UMASS DONAHUE INSTITUTE

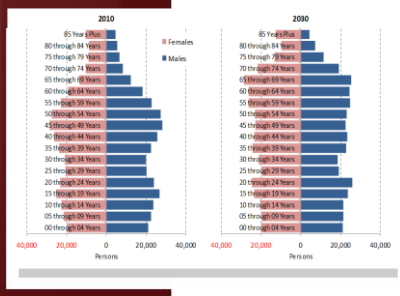
Long-term Population Projections for Massachusetts Regions and Municipalities

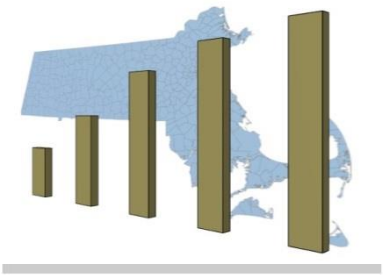
Prepared for the Office of the Secretary of the Commonwealth of Massachusetts

Henry Renski, PhD
University of Massachusetts, Amherst
Department of Landscape Architecture and Regional Planning

Lindsay Koshgarian, M.P.P.
Research Manager, Economic and Public Policy Research
UMass Donahue Institute

Susan Strate
Population Estimates Program Manager
UMass Donahue Institute





November 2013

Table of Contents

List of Tables and Figures

I. Project Overview

Massachusetts agencies and entities have not had access to detailed, publically available, statewide municipal population projections by age and sex since the Massachusetts Institute for Social and Economic Research (MISER) last produced projections in 2003 based on Census 2000. The U.S. Census Bureau previously produced state-level projections by age and sex, but has at present discontinued them, with the last Census-produced state population projections based on Census 2000 data and released in 2005. These projections do not reflect the shift in economic and social trends that has taken place since 2000, and their usefulness has likely passed. While some regional planning agencies (RPAs) and statewide agencies produce municipal population projections, they are limited to either municipal totals, subsets of the population (i.e. children of school age), or certain geographical regions, and their methodologies vary. Agencies with broad, statewide planning needs such as water resource management or public health are challenged with having to somehow reconcile different and sometimes conflicting sets of methods and results, when municipal projections are available at all.

Massachusetts is also in a minority of states that do not produce regularly updated population projections. According to a 2009 member survey by the Federal State Cooperative for Population Projections (FSCPP; a partnership between the U.S. Census Bureau and designated state agencies), only eight states – including Massachusetts – do not regularly produce publicly available population projections. Thirty-nine states produce at least state and county level projections; 35 produce these at least every two years.

To meet this statewide need, the Massachusetts Secretary of the Commonwealth contracted with the University of Massachusetts Donahue Institute (UMDI) to produce population projections by age and sex for all 351 municipalities (also referred to here as minor civil divisions – or MCDs) in Massachusetts.
The resulting set is the product of well over a year of preparation and analysis by experienced researchers on the UMDI staff as well as input and commentary by an Advisory Committee that included public stakeholders as well as state and national experts working in the field.[1] The methodology was developed by Dr. Henry Renski of the University of Massachusetts in Amherst, who previously produced projections for the state of Maine and who is well regarded and published in the fields of regional planning and projections methods.

UMDI produced cohort component model projections for two different geographic levels: municipalities and eight sub-state regions that we defined for this purpose. These sub-state regions include the Berkshire/Franklin, Cape and Islands, Central, Greater Boston, Lower Pioneer Valley, MetroWest, Northeast, and Southeast regions. The UMDI projections are available for all

[1] Listed in Appendix A: *UMDI Population Projections Advisory Committee Members*

municipalities by sex and 5-year age groups, from 0-4 through 85+, and at 5-year intervals beginning in 2015 and ending in 2030. While the municipal-level projections provide a great level of detail, the regional projections describe in broad strokes the ways that components of change such as fertility, mortality, and migration are expected to play out over the next few decades in each part of the state, according to our projections model.

Modeled projections cannot and do not purport to predict the future, but rather may serve as points of reference for planners and researchers. Like all forecasts, the UMDI projections rely upon assumptions about future trends based on past and present trends which may or may not actually persist into the future. In general, projections for small geographies and distant futures will be less predictive than projections for larger populations and near terms. Also, any statewide method will tend to produce unusual looking results in very small geographies or in small age cohorts. While our method makes adjustments for small geographies or cohorts in some of its rates, researchers are nonetheless encouraged to use their best judgment in deciding for which cases aggregate populations are more appropriately used.

For our projections, we use a cohort-component model based on trends in fertility, mortality, and migration from 2000 through 2011. Our regional-level method makes use of American Community Survey sample data on migration rates by age and uses a gross, multi-regional approach in forecasting future levels of migration. Our sub-regional, municipal-level estimates rely instead on residual net migration rates computed from vital statistics. The municipal-level method is applied uniformly to all municipalities in Massachusetts, except for adjustments made to calculated rates in very small geographies. The municipal projections are finally controlled to the regional projections to produce the end results.

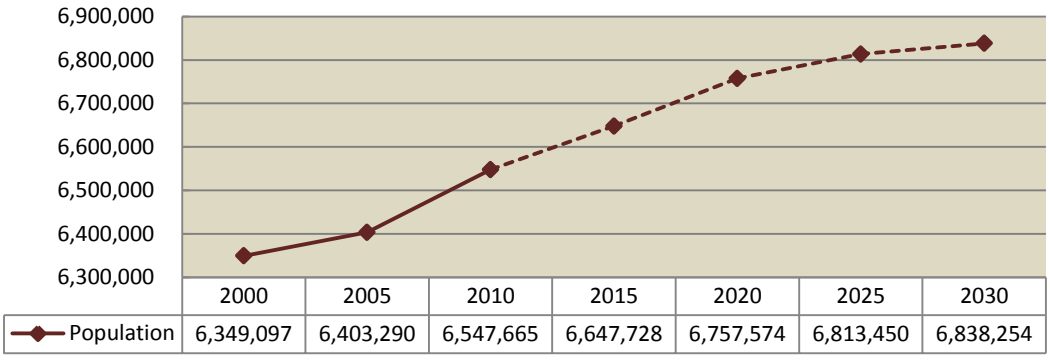
The next section of this report, *Section II. State-Level Summary*, highlights the total population change anticipated for Massachusetts through 2030 after the regional projections are summed together, while the subsequent *Section III* describes in greater detail the regional-level population projections, including an *Analysis* section for each of the eight distinct Massachusetts regions. *Section IV* of this report, *Technical Discussion of Methods and Assumptions,* provides more specific information on both the regional and MCD-level projections methods utilized here, and finally attached are the MDC-level projection results to 2030.

II. State-Level Summary

Massachusetts Growth: 2000 to 2030 Trends

At the state level, the UMass Donahue Institute projections anticipate that the Massachusetts population will grow by 4.4% from 2010 to 2030, with population increasing by 290,589 over the 20-year term to a new total of 6,838,254. Most of this growth is expected to occur in the near term and to then trail off, with an increase of 209,909 persons, or 3.2%, in the first ten years, and just 80,680, or 1.2%, in the subsequent ten. By comparison, Massachusetts grew 3.1% in the ten years from 2000 to 2010, also at an uneven pace, increasing just 0.9% from 2000 to 2005 and then accelerating to 2.3% from 2005 to 2010 (Figure 2.1).

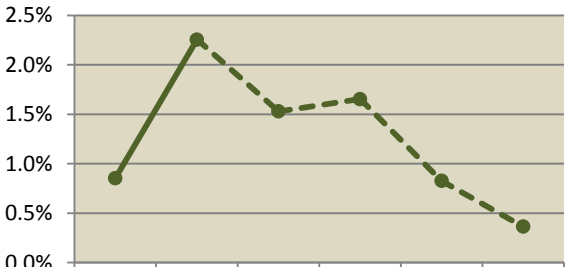
Figure 2.1: Massachusetts Actual and Projected Population, 2000-2030



	2000	2005	2010	2015	2020	2025	2030
Population	6,349,097	6,403,290	6,547,665	6,647,728	6,757,574	6,813,450	6,838,254

Sources: U.S. Census Bureau, Census 2000, 2005 Interim State Population Projections, and Census 2010; UMass Donahue Institute Population Projections, 2013.

Figure 2.2: Actual and Projected Percent Change in Massachusetts Population 2000-2030



	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
% Change	0.9%	2.3%	1.5%	1.7%	0.8%	0.4%

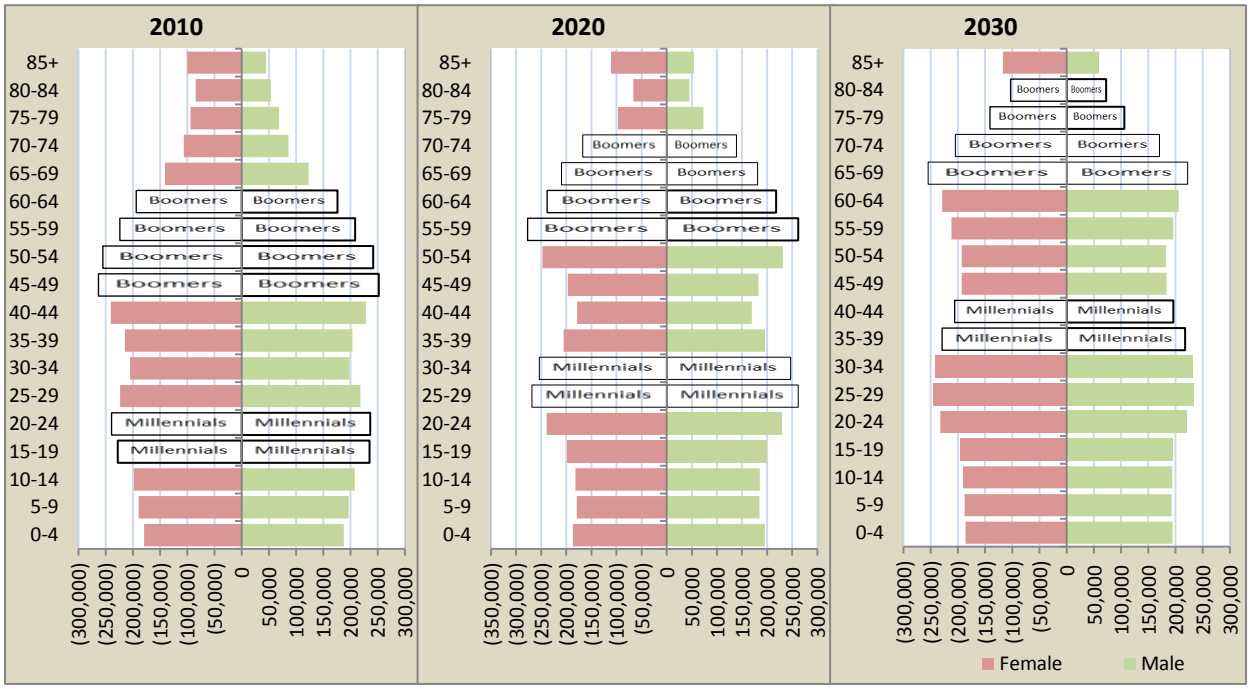
Factors Affecting Growth Rates

This slowdown in growth over time is attributable to the age profiles of both Massachusetts and the United States overall, as they relate to forces of change such as fertility, mortality, and migration. In both the United States and Massachusetts, the aging of the population will result in slower population growth in the decades to come. As the United States grows older, the bulk of its population ages out of childbearing years and, eventually, into higher mortality cohorts – both of which factors will slow population growth. In Massachusetts the effect of this aging is even more pronounced, as the state is already older than the United States on average, with a larger share of

population in the older age-groups and a smaller share in the younger[2]. An increasing pool of retirees in Massachusetts exacerbates this effect to some extent by increasing out-migration from many regions of the state to places in the South and West, while a group of younger, post-college cohorts also continues to contribute to a net domestic outflow.

While an aging population means slowed population growth in Massachusetts from 2010 to 2030, the slowdown is somewhat tempered in the first 10 years, in part by a large "millennial" generation in the United States overall. This group is now aging into the cohorts associated with increased migration to college and work destinations, factors that historically have led to population increase in Massachusetts, especially in the Greater Boston region. At the top end, this generation is also entering the age group associated with starting families, and so additionally increases the overall population with children as it ages. The millennials, born from about 1982 through 1995 and sometimes called the "Echo-Boomers, represent the second-largest population "bulge" in the U.S. age pyramid after the baby-boomers and, like the boomers, their collective life-stage heavily influences the components of population change in the United States and its sub-regions. In the Massachusetts 2010 population pyramid (Figure 2.3), this group appears in the 15-24 year-old cohorts. By 2020, this group will be enlarged by college-aged in-migrants and will have aged forward into the 25-34 year old cohort.

Figure 2.3: Massachusetts Actual and Projected Population by Cohort, 2010, 2020, and 2030

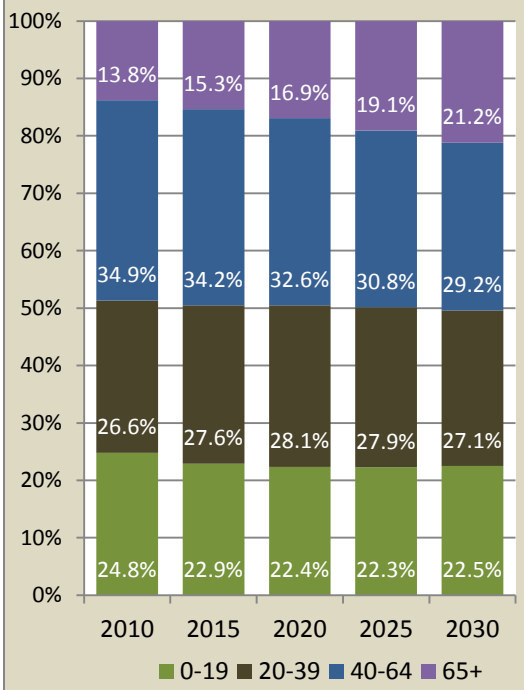


Source Data: U.S. Census Bureau 2010 Census Summary File 1; UMass Donahue Institute Population Projections, 2013.

[2] The Massachusetts population under 18 represents 21.7% of its population compared to 24% for the U.S. The Massachusetts population 40 and over is 48.7% compared to 46.3% for the U.S. Source data: U.S. Census Bureau, 2010 Census Summary File 1.

This aging effect of both the boomers and millennials also helps to explain why Massachusetts population growth slows to an even greater extent after 2020. Looking across the 20 year period, the initial increase in the percent of population aged 20-39 experienced from 2010 to 2015 and increased again through 2020 (representing the millennial bulge) falls off again by 2025 and 2030. Meanwhile, the population of persons in their 40s and 50s steadily decreases from about 35% of the state's population to 29%, now aging into the older cohorts. The younger cohort of children aged 0-19 likewise decreases over time, roughly following the pattern of their parents' cohorts, and changing from 25% of the 2010 Massachusetts population to 22% by 2030. In sharp contrast, the population aged 65 and over in the state increases from 14% to 17% in the first 10-year period, and then increases even more in the second. By 2030, the 65-and-over population will represent 21% of the state's population compared to just 14% in 2010.

Figure 2.4: Massachusetts Projected Population Distribution by Age Group

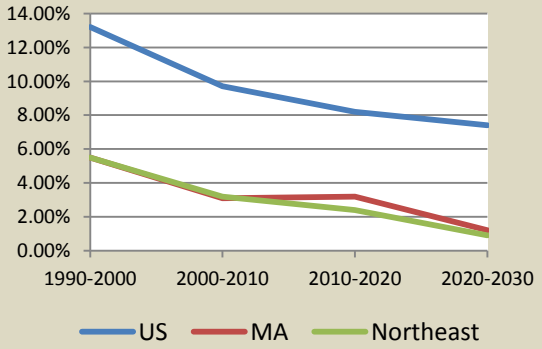


Source Data: U.S. Census Bureau, 2010 Census Summary File 1; UMass Donahue Institute Population Projections 2013.

Massachusetts and United States Growth Comparison

Although Massachusetts will continue to grow, and even to outpace the Northeast Region as it has in recent years, its growth will be slow compared to the United States as a whole (Figure 2.5). While Massachusetts will grow by 3.2% from 2010 to 2020, the Northeast will grow by just 2.4%[3]; however the U.S. will grow by a projected 8.2%[4]. From 2020 to 2030, Massachusetts growth will slow to 1.2%, still ahead of the Northeast at just 0.9%, while the U.S. average also slows yet remains much higher at 7.4%. A major contributor to this is the fact that while Massachusetts, and particularly the Boston area, are attractors of college aged students and can rely on an import of younger

Figure 2.5: Actual and Projected Percentage Growth by 10-Year Period for Massachusetts, the United States, and the Northeast Region 1990-2030



[3] Source: U. S. Census Bureau 2005 Interim State Population Projections, April 2005. While a later set of National-level projections was produced in 2012, we use the 2005 set here in order to include a Northeast regional comparison in this discussion.

[4] Source: U.S. Census Bureau. Projections of the Population and Components of Change for the United States: 2015 to 2060 (NP2012-T1). Release Date: December 2012.

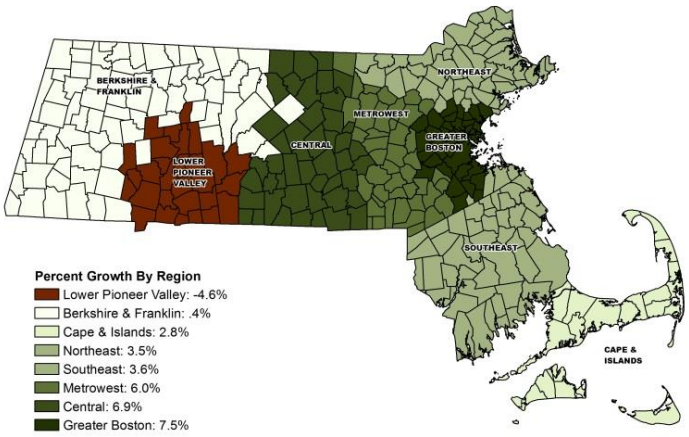
people into the state, other parts of the United States start out with much higher percentages of younger cohorts already resident in their age profiles, especially in the 0-18 year old age groups[5]. Lagging behind U.S. growth is also not new for Massachusetts. From 1990 to 2000 the U.S grew 13.2% compared to 5.5% for Massachusetts and the Northeast region. Similarly, from 2000 to 2010 the U.S. grew by 9.7% compared to 3.2% in the Northeast and 3.1% in Massachusetts[6].

Projected Geographic Distribution of Population

The projected growth in Massachusetts is not shared evenly around the state. As *Section II. Long Term Regional Population Projections* of this report shows, some regions anticipate growth well above the 4.4% anticipated for the state by 2030. The Greater Boston region is expected to increase by 7.5% from 2010 to 2030, the Central region by 6.9%, and MetroWest by 5.8%. At the other end of the spectrum, the Lower Pioneer Valley may expect a decrease of 4.5% if recent trends in migration, fertility, and mortality continue, while the Berkshire and Franklin region will remain nearly level over the long term, at just 0.4% growth by the end of 20 years.

Not surprisingly, the large cities in these regions, also the three largest cities in Massachusetts, drive their respective regional trends. Boston is expected to increase by 11.7% by 2030, with the lion's share of this increase – 9.7% - occurring in the first ten-year interval. Worcester follows in the Central region with a 7.7% increase, while the Lower Pioneer Valley city of Springfield is expected to decrease in population size by 4.8%. Analysis on why growth varies so significantly by region is presented in more detail in Section III of this report.

Figure 2.6:
Projected % Growth by Massachusetts Region, 2010-2030



[5] Source: U.S. Census Bureau, 2010 Census Summary File 1.

[6] Source: U.S. Census Bureau, Census 2000 and Census 2010; 1990 Census, Population and Housing Unit Counts, United States (1990 CPH-2-1).

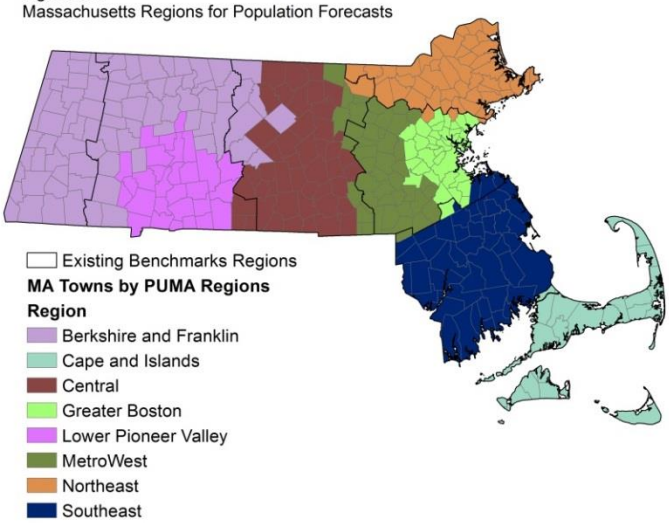
III. Long Term Regional Population Projections

A. Introduction

This section presents long-term regional population projections for eight Massachusetts regions for the years from 2010 to 2030. The forecasts are presented in five-year increments (i.e. 2010, 2015, 2020, etc.) and broken down by age and gender. These projections were developed by Dr. Henry Renski of the University of Massachusetts Amherst in collaboration with the Population Estimates Program of the Economic and Public Policy Research Unit of the UMASS Donahue Institute and with input from an external Advisory Committee[7] including stakeholders and state and national experts working in the field. Funding for this project was provided by the Office of the Secretary of the Commonwealth.

The ultimate goal of this project was to develop long-term projections by age and sex for the 351 municipalities in the Commonwealth of Massachusetts. To do so, our method first requires the production of regional-level population projections. It is common for municipal projections to be derived from regional-level projections, in part, because key information on migration patterns does not typically exist for small geographies. We first develop regional projections to take advantage of the superior data sources and then allocate these results to the individual municipalities in each region according to a separate distributing formula. In this way, the regional projections serve as 'control totals' for municipal projections. Beyond their use in creating municipal projections, our regional forecasts have additional value in that their production helps shed light on the demographic forces driving population change across different parts of the Commonwealth. We developed projections for eight separate regions (Figure 3.1), whose specific boundaries approximate the "Massachusetts Benchmarks" regions often used to characterize the distinct sub-economies of the state. But whereas the Benchmarks regions are based on counties, data limitations required us to make some boundary approximations.[8]

Figure 3.1:
Massachusetts Regions for Population Forecasts



[7] See Appendix A.
[8] The data required to estimate the domestic migration component of our model are reported by Public Use Micro-sample Areas (PUMAs) as defined by the U.S. Census Bureau. PUMAs do not typically match county boundaries. The boundaries of our forecast regions were designed to match PUMA boundaries and also municipal boundaries, so as to match municipal-level vital statistics data.

Our projections are based on a demographic accounting framework for modeling population change, commonly referred to as a cohort-component model.[9] The cohort-component approach recognizes only four ways by which a regions population can change from one time period to the next. It can add residents through either births or in-migration, and it can lose residents through deaths or out-migration.

The cohort-component model also accounts for regional difference in the age profile of its residents. Birth, death, in- and out-migration rates all vary by age and across regions. To account for this, a cohort-component model classifies the regional population into five year age "cohorts" (e.g. 0 to 4 years old, 5 to 9,… 80 to 84, and 85 or older) and develops separate profiles for males and females. We use data from the recent past (primarily 2005 to 2010) to determine the contribution of each component to the changes in the population within each age-sex cohort. The counts are converted into rates by dividing each by the appropriate eligible population. We then apply these rates to the applicable cohort population in the forecast launch year (for us, 2010) in order to measure the anticipated number of births, deaths, and migrants in the next five years. The number of anticipated births, deaths and migrants are added to the launch year population in order to predict the cohort population five years into the future. As a final step, the surviving resident population of each cohort is aged by five years, and becomes the baseline for the next iteration of projections.

Our approach to cohort-component modeling in this projections set introduces several methodological innovations not found in the standard practice of cohort-component modeling. Most follow a net-migration approach, where a single net migration rate is calculated as the number of net new migrants (in-migrants minus out-migrants) divided by the baseline population of the study region. While commonly used, this approach has been shown to lead to erroneous projections—particularly for fast growing and declining regions (Isserman 1993). Instead, we use a gross-migration approach that develops separate rates for domestic in- and out-migrants. The candidate pool of in-migration is based on people not currently living in the region, thereby tying regional population change to broader regional and national forces.[10] We further divide domestic in-migrants into those originating in from neighboring regions and states and those coming from elsewhere in the U.S. to further improve the accuracy of our estimates. This type of model is made possible by utilizing the rich detail of information available through the newly released Public Use Micro-Samples of American Community Survey. We also include a residual component, which accounts for unknown measurement and sampling error in the data and prevents the model from departing too dramatically from historical trends.

While we take pride in using highly detailed data and a state of the art modeling approach, no one can predict the future with certainty. Our projections are simply one possible scenario of the future—one conditioned largely on whether recent trends in births, deaths and migration continue into the foreseeable future. If past trends continue, then we believe that our model should provide an accurate reflection of population change. However, past trends rarely continue. Economic expansion and recessionary cycles, medical and technological breakthroughs, changes in cultural

[9] A more detailed description of our methodology is provided in Section IV. of this report: *Technical Discussion of Methods and Assumptions.*

[10] The rationale behind the development of a distinct in-migration rate is that the potential population of in-migrants is not the people already living in the region (as assumed in a net migration approach), but those living anywhere but.

norms and lifestyle preferences, regional differences in climate change, even state and federal policies – all of the above and more can and will influence birth, death and migration behavior. We humbly admit that we lack the clairvoyance to predict what these changes will be in the next two decades and what they will mean for Massachusetts and its residents. Of particular note is the consideration that the data used for developing component-specific rates of change were largely collected for the years of 2005 to 2010. This period covers, in equal parts, periods of relative economic stability and severe recession. It is difficult to say, for example, whether the gradual economic recovery will lead to an upswing in births following a period where many families put-off having children, or whether birth rates will rebound slightly and thus return to the longer-term trend of smaller families. We expect economic recovery to lead to greater mobility, however, we do not know if this will result in relatively more people moving in our out of Massachusetts. Likewise, we cannot predict the resolution of contemporary debates over immigration reform, housing policy, and/or financing of higher education and student loan programs. Nor can we even begin to assess whether climate change will lead to a re-colonization of the Northeast, which has been steadily losing population to the South and Southwest for the past several decades. Making predictions like these is far beyond our collective expertise and the scope of this study.

These caveats are not meant to completely dismiss the validity of our projections, but rather to situate them in a reasonable context. Population change tends to be a gradual process for most regions in the Northeast. Most of the people living in a region five years from now will be the same folks living here today – only a little bit older. Regions with an older resident population can expect to experience more deaths as these people age. Places with large number of residents in their late twenties and thirties can expect more births in the coming years. A large number of U.S .residents in grade school today will mean a larger pool of potential college students ten or fifteen years down the road. These are many trends that we can anticipate with relative certainty, and which are reflected in the regional results that follow.

B. Analysis by Region

1. Berkshire/Franklin Region

The Berkshire/Franklin county region consists of 76 communities spanning the Commonwealth's western and northwestern borders. It is predominantly rural, with its primary population and employment centers of Pittsfield in Berkshire County and Greenfield in Franklin County.

The Berkshire/Franklin region experienced slight population decline of approximately 2,300 residents over the past decade (2000 to 2010)—equivalent to an annualized rate of growth of -.1%. Our models predict that recent trends of slow decline will temporarily reverse between 2015 and 2025, with more in-migration from retiring baby boomers (Figures 3.1b & 3.1c). The regional population will peak in 2025 at just over 238,000 residents — roughly 2,000 more persons than reported in the 2010 Census. However, this retirement-fueled growth will be only temporary, as increasing deaths associated with an aging population will eventually erode all gains. By 2030, the population of the Berkshire/Franklin region will return to a level near even the 2010 Census.

Figure 3.1a
The Berkshire/Franklin Region

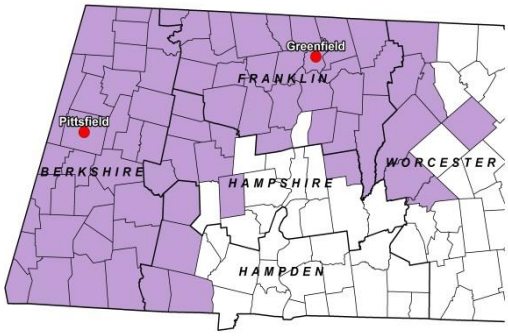


Figure 3.1b
Recent and projected population, Berkshire/Franklin Region

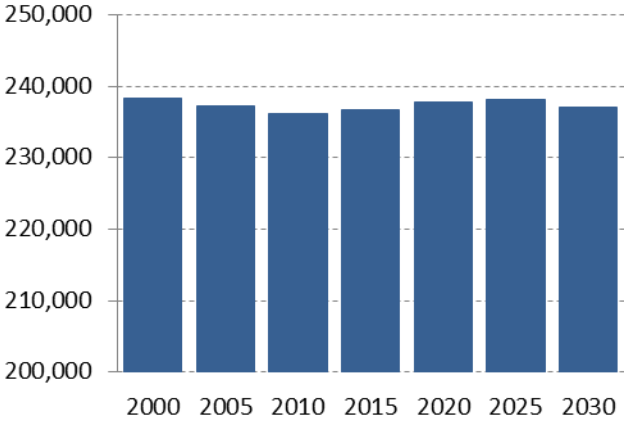
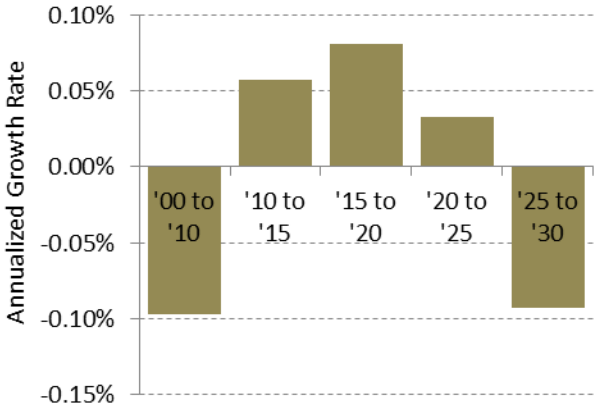


Figure 3.1c
Annualized rates of population change

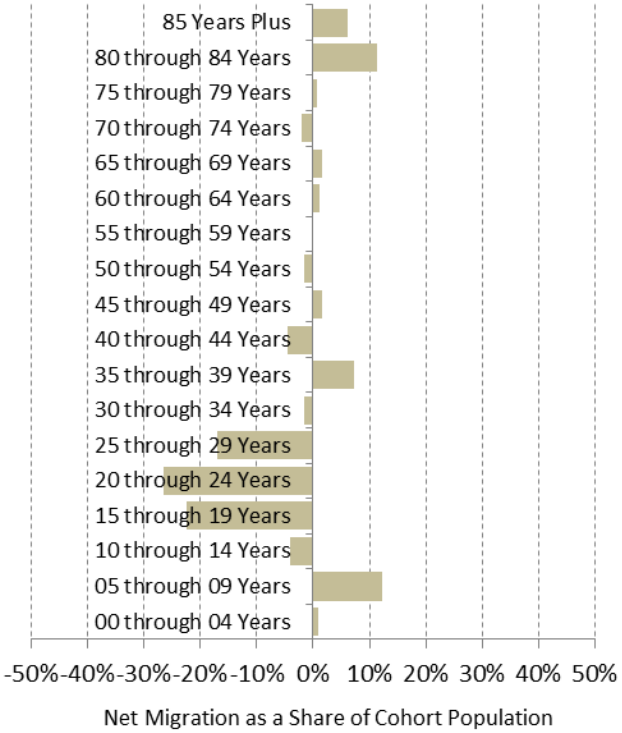


The Sources of Population Change

Table 3.1
Summary Results: Estimated Components of Population Change, Berkshire/Franklin Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	237,222	236,058	236,728	237,689	238,078
Births	10,833	10,526	9,644	9,364	9,131
Deaths	11,513	12,844	13,798	14,753	16,031
Natural Increase	*-680*	*-2,318*	*-4,154*	*-5,389*	*-6,900*
Domestic In-migration, MA & Border	33,955	34,169	34,770	34,766	34,935
Domestic In-migration, Rest of U.S.	13,245	13,492	13,990	14,432	14,888
Domestic Out-migration	54,040	52,557	49,939	48,025	47,285
Net Domestic	*-6,840*	*-4,896*	*-1,179*	*1,173*	*2,538*
Residual (Actual - Predicted Ending Pop.)	6,356	7,884	6,294	4,605	3,254
Ending Population	236,058	236,728	237,689	238,078	236,970

Figure 3.1d
Age profile of net domestic migrants, 2005 to 2010



Domestic out-migration has been the Berkshire/Franklin region's major source of population loss in recent years (Table 3.1). From 2005 through 2009, the region lost 54,040 residents due to domestic out-migration, while gaining only 47,200 new residents from other regions in the U.S. In the recent past, these out-migrants have predominantly been teens and young adults – groups presumably leaving the region for college or to seek job prospects elsewhere (Figure 3.1d). The region tends to gain new residents in the 35 to 39 age cohort, along with their pre-teen children. It is also an attractive destination for the elderly. Among the domestic in-migrants, over 70% moved into the Berkshire/Franklin region from other areas of Massachusetts and bordering states (Table 3.1).

Assuming the Berkshire/Franklin region remains an attractive lifestyle and retirement destination, the continued in-migration of thirty-somethings and the elderly is expected to partly offset the population loss due to out-migration of youth (Figure 3.1e). Starting around 2020, domestic in-migration will begin to surpass domestic

out-migration coinciding with the aging of the millennials into their thirties and the expansion of the U.S. elderly population. The steady decrease in out-migration shown in Figure 3.1e is largely the result of the shrinking number of 15 to 29 year-olds in the region. So while we assume that the *rates* of youth out-migration are constant over time, the total number of out-migrants is expected to slow as the millennials begin to age out of their teens and twenties. In short – there will be fewer young people moving into the high-out-migration cohorts, resulting in less out-migration.

A smaller portion of the region's recent population loss is due to natural decline, i.e. more deaths than births, although natural decline is expected to play a much larger role in population loss in the years ahead. Between 2005 and 2010, there were 10,833 births in the region, compared to 11,513 deaths, resulting in a net loss of 680 residents. Over time, we anticipate a steady increase in deaths coupled with a slight decline in the number of births (Figure 3.1f). Generally, the number of deaths rises with an aging population. This is particularly true in regions, such as the Berkshire/Franklin region, with a large and growing population aged 70 years and older—ages where mortality rates begin to show a marked increase.

Figure 3.1e
Projected levels of domestic in and out-migration, 2005 to 2030

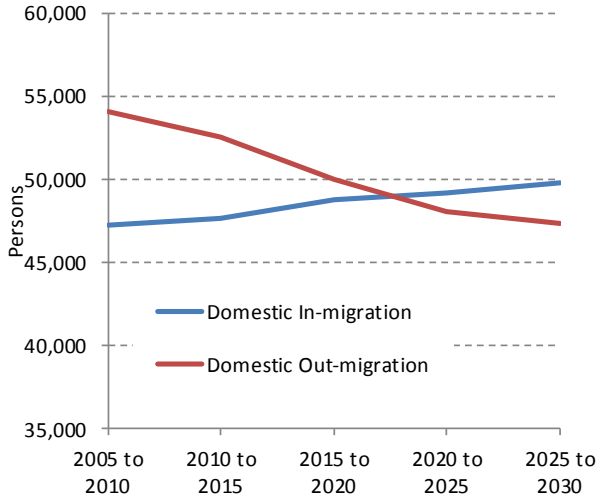
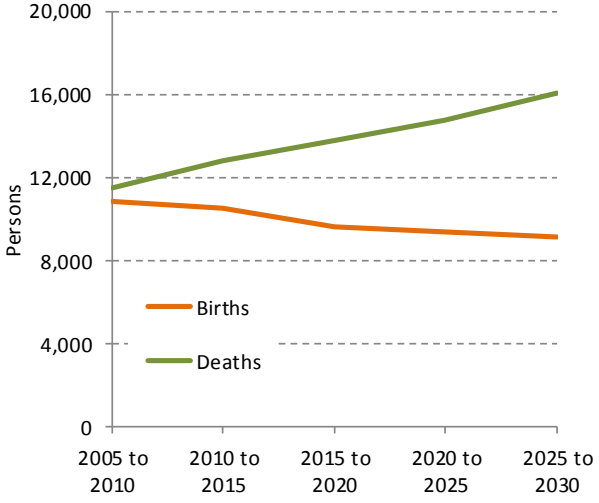


Figure 3.1f
Projected levels of births and deaths, 2005 to 2030

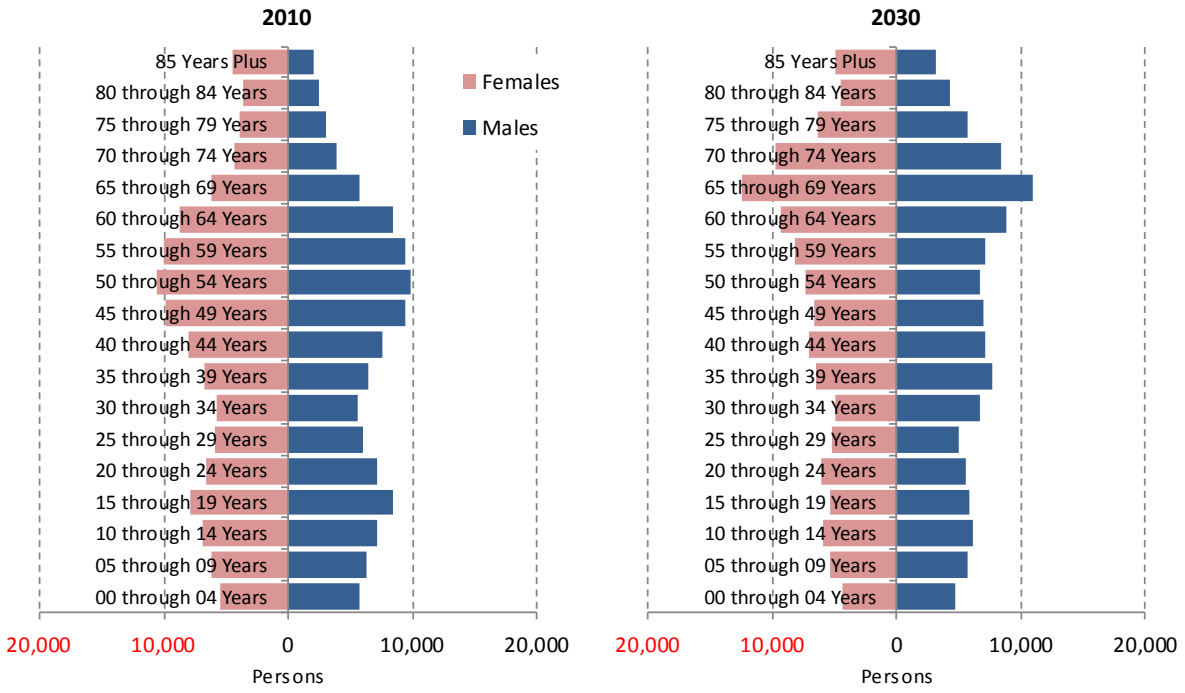


The out-migration of youth, importation of retirees and older residents, and the general lull in young families combine to paint a portrait of the Berkshire Region that is relatively old and getting older. In 2010, a third of the region's population was between the ages of 45 to 64 - roughly analogous to the baby boomer generation. We also find a secondary concentration (21%) between the ages of 10 and 25— associated with the millennial generation or echo boomers (Figure 3.1g). By 2030, the baby boomers will have moved into 65 and older cohorts, with the millennials entering their thirties. The aging of the millennials is less pronounced than their boomer parents because many leave the region rather than age in place. Also pertinent is the relative scarcity of residents between 20 and 30 years old in the region in 2010 – the age where we might expect

people to start their families over the coming decade.

Assuming recent trends persist, the Berkshire/Franklin population of the next 30 years will be considerably older than today. In 2010, roughly 33% of the region's population was 55 years old or older. By 2030, this share will increase to 43%. Over the next twenty years we expect stagnancy or a relative decline in the population share of nearly all cohorts except those between 60 and 84 years old. We also expect slight increase in the population share of 30- to 40-year-olds by 2030 – namely due to the aging in-place and in-migration of millennials.

Figure 3.1g
The age and gender composition of the Berkshire/Franklin population, 2010 (actual) vs. 2030 (forecasted)



2. Cape and Islands Region

Summary

The Cape and Islands region covers the eastern-most reaches of the Commonwealth, including 23 communities in Barnstable, Dukes and Nantucket counties. Its largest (year round) population centers are Barnstable and Falmouth (Figure 3.2a).

Between 2000 and 2010 the Cape and Islands region experienced a net loss of just over 4,000 residents, much of which was due to the out-migration of youth and a large number of deaths characteristic of an older resident population. Despite past trends of decline, our models predict a slight rebound in the regional population in the latter half of this decade. By 2030, the resident population will reach 249,438 persons, exceeding its size as measured at the time of the 2000 Decennial Census (Figure 3.2b).

Recent trends of gradual population loss are expected to continue through 2015 after which the region will experience a slight upswing in population. This growth will be largely driven by aging baby boomers moving into the area for retirement and a slowdown in the outflow of young adults. Population growth will be fastest between 2015 and 2020, with an annualized growth rate close to 0.3% (Figure 3.2c). These gains will likely only be temporary, as the higher death rates and slowing birth rates associated with an aging population eventually overtake gains from migration.

Figure 3.2a
The Cape and Islands Region

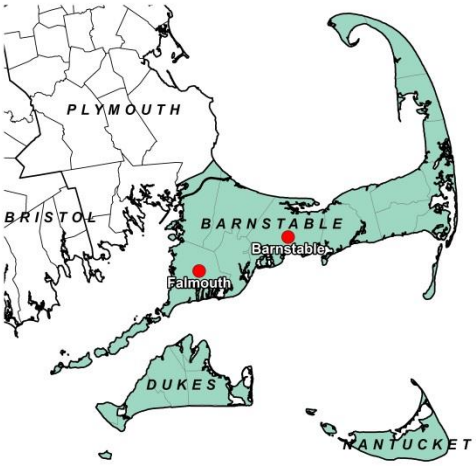


Figure 3.2b
Recent and projected population, Cape and Islands Region

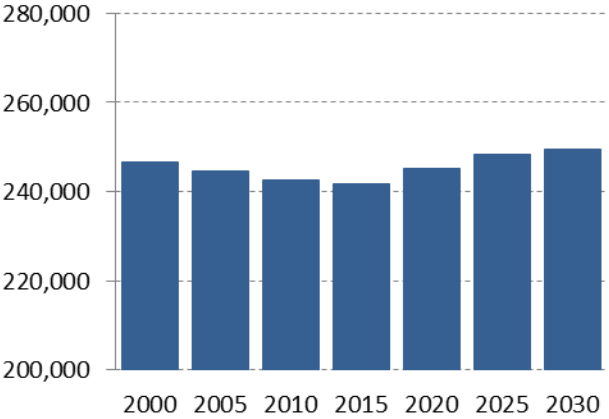
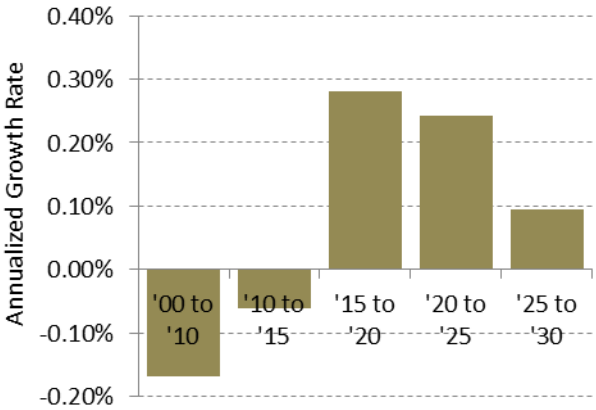


Figure 3.2c
Annualized rates of population change

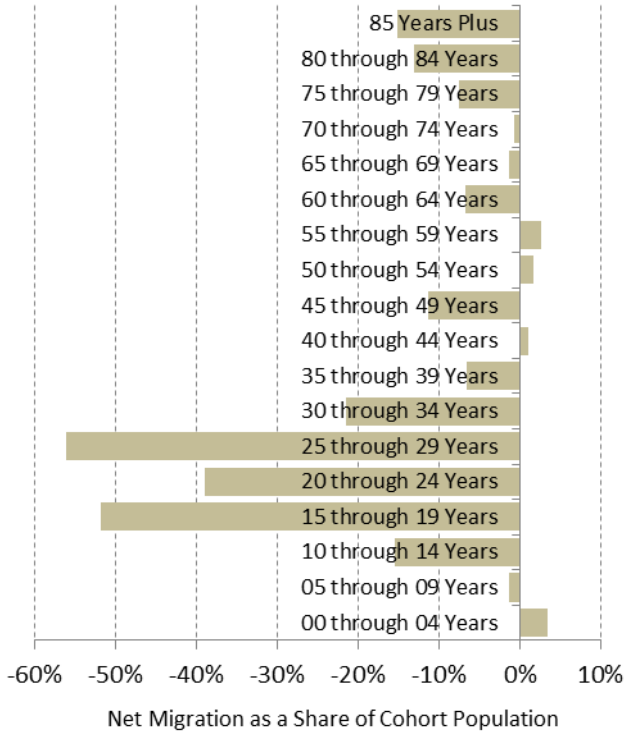


The Sources of Population Change

Table 3.2
Summary Results: Estimated Components of Population Change, Cape and Islands Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	244,673	242,595	241,866	245,278	248,257
Births	11,193	10,069	11,259	11,159	10,707
Deaths	13,959	15,972	16,640	17,652	19,339
Natural Increase	*(2,766)*	*(5,903)*	*(5,381)*	*(6,493)*	*(8,632)*
Domestic In-migration, MA & Border	26,600	26,778	27,584	27,849	27,941
Domestic In-migration, Rest of U.S.	15,105	15,604	16,212	16,670	17,244
Domestic Out-migration	70,055	66,273	62,165	59,647	58,376
Net Domestic	*(28,350)*	*(23,891)*	*(18,369)*	*(15,128)*	*(13,191)*
Residual (Actual - Predicted Ending Pop.)	29,038	29,065	27,162	24,600	23,004
Ending Population	242,595	241,866	245,278	248,257	249,438

Figure 3.2d
Age profile of net domestic migrants, 2005 to 2010



The main source of the Cape and Islands region's recent population loss has been domestic out-migration. Domestic migration accounted for a net loss of nearly 30,000 residents between 2005 and 2010 (Table 3.2). Out-migration is particularly high among the region's youth, many of whom presumably leave the region for college or job prospects in their late teens continuing through their twenties and thirties (Figure 3.2d). The only adult cohorts with net positive in-migration in the past decade were those in their fifties. Most of these new residents come from neighboring areas, with two-thirds of all new in-migrants re-locating from other regions in Massachusetts or bordering states. It is worth noting that population loss through domestic out-migration has been offset by a nearly equivalent population residual of just under 30,000 persons. This residual means that past estimates of population change based on domestic migration and natural increase tend to undercount the actual population, thus the model adjusts that total population upward to

compensate[11]. While we expect this residual to mainly reflect net international immigration, it also captures prediction error associated with past components of change and thus is difficult to interpret.

Our model predicts that population growth will temporarily eclipse population loss as many of the baby boom generation pass through their fifties in the coming decade. Figure 3.2e shows a gradual narrowing of the gap between domestic in- and out-migration over time. In-migration will increase slightly due to a greater number of U.S. and Northeast U.S. residents moving through their fifties in the coming years, the key demographic for people that tend to move to the Cape and Islands region. Out-migration rates will decline as the numbers of young residents and families - the age groups associated with out-migration from the Cape - continue to shrink. Note that the anticipated age profile of domestic migrants in 2030 still predicts net out-migration among persons in their teens, twenties and thirties, but the actual levels of out-migration among these cohorts will be far less than found for 2010. In short, there will be fewer teens and twenty-somethings in the future to leave the region. This turnaround, however, will be rather short-lived as the in-migration of older persons begins to slow and natural decline inevitably overtakes any migration-induced growth. The result will be a regional population that will be roughly the size it was back in 2000.

Figure 3.2e
Projected levels of domestic in and out-migration, 2005 to 2030

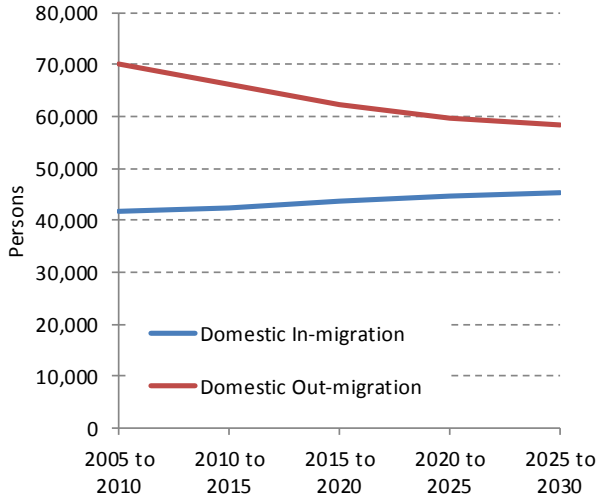
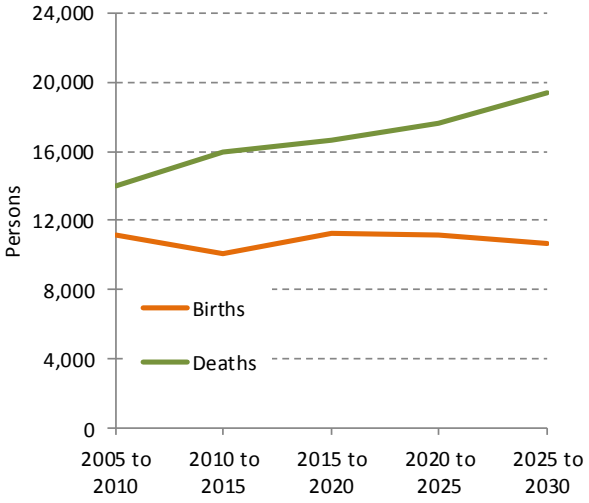


Figure 3.2f
Projected levels of births and deaths, 2005 to 2030



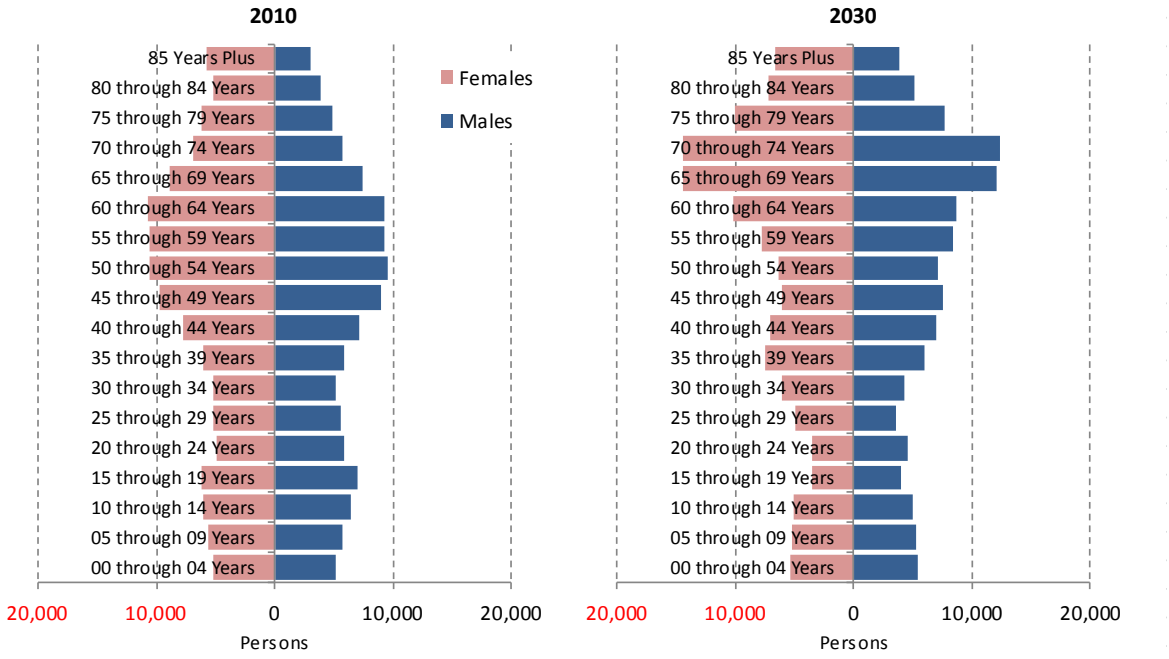
A smaller portion of the region's recent decline is through natural decrease, i.e. more deaths than births. Between 2005 and 2010, there were 11,193 births in the region, compared to 13,959 deaths, resulting in a net loss of nearly 3,000 residents due to natural decline. Over time the gap between births and deaths will continue to widen as young people continue to leave and older people continue move in (Figure 3.2f). With the number of births essentially flat over the next twenty

[11] For a full discussion of the residual component, see page 50 in Section IV of this report: *Technical Discussion of Methods and Assumptions.*

years, the gap between deaths and births will continue to widen. By the 2025-30 period, the region should expect a near 2:1 ratio of deaths over births with 19,339 deaths compared to 10,707 births. A longer time horizon (i.e. 2040, 2050) would like show an even greater rise in regional deaths, and likely a return to negative population growth, as the great population mass of baby boomers moves into their seventies and eighties, where mortality rates rise considerably.

The increasing number of deaths over births reflects a regional age profile that is notably older than both the state and the nation. Figure 3.2g shows a sizable population mass among persons 45 to 69 years old in 2010. In the Cape and Islands this group accounts for 40% of the regional population, compared to roughly 30% for the nation. There is also a far larger share of elderly residents in the Cape and Islands. In 2010, residents 70 years and older comprised 9% of the U.S. population compared to 17% of the Cape and Islands.

Figure 3.2g The age and gender composition of the Cape and Islands population, 2010 vs. 2030



The next twenty years will bring a sizable upward shift and consolidation of the population profile among persons in their sixties, seventies, and eighties. By 2030, roughly 37% of the population will be 65 years or older – compared to 24% in 2010. The region loses population in every cohort younger than 65, with the exception of the 35- to 39-year-old cohort (age as of 2030) which gains roughly 2,000 residents between 2010 and 2030 – namely due to the aging in place of millennials. The region is also underrepresented in all of the younger age cohorts. Of particular interest is the near absence of the children of the baby boomers (the millennials) as a secondary bulge in the 2010 population profile—as you might commonly find in other regions. This is a result of the massive out-migration of people moving into and through their college years and their twenties. However, unlike other regions, the young tend not to return the Cape and Islands as they approach their thirties and forties and start families of their own.

3. Central Region

Summary

The Central region lies on the western fringe of the 495 Corridor. It includes 46 communities—anchored by the city of Worcester, with secondary industrial/population centers, Leominster and Fitchburg, to the north (Figure 3.3a).

We anticipate continued population growth in the Central region over the next several decades. The Central region added just under 40,000 residents during the 2000s (Figure 3.3b), and is expected to grow from the 693,813 persons counted in the 2010 Census to nearly 760,000 by 2030.

The rate of population growth will slowly diminish as the number of death begins to rise with the aging of the regional population. Between 2000 and 2010, the Central region experienced a relatively robust annualized population growth rate of 0.6% per year (Figure 3.3c). By the end of our forecast period (2025 to 2030) the annualized rate is expected to slow to just below 0.2% percent per year.

Figure 3.3a
The Central Region

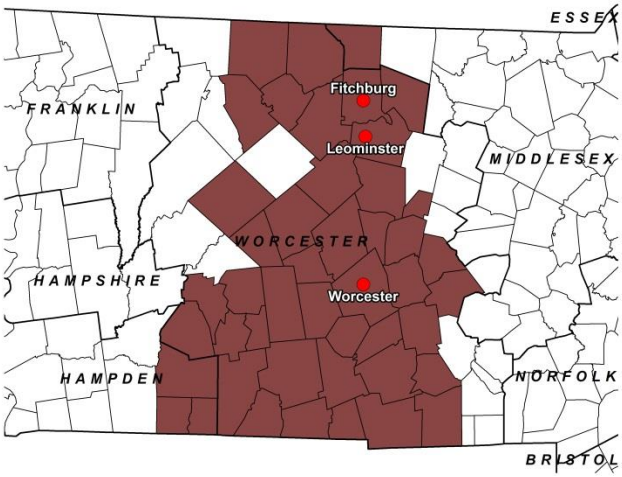


Figure 3.3b
Recent and projected population, Central Region

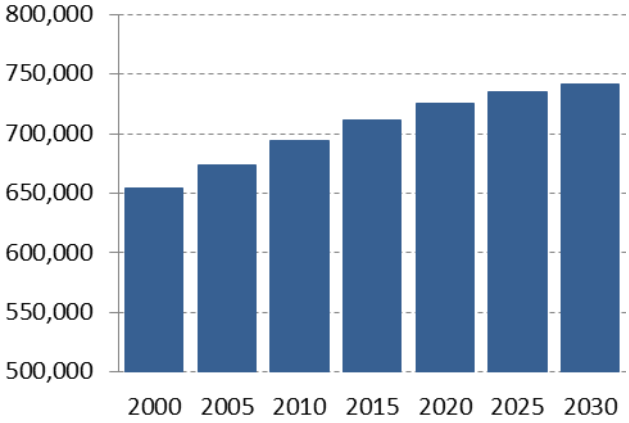
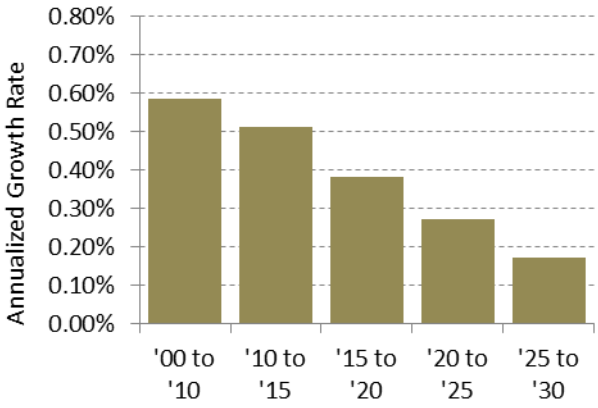


Figure 3.3c
Annualized rates of population change



The Sources of Population Change

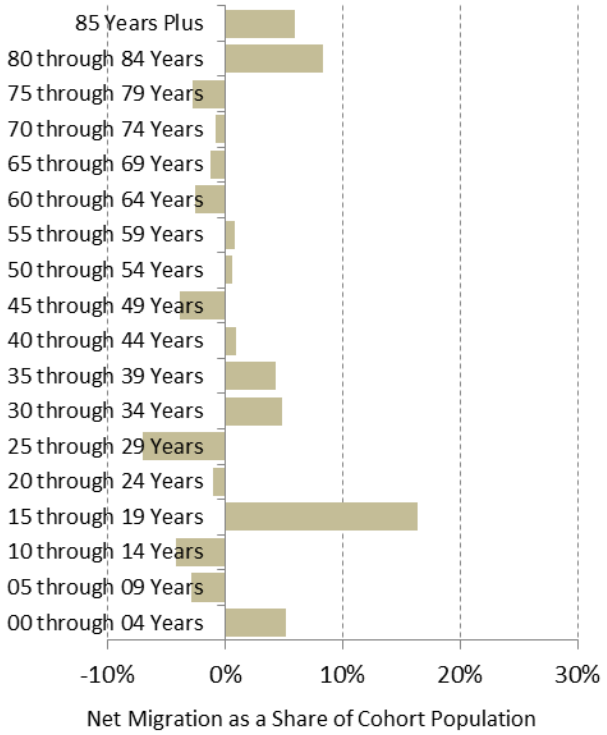
Table 3.3
Summary Results: Estimated Components of Population Change, Central Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	674,238	693,813	711,671	725,295	735,150
Births	42,155	41,444	41,912	41,909	41,222
Deaths	28,966	32,119	33,849	35,966	39,081
Natural Increase	13,189	9,325	8,063	5,943	2,141
Domestic In-migration, MA & Border	99,475	97,413	99,343	98,519	97,997
Domestic In-migration, Rest of U.S.	28,920	28,877	29,619	30,358	31,251
Domestic Out-migration	120,590	118,246	120,876	120,580	119,281
Net Domestic	7,805	8,044	8,086	8,297	9,967
Residual (Actual - Predicted Ending Pop.)	-1,419	489	-2,525	-4,385	-5,833
Ending Population	693,813	711,671	725,295	735,150	741,425

The growth of the Central region over the past decade was due to a combination of natural increase (more births than deaths) coupled with positive net in-migration of people moving from elsewhere in Massachusetts and the U.S. (Table 3.3). From 2005 to 2010, the Central region gained 7,805 more residents through domestic in-migration than it lost from domestic out-migration. Just over 75 percent of these domestic migrants came from other regions in Massachusetts and its bordering states. The rather small residual suggests a near balance in gains from international immigration and losses due to international emigration.

Home to several large colleges and universities, the Central region is a net importer of persons in the 15- to 19-year-old cohort (Figure 3.3d), although many leave the region following graduation, as suggested by net negative out-migration among those in their twenties. The region also appears to be a

Figure 3.3d
Age profile of net domestic migrants, 2005 to 2010



relatively attractive destination for elderly persons and those in their thirties—many of whom are families with young children.

The historic gap between domestic in- and out-migration is expected to continue into the foreseeable future (Figure 3.3e). If anything, our models will predict that the gap between in- and out-migration will expand slightly with the millennial population soon moving into its thirties and more in-migrant baby boomers moving into their seventies and eighties.

Figure 3.3e
Projected levels of domestic in and out-migration, 2005 to 2030

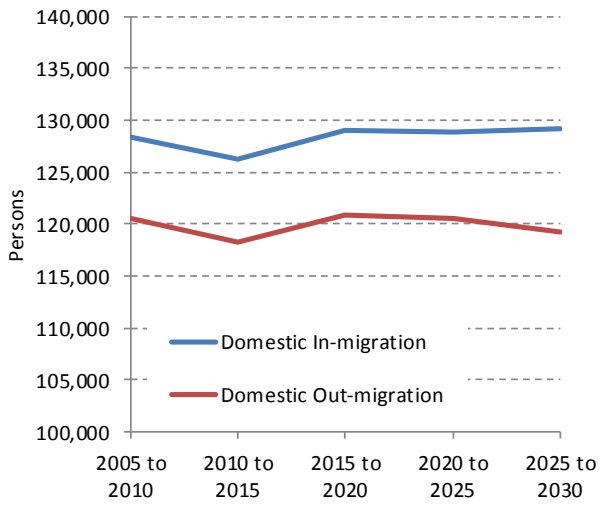
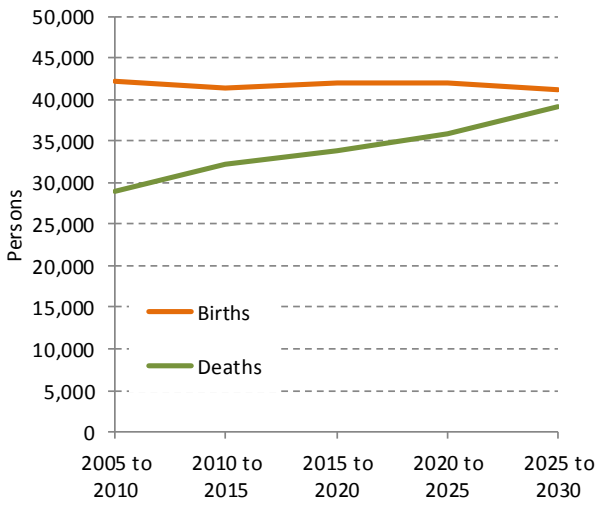


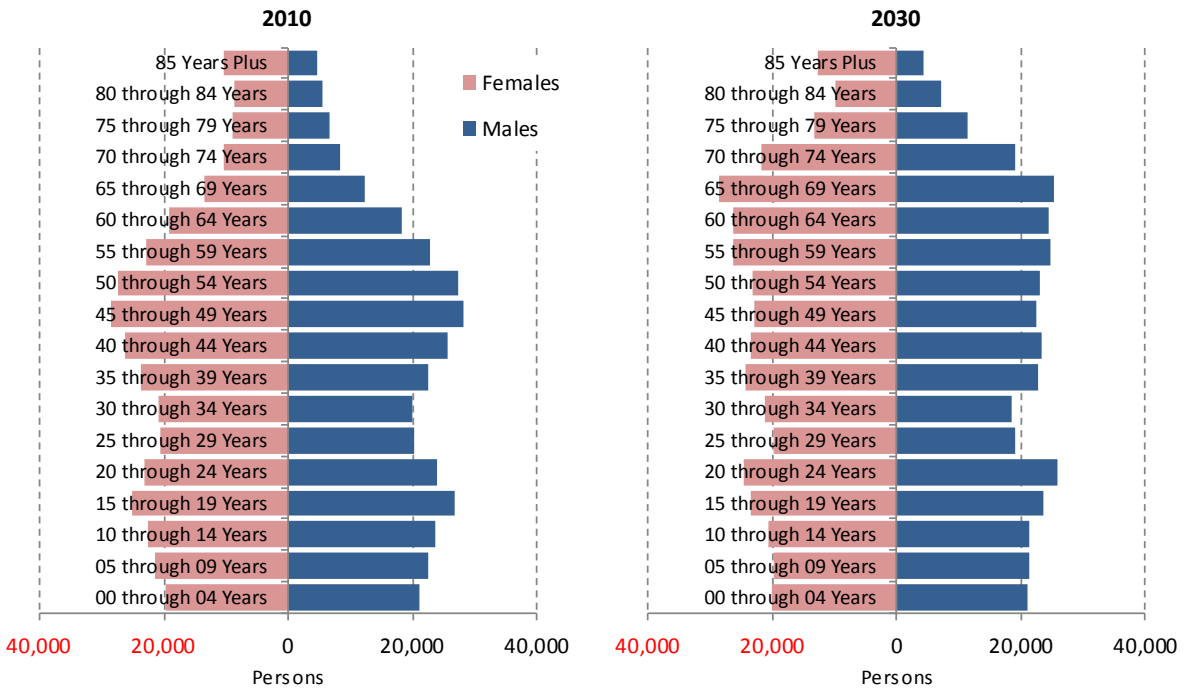
Figure 3.3f
Projected levels of births and deaths, 2005 to 2030



Natural increase was an even more dominant factor driving regional population growth over the 2000's. Between 2005 and 2010, there were 42,155 births in the region, compared to 28,966 deaths – resulting in a natural increase of just over 13,000 (Table 3.3). This reflects the age composition of the region which, as of 2030, had fairly substantial numbers of residents in their later twenties and thirties and relatively few elderly residents (Figure 3.3g).

The gap between births and deaths is expected to narrow over the next several decades, leading to a slowdown in the rate of population growth Figure 3.3f). The region continues to attract a steady stream of young families in their later twenties and thirties. Accordingly, the number of births is expected to hold steady over the next twenty years—hovering between 41,000 and 44,000 for each of the five year increments between 2010-2015 and 2025-2030. But the number of deaths is expected to rise with the aging of the population—growing from roughly 29,000 in the five-year span between 2005-09 periods to just over 39,000 by 2025-30. This coincides with the aging of the resident population, particularly the sizable baby boom generation which will begin moving into its seventies by 2030 (Figure 3.3g). A longer forecast would likely predict deaths to easily exceed births by 2040 as boomers move into their eighties, when mortality rates tend to make a dramatic rise, and as millennials move beyond the family starting portion of their life cycle.

Figure 3.3g
The age and gender composition of the Central region population, 2010 (actual) vs. 2030 (forecasted)



4. Greater Boston Region

Summary

The Greater Boston region is the major employment and population center of the Commonwealth of Massachusetts. It covers the entirety of Suffolk County, and extends into portions of Middlesex, Norfolk, and Essex counties. There are 36 municipalities in the Greater Boston region, including the cities of Boston, Cambridge, Quincy and Newton (Figure 3.4a).

Our long-term forecasts predict a steady increase in the Greater Boston population over the next 20 years, adding nearly 150,000 additional residents between 2010 and 2030 (Figure 3.4b). Population change in the Greater Boston region is driven by migration—particularly by the in-migration young adults. Population growth will be fastest in the next few years (Figure 3.4c) as the swell of millennials (the children of the baby boom generation) moves into and through their twenties. The region tends to lose residents to out-migration as they move through the family-building and retirement phases of life. Therefore, we expect population growth to slow in the 2020s as the millennials age into their thirties and early forties and more baby boomers enter their sixties and seventies. However, the region's population will continue to grow during this time – albeit at a slower pace—as international immigration and steady increases in births will more than offset population loss associated with domestic out-migration and a slight increase in the number of resident deaths.

Figure 3.4a
The Greater Boston Region

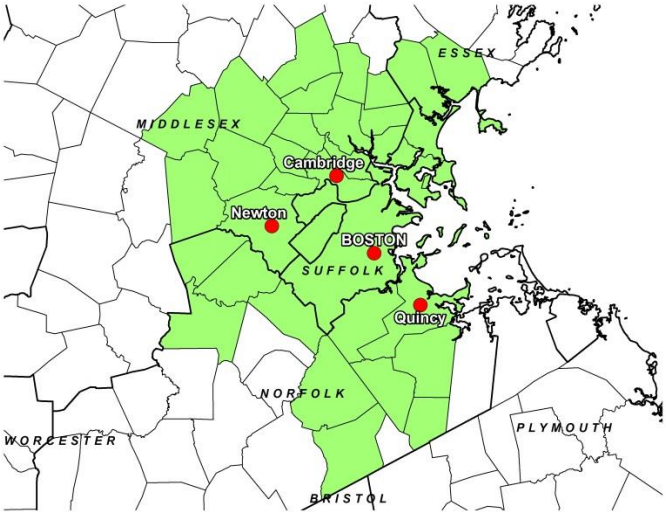


Figure 3.4b
Projected Population, Greater Boston Region

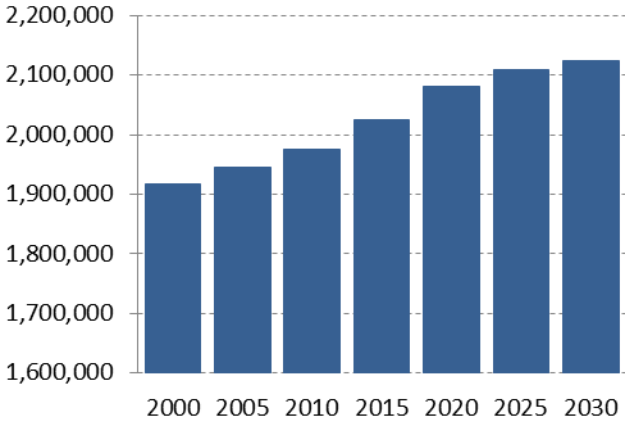
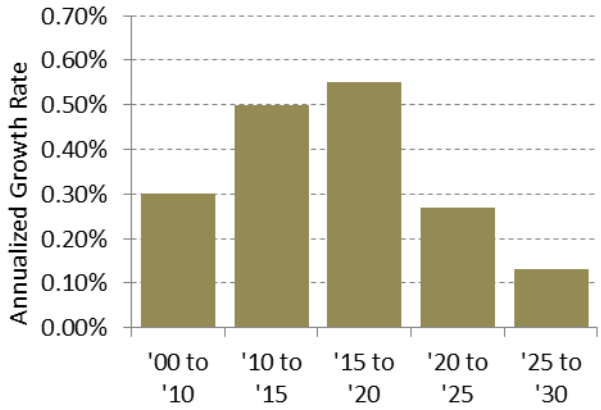


Figure 3.4c
Annualized rates of population change



The Sources of Population Change

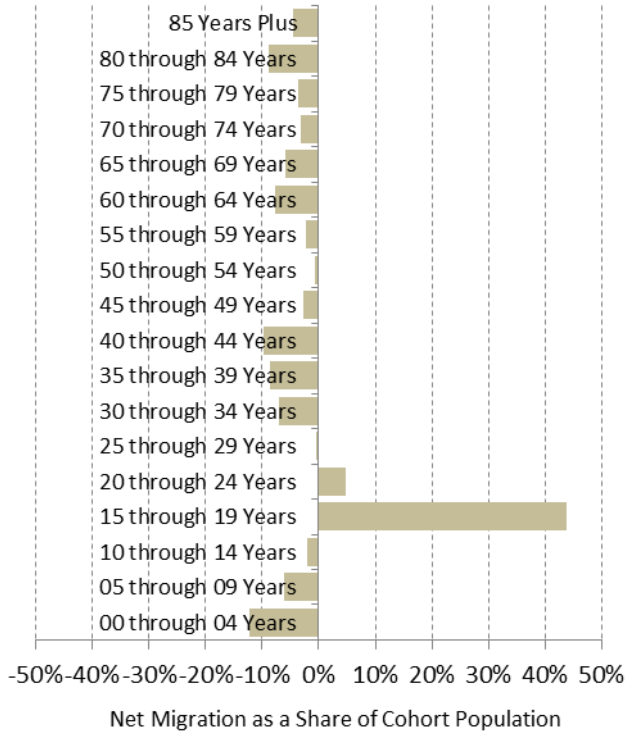
Table 3.4
Summary Results: Estimated Components of Population Change, Greater Boston Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	1,945,942	1,975,155	2,024,808	2,081,182	2,109,264
Births	122,374	123,710	132,135	136,953	136,705
Deaths	71,113	78,338	79,705	82,028	86,055
Natural Increase	*51,261*	*45,372*	*52,430*	*54,925*	*50,650*
Domestic In-migration, MA and Border States	303,920	308,034	330,303	324,015	318,746
Domestic In-migration, Rest of U.S.	222,590	224,963	230,705	234,369	238,223
Domestic Out-migration	547,465	530,536	552,980	567,474	569,114
Net Domestic	*-20,955*	*2,461*	*8,028*	*-9,090*	*-12,145*
Immigration (International)	153,105	145,506	151,274	156,502	156,701
Residual (Actual - Predicted Pop. Ending)	*-154,198*	*-143,686*	*-155,359*	*-174,255*	*-181,217*
Ending Population	1,975,155	2,024,808	2,081,182	2,109,264	2,123,253

The Greater Boston region added roughly 60,000 residents between 2000 and 2010, reflecting a modest annualized growth rate of 0.3%. Most of this growth was due to the combination of natural increase (births minus deaths) and international immigration (Table 3.4). On the domestic side, the region lost residents due to a higher level of domestic out-migration than in-migration between 2005 and 2010. Between 2005 and 2010, approximately 527,000 people moved into the Boston region from other places in Massachusetts and the U.S. This was more than offset by the out-migration of nearly 550,000 during this same period.

Domestic migration patterns in the Boston region are highly age-specific—driven by the massive in-migration of young adults followed by steady out-migration of

Figure 3.4d
Age profile of net domestic migrants, 2005 to 2010



residents as they age, taking their children with them (Figure 3.4d). People come to Boston in their late teens and early twenties for education, economic opportunities, or the cultural amenities of urban life. There is no mass exodus immediately after graduation, but rather a steady outflow through the upper age-cohorts. A good number of young adults stay through their twenties (thus contributing to a steady number of births), but as they age into their thirties they are increasingly more likely to move out of the region. The rates of net-out-migration are particularly high among those in their thirties and early forties (young families) as well as among those nearing or in retirement age.

The Boston region is also more of a national (and international) draw compared to other areas of the state. While the majority (58%) of in-migrants do come from Massachusetts or neighboring states, in most other regions this "local" share represents more typically between 65 to 75 percent of all domestic migrants. For this reason, the effect of migration on the region's population change depends on generational shifts in the age profile of the U.S. as a whole to a much larger extent than do the other Massachusetts regions. International migration is also a major factor in understanding population change in the Greater Boston region. Because of the large size of the region, we are able to separately estimate the number of international immigrants and their contribution to population change. We estimate that immigration contributed 153,105 new area residents between 2005 and 2010. Data limitations prohibit us from directly estimating emigration— existing residents that move to other countries. The negative residual of 154,198 is a near balance to the gains made by immigration. While we expect much, if not most, of the residual is due to emigration, we cannot say for sure.

Natural increase has also been a major contributor to the growth of Greater Boston region in recent years. Births greatly exceed deaths—leading to a net natural increase of over 51,000 residents between 2005 and 2010. Compared to other regions, the elderly comprise a relatively small share of the Greater Boston population. Also, the region's large numbers of residents in their twenties results in a sizable number of births – although many choose to leave Greater Boston soon after starting a family, as evidenced by high out-migration rates among those under 4 years old (Figure 3.4d). The aging of the baby boomer generation will eventually lead to an increase in death rates in the Greater Boston region – although the increase will be rather gradual and will have a less dramatic impact compared to other regions in the state.

Given these recent trends in domestic and international migration, natural increase, and the age profile of the region and the nation, our models anticipate continued growth in the Greater Boston population over the next twenty years, but with considerable variance in the pace of that growth over time. Population growth will accelerate in the next few years but will gradually diminish. The initial rise is driven by the continued in-migration of millennials entering college between 2010 and 2015. This is coupled with a modest decline in domestic out-migration with relatively few residents moving through age cohorts associated with a high likelihood of out-migration (Figure 3.4e). The recent recession and slow recovery may also factor into this temporary reversal, as many decide to postpone moving or buying a home in conditions of economic uncertainty.

However this period of positive net domestic migration will only be temporary. The national pool of college entrants will begin to shrink after 2015, as the peak of the millennial generation (currently

in the 15- to 24-year-old cohorts) moves beyond college age. While we expect that the region's world-class colleges and universities and a recovering job market will to continue to draw domestic and international migrants to the region, the aging millennials and retiring baby boomers will increasingly move out of Greater Boston, leading to a return to net domestic out-migration for the remainder of the forecast horizon. With more twenty- and thirty-year-olds expected in the region in the next few decades, there will also be more babies. We predict a steady increase in births over the next two decades as the millennial cohort ages (Figure 3.4f). Although the rise in births will be nearly matched by an increase in deaths among older cohorts, the difference between births over deaths will persist and largely accounts for the continued growth of the region despite increasing loss due to net out-migration.

Figure 3.4e
Projected levels of domestic in and out-migration, 2005 to 2030

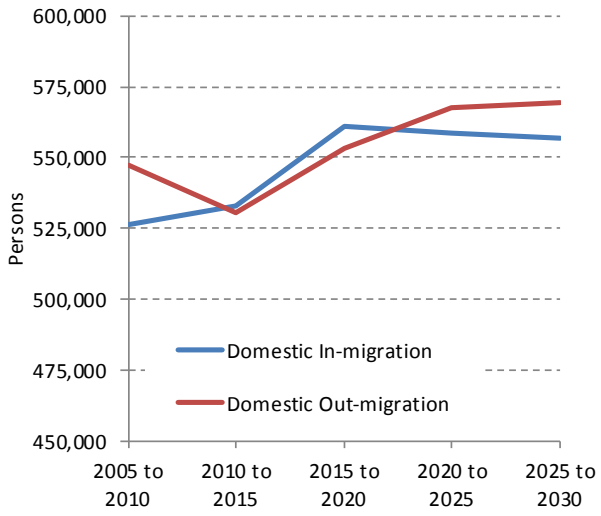
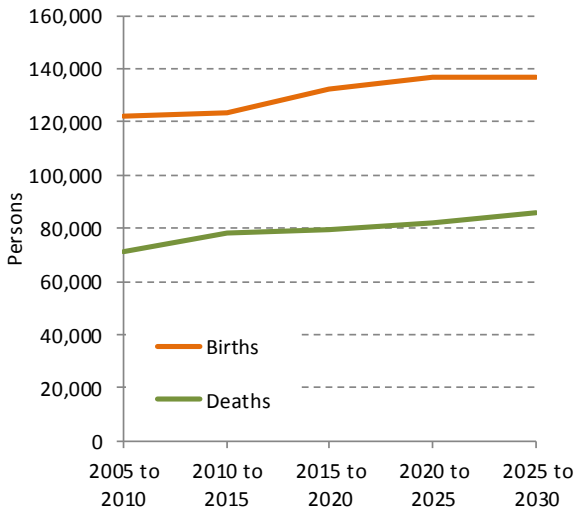


Figure 3.4f
Projected levels of births and deaths, 2005 to 2030

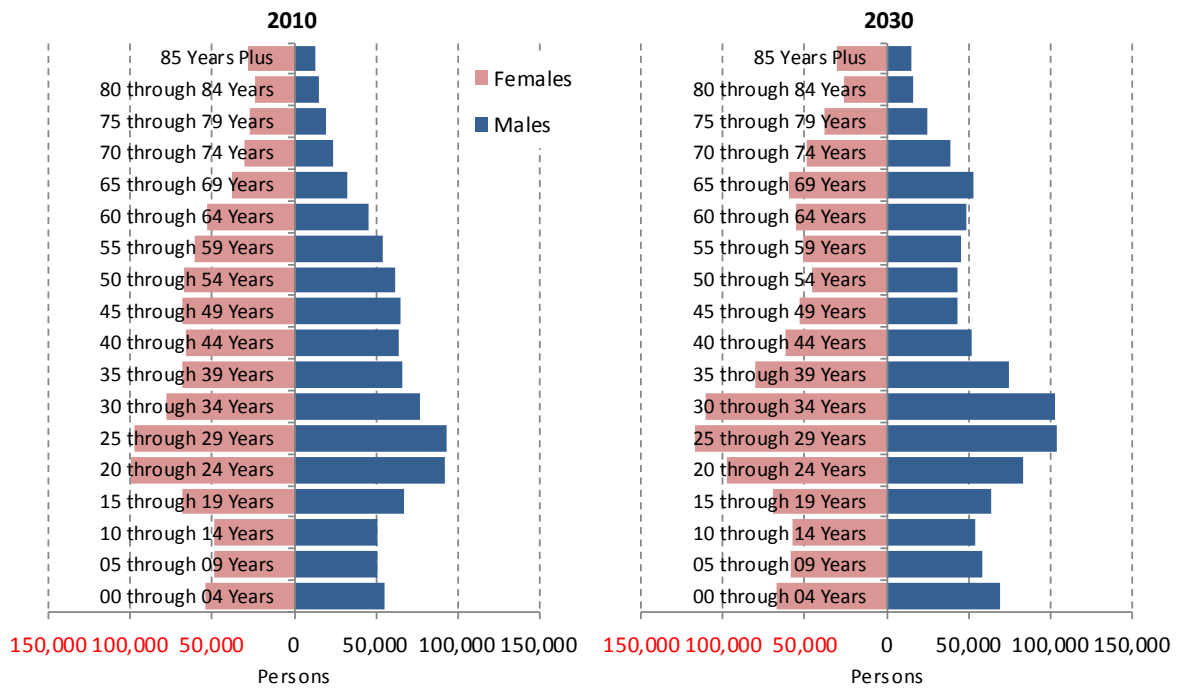


Due to its rather unique age-specific migration patterns, the Greater Boston region is exceptionally young relative to other regions in the Massachusetts. Greater Boston lacks the typically hourglass shape of the national age profile – with the sizable baby boom generation (people their fifties and early sixties as of the 2010 census) barely showing as a bubble in the region's age profile (Figure 3.4g). Instead, Greater Boston has a rather unimodal age distribution peaking among residents in their early twenties and declining in a near linear fashion thereafter.

Greater Boston's population distribution remains fairly steady within age cohorts over time. Whereas changes in the profile of most regions are dominated by the aging in place, in Greater Boston education and opportunity draw a consistent number of young adults. Many leave as they age, only to be replaced by a new cohort of young coming in. While this makes Boston's demographic profile rather unique among New England regions, it does not divorce them from the influence of broader national demographic trends, such as the aging of the baby boomers and their children.

As the millenials pass through their twenties into their thirties, we expect a slight upward shift in the overall age distribution of the Greater Boston Region – peaking in the 25 to 34 year range. There will be relatively more infants and pre-schoolers under the age of five, growing from 5.6% of

Figure 3.4g
The age and gender composition of the Greater Boston region, 2010 (actual) vs. 2030 (forecasted)



the population in 2010 to 6.4% percent in 2030 (Figure 3.4g). There will also be a relatively higher share of recent retirees (65- to 74-year-old cohort) coinciding with the aging in place of the baby boomer generation. The relative increases in these cohort will be countered by a large loss in the middle-aged cohorts, those roughly between the ages of 40 to 60 years old. Although there are fewer U.S. residents that will be approaching college age in the next few decades, we anticipate only a small decline in the region's population share of 15- to 19-year-olds over the next twenty years.

5. Lower Pioneer Valley Region

Summary

The Lower Pioneer Valley region is located in the west-central portion of the Commonwealth. It follows the Interstate 91 corridor from the Connecticut state line, northward through Hampden and Hampshire counties, terminating in the lower portion of Franklin County. The region includes 29 municipalities, with primary employment and population centers in Springfield, Chicopee and Holyoke (Figure 3.5a).

The Lower Pioneer Valley experienced slow growth in population over the last decade (Figure 3.5b). This growth was partly the consequence of a particularly large college-age population attending one of the many post-secondary educational institutions in the region. However, over the next two decades the pool of college age students in the U.S. and Northeast will shrink, and the region is not expected to sustain the exceptionally large student population of recent years. The numbers of deaths in the region will also overtake new births, consistent with the region's aging population and relatively small proportion of young families in their thirties and early forties. Thus, we expect a slight reversal of recent growth trends after 2015. During the 2000s the annualized population growth rate was close to 0.2%. Between 2010 and 2030 the region will shrink at an annualized rate of-0.1% (Figure 3.5c). Given such trends, our model predicts that by 2030 the region will have approximately 580,000 residents, slightly below its size as measured in the 2000 Census.

Figure 3.5a
The Lower Pioneer Valley Region

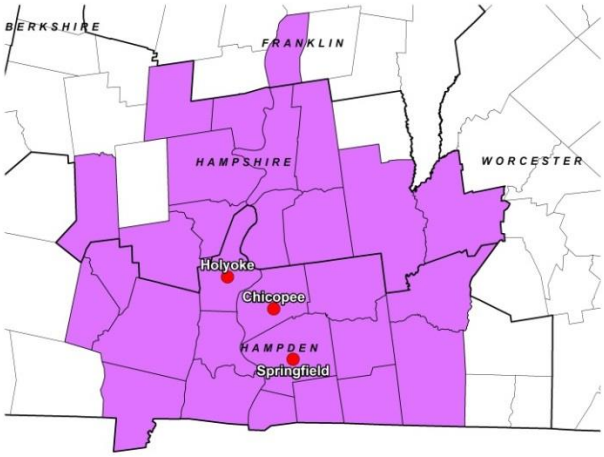


Figure 3.5b
Projected Population, Lower Pioneer Valley Region

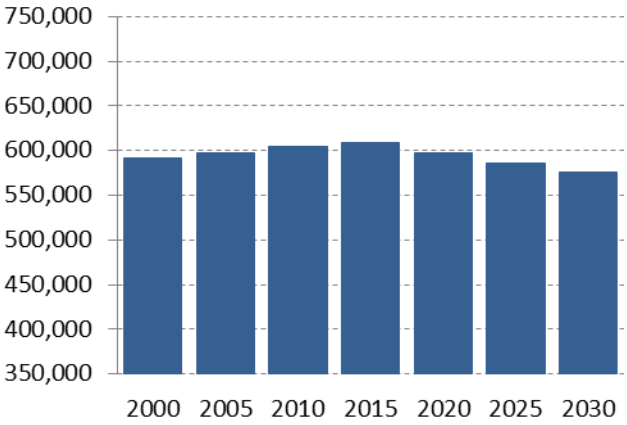
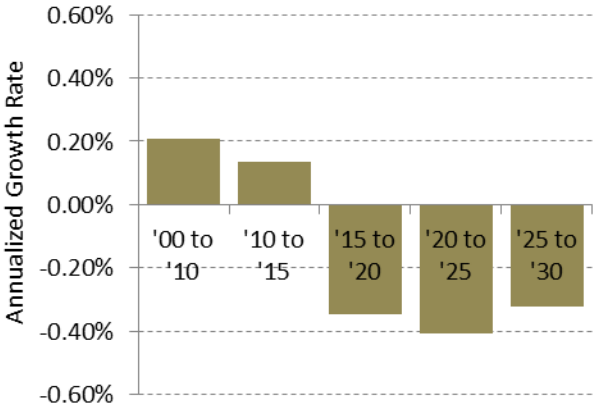


Figure 3.5c
Annualized rates of population change



The Sources of Population Change

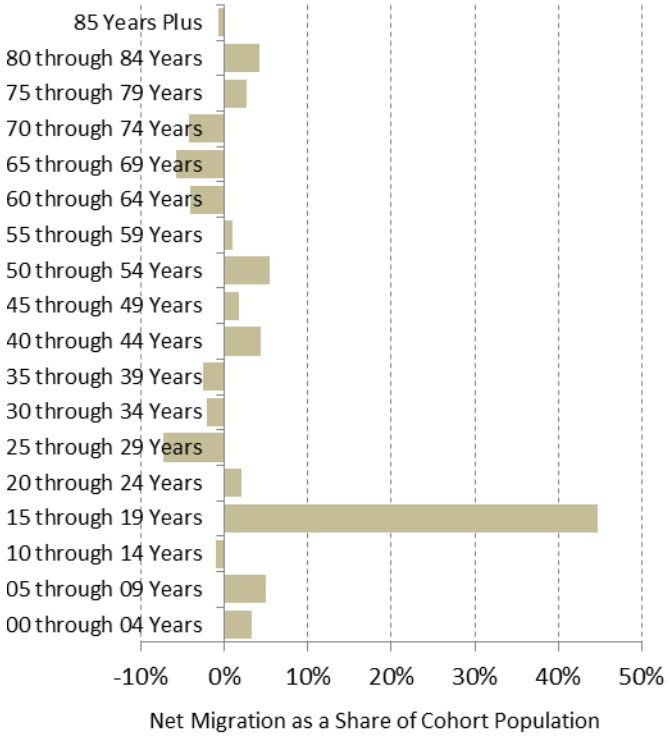
Table 3.5
Summary Results: Estimated Components of Population Change, Lower Pioneer Valley Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	598,128	604,304	608,446	598,040	585,918
Births	33,827	34,829	29,006	28,022	27,701
Deaths	26,748	29,507	30,081	31,120	33,063
Natural Increase	7,079	5,322	-1,075	-3,098	-5,362
Domestic In-migration, MA & Border	83,410	82,029	81,798	80,523	80,396
Domestic In-migration, Rest of U.S.	46,745	46,958	47,911	48,695	49,841
Domestic Out-migration	103,320	103,326	107,849	105,520	102,560
Net Domestic	26,835	25,661	21,860	23,698	27,677
Residual (Actual - Predicted Ending Pop.)	-27,738	-26,841	-31,191	-32,722	-31,687
Ending Population	604,304	608,446	598,040	585,918	576,546

The Lower Pioneer Valley region added just over 12,000 residents between 2000 and 2010 – due to a combination of natural increase (more births than deaths) and net domestic in-migration (Table 3.5).

Domestic migration is heavily concentrated among college age students. More than 50% of all domestic in-migrants between 2005 and 2010 were between 15 and 25 years old (Figure 3.5d). However, a large number leave the region after completing their studies –reflected by a net migration rate closer to zero in the 20 to 24 year cohorts and a negative net migration rate among those 25 to 39 years of age. The sizable student population results in a higher portion of domestic in-migrants coming from outside the Northeast. Between 2005 and 2010, 64% of all domestic in-migrants came from Massachusetts or one of its bordering

Figure 3.5d
Age profile of net domestic migrants, 2005 to 2010



states. Although a majority, this share is among the lowest of all regions in the state. Therefore, the future size of the region is heavily influenced by not only regional demographic trends, but also national and international ones.

Over the next 10 years we anticipate a small narrowing of the gap between domestic in- and out-migration, reducing the overall positive net domestic migration that helped fuel the region's growth during the 2000s (Figure 3.5e). The large pool of college age students in the Northeast and U.S. that increased enrollments in the past few years will begin to shrink after 2015, however this will only have a small overall impact on the overall size of the Pioneer Valley population. We expect a temporary increase in out-migration by 2015-2020, as resident millennials begin moving into their late twenties and early thirties – a time when they are increasingly prone to leave the region. By 2025-2030 we should anticipate a greater number of new residents in the thirties and forties, and with them more young children under the age of ten (Figure 3.5e). There is also a notable tendency toward out-migration among those approaching retirement age. With a large portion of the region's population soon moving into the retirement phases of their life cycle, the anticipated out-migration of baby boomers is a major factor behind of the population loss we predict in the next several decades.

Much of the anticipated decline of the near future is attributable to a slowdown in births and a corresponding increase in the number of deaths (Figure 3.5f). From 2005 to 2010, the region had 7,079 more births than deaths. However, the number of births in the current decade is expected to decline, with a shrinking number of young families in the region, while the number of deaths will steadily rise with an aging population. Sometime between 2015 and 2020 the number of deaths will overtake births, and by 2025-2030 the region will experience a population loss due to nature decline of roughly 5,000 persons.

Figure 3.5e
Projected levels of domestic in and out-migration, 2005 to 2030

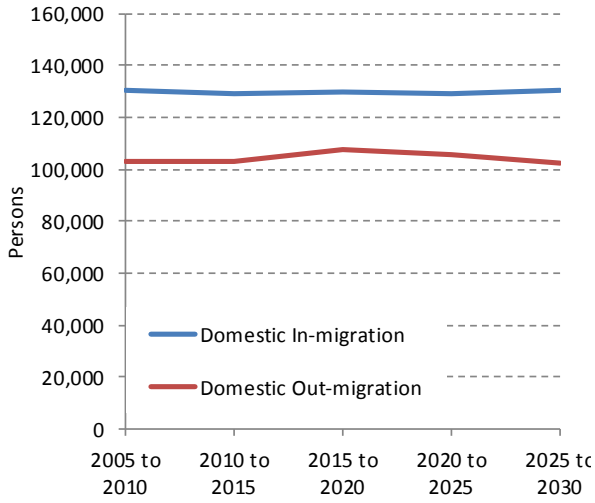
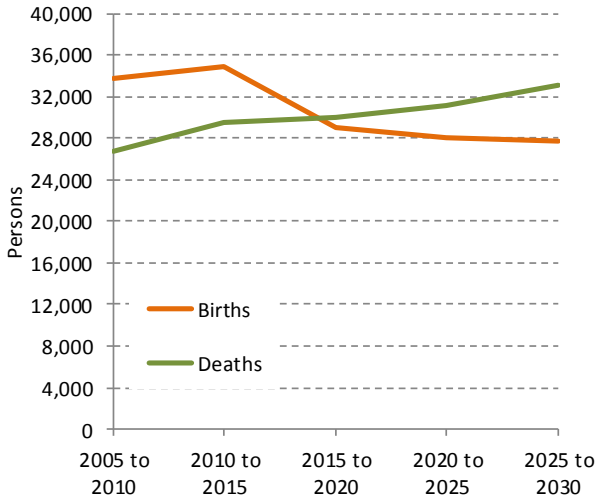
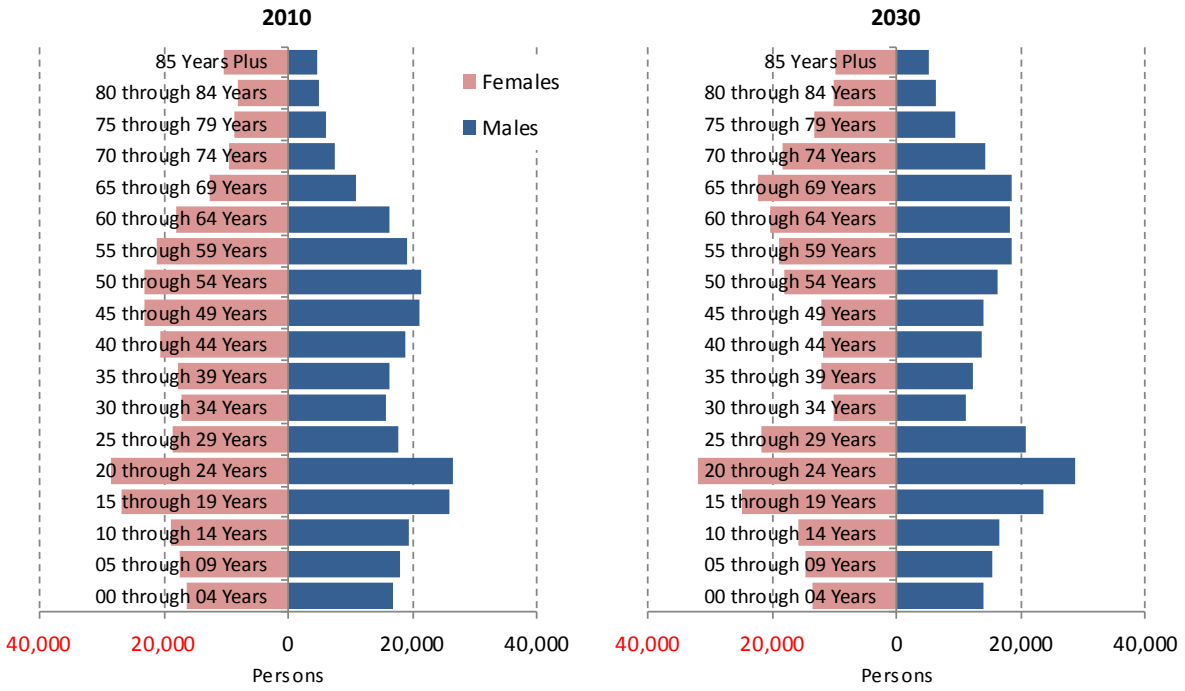


Figure 3.5f
Projected levels of births and deaths, 2005 to 2030



The dominance of the college population in the region is also apparent in the overall age distribution of the population. In most regions, the population age distribution is dominated by the baby boom generation (roughly 45 to 64 years old in 2010). This is not true for the Lower Pioneer Valley. Although there are still many boomers, they are eclipsed by an even larger concentration of 15- to 24-year-olds (Figure 3.5g). While some of these will be children of resident baby boomers, most are students from other regions. Also, unlike other age cohorts that tend to age in place and progress into older age cohorts with the passage of time, the size of the college age population in the Lower Pioneer Valley remains fairly constant over time. By 2030, there also be will be far more residents their sixties and seventies and notably fewer residents in their thirties, forties as well as a smaller number of children below the age of 14.

Figure 3.5g
The age and gender composition of the Lower Pioneer Valley, 2010 (actual) vs. 2030 (forecasted)



A rather large portion of past and anticipated population change in the Lower Pioneer Valley is attributed to the residual component. The residual is difficult to interpret, because it serves as an adjustment factor to keep future population counts from diverting too radically from past trends. The negative residual suggests that estimates based on births, deaths, and domestic migration over the 2000s would grossly over-predict actual population counts of the Lower Pioneer Valley in 2010. Some of this may be reflect net outflows of international residents, but some may also account for estimation error in one of the other components, such as student migration.[12] Our model accounts for this by downward adjusting future population projections. However, the existence of a large

[12] Even with the best information available; estimating the migration patterns of the student population is notoriously difficult. This is due to the fluid nature of their residency and the inability to measure the emigration behavior of international students. Furthermore, the size of the student population is dependent on a host of unknown administrative and policy decisions (such as enrollment standards/targets, student VISA policies, and funding for higher education both in the U.S. and abroad, etc.).

residual should serve as a warning against a strict interpretation of our long-term projections as definite.

6. MetroWest Region

Summary

The MetroWest region lies at the western fringe of the Boston metro area, occupying much of the area between the outer and inner loop highways (Interstates 495 and 95/Route 128, respectively). There are forty-five communities in the MetroWest region, including its most heavy populated centers of Framingham, Marlborough, and Natick (Figure 3.6a).

The steady growth of the MetroWest region over the past decade is expected to continue into the foreseeable future, although at a slightly slower pace (Figures 3.6b and 3.6c). The MetroWest region added nearly 30,000 residents between 2000 and 2010, for an annualized growth rate of just below 0.5% per year. By 2030, the region will add approximately 40,000 additional residents over the 655,126 measured at the time of the 2010 Census, representing an annualized growth rate of roughly 0.3% per year.

This growth will be the result of a combination of factors: a steady increase in domestic in-migration coupled with slight decline in domestic out-migration; continued international immigration; and a slight increase in new births. This growth will be partly offset by a steady rise in the number of deaths, coinciding with the aging of the region's population.

Figure 3.6a
The MetroWest Region

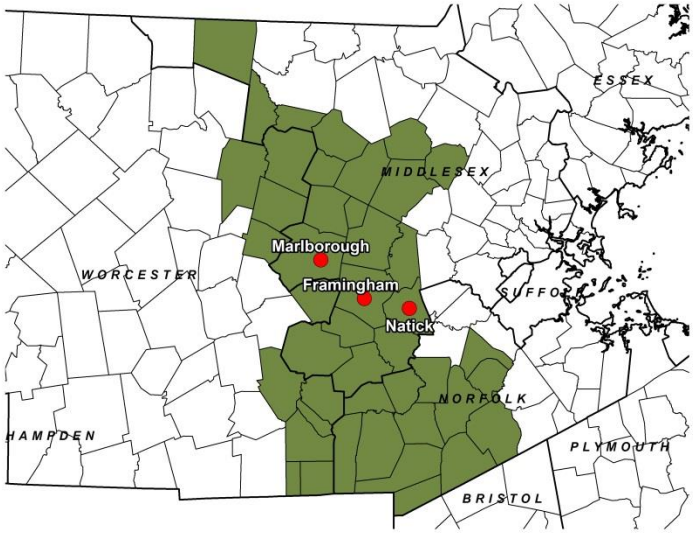


Figure 3.6b
Projected Population, MetroWest Region

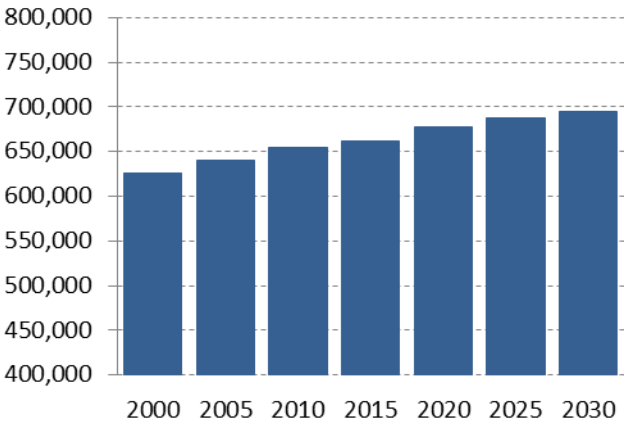
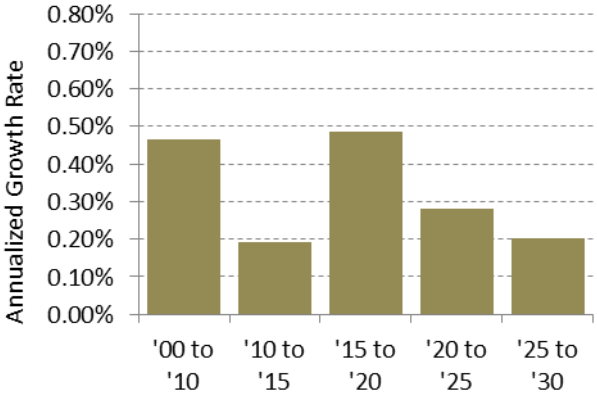


Figure 3.6c
Annualized rates of population change



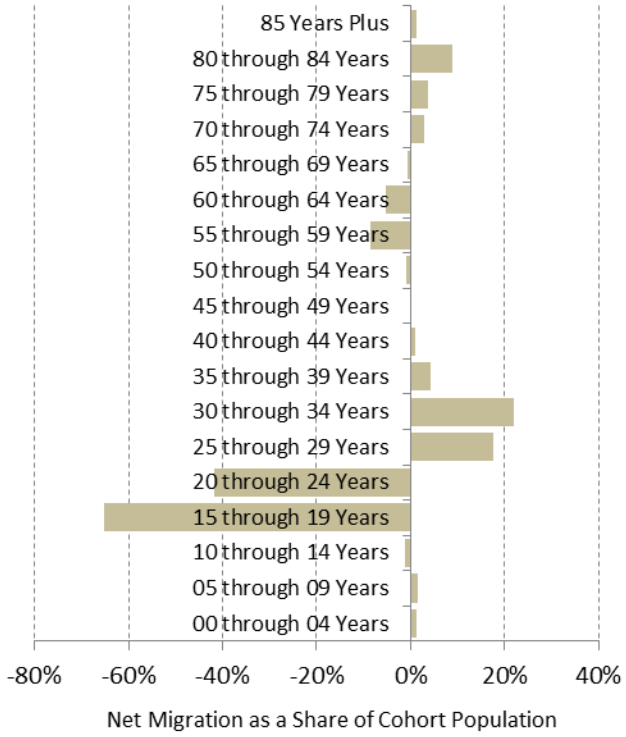
The Sources of Population Change

Table 3.6
Summary Results: Estimated Components of Population Change, MetroWest Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	640,324	655,126	661,458	677,654	687,270
Births	36,489	31,412	38,182	38,870	37,843
Deaths	21,393	25,551	28,455	31,091	34,096
Natural Increase	15,096	5,861	9,727	7,779	3,747
Domestic In-migration, MA & Border	119,865	119,684	124,470	124,388	123,789
Domestic In-migration, Rest of U.S.	37,145	36,507	37,885	39,107	40,256
Domestic Out-migration	184,935	188,051	182,875	182,250	178,258
Net Domestic	-27,925	-31,860	-20,520	-18,755	-14,213
Residual (Actual - Predicted Ending Pop.)	27,631	32,331	26,989	20,592	17,416
Ending Population	655,126	661,458	677,654	687,270	694,221

MetroWest is a dynamic region with a significant flow of migrants moving in and out. In the recent past, this resulted in a near balance in net population change associated with migration. Between 2005 and 2010, the region gained just over 157,000 domestic migrants but lost nearly 185,000 (Table 3.6). However, the region gained an additional 28,000 residents through a positive residual, likely due to international immigration, which almost precisely offset the loss due to net domestic out-migration. As shown in Figure 3.6d, net domestic out-migration is heavily concentrated among college-age youth and young adults in their early twenties. However, the region gains many new residents in their later twenties and thirties—the age at which many settle into a home and start a family. The vast majority (76%) of these in-migrants come from elsewhere in Massachusetts or from neighboring states.

Figure 3.6d
Age profile of net domestic migrants, 2005 to 2010



Because the MetroWest region has a history of attracting residents in their late twenties and thirties, the aging of the millennial generation will lead to a steady increase in domestic in-migration, helping to narrow the gap between domestic in-

migration and domestic out-migration (Figure 3.6e). However, the region is still expected to lose more domestic migrants than it gains between 2010 and 2030. Most of this out-migration will be among college students and retiring baby boomers, although there will be far fewer residents approaching college age (15-19 years old) in the next two decades than in the recent past. We also expect international migration to remain positive during this time, as indicated by a positive residual component, which will more than offset any losses from domestic out-migration.

With migration nearly balancing out, natural increase (births minus deaths) has been the dominant force behind net population growth over the past decade. Between 2005 and 2010, there were 36,489 births to MetroWest residents. During this same period, the region counted 21,393 deaths – resulting in a net gain of 15,096 persons due to natural increase (Table 3.6). The numbers of births and deaths largely follow changes in the age composition of the population over the past decade, with a considerably larger share of the population moving through their twenties and thirties and relatively few elderly (see Figure 3.6g).

Population growth will be partially constrained by a steady increase in deaths while the number of births is expected to remain relatively constant during the forecast horizon (Figure 3.6f). The number of deaths increases as the population ages, particularly so when residents age into cohorts of 70 years and older where mortality rates begin to show a marked increase. The baby boom population will only begin to move into these higher-mortality cohorts by 2030.

Figure 3.6e
Projected levels of domestic in and out-migration, 2005 to 2030

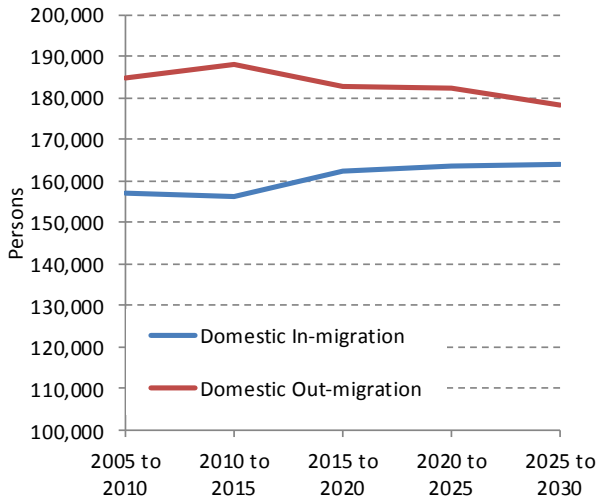
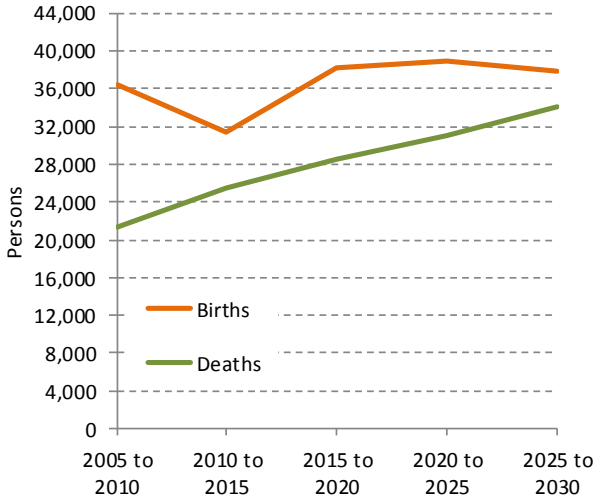


Figure 3.6f
Projected levels of births and deaths, 2005 to 2030

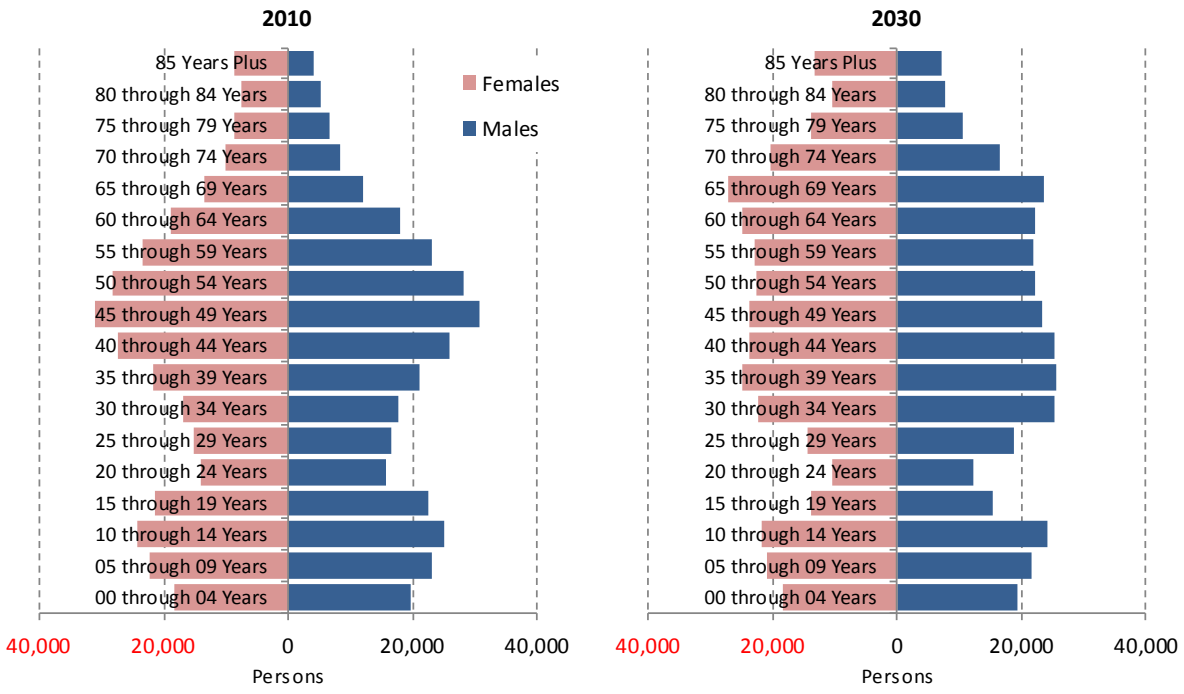


Overall, the MetroWest region of the future will be older than it is today, with a notable increase in elderly residents (Figure 3.6g). By 2030, roughly 8.5% of the population will be age 75 and older, compared to just 6.3% as of the 2010 census. More than a third of area residents will be age 55 and older. However, the population distribution will also become more evenly distributed among retirees, middle-aged households, and young families with school age children. The massive

concentration of the baby boomer generation found in 2010 is far less evident in 2030. This is, in part, because MetroWest residents are somewhat prone to leave the region as they approach retirement, diminishing the impact of the age progression of the baby boom generation within the region. MetroWest also tends to gain residents in their thirties and forties through migration, resulting in a more even distribution in the middle age cohorts than found in other regions.

Figure 3.6g

The age and gender composition of the MetroWest region, 2010 (actual) vs. 2030 (forecasted)



7. Northeast Region

Summary

The Northeast region borders New Hampshire to the north and the Atlantic Ocean to the east. The region includes 46 communities encompassing all of Essex County as well as the northern portion of Middlesex County (Figure 3.7a). Its primary cities are Lowell, Lawrence and Haverhill – all located along the Interstate 495 corridor.

Given current trends, we expect that by 2030, the Northeast region will gain an additional 36,100 residents over its size in 2010 –resulting in a total population of just over 1,067,000 persons (Figure 3.7b). The Northeast region added nearly 30,000 residents between 2000 and 2010 for an annualized growth rate of roughly 0.3% per year over the decade. We predict that growth in the Northeast region will continue at a similar steady pace over the next decade, but will slow slightly after 2020 (Figure 3.7c). With the aging of the population, the current gap between births and deaths will begin to narrow. However, this will be partially offset by an increase in domestic in-migrants and relatively fewer out-migrants.

Figure 3.7a
The Northeast Region

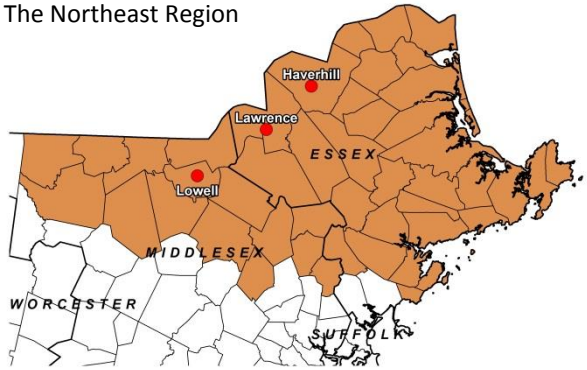


Figure 3.7b
Projected Population, Northeast Region

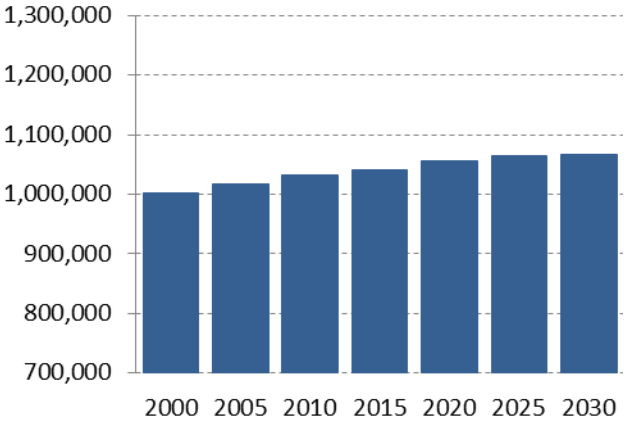
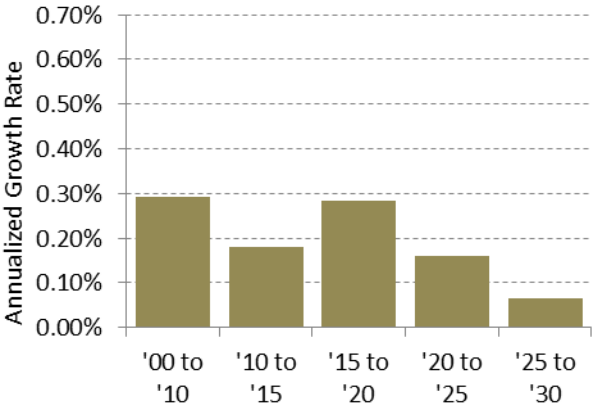


Figure 3.7c
Annualized rates of population change



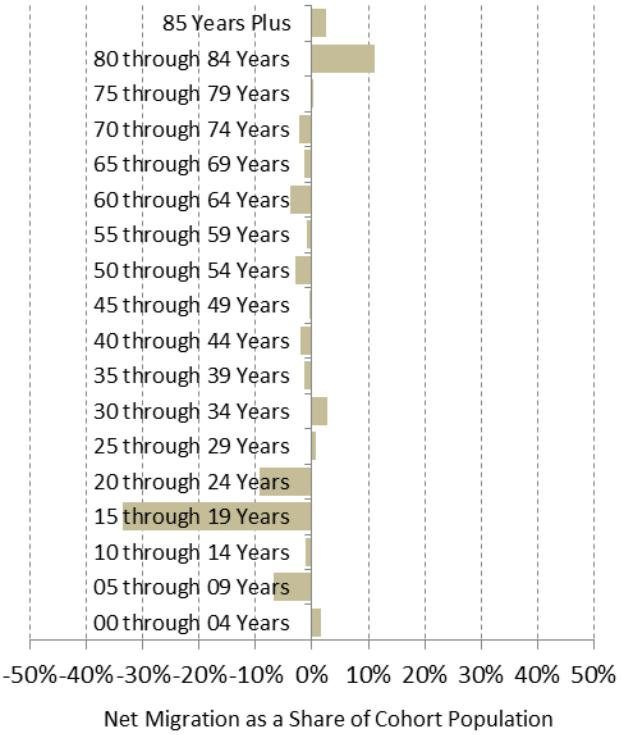
The Sources of Population Change

Table 3.7
Summary Results: Estimated Components of Population Change, Northeast Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	1,016,886	1,031,733	1,041,018	1,055,889	1,064,326
Births	60,178	56,362	61,525	62,084	60,462
Deaths	40,098	46,144	49,836	53,515	58,149
Natural Increase	*20,080*	*10,218*	*11,689*	*8,569*	*2,313*
Domestic In-migration, MA and Border States	128,695	128,217	133,859	132,927	132,031
Domestic In-migration, Rest of U.S.	45,265	45,886	47,913	49,507	51,261
Domestic Out-migration	210,615	208,825	208,381	206,539	202,257
Net Domestic	*-36,655*	*-34,722*	*-26,609*	*-24,105*	*-18,965*
Immigration (International)	22,530	19,706	20,309	20,545	20,696
Residual (Actual - Predicted Pop. Ending)	*8,892*	*14,083*	*9,482*	*3,428*	*-537*
Ending Population	1,031,733	1,041,018	1,055,889	1,064,326	1,067,833

In recent years, the Northeast region has lost more residents to domestic migration than it has gained (Table 3.7). Between 2005 and 2009, we estimate the number of domestic in-migrants to be close to 174,000 persons, with the bulk (74%) coming from either Massachusetts or a neighboring state. During this time the region also lost nearly 211,000 residents moving to other areas of the U.S. The largest cohorts of out-migrants are the 15- to 24-year-olds, many of whom headed off to college or to look for work opportunities elsewhere (Figure 3.7d). Those approaching retirement age are also somewhat prone to move elsewhere in the U.S., although the region tends to be a net importer of the elderly. However, similar to other regions on the fringe of the Boston Metropolitan area, the Northeast is a net attractor of young families and others in their early thirties.

Figure 3.7d
Age profile of net domestic migrants, 2005 to 2010



The aging of the millennial generation into its thirties will lead to a slight increase in domestic in-migration over the next two decades—helping narrow the gap between domestic in- and out-migration (Figure 3.7e). Out-migration is also expected to decline, the consequence of relatively smaller resident population of college-aged and young adults (15-24 years old) in the next several decades.

Figure 3.7e
Projected levels of domestic in and out-migration, 2005 to 2030

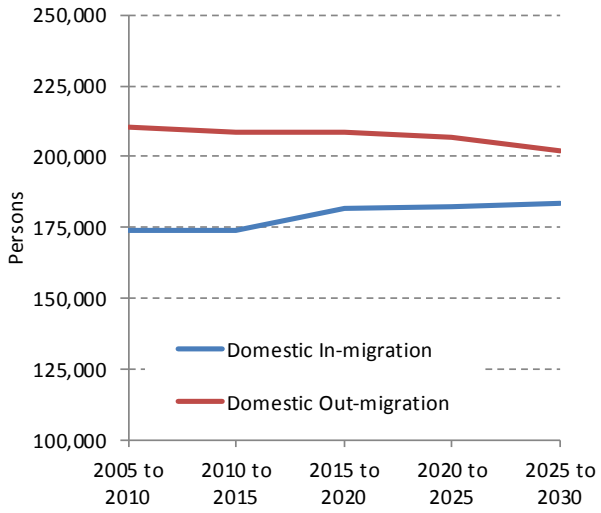
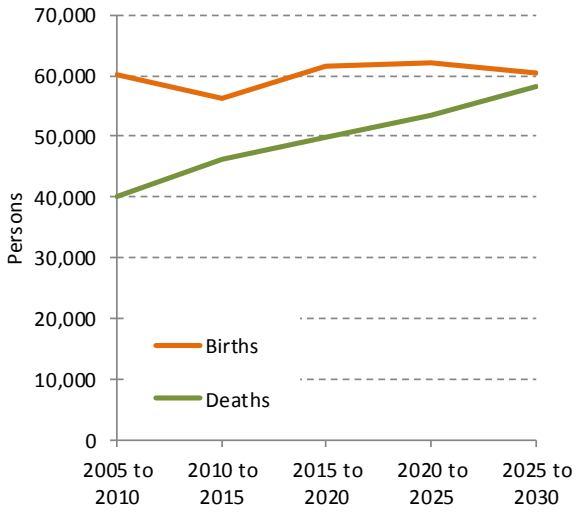


Figure 3.7f
Projected levels of births and deaths, 2005 to 2030

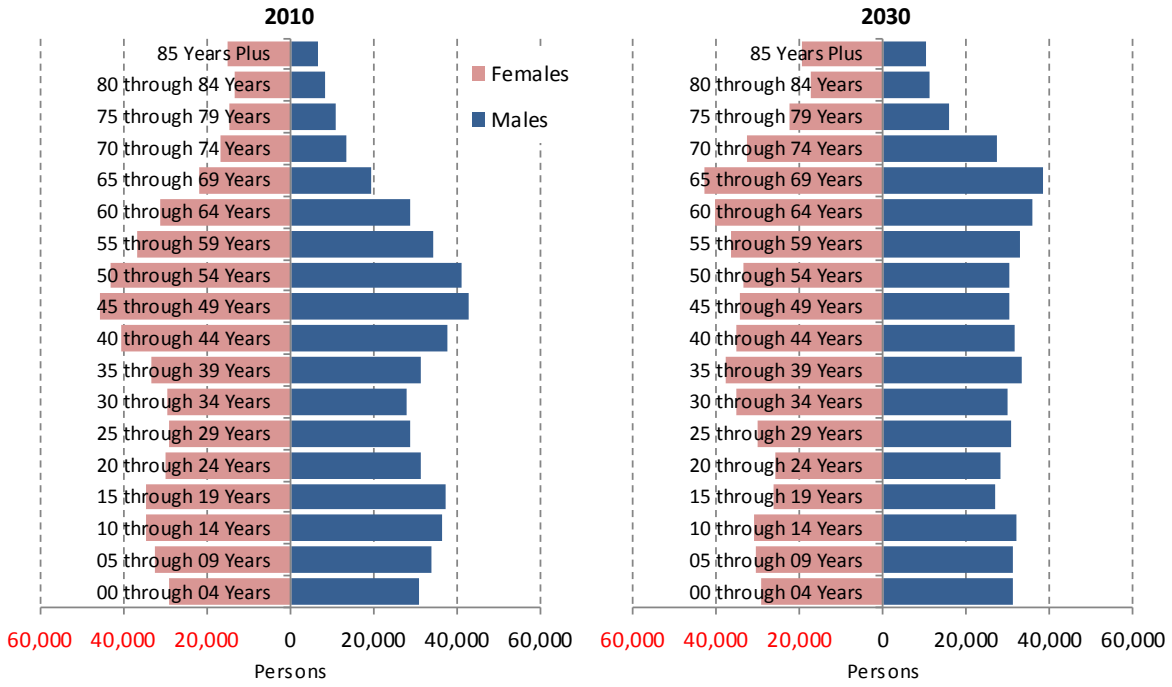


While the region lost more residents than it gained from domestic migration, international migration has been a steady force behind the region's growth. Between 2005 and 2010, we estimate the region added roughly 22,000 new residents due to international immigration – a level that is expected to carry forward for the next several decades. Although we cannot produce a direct estimate of international emigration, the small and generally positive residual component supports the interpretation that the Northeast region generally adds more international residents than it loses.

With domestic and international migration in near balance, natural increase (births minus deaths) sets the pace for overall population growth in the coming years. According to vital statistics data, there were 60,178 births and 40,098 deaths between 2005 and 2010 – resulting in a natural increase of just over 20,000 persons. The numbers of births and deaths is largely dictated by changes in the region's age profile over the past decade, with a larger share of the population moving through their twenties and thirties and relatively few elderly residents (see Figure 3.7g). This will begin to shift in the coming decades, with increasing numbers of baby boomers moving into their seventies by the end of our study period. The result will be a steady increase in the number of deaths between 2005 and 2030, from its current five-year value of 40,000 to close to 60,000 by 2030. The number of births is expected to remain relatively constant during this time, hovering around 60,000 births during each five year period from 2010 to 2030 (Figure 3.7f). A longer forecast horizon (e.g. 2040) would almost certainly show deaths exceeding births after 2030.

Overall, the Northeast of the future will be notably older, although with a population age distribution much more evenly spread across age groups than it is today (Figure 3.7g). The two population bulges associated with the baby boomers and the millennial children are less pronounced in 2030 than they were in 2010. Commensurate with the aging of the U.S. population, there will be a notable increase in the share of older and elderly residents, with nearly thirty percent of the region's residents age 60 and older by 2030—compared to the twenty percent reported in the 2010 census. There will also be a secondary mass of relatively young families, providing some balance to the regional age profile. The millennial generation will be moving into their thirties and early forties by 2030, many with school age children under the age of 15.

Figure 3.7g
The age and gender composition of the Northeast Region, 2010 (actual) vs. 2030 (forecasted)



8. Southeast Region

Summary

The Southeast region includes 50 municipalities, covering the entirety of Plymouth and Bristol counties and extending into the southeastern reaches of Norfolk County. Its largest cities are New Bedford and Fall River, on the region's Southern coast, and Brockton to the north (Figure 3.8a).

The Southeast region experienced modest population growth in the past decade, with an annualized population growth rate of 0.3% between 2000 and 2010. The region should expect to see continued population growth over the next twenty years, although at an increasingly slower rate as time moves on (Figures 3.8b and 3.8c). By 2030, the population of the Southeast region will approach 1.15 million persons, a gain of roughly 36,000 residents over the 2010 Decennial Census. Population growth in the region will be driven largely by the in-migration of persons in their thirties, and, with these young families, a fairly steady number of births. However, increasing deaths with the aging in place of the sizable baby boom population will slowly chip away at the rate of population growth, eventually exceeding new births by 2020.

Figure 3.8a
The Southeast Region

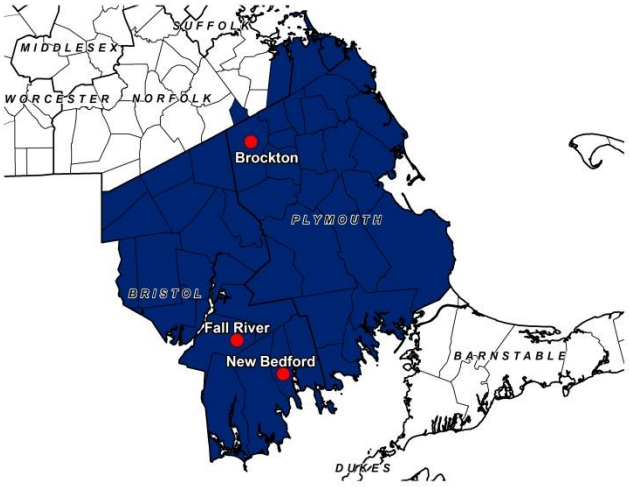


Figure 3.8b
Projected Population, Southeast Region

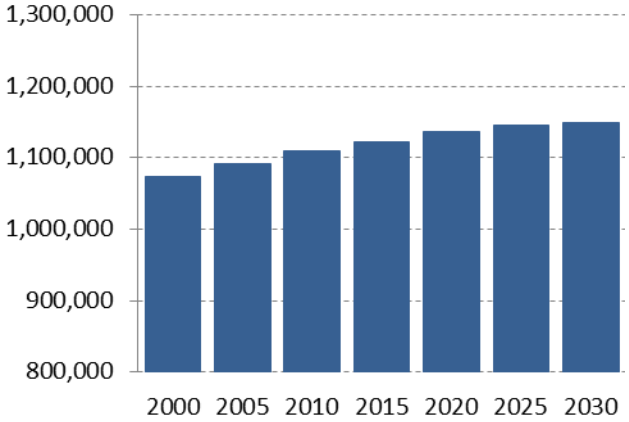
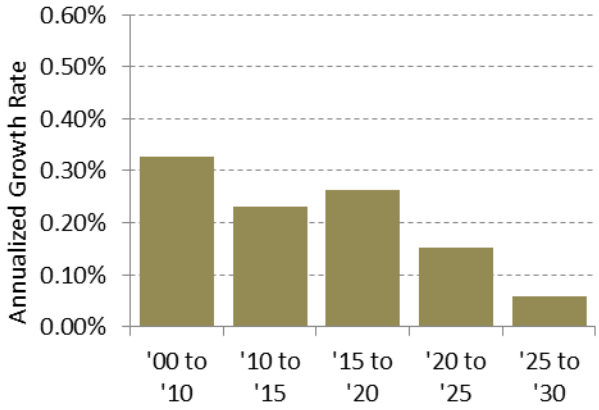


Figure 3.8c
Annualized rates of population change



The Sources of Population Change

Table 3.8 Summary Results: Estimated Components of Population Change, Southeast Region

	2005 to 2010	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Starting Population	1,091,027	1,108,845	1,121,673	1,136,528	1,145,192
Births	60,903	57,433	58,392	58,382	57,312
Deaths	45,532	52,143	55,342	59,353	64,827
Natural Increase	*15,371*	*5,290*	*3,050*	*-971*	*-7,515*
Domestic In-migration, MA and Border States	135,965	134,923	140,624	139,440	138,321
Domestic In-migration, Rest of U.S.	44,820	45,162	46,905	48,212	49,691
Domestic Out-migration	195,650	191,146	191,359	190,032	187,546
Net Domestic	*-14,865*	*-11,061*	*-3,830*	*-2,380*	*466*
Immigration (International)	25,145	22,673	22,774	22,731	22,547
Residual (Actual - Predicted Pop. Ending)	*-7,833*	*-4,074*	*-7,139*	*-10,716*	*-12,088*
Ending Population	1,108,845	1,121,673	1,136,528	1,145,192	1,148,602

During the five year period from 2005-2010, the Southeast region lost nearly 15,000 residents to net domestic migration (Table 3.8). However, international migration offset net domestic losses, with net gains of just over 17,000 from the combination of immigration and the residual component – the latter largely accounting for international emigration.

Domestic out-migration is heavily concentrated among the college-age population, and, to a lesser extent, older residents in the 55+ cohorts (Figure 3.8d). However, the region tends to import residents in their later twenties through their early forties, as well as their school-age children. With the influx of millennials and only modest out-migration of boomers, we expect domestic in-migration will match out-migration by 2025-2030 (Figure 3.8e). Net international migration is expected to decline slightly from current levels but to remain positive.

Figure 3.8d
Age profile of net domestic migrants, 2005 to 2010

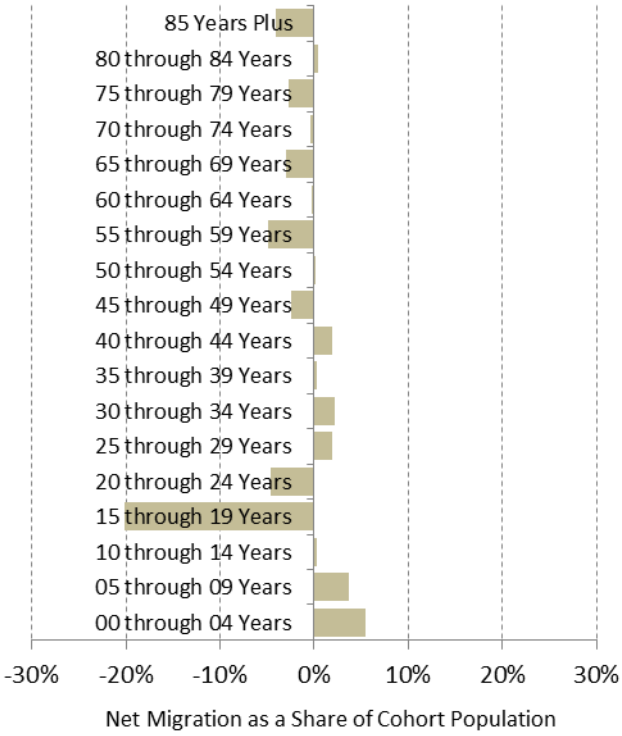


Figure 3.8e
Projected levels of domestic in and out-migration, 2005 to 2030

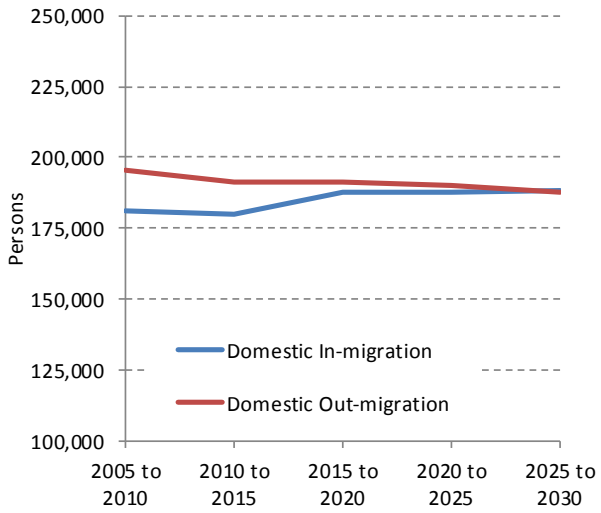
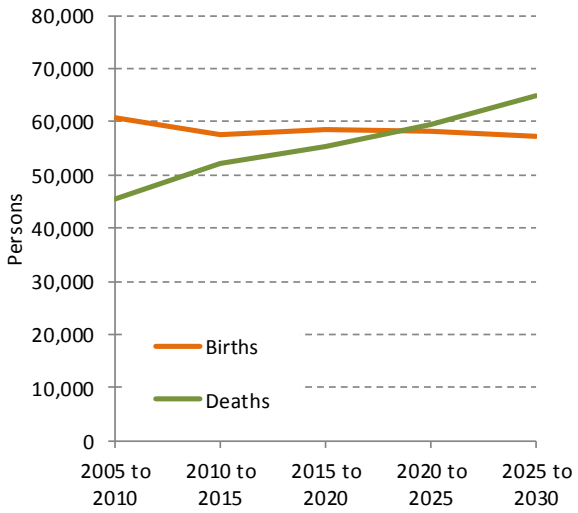


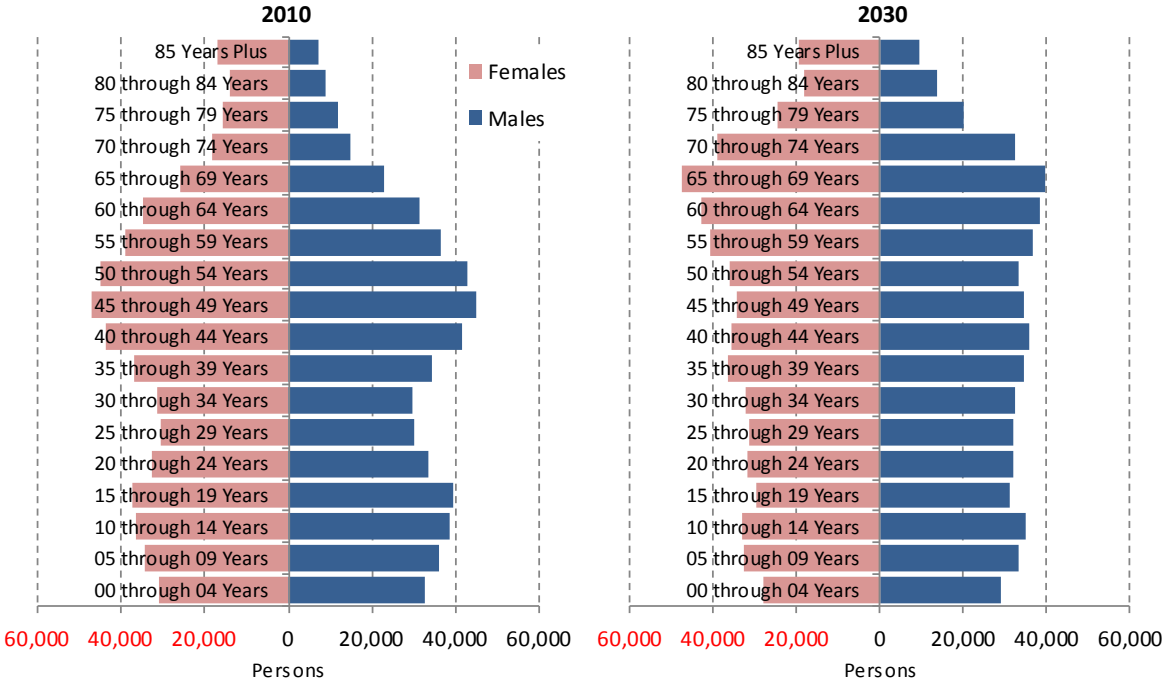
Figure 3.8f
Projected levels of births and deaths, 2005 to 2030



Growth in the Southeast region will be partially constrained by a steady increase in deaths in the coming years coupled with a small decline in births (Figure 3.8f). Natural increase was a major contributor factor to the region's growth over the past decade, with approximately 15,371 more births than deaths between 2005 and 2010. This reflects the region's status as a favored residence among young families. During the 2000s, the Southeast region had a particularly high concentration of residents progressing through their thirties, forties and early fifties (Figure 3.8g). Likewise, the region also had a high concentration of children with relatively few elderly residents. However, we expect the number of deaths to increase with the aging of the baby boomers. Mortality rates show a marked increase as people approach their seventies and eighties. The baby boom population will only begin to move into these high-mortality cohorts by 2030, and thus the largest increase in population loss due to natural decrease is likely to be felt in the decade just beyond our forecast horizon.

By 2030, baby boomers will move into the retirement phase of their life cycles. Although some older residents will retire outside the region, these will be eclipsed by those deciding to age in place, shifting the entire population distribution upward (Figure 3.8g). Yet the Southeast will continue to attract young families, including many from the millennial generation who will be moving into their thirties and early forties by 2030. The result will be a regional age profile that, while older, will be more evenly distributed among the different age groups.

Figure 3.8g
The age and gender composition of the Southeast Region, 2010 (actual) vs. 2030 (forecasted)



IV. Technical Discussion of Methods and Assumptions

This section provides a technical description of the process used to develop the 1) regional and 2) municipal-level population projections using a cohort component approach. While both levels of projections are prepared using a cohort component method, the major methodological difference is in the way migration is modeled: the municipal-level estimates (also referred to as Minor Civil Divisions, or MCDs) rely on residual net migration rates computed from vital statistics, while the sub-state regional projections use gross domestic migration rates based on the American Community Survey Public Use Microdata (ACS PUMS). MCD projections are controlled to the eight regions' projections in order to smooth out variations due to data quality issues at the MCD level and ensure more consistent and accurate projections at higher-level geographies. These controlled MCD projections can then be re-aggregated to other areas of interest, such as counties, regional planning areas, etc.

A. Regional-Level Methods and Assumptions

Summary

This section describes the process and data used to develop the regional population projections. These projections were developed separately for eight regions, although each region was produced following a generally similar framework. The methodology describing how the regional projections were used to estimate municipal population projections follows in Part B of this section.

Our regional projections are based on a demographic accounting framework for modeling population change, commonly referred to as a cohort-component model. The cohort-component method recognizes that there are only four ways that a region's population can change from one time period to the next. It can add residents through either births or in-migration, or it can lose residents through deaths or out-migration. We further divide migration by whether domestic or international, and use separate estimation methods for each.

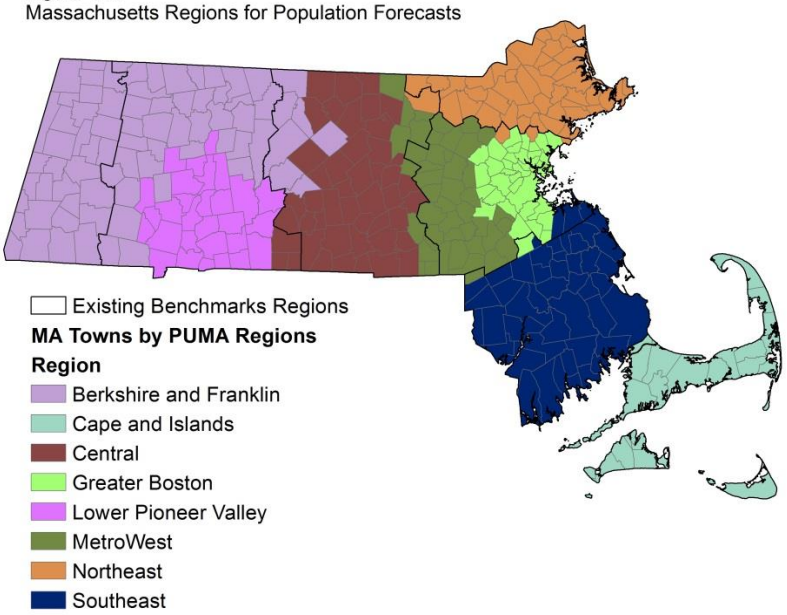
The cohort-component approach also accounts for population change associated with the aging of the population. The current age profile is a strong predictor of future population levels, growth and decline. The age profile of the population can differ greatly from one region to another. For example, the Greater Boston region has a high concentration of residents in their twenties and early thirties, while the Cape and Islands have large shares of near and post-retirement age residents. Furthermore, the likelihood of birth, death, and in- and out-migration all vary by age. Because fertility rates are highest among women in their twenties and early thirties, a place that is anticipating a large number of women coming into their twenties and thirties in the next decade will likely experience more births. Similarly, mortality rates are notably higher for persons seventy years and older, such that an area with a large concentration of elderly residents will experience more deaths in decades to come.

Developing a cohort-component model involves estimating rates of change for each separate component and age-sex cohort (i.e. age-specific fertility rates, survival rates, and in- and out-migration rates) - typically based on recent trends. It then applies these rates to the current age profile in order to predict the likely number of births, deaths, and migrants in the coming years. The changes are added to or subtracted from the current population, with the resulting population aged forward by a set number of years (five years, in our case). The result is a prediction of the anticipated number of people in each cohort X years in the future. This prediction becomes the new starting baseline for estimating change due to each component an additional X years in the future. The process is repeated through several iterations until the final target projection year has been reached.

Regional definitions

A preliminary step in generating our regional projections was to determine the boundaries for each of our study areas. We use the definitions for the MassBenchmarks regions as a starting point. The Benchmarks regions were designed by the UMASS Donahue Institute to approximate functional regional economies (sets of communities with roughly similar characteristics in terms of overall demographic characteristics, industry structure, and commuting patterns). These Benchmarks regions constitute a widely accepted standard among policy officials and analysts statewide that meet common perceptions of distinct regional economies in Massachusetts.

Figure 4.1:
Massachusetts Regions for Population Forecasts



We then compared the Benchmarks regions to the boundaries of Public Use Micro-Sample Areas, also known as PUMAs. PUMAs are the smallest geographic units used by the U.S. Census Bureau for reporting data taken from the detailed (micro) records of the 2005-2009 American Community Survey (ACS) – our primary source of migration data. PUMA boundaries are defined so that they include no fewer the 100,000 persons, and thus their physical size varies greatly between densely settled urban and sparsely settled rural areas. And although PUMAs do not typically match county boundaries, in Massachusetts individual PUMAs can be grouped together to form regions whose outer boundaries match aggregated groups of individual municipalities. This critically important

feature allows us to match Census micro-data with other Census data and State vital statistics estimates we obtained at the municipal level (i.e. births and deaths). We performed our regional grouping using Geographic Information System mapping software. The resulting study regions are presented in Figure 4.1.

Estimating the components of change

Determining the launch year and cohort classes

We begin by classifying the composition of resident population into discrete cohorts by age and sex. Following standard practice, we use five year age cohorts (e.g. 0 to 4 years old, 5 to 9,… 80 to 84, and 85 or older) and develop separate profiles for males and females, based on information provided in the 100% Count (SF 1) file of the 2010 Decennial Census of Population. This will also serve as the starting point (i.e. launch year) for generating forecasts.

Deaths and Survival

The first component of change is survival. Our projections require an estimate of the number of people in the current population who are expected to live an additional five years into the future. Estimating the survival rate of each cohort is fairly straightforward. The Massachusetts Department of Public Health provided us with a detailed dataset that included all known deaths in the Commonwealth that occurred between 2000 to the end of calendar year 2009. This database includes information on the sex, age, and place of residence of the deceased, which we aggregated into our study regions by age/sex cohort. We estimate the five year survival rate for each cohort (*j*) in study region (*i*) as one minus the average number of deaths over the past five years (2005 to 2009) divided by the base population in 2005 and then raised to the fifth power, or:

$$Survival\ Rate_{i,j} = \left[1 - \left(\frac{Deaths_{i,j}}{Population_{i,j}}\right)\right]^5. \quad (1)$$

Following the recommendations of Isserman (1993), we calculate an operational survival rate as the average of the five year survival rates across successive age cohorts. The operational rate recognizes that, over the next five years, the average person will spend half their time in their current age cohort and half their time in the next cohort. We estimate the number of eventual survivors in each cohort by 2015 by multiplying the operational survival rate against the cohort population count as reported by the 2010 Census.

Domestic Migration

Migration is the most dynamic component of change, and often makes the difference between whether a region shows swift growth, relative stability, or gradual decline. Migration is also the most difficult component to estimate and is the most likely source of uncertainty and error in population projections. Whereas fertility and mortality follow fairly regular age-related patterns, the migration behavior of similar age groups is influenced by regional and national differences in socio-economic conditions. Furthermore, the data needed to estimate migration is often restricted

or limited, especially for many small areas. Even when it is available, it is based on statistical samples and not actual population counts, and thus is prone to sampling error – which will be larger for smaller regions.

Due to data limitations and the other methodological challenges, applied demographers have developed a variety of alternate models and methods to estimate migration rates. No single method works best in all circumstances, and we evaluated numerous approaches in the development of our projections. Those presented in this report are based on a particularly novel approach known as a multi-region gross migration model as discussed by Isserman (1993); Smith, Tayman and Swanson (2001); and Renski and Strate. Most analysts use a net-migration approach, where a single net migration rate is calculated as the number of net new migrants per cohort (in-migrants minus out-migrants) divided by the baseline cohort population of the study region. Although common, the net migration approach suffers from several conceptual and empirical flaws. A major problem is that denominator of the net migration rate is based purely on the number of residents in the study region. However, none of the existing residents are at risk of migrating into the region – they already live there. While this may seem trivial, it has been shown to lead to erroneous and biased projections especially for fast growing and declining regions.

A gross-migration approach calculates separate rates for in- and out-migrants. Beyond generating more accurate forecasts in most cases, it has an added benefit in that it connects regional population change to broader regional and national forces – rather than simply treating any one region as an isolated area. This type of model is made possible by utilizing the rich detail of information available through the newly released Public Use Micro-Samples (PUMS) of American Community Survey (ACS). The ACS is a relatively new data product of the U.S. Census Bureau that replaced the detailed information collected on the long-form of the decennial census (STF 3). It asks residents questions about where they lived one year prior, which can be used to estimate the number of domestic in- and out migrants. Unfortunately, the ACS does not report enough detail to estimate migration rates by detailed age-sex cohorts in its standard products. This information can be tabulated from the ACS PUMS – which is 5% random sample of individual records taken drawn the ACS surveys. Each record in the PUMS is given a survey weight, which we use to estimate the total number of migrants by detailed age and sex cohorts. It is very important to realize that the PUMS records are based on small, although representative, samples – and that the smaller the sample the greater the margin of error. Sample sizes can be particularly small when distributed by age and sex cohorts for different types of migrants, especially in small regions.

Estimating domestic out-migration is largely similar to estimating net-migration. Because current residents of the study region (*i*) are those who are 'at risk' of moving out, so the appropriate cohort (*j*) migration rate is:

$$Out\ Migration\ Rate_{i,j} = \left(\frac{OutMigrants_{i,j}}{Population_{i,j}}\right). \tag{2}$$

Because migration in the ACS is based on place of residence one year prior, the out-migration rate reported in equation (2) is the equivalent of a single year rate. We multiply this by five to estimate the five-year equivalent rate, and, as we did with survival rates, average the five year rates across

succeeding cohorts to craft an operational five year rate.[13] The operational rate for each cohort is then multiplied against the number of eventual survivors in 2015 to estimate the number of likely out-migrants from the surviving population.

In-migration is more challenging. The candidate pool of potential domestic in-migrants is not those currently living in the region, but people living elsewhere in the U.S. Modeling in-migration thus requires collecting data on the age-sex profile of not only the study region, but for other regions as well. We model two separate regions as possible sources of incoming migrants in the multi-regional framework - those originating in neighboring regions and states (New York, Connecticut, Rhode Island, New Hampshire, and other Massachusetts regions) and those coming from elsewhere in the U.S. By doing so, we recognize that most inter-regional migration is fairly local and that the migration behavior of the Northeast is likely to differ considerably from that of the rest of the nation – in part due to our older and less racially diverse demographic profile.

Thus the in-migration rates characterizing migration behavior from neighboring regions (*NE*) to study region (*i*) and from the rest of the United States (U.S.) are calculated as:

$$In\ Migration\ Rate_{NE\ to\ i,j} = \left(\frac{InMigrants_{NE\ to\ i,j}}{Population_{NE,j} - Population_{i,j}}\right) \tag{3}$$

$$In\ Migration\ Rate_{US\ to\ i,j} = \left(\frac{InMigrants_{US\ to\ i,j} - InMigrants_{NE\ to\ i,j}}{Population_{US,j} - Population_{NE,j}}\right). \tag{4}$$

As with the out-migration, each single-year in-migration rate is converted into a five-year operational migration rate. Unlike out-migration, these in-migration rates are not multiplied against the surviving regional population for the study region but instead the cohort population for the region of origin (neighboring regions for equation 3 or the rest of the U.S. for equation 4) to reflect the true population at risk of in-migration. The data for estimating the launch year cohort size for other regions is aggregated from the 2010 Census of Population (SF 1), with the study region cohort population subtracted from the base of neighbor regions and neighbor populations subtracted from the United States cohort population.

International Migration (immigration and emigration)

One quirk of the ACS is that while it does contain information on the residence of recent international immigrants, it contains no information that might be used to estimate emigration. This is because the ACS only surveys people currently living in the U.S. This includes recent immigrants, but not people that moved out of the nation during the last year.

There is no consensus on how best to deal with emigration. Writing in the era when immigration statistics came from the Decennial Census and were based on a five-year rate, Isserman (1993) argues that emigration can be safety ignored. In part, this is because emigration for most areas is typically very small. He also argues that since emigrants are not surveyed in the Census (they

[13] This differs from calculating the five-year survival rate, where the one-year rate was taken to the fifth power. Survival is modeled as a non-recurring probability, since you can only die one. However, we assume that any individual migrant could move more than once during the study period, and multiply the single year rate by five to estimate a five-year equivalent.

already left the region), so technically they are not counted in the population at risk - i.e. smaller denominator), there would be no resulting bias. However, this is less true for ACS-based surveys because they are estimated as multi-year rolling surveys with a single-year migration question. A person surveyed in year 1 could technically out migrate in years 2 – 5, and therefore international emigration may be undercounted if ignored. The large numbers of foreign students that attend college and university in some regions make underestimated emigration issues far from trivial and might well overstate future growth.

A second problem is that there are often very few international immigrants included in the ACS PUMS for some sex-age cohort combinations. This is especially problematic for smaller regions and among elderly cohorts where people tend to be less mobile. The result in such places might be wildly erratic estimates of immigration.

We take two different approaches to estimating the international migration component, depending upon the size of the study region. For large regions, we estimate international immigration directly based on information reported in the ACS PUMS files – ensuring that there was a sufficient number of sample points in each cohort. We do not estimate emigration directly, but rather indirectly adjust for emigration using the survival/residual method that will be discussed shortly. We distinguish large regions as those with populations in excess of one million persons in 2010. This includes the Greater Boston, Northeast, and Southeast regions. In the case of the five remaining small regions (under 1 million) we provide no direct estimates of either immigration or emigration, but use the survival/residual approach to the estimate both missing components.

The survival/residual approach uses the basic population change accounting framework of the cohort-component model coupled with data from the recent past to estimate the change attributable to the missing component(s). For us, the missing components are international net migration (immigration – emigration) for small regions, and international emigration for large regions. Consider the case of the small region, where the change in population between two intervals (say 2005 and 2010) can be described as:

$$Population_{2010} - Population_{2005} = Births - Deaths + InMigrants - OutMigrants + Immigrants - Emmigrants + \epsilon \quad (5)$$

where *InMigrants* and *OutMigrants* represent domestic migration only. Births, deaths, and domestic in- and out- migration are estimated for the historical period (2005 to 2010). The unknown component is net international migration (immigrants – emigrants) plus any error associated with imprecision in the population counts or other components of change – most likely from sampling error in the measurement in domestic migration. By re-arranging (5) we can isolated the unknown component, resulting in:

$$Immigrants - Emmigrants + \epsilon = Population_{2010} - (Population_{2005} + Birth - Deaths + InMigrants - OutMigrants) \quad (6)$$

In other words, we simply make a prediction of what the population should have been in 2010 if the 2005 population changed only according to births, deaths, and net domestic migration. We then subtract the predicted value from the actual (observed) population in 2010. This residual can be

attributed to population change associated with the missing components and historic forecast error. This process must be completed for each separate cohort, noting that births are only relevant to estimating population change in the first (zero to five year-old) cohort and the deaths and migration data should be averaged over succeeding cohorts to account for the amount of time spent in each cohort over a five year interval (the equivalent of calculating an operational rate).

For forecasting future population levels, the estimated residual component must first be converted into the form of a rate and then applied to the appropriate 'at risk' population. Because the residual is a composite (net migration plus error) and there is no reliable source of information on the population 'at risk' in this instance, we instead divide the residual by the study region population in each cohort for the base year (2005 in this case). The result is a ratio of the size of the residual to the size of the cohort, and not a true rate. This residual ratio is then multiplied against the expected surviving population for each cohort to generate an estimate of the residual component. It is worth noting, that calculating a residual component in this manner has the practical effect of partially 'constraining' future population growth to rates close to those in the recent past. This means that if the projected growth without the residual component is much greater than what actually occurred, the residual rates will tend to be negative, and the future level of growth will be reduced. Conversely, if the unadjusted model under-predicted population levels in the recent past the residual rates would trend positive - thus accelerating growth over the level predicted by observable factors.

The final step of the migration model adds the estimated net number of domestic migrations (in-migrants minus out-migrants) and the estimated residual component (i.e. net international migration + error) to the expected surviving population in order to estimate the expected number of "surviving stayers." This is an estimate of the number of current residents who neither die nor move out of the region in the coming five years, plus any new migrants to the region. These surviving stayers are then used as the basis for estimating anticipated births.

Births and Fertility

The final component requires estimating fertility rates using past data on the number of live births by the age of the mother. Like survival, information on births comes from the Massachusetts Department of Public Health which was aggregated, by region, into our five-year age cohorts according to the mother's age, and averaged over five years (2005-09). The number of births is then divided by the corresponding number of women in 2005 for each cohort to generate an approximate age-specific fertility rate. The births of males and females are modeled separately in our approach, however in both cases it is the only the number of women in each cohort that represents the population 'at risk' and appears in the denominator of the fertility rate. This single year fertility rate is multiplied by five to estimate a five-year equivalent, or:

$$Fertility\ Rate_{i,j} = 5\left[\left(\frac{Births_{i,j}}{Number\ of\ Women_{i,j}}\right)\right]. \tag{7}$$

Next, the estimated fertility rates are multiplied against the number of females in the child-bearing age cohorts among the number of 'surviving stayers' as estimated in the previous step. This

provides an estimate of the number of babies that are anticipated within the next five years, and this number is summed across all maternal age cohorts.

Aging the population and generating projections for later years

The final step in generating our first set of five year forecasts (for year 2015) is to age the surviving stayers in all cohorts by five years. The first (0 to 4) and final (85+) cohorts are treated differently. The number of anticipated babies estimated in the previous step becomes the number of 0 to 4 year olds in 2015. The number of persons in the 85+ cohort in 2015 is the number of surviving stayers in the 80 to 84 age cohort (in 2010) added to the number of surviving stayers in the 85 and older cohort. As we made separate estimated for males and females the two populations are added and summed across all cohorts to determine the projected number of residents in 2015.

This process is essentially repeated for all future year projections, except that the rates developed from historic data remain the same throughout the forecast horizon. Our 2015 projection becomes our launch year population for estimating the 2020 population, which in turn is used to seed the 2025 population and so-forth. The only notable difference in the process used to generate the later year forecasts is the need to have outside projections of future population levels for the nation as a whole and for neighboring states. This is necessary for estimated the population 'at-risk' of domestic in-migrants. The U.S. Census Bureau regularly generates highly detailed national population forecasts.[14] We use the latest release of national forecasts (release date May, 2013) which are based on information from the 2010 Decennial Census. Unfortunately, the Census Bureau no longer generates detailed state-level long-term projections. Lacking a better source, we use the final set of Census-based state projections (release date 2005) for estimating future in-migrants from neighboring states. In future updates, we hope to either develop or acquire more updated state-level projections.

[14] http://www.census.gov/population/projections/

B. Municipal-Level Methods and Assumptions

MCD-Level Model Overview

As described in the regional-level methods section of this report, separate projections are produced for the 351 MCDs and for the eight state sub-regions. The MCD results are then controlled to the corresponding projected regional cohorts to help smooth any inconsistences in the MCD-level results and to reflect migration trends that may be more accurately reflected by the regional projection methodology.[15] While both of the regional and MCD-level projections are prepared using a cohort component method, the MCD estimates rely on residual net migration rates computed from vital statistics, while the sub-region projections use gross domestic migration rates based on the American Community Survey Public Use Microdata (ACS PUMS).

The population age 5 and over is projected by the mortality and migration methods, while the population age 0-4 is projected by the fertility method. The initial launch year is 2010, with projections made in five-year intervals from 2015 to 2030 using the previous projection as the new launch population. Projections for seventeen five-year age groups (0-4, 5-9 …80-84, and 85+) are reported for males and females. (Throughout this document, the term "age" refers to a 5-year age cohort). The cohort component method is used to account for the effects of mortality, migration, and fertility on population change.

Population projections for each age and sex cohort for each five-year period are created by applying a survival rate to the base population, adding net migration for each age/ sex/ MCD cohort, and finally adding births by sex and mother's age, as shown in the table below.

Component	Projection
Mortality	Survived population by age/sex
Migration	Net migration by age/sex
Fertility	Births by sex and mother's age
Launch	2010 Census count by age/sex for 2015 projection; Five-year projection thereafter

Data Sources

The launch populations by sex, age cohort, and MCD were obtained from U.S. Census 2010 data. UMDI estimated population by age and sex for 2005 from the 2000 and 2010 U.S. Censuses using a simple linear interpolation by age and sex.

[15] The regional projection methodology, discussed at length in Section IV.A. of this report, projects domestic migration using migration data from the American Community Survey, therefore explicitly accounting for recent domestic migration trends. As explained in this section, the MCD methodology uses a "residual" method based on vital statistics to project migration.

UMDI requested and received confidential vital statistics data for births and deaths from January 1, 2000 through December 31, 2009 from the Massachusetts Department of Public Health. From these, UMDI estimated survival, birth and residual net migration rates.

MCD Projections Launch Population

Initial Launch Population

The initial launch population for the 2015 projection is the 2010 Census population by age/sex for each MCD. Corrected census counts from the Count Question Resolution (CQR) program are incorporated where applicable. Each projection thereafter uses the previous projection as the launch population (i.e. the 2020 projection uses the 2015 projection as the launch population).

MCD Projections: Mortality

Forward Cohort Survival Method

The forward cohort survival method is used to account for the mortality component of population change. This procedure applies five-year survival rates by age/sex to the launch population by age/sex for MCDs in order to survive their populations out five years, resulting in the expected population age five and over before accounting for migration.

5-Year Survival Rates by Age/Sex

UMDI calculated five-year survival rates by age and sex using deaths by age, sex and MCD from 2000 to 2009 (January 1, 2000 through December 31, 2009). Survival rates by age, sex and MCD were assumed to be constant for the duration of the projections (from 2010 through 2030). Survival rates for each age cohort up to 80-84 were averaged with the next-older cohort to account for the fact that roughly half of each cohort would age into the next cohort over the course of each 5-year period. The 85+ cohort's survival rate was used as-is, since there was no older cohort to average.

MCDs with smaller populations demonstrated a degree of variability in survival rates that we considered too broad for optimal results. Therefore, for MCDs with populations lower than 10,000 as of the 2000 Census, we used regional survival rates by age and sex instead of MCD-specific rates to smooth the results. We calculated regional rates using the same MCD-based vital statistics data from 2000-2009 as we used in calculating the MCD rates.

Survived Population for MCDs

The base population by age/sex for MCDs is survived to the next 5-year projection by applying the corresponding averaged five-year survival rates by age/sex.

Lag in Death Data

For each current vintage, vital statistics data showing deaths will only be available for past years – for instance, in producing the Vintage 2013 estimates (the first vintage), we have death data only through 2009.

Key Assumptions

The methodology assumes that survival rates vary most significantly by age and sex. To some extent, the use of MCD-specific rates will also indirectly account for varying socioeconomic factors, including race and ethnicity, which vary by MCD and may affect survival rates. The methodology assumes that survival rates by age, sex and MCD will stay constant over the next 20 years.

MCD Projections: Migration

Residual Net Migration from Vital Statistics

The residual net migration method is used to account for the migration component of population change. "Residual" refers to the fact that migration is assumed to be responsible for past population change after accounting for births and deaths. This residual net migration is then used to estimate past migration rates. The procedure applies the resulting net migration rates by age/sex estimated for each MCD to the MCD's survived population by age/sex in order to project net migration by age/sex for the population age 5 and over. For the population ages 0-4, it is assumed that residence of infants will be determined by the migration of their birth mothers. For MCDs with 2000 Census population below 10,000, a linear migration assumption (described below) is used to smooth migration.

Determination of Net Migration Rates

Vital statistics are used to infer net migration totals for 2000-2009. In order to calculate five-year net migration by age, sex and MCD, natural increase (births minus deaths) by age/ sex for 2000-2005 is added to the 2000 population by age/ sex for each MCD, and then the results are subtracted from the interpolated 2005 population by age/ sex for each MCD to estimate net migration by age/ sex and MCD for 2000-2005. A similar process calculates migration between 2005 and 2010.

For MCDs with 2000 population equal to or greater 10,000, the two five-year net migration estimates are averaged and rates are then calculated for each age, sex and MCD. The resulting rates are applied to the base population to project five-year net migration. The resulting average five-year net migration rates by age/sex are held constant throughout the projection period.

For MCDs with 2000 population under 10,000, five-year net migration by age, sex and MCD is held constant, and population cohorts are never allowed to go below zero. This avoids applying unrealistically high migration rates to small populations. For instance, if an MCD starts with 4 males aged 70-74 and net migration shows 4 more move in over five years, the result is a migration rate of 2. This results in highly variable and unrealistic results in some cases. . In this example, holding migration linear means that in each five-year projection period, four males aged 70-74 will move into the MCD. UMDI conducted sensitivity testing for this method and found that the model with constant migration for small places in most cases resulted in more realistic, gradual population growth or decline, as well as more realistic sex and age profiles for these MCDs.

Key Assumptions

The use of a net migration rate relies on a base for migration that includes only current residents – in other words, only those at risk of out-migration. Nonresidents who are at risk of in-migration are not explicitly accounted for in the MCD method, and this results in some inaccuracy which is minimized by the process of controlling to regional total projections that are based on a gross migration model.

We assume that age, sex and MCD are the key factors by which migration rates vary. Other factors, including non-demographic factors such as macroeconomic factors, or local policy changes, are not explicitly included in this model. Future projections models may incorporate these or other factors.

Fertility

Vital Statistics Method

We apply age-specific fertility rates to the migrated female population by age to project births by age of mother, followed by survival rates for the population aged 0-4. Total survived births are then derived by summing across all maternal age groups, and the results represent the projected population age 0-4. For each MCD, the number of males and females is assumed to be the same as the proportion of male or female births statewide.

Fertility by Age of Mother

Average births by age of mother for each MCD are calculated for two five-year periods (2000-2005 and 2005-2010) using nine maternal age groups, from 10-14…50-54.

Fertility Rates

Age-specific fertility rates are computed for each time period by dividing the average number of births by age of mother by the corresponding number of females of that age group. The average age-specific fertility rates are held constant throughout the projection period. The base population for launching a new five-year projection is the survived, post-migration projected female population by age.

MCDs with smaller populations demonstrated a degree of variability in fertility rates that we considered too broad for optimal results. Therefore, for MCDs with populations lower than 10,000 as of the 2000 Census, we used regional fertility rates by age and sex instead of MCD-specific rates to smooth the results. We calculated regional rates using the same MCD-based vital statistics data from 2000-2009 as we used in calculating the MCD rates.

Lag in Birth Data

For each current vintage, birth data will only be available for past years – for instance, in producing the Vintage 2013 estimates (the first vintage), we have birth data only through 2009.

Key Assumptions

We assume age, sex and MCD to be adequate indicators of fertility rates for MCD for the first vintage projections. We assume that the proportion of male to female births does not vary significantly by geography or maternal age. We assume that fertility rates by maternal age and MCD will not change significantly over time. Future iterations of the projections may amend these assumptions based on available data.

Controlling to the Regional-level Projections

The resulting MCD-level projected cohorts are finally controlled to the regional-level projected cohorts. To do this, we assume that each MCD's share of the region's population, for each age and sex cohort, is given by the MCD population projections. Those shares are then applied to the regional projections to arrive at adjusted age/ sex cohorts for each MCD.

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Appendix A

UMass Donahue Institute Population Projections Advisory Committee

Joseph Buckley
Massachusetts School Building Authority

Bradley Egan
Project Manager
Massachusetts School Building Authority

Dr. Alan Clayton Matthews
Professor and Director of Quantitative Methods
Northeastern University

Saul Franklin
Consultant / Former Director of MassChip
Massachusetts Department of Public Health

Molly Goren-Watts
Principal Planner/Manager
Pioneer Valley Planning Commission

Marilyn McCrory, AICP
Water Resources Planner, Office of Water Resources
Massachusetts Dept. of Conservation & Recreation

Dr. James West
Senior Demographer/Epidemiologist
Massachusetts Department of Public Health

Dr. Stefan Rayer
Research Demographer, Bureau of Economic & Business Research
University of Florida
Federal-State Cooperative for Population Projections Member

Timothy Reardon
Manager of Planning Research
Metropolitan Area Planning Council

Jennifer Song
State Demographer
North Carolina Office of State Budget and Management
Federal-State Cooperative for Population Projections Member

Jan K. Vink
Research Support Specialist, Program on Applied Demographics
Cornell University
Chair, *Federal State Cooperative for Population Projections*