lost each day to development, or further degraded and fragmented due to nearby human activity.

Recommended state level actions include the following.

- State allocation of at least $70 million annually for land acquisition under the previously approved Environmental Bond of 2002. This funding is needed to meet the Commonwealth's commitment in the Statewide Land Conservation Plan of protecting one million acres over the next 20 years, a level to be matched by local communities and nonprofit organizations. Stable and predictable bond spending levels are critical to the plan's success.
- Identification of a direct, stable, and reliable dedicated funding source for statewide land conservation—beyond general obligation bonds and the Community Preservation Act.
- Focus of short-term land protection efforts on the identification and conservation of at-risk rare species habitat, particularly in development hot spots, as well as remaining intact forest blocks and riparian areas throughout the state.
- Permanent funding for the ongoing monitoring and management of protected lands to prevent inappropriate land use changes by users or abutting property owners.
- Development of land management plans, and a public review process for those plans, for all permanently protected state lands, starting in those areas identified as rare species habitat or rare natural communities, and in areas where conflict of use is most likely because of recreation, timber harvesting, and development. Tools like GIS can be used to accelerate the process of resource identification.
- Establishment of a state income tax credit for landowners who make permanent gifts of land or conservation restrictions to public agencies or qualified, nonprofit, conservation organizations.
- Passage of Article 97 no-net-loss legislation to prevent inappropriate conversions of state or municipally owned conservation land to other uses.
- Identification of areas, such as riparian zones, coastal areas, and floodplains, where additional land protection is more cost-effective than state or local infrastructure investment.

Recommended local action includes the following.

- Passage of the Community Preservation Act, which allows cities and towns to approve a property tax surcharge to provide resources for open space protection, historic preservation, and affordable housing. Cities and towns adopting the act are eligible for state matching funds. To date, 61 communities have adopted this measure.

Land Use and Development

State level reforms to address the impact of development on habitat and quality of life include the following.

- Meaningful zoning reform through legislative action that eliminates loopholes to local land use planning such as Approval Not Required (ANR) development and grandfathering provisions that can freeze local zoning changes for a period of eight years. Individual communities need to ensure closer integration between municipal master planning and local zoning laws.
- State-level incentives that encourage denser development close to municipal centers and mass transit. In some cases, municipalities that have avoided large water and sewer infrastructure costs by requiring large house lots may need state assistance in making the transition to denser housing.
- Coupling of future transit improvements, such as extensions to commuter rail lines, with regional planning for higher density development, and mitigation funds for protection of open space impacted by transit-induced growth.
- Reform of Chapter 40B affordable housing laws to encourage development near existing city and town centers and infrastructure, reusing existing structures where possible.
- Continued incentives to encourage "brownfield" development and "greenfield" preservation.

Recommended local action includes the following.

- Local adoption of cluster and conservation subdivision zoning that allows developers to build denser housing while setting aside more open space. We encourage municipalities to consider adopting Open Space Residential Design bylaws, as developed by the Green Neighborhoods Alliance. Open Space Residential Design includes setting aside at least half of a subdivision for open space, with shorter roads and smaller and more diverse house lot sizes. This approach can support the same number of houses as a traditional subdivision while providing both open space protection and more affordable housing.
- Special districting to allow multifamily housing in specific areas of a community near public transportation and town centers.
- Use of transferable development rights, whereby a developer who agrees not to build on environmentally sensitive land can sell development rights to another developer, who can then build in an area of a community more appropriate for development, with higher density than allowed under current local zoning.

Impact of Development on Biodiversity

- Our understanding of rare species locations and habitat requirements has been possible through the work of the Natural Heritage and Endangered Species Program. The legislature needs to ensure that ongoing funding is preserved in trust for this program through the current check-off on Massachusetts income tax returns, and through matching funding by the state.
- Review areas where rare species habitat and water supply sub-basins intersect as an opportunity for increased land protection and for ensuring joint management of water and habitat resources.
- Consider rare species habitat areas most at risk due to development and fragmentation as priorities within the Statewide Land Conservation Plan.

Additional Monitoring and Research

- We recommend updating statewide land use data collection at least every five years. Interpretation of aerial photography should include additional residential lot-size categories.
- State agencies should provide assistance to nonprofit conservation organizations and land trusts to improve the collection of GIS data on protected, nonstate lands.
- To refine the preliminary ecosystem services valuations provided here, we encourage more research on the value of land cover specific to Massachusetts, perhaps focused on a priority watershed or natural community.

Mass Audubon's Land Protection Strategy

Given the closing window of opportunity to make a meaningful difference in the Commonwealth's protected landscape, it is critical that future land protection efforts be targeted to the most significant areas. This can best be achieved by using sound reference data and proactive outreach to landowners of priority holdings. Mass Audubon has recently completed an update of its statewide Land Protection Strategy. It is clear that the decisions that Mass Audubon and the rest of the land protection community make regarding conservation priorities and funding over the next 10 to 15 years will fundamentally shape the future of the Massachusetts landscape, its habitats, and its species, forever. We will be working proactively and in conjunction with our conservation partners to make the most of the time remaining to protect key lands.

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