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Long-term Population Projections for Massachusetts Regions and Municipalities

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UMASS DONAHUE INSTITUTE

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

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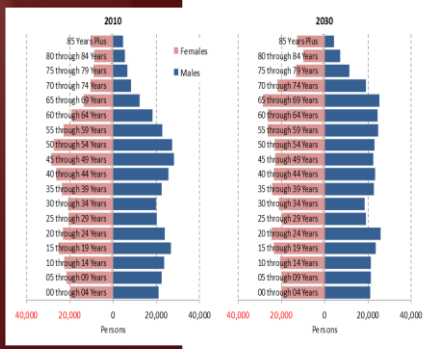

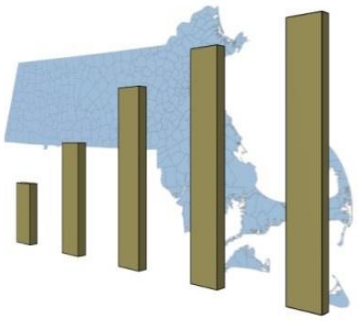

March 2015

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I. Project Overview

Introduction

The March 2015 release of the UMass Donahue Institute's *Long-Term Population Projections for Massachusetts Regions and Municipalities* offers public-use, age/sex detailed population projections—now extended to 2035—for use in research and planning. This vintage series (Vintage 2015) builds off of the previously released Vintage 2013 set released in December of 2013, but with some important distinctions that include updated model inputs as well as methodological revisions.

Prior to the Vintage 2013 release, Massachusetts agencies and entities had not had access to detailed, publically available, statewide municipal population projections by age and sex since 2003 when the Massachusetts Institute for Social and Economic Research (MISER) produced projections based off of the 2000 Census. The U.S. Census Bureau previously produced state-level projections by age and sex, but has at present discontinued them. The last Census-produced state population projections were released in 2005. While some regional planning 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 or public health management are challenged with having to somehow reconcile different and sometimes conflicting sets of methods and results, when municipal projections are available at all.

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. In 2013 UMDI published its first post-2010 series, referred to here as the "UMDI V2013" series. These V2013 projections were based on the patterns in mortality, fertility, and migration observed from 2000 to 2010, and they projected growth through 2030 at a level consistent with that 2000 to 2010 period. Statewide growth in that series was projected at about 3.2% from 2010 to 2020, similar to the 3.1% growth from 2000 to 2010 observed in U.S. Census counts.

Since that time, Massachusetts has experienced rapid growth that the rates observed from 2000 to 2010 could not have anticipated. From April 1, 2010 through July 1, 2014, Massachusetts has been growing at a rate of 0.71% per year on average, according to U.S. Census Bureau estimates.[1] This annual rate is over twice that observed in the previous decade when the state grew an average of

[1] U.S. Census Bureau: Cumulative Estimates of the Components of Resident Population Change for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014 (NST-EST2014-04). Release date: December 23, 2014.

just 0.31% per year.[2] Just last year, in the 2012 to 2013 period, Massachusetts' annual percentage growth caught up to the U.S. for the first time since 1968.

This recent acceleration in population growth warrants an update to the statewide projections series, allowing us to reconcile future projections to the growth experienced from 2010 to date. At the same time, a new release also allows us to update the data sources used in our projections model and to make some methodological revisions to improve the model overall.

Updates to data inputs

Foremost, the Vintage 2015 series (V2015) now aligns with the population growth in Massachusetts estimated by the U.S. Census Bureau through their most current release—the 2014 state-level estimates. While still maintaining the detailed distribution of migration-by-age available through the American Community Survey Public Use Microdata sample (ACS PUMS), the V2015 method adds an adjustment factor to the ACS migration rates in order to reconcile them with growth experienced through 2014.

The ACS-PUMS data used to calculate migration-by-age rates has also been updated in this series. We now combine the 2005 to 2009 data used for Vintage 2013 with the 2007-2011 dataset, which constitutes the most current five-year ACS dataset using consistent PUMA geographies.[3] The two sets together also represent a longer representative period in migration, which is helpful when projecting forward over a long term.

Finally, we replace the long term population projections for U.S. cohorts released by the U.S. Census Bureau in 2012 with their 2014 release series.[4] For neighboring states' age/sex populations, we use projections released by the Weldon Cooper Center in 2013.[5] These replace the state-level age/sex projections released by the U.S. Census Bureau in 2005, their most recent state-level age/sex projections series. These U.S. and neighboring states' populations-by-cohort are used as inputs in calculating the future number of in-migrants for Massachusetts regions in our model.

Methodological changes

One of the major changes to the V2015 series compared to the V2013 is the elimination of a "residual" component in our model. This component was used in the original model to account for international emigration and to capture estimation error. In the Vintage 2015, international emigration is instead estimated as a distinct component.

[2] Source: U.S. Census 2000 and 2010.

[3] Although an even more recent ACS PUMS dataset is available for the 2008-2012 period, it is split over two different periods of PUMA boundaries, with one year referencing 2010 PUMAs and four years using 2000 PUMA boundaries. This split makes it unusable for analysis below the state level.

[4] Source: 2014 National Population Projections, U.S. Census Bureau, Population Division, December 2014.

[5] Source: *Population Projections by Age for the U.S. and States*. Updated August 9, 2013. Weldon Cooper Center for Public Service, University of Virginia. http://www.coopercenter.org/demographics/national-population-projections

The second major change to our model is the introduction of a "college fix" approach to regions that count a high percentage of college students among their population. In the basic application of the "college fix", the college-enrolled population in a region is held back from aging and the migration experienced by the non-college population over the specified time period, and is then restored to the region at the end of the period. In this way, the college-enrolled population remains more or less fixed for a region while other cohorts migrate and age over time. This fix significantly reduced cohort variability in college regions observed in the results of the Vintage 2013 model. For a full description of these changes and other details of the Vintage 2015 method, refer to Section IV of this report.

Summary

The resulting Vintage 2015 projections 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 stakeholders and state and national experts working in the field. The methodology was developed in partnership with Dr. Henry Renski of the University of Massachusetts, Amherst. Dr. Renski also produced the methodology for the original UMDI V2013 projections series and, in previous years, projections for the state of Maine. He 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 are the Berkshire/Franklin, Cape and Islands, Central, Greater Boston, Lower Pioneer Valley, MetroWest, Northeast, and Southeast regions. The UMDI projections are available for all municipalities by sex and five-year age groups, from 0-4 through 85+, and at five-year intervals beginning in 2015 and ending in 2035. 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.

For our projections, we use a cohort-component model based on trends in fertility, mortality, and migration from 2000 through 2011 and population growth through 2014. 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, however, rely instead on residual net migration rates computed from vital statistics. The municipal-level method is applied uniformly to all cities and towns 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.

It is important to note that 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. Like the Vintage 2013 model, the Vintage 2015 uses

a *status-quo* model approach to predict future population change. It assumes that recently observed trends in the components of population change, including birth, death, and migration rates, will persist in future years. It is also a demographically-based model, assuming that population change is driven by births, deaths, and the persistence of historic migration rates into the future. As such, it does not account for changes in state or regional economies over time such as new economic, transportation or other development initiatives; changes in broad or localized policy such as immigration; or building restrictions or expansions. Planners evaluating the use of these projections should consider whether future changes mentioned above will impact their study region in a way that sets it apart from its recent history and relative to other regions and other parts of the U.S. Giving consideration to these more localized components may help one to more successfully modify the population change predicted in our model.

It is also critical to note that any statewide method will tend to produce unusual looking results in very small geographies or in small age cohorts. In general, projections for small geographies and distant futures will be less predictive than projections for larger populations and near terms. 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. Because we control town-level age/sex cohorts to the larger regional age/sex populations generated in by our model, the age/sex distribution in small towns may look particularly irregular. We publish the full detailed series for all 351 municipalities, even knowing that the small geographies will be irregular, so that researchers may at least have the option of aggregating results across these small geographies or combined cohorts, but these estimates and projections should be used with caution and with their context noted.[6]

The next section of this report, *Section II. State-Level Summary*, highlights the total population change anticipated for Massachusetts through 2035 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 2035.

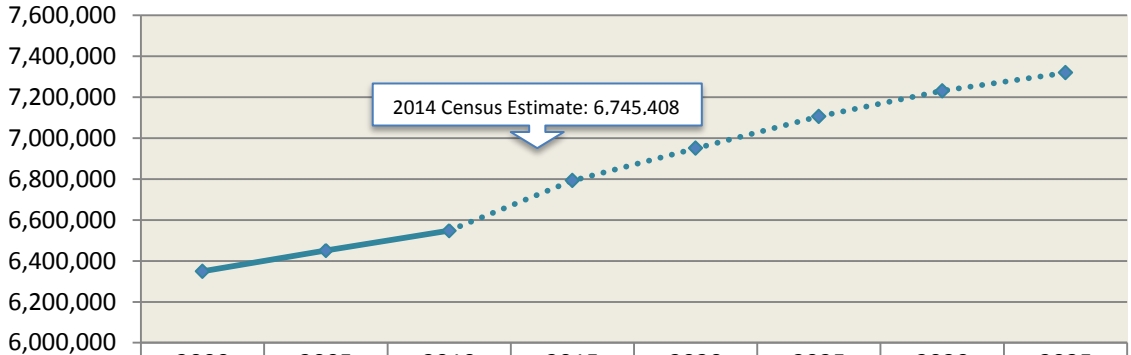
[6] A small town needing age/sex projections that are not controlled to the larger regions for specific age-related projects, for example, is encouraged to contact our program and inquire about alternatives for their municipality. We will provide these, upon request, as a public resource.

II. State-Level Summary

A. Massachusetts Growth: 2000 to 2035

The UMass Donahue Institute projections anticipate that the Massachusetts population will grow by 11.8% from 2010 to 2035, with population increasing by 771,840 over the 25-year term to a new total of 7,319,469. This projection picks up on the recent rapid growth experienced in Massachusetts through 2014, estimated at 3% cumulatively since the 2010 Census and averaging 46,492 persons per year according to U.S. Census estimates.[7] In this projection series, growth will continue at about this same rate through 2015, adding about 245,000 persons in the first five-year period, and then gradually diminish over the following time periods, slowing to about 1.2% growth in the 2030 to 2035 period. By comparison, Massachusetts grew 3.1% in the ten years from 2000 to 2010, increasing just 0.9% from 2000 to 2005 and then accelerating to 2.3% from 2005 to 2010 (Figure 2.1[8]).

Figure 2.1: Massachusetts Actual and Projected Population, 2000-2035



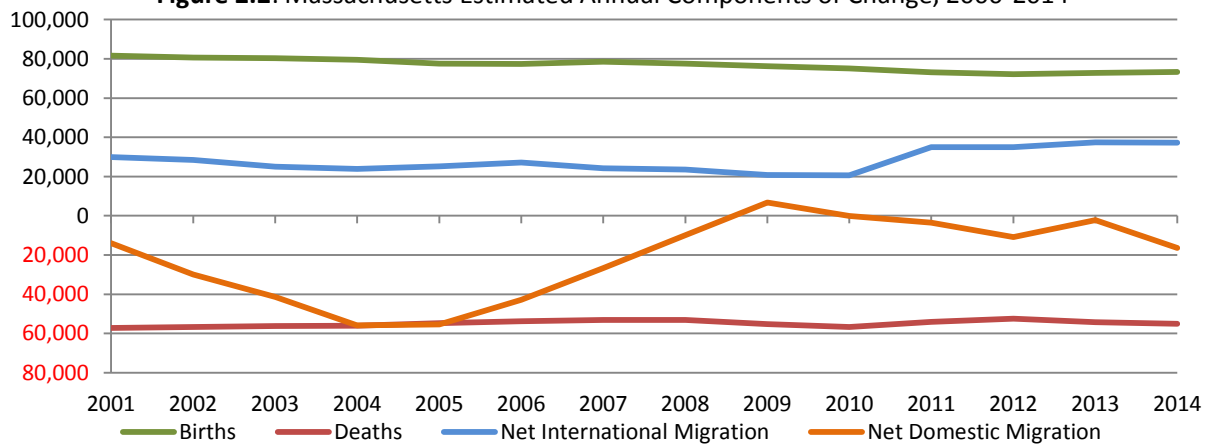
	2000	2005	2010	2015	2020	2025	2030	2035
Population	6,349,097	6,450,755	6,547,629	6,792,591	6,950,668	7,105,878	7,231,126	7,319,469
Numeric Change		101,658	96,874	244,962	158,077	155,210	125,248	88,343
5-Year % Change		1.6%	1.5%	3.7%	2.3%	2.2%	1.8%	1.2%

[7] Source: U.S. Census Bureau Population Division, Cumulative Estimates of the Resident Population Change for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014 (NST-EST2014-02), December 23, 2014.
[8] Sources: U.S. Census Bureau: Census 2000; 2005 Interim State Population Projections; Census 2010; 2014 Estimates; and UMass Donahue Institute Population Projections, 2015.

B. Factors Affecting Growth Rates

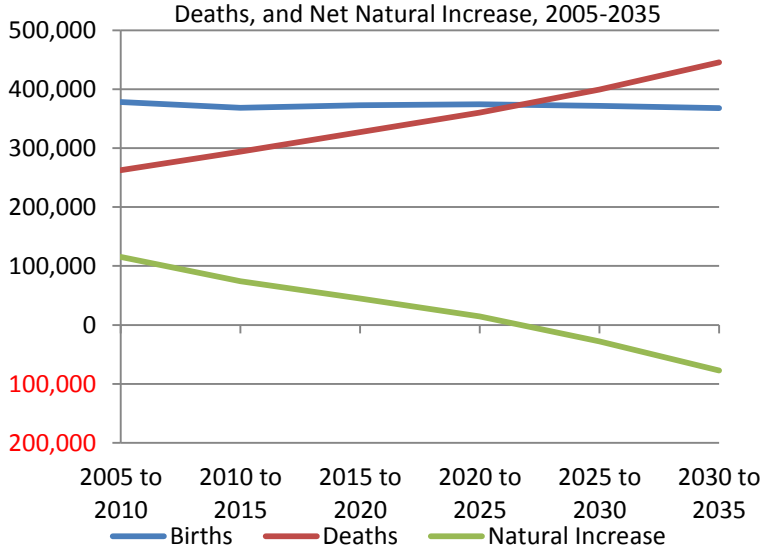
Recent rapid growth in Massachusetts is attributed to a combination of natural increase – more births than deaths, and positive total migration, which is the sum of slightly negative domestic migration to other parts of the U.S. offset by positive international immigration into the state (Figure 2.2).

Figure 2.2: Massachusetts Estimated Annual Components of Change, 2000-2014



Sources: U.S. Census Bureau, Population Division Tables ST-2000-7, CO-EST2010-ALLDATA, and NST-EST2014-ALLDATA.

Figure 2.3: Massachusetts Actual and Projected Births, Deaths, and Net Natural Increase, 2005-2035



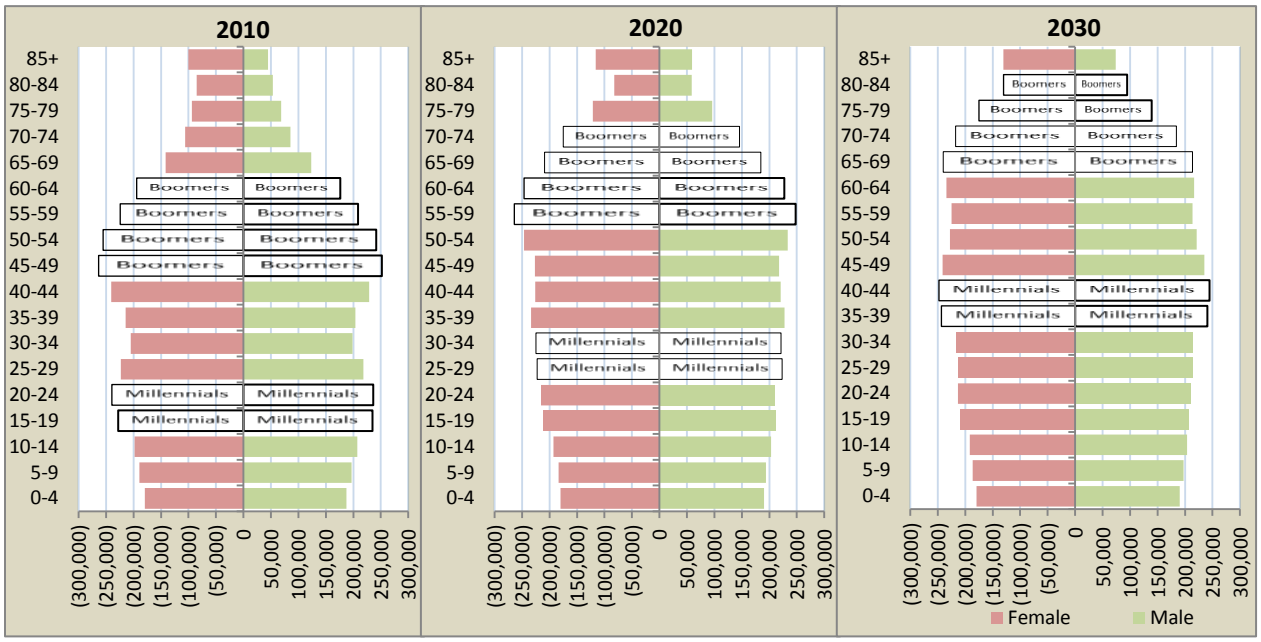
In recent years, Massachusetts has stood out as the fastest grower in the Northeast due to its relatively low domestic outflow and high immigration,[9] and this projection series anticipates that future migration in Massachusetts will carry forward at rates that reflect these recent trends. The eventual slow-down in growth, on the other hand, is attributable to the age profiles of Massachusetts and the United States overall, both directly impacting future numbers of births and deaths. As the United States grows older, the bulk of its population ages out of childbearing years and eventually into higher mortality cohorts—factors that will contribute to slower 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

[9]Source: U.S. Census Bureau Population Division, NST_EST2014. For a full summary of Massachusetts' recent growth and components of change, see *UMass Donahue Institute Summary of The U.S. Census Bureau's 2014 State-Level Population Estimates*, December 23, 2014 at http://www.massbenchmarks.org/statedata/data/UMDIsumStatePop2014.12.23.pdf.

share of its population in the older age-groups and a smaller share in the younger.[10] So while the population continues to grow, with births declining only slightly, the increasing number of deaths in an aging population starts to erode the net natural increase in Massachusetts. By 2030 the number of deaths is expected to outnumber new births in the state (Figure 2.3). 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 an aging baby boom population results in diminishing population growth over time, the effect is offset in part by a large "millennial" generation in the United States overall. By 2010 this group was 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, additionally increasing 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-boomer. 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 2.4), 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: an age-span associated with both high fertility and high levels of migration.

Figure 2.4: Massachusetts Actual and Projected Population by Cohort 2010, 2020, and 2030

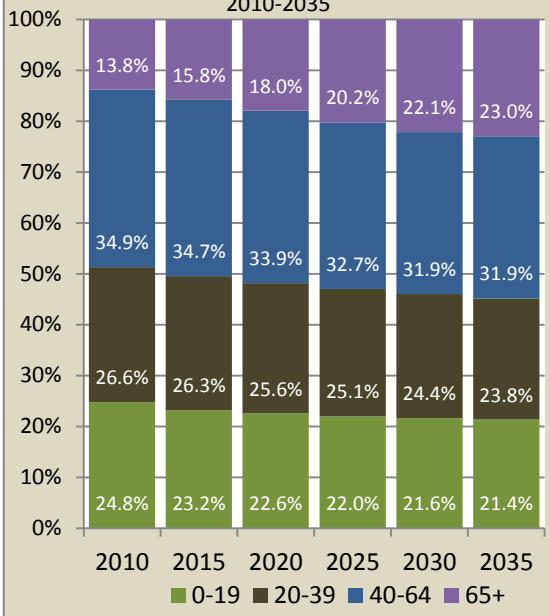


Sources: U.S. Census Bureau 2010 Census Summary File 1; UMass Donahue Institute Population Projections, 2015

[10] 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: 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 2025. Looking across the 25-year period, the swell in the percent of population aged 20-39 experienced in 2010 and 2015 (representing the millennial bulge) starts to falls off somewhat in 2020 and increasingly so thereafter (Figure 2.5). Meanwhile, the population of persons in their 40s and 50s steadily decreases from about 35% of the state's population in 2010 to 31.9% by 2035. The 0-19 age group also decreases over time, roughly following the pattern of their parents, and changing from almost 25% of the 2010 Massachusetts population to 21.4% by 2035. In sharp contrast, the population aged 65 and over in the state increases from about 14% to almost 16% in the first five-year period, and then increases even more in the second. By 2035, the 65-and-over population will represent 23% of the state's population.

Figure 2.5: Massachusetts Projected Population Distribution by Age Group, 2010-2035

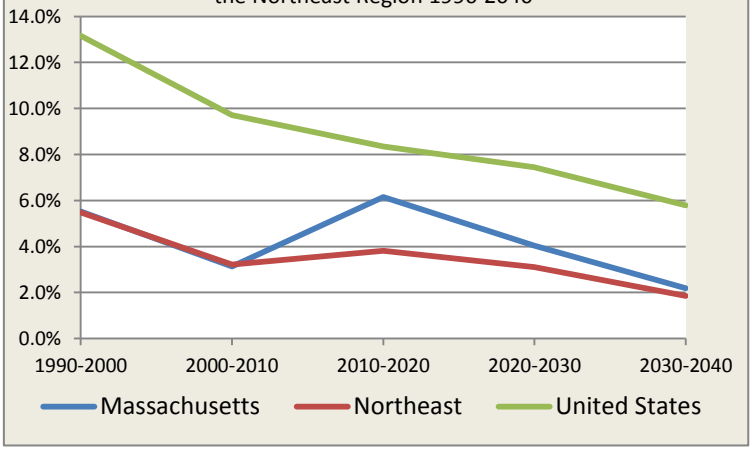


Source Data: U.S. Census Bureau, 2010 Census Summary File 1; UMass Donahue Institute Population Projections 2015.

C. Massachusetts and United States Growth Comparison

Although Massachusetts will continue to grow in population through 2035 and even outpace the Northeast Region as in recent years, its growth will still lag that of the United States as a whole (Figure 2.6[11]). While Massachusetts is projected to grow by 6.2% from 2010 to 2020, the Northeast will grow by just 3.8%[12] and the U.S. by a projected 8.3%.[13] From 2020 to 2030, Massachusetts growth will slow to 4.0%, still ahead of the Northeast at just 3.1%, while the U.S. average also slows to 7.4% yet remains higher than Massachusetts.

Figure 2.6: Actual and Projected Percentage Growth by 10-Year Period for Massachusetts, the United States, and the Northeast Region 1990-2040



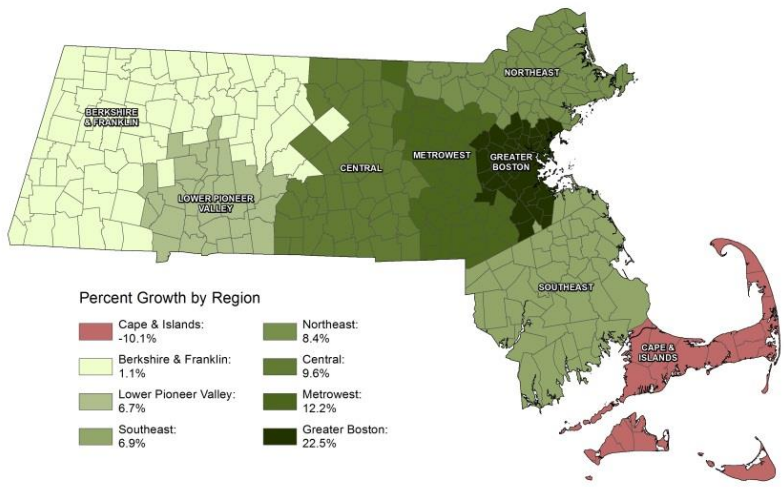
[11] Sources: U.S. Census Bureau, Census 2000 and Census 2010; 1990 Census, Population and Housing Unit Counts, United States (1990 CPH-2-1); *Observed and Total Population for the U.S. and the States, 2010-2040, Weldon Cooper Center for Public Service, University of Virginia, August 2013* and UMass Donahue Institute Population Projections, January 2015.
[12] Source: ibid, Weldon Cooper Center August 2013 and UMass Donahue Institute Population Projections, January 2015.
[13] Source: Projected Population by Single Year of Age, Sex, Race, and Hispanic Origin for the United States: 2014 to 2060. U.S. Census Bureau, Population Division. Release Date: December 2014.

One of the reasons why Massachusetts will continue to grow more slowly than the U.S. average is because it has an older age distribution than the national average. Although some parts of the state—particularly the Boston area—attract college-aged students, the Southern and Western regions of the U.S. start out with much higher percentages of younger cohorts in their resident populations, especially in the 0-18 year old age groups.[14] Younger populations in these regions ensure a greater number of births and fewer deaths in future years as compared to Massachusetts and the Northeast. Areas of the South and West also continue to experience positive net domestic migration while the Northeast tends to experience net domestic out-migration. That said, Massachusetts is affected by these components to a much lesser degree than other states in the Northeast. Its outmigration in recent years has tended to be minimal compared to other Northeast states, and the small domestic loss has been offset by strong positive international immigration. In 2013 Massachusetts' annual percent growth actually caught up with the U.S. rate for the first time since 1968.[15] Massachusetts has also consistently led the rest of the Northeast states in growth since the last Census in 2010. By the 2030 to 2040 period, an aging U.S. profile means that all comparison regions slow in growth significantly, the U.S. to 5.8%, Massachusetts to 2.2% and the Northeast region to 1.9%.

D. Projected Geographic Distribution of Population Growth

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 11.8% anticipated for the state by 2035 (Figure 2.7). The Greater Boston region, which has been growing at an estimated 1.1% per year since 2010,[16] is expected to increase by 22.5% in the 2010 to 2035 period. Concurrently, most other regions around the state are expected to experience strong but more moderate levels of growth. The Metrowest region is expected to increase 12.2% by 2035, the Central region by 9.6%, the Northeast by 8.4%, the Southeast by 6.9%, and the Lower Pioneer

Figure 2.7:
Projected % Growth by Massachusetts Region 2010-2035



[14] Source: U.S. Census Bureau, 2010 Census Summary File 1.
[15] Sources: U.S. Census Bureau Annual Estimates of the Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2013 (NST-EST2013-01). Release Date: December 30, 2013, Population Division; and Intercensal Estimates of the Total Resident Population of States: 1960 to 1970. Release date: Aug. 1996. Population Distribution Branch. Both: U.S. Census Bureau.
[16] Source: U.S. Census Bureau NST-EST2013-01.

Valley by 6.7%. At the other end of the spectrum, the Cape and Islands region is predicted to decrease in population by 10.1% over 25 years if recent trends in migration, fertility, and mortality continue, while the Berkshire and Franklin region will remain nearly level, with a slight increase of just 1.1% during that same period. Both of these regions stand apart from the Massachusetts average due to their older population structure compared to other regions around the state. Further analysis on why growth varies significantly by region is presented in more detail in Section III of this report.

III. Long-Term Regional Population Projections

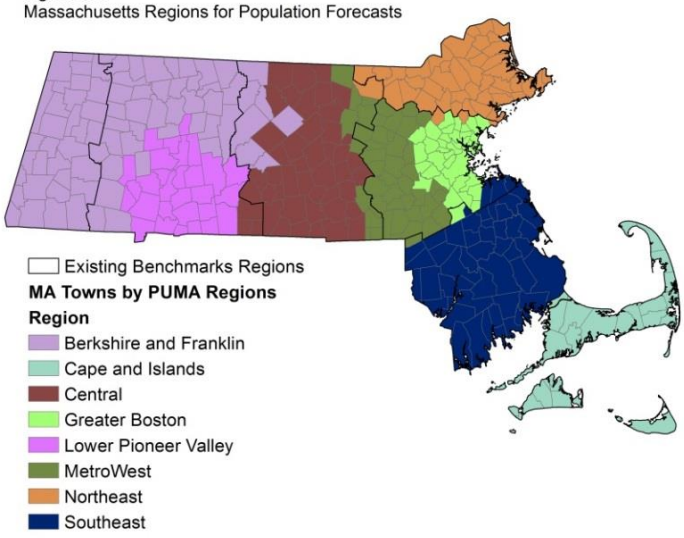
A. Introduction

This section presents long-term regional population projections for eight Massachusetts regions for years 2010 through 2035. 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. 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.[17]

Figure 3.1:
Massachusetts Regions for Population Forecasts



[17] 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.[18] 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. ages 0-4, 5- 9,… 80- 84, and 85 and 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 series 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.[19] 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.

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 norms and lifestyle preferences, regional differences in climate change, even state and federal

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

[19] 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.

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 or 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 ones 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

Summary

The Berkshire/Franklin county region consists of 76 communities spanning the Commonwealth's western and northwestern borders (Figure 3.1a). It is predominantly rural with its primary population and employment centers in 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 -0.1%. Our model predicts that recent trends of slow decline will continue through 2015 and then temporarily reverse between 2015 and 2030, with more in-migration from retiring baby boomers coupled with a reduction in domestic out-migration, as the region includes fewer persons in the younger cohorts more prone to leave the region. The effect of retirement-fueled growth will be only temporary however, as increasing deaths associated with an aging population will eventually erode all gains. The regional population is expected to peak in 2030 at 238,425 residents—about 2,300 more than were counted in the 2010 Census—and then start to slowly decline again towards 2035. (Figures 3.1b & 3.1c). This said, the region may be thought of as very stable over the time series in terms of total population. The population varies by less than 5,000 from the highest to lowest point in the 2010 to 2035 time series with a 25-year increase of just 1.1%.

Figure 3.1a
The Berkshire/Franklin Region

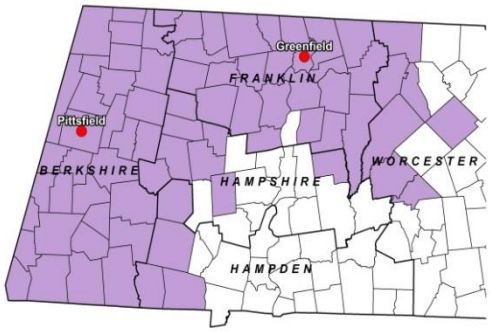


Figure 3.1b
Recent and projected population, Berkshire/Franklin

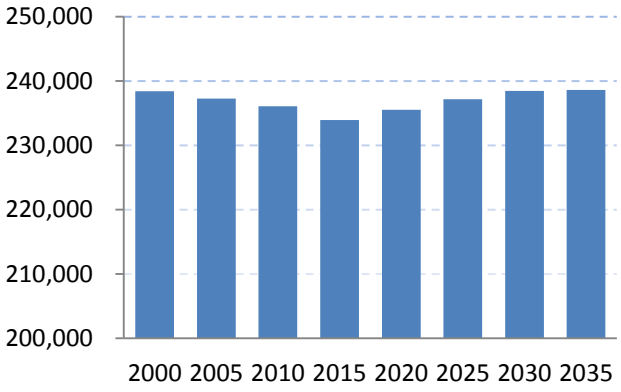


Figure 3.1c
Annualized rates of population change, Berkshire/Franklin

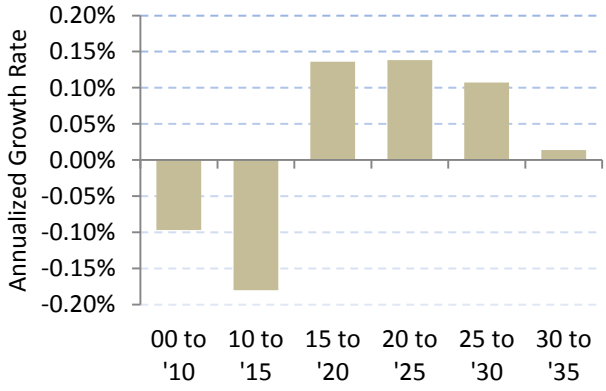
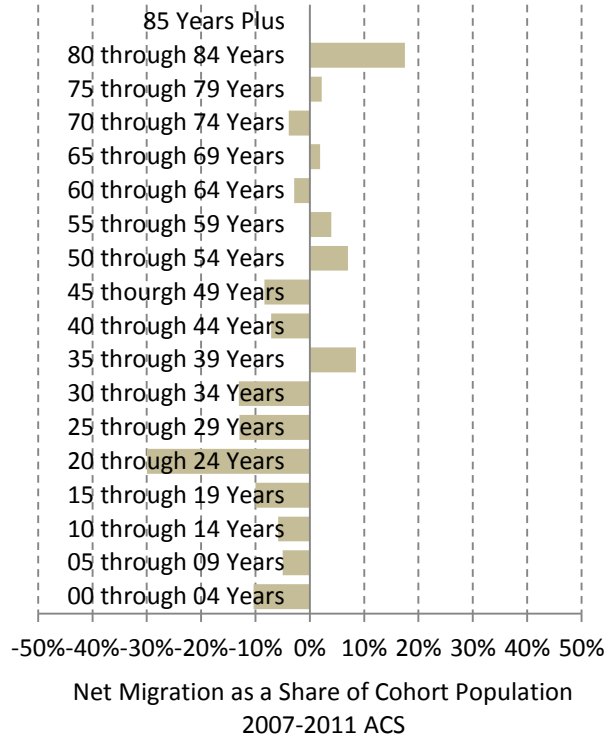


Table 3.1
Summary Results: Estimated Components of Population Change, Berkshire/Franklin

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	236,058	233,932	235,525	237,153	238,425
Births	10,577	10,166	10,079	9,900	9,781
Deaths	12,886	14,582	16,415	18,386	20,633
Natural Increase	*-2,310*	*-4,416*	*-6,336*	*-8,485*	*-10,851*
Domestic In-migration, MA & Border	31,141	33,300	33,393	33,885	34,467
Domestic In-migration, Rest of U.S.	12,681	13,571	14,068	14,546	14,948
Domestic Out-migration	48,113	45,305	43,924	43,096	42,814
Net Domestic Migration	*-4,292*	*1,566*	*3,536*	*5,335*	*6,601*
Net International Migration	*4,475*	*4,444*	*4,428*	*4,422*	*4,416*
Ending Population	233,932	235,525	237,153	238,425	238,592

Table 3.1 above shows future estimated components of population change for the region. While births decrease over time, the number of deaths will increase, leading to decreasing net population change due to natural events. At the same time, the number of in-migrants increases over time while the number of out-migrants decreases: resulting in increasing population due to migration. Together, these sum to the population variations anticipated from one period to the next. In the case of all components, the predicted trends are very much related to the age structure of the region and how recent trends in migration-by-age will affect future populations.

Figure 3.1d: Age profile of net domestic migrants, Berkshire/Franklin, 2007-2011, American Community Survey



Domestic out-migration has been the Berkshire/Franklin region's major source of population loss in recent years. ACS data for the 2007-2011 period indicates that the region lost 57,435 residents due to domestic out-migration, while gaining only 43,995 new residents from other regions in the state and the U.S. The region has gained some new residents in the 35- 39 age group, however all other

in-migrants have been in the older cohorts aged 50 and above. 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).

Age Profile

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 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 15-29 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 decrease 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.

Figure 3.1e: Projected levels of domestic in and out-migration, Berkshire/Franklin, 2010-2035

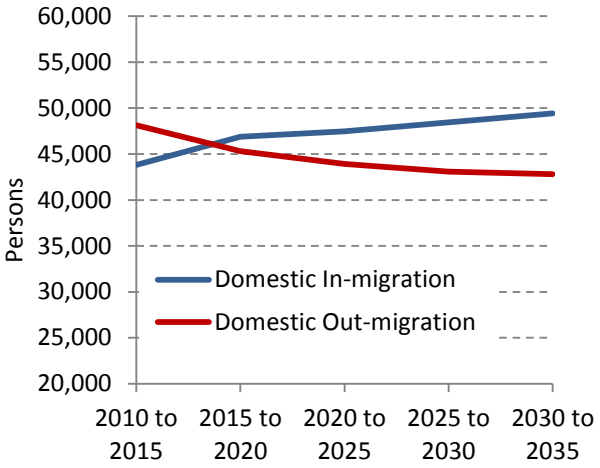
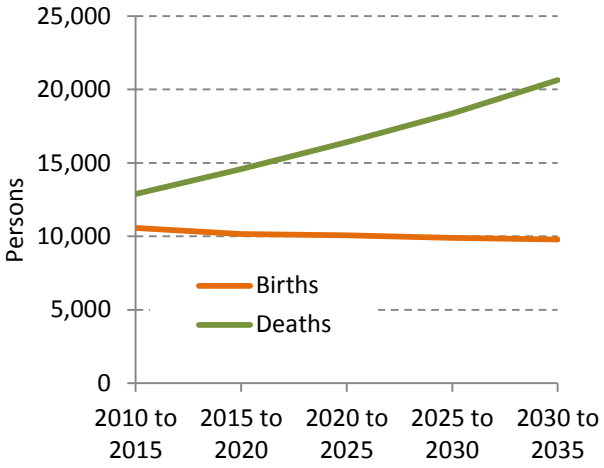


Figure 3.1f: Projected levels of births and deaths, Berkshire/Franklin, 2010-2035



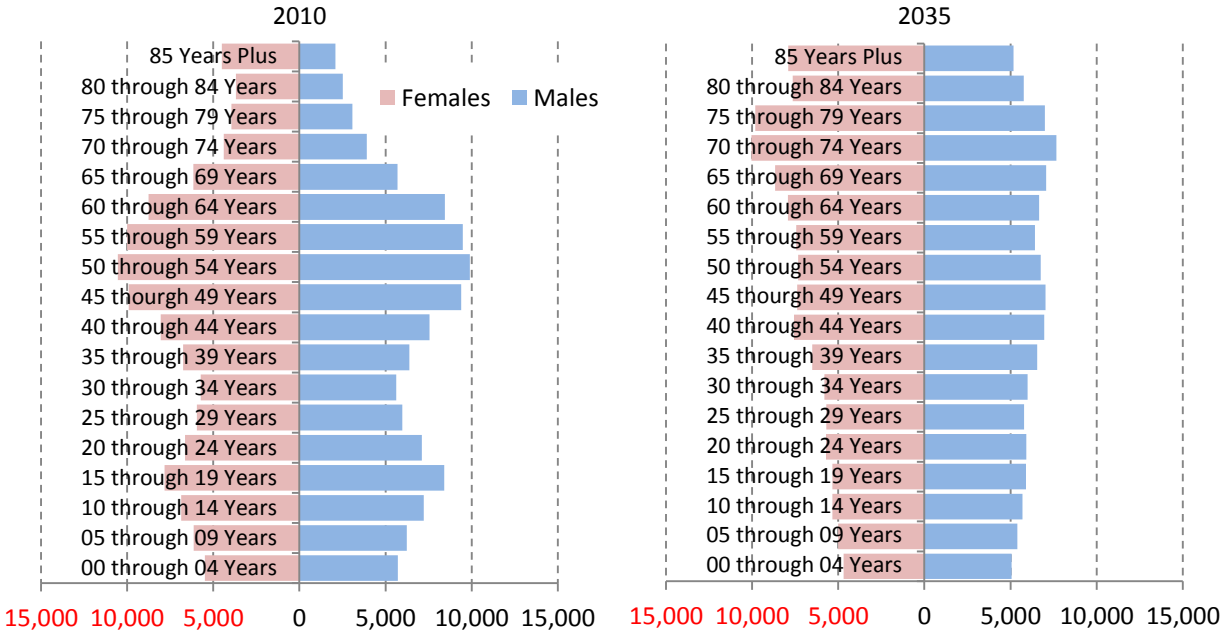
A smaller portion of the region's recent population loss has been due to natural decline, i.e. more deaths than births; however, this is expected to play a much larger role in population loss in the years ahead. Between 2005 and 2010, there were 10,833 births in the region compared to 11,513 deaths, 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, growing population 70 years and older—ages when mortality rates begin to show a marked increase.

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- 64—cohorts roughly

analogous to the baby boomer generation. We also find a secondary concentration (21%) between the ages of 10-25—ages associated with the millennial generation or echo boomers (Figure 3.1g). By 2030, the baby boomers will have moved into 65-years 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 the ages of 20 and 30 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 25 years will be considerably older than today. In 2010, roughly 32% of the region's population was 55-years or older. By 2035, this share will increase to 44%. In the next twenty-five years, we expect stagnancy or a relative decline in the population share of nearly all cohorts except those over 65. Figure 3.1g, below, shows the change in the age and gender composition of the region anticipated by 2035 compared to 2010. Figure 3.1h shows the population by age at 2000, 2010 and then projected at 5-year intervals through 2035, demonstrating how the population ages forward through the time-series.

Figure 3.1g
The age and gender composition of the Berkshire/Franklin population, 2010 (actual) vs. 2035 (forecasted)



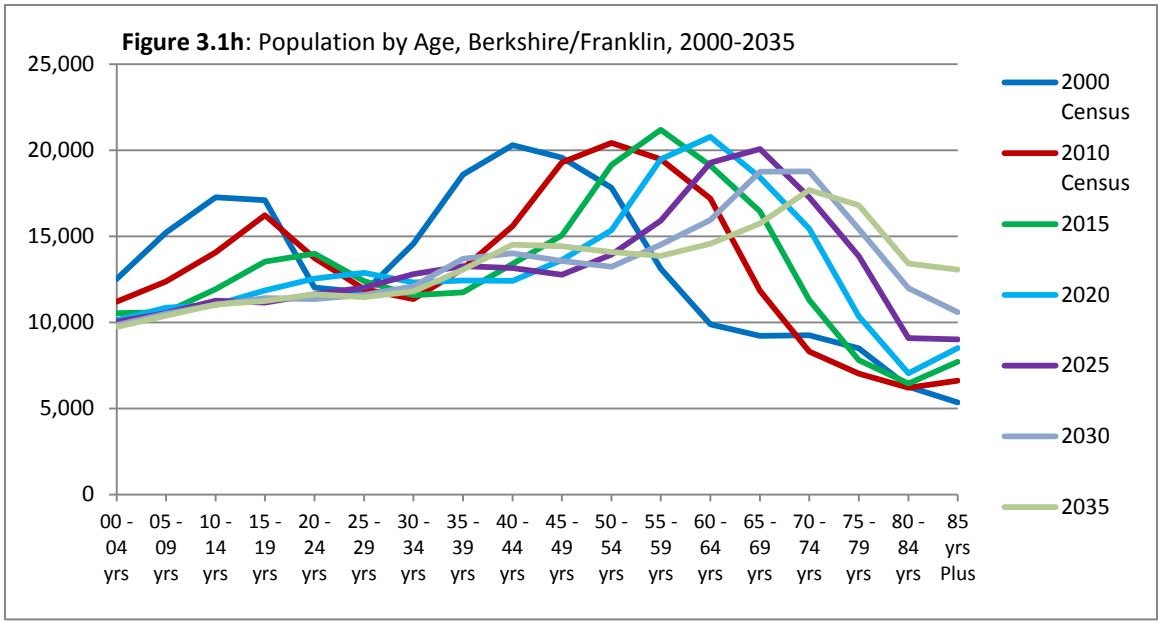


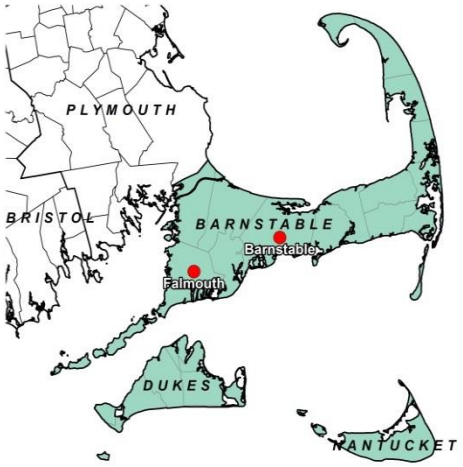
Figure 3.1h: Population by Age, Berkshire/Franklin, 2000-2035
25,000
20,000
15,000
10,000
5,000
0
00 - 04 yrs
05 - 09 yrs
10 - 14 yrs
15 - 19 yrs
20 - 24 yrs
25 - 29 yrs
30 - 34 yrs
35 - 39 yrs
40 - 44 yrs
45 - 49 yrs
50 - 54 yrs
55 - 59 yrs
60 - 64 yrs
65 - 69 yrs
70 - 74 yrs
75 - 79 yrs
80 - 84 yrs
85 yrs Plus
2000 Census
2010 Census
2015
2020
2025
2030
2035

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).

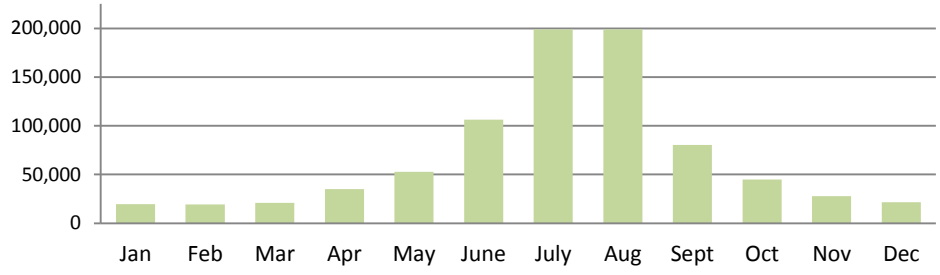
Figure 3.2a
The Cape & Islands Region



Before describing population and population change in the Cape and Islands region, it is important to first note that our projection series accounts only for the "resident" population of the region, as captured by the U.S. Census Bureau. During significant portions of any given year, however, the region is also home to a large number of "seasonal" residents not counted by the Census Bureau and, likewise, not considered in the scope of this projection series.

Estimates produced by the Cape Cod Commission, using survey data on second homes indicate that the seasonal population on Cape Cod, when averaged over a full year, is equivalent to 68,856 full-time residents in addition to the 215,888 counted by the U.S. Census Bureau in 2010 (Figure 3.2b).[20] The extent of this seasonal population is also apparent in Census Bureau housing unit data. Out of 3,221 U.S. counties tallied in Census 2010, the three Cape and Island counties all rank in the top 100 in terms of vacant/seasonal units as a percent of all housing units. Nantucket County ranks 9th at 58%; Dukes County ranks 14th at 54%; and Barnstable County is 75th at 36%. In terms of the total number of vacant/seasonal housing units, Barnstable County, with 56,918 units, has the 4th largest number in of all counties in the United States, just behind Maricopa County Arizona and Lee and Palm Beach counties in Florida.[21]

Figure 3.2b: Second Home Population Estimate , Cape Cod, 2010

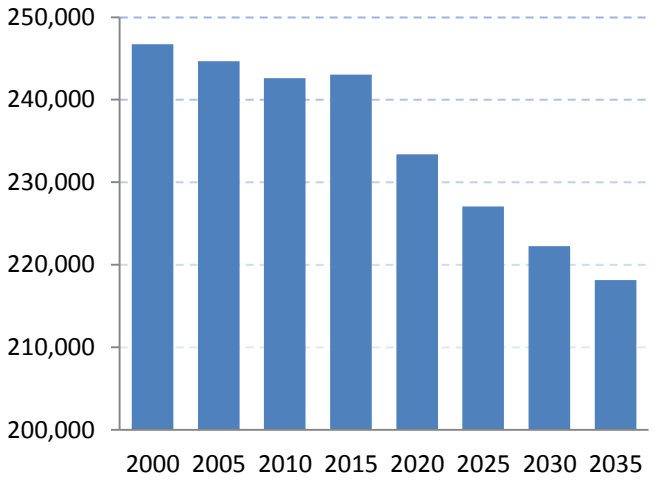


Source Data: Cape Cod Commission 2015. Calculations based on UMass Donahue Institute's *Second Home Owner Survey* 2008 and 2010 U.S. Census.

[20] For more information on the estimate of full-time resident equivalency, contact the Economic Development Department of the Cape Cod Commission in Barnstable, MA at http://www.capecodcommission.org.
[21] Source: U.S. Census Bureau, DP-1: Profile of General Population and Housing Characteristics, 2010 Census.

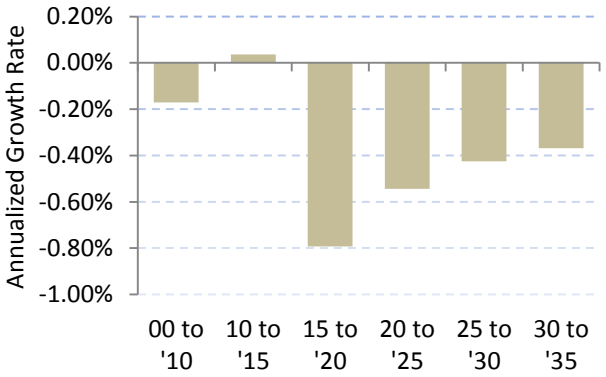
Between 2000 and 2010, the Cape and Islands region experienced a net loss of just over 4,000 residents, much of which was due to the out-migration of youth and a large number of deaths characteristic of an older resident population. Our model shows a slight increase in population from 2010 to 2015 to align the region with recent U.S. Census Bureau estimates for the area,[22] but the recent trend of population loss continues for the rest of the time period. From 2010 to 2015, the population increases to just over 243,000 persons, but then starts to lose population again at a level of about 6,225 persons on average every five years through 2035 (Figure 3.2c).

Figure 3.2c
Recent and projected population, Cape & Islands



Annualized growth from 2010 to 2015 is minimal—just 0.04%—and is followed by a decrease of -0.8% from 2015 to 2020 (Figure 3.2d). From 2000 to 2010, the region decreased by -0.17%. In the 2015 to 2020 period, decreasing population in the region is driven largely by the outflow of young people from the region. After 2020, the decrease is due largely to vital events as the number of deaths increasingly outnumbers the number of births in an aging region.

Figure 3.2d
Annualized rates of population change, Cape & Islands



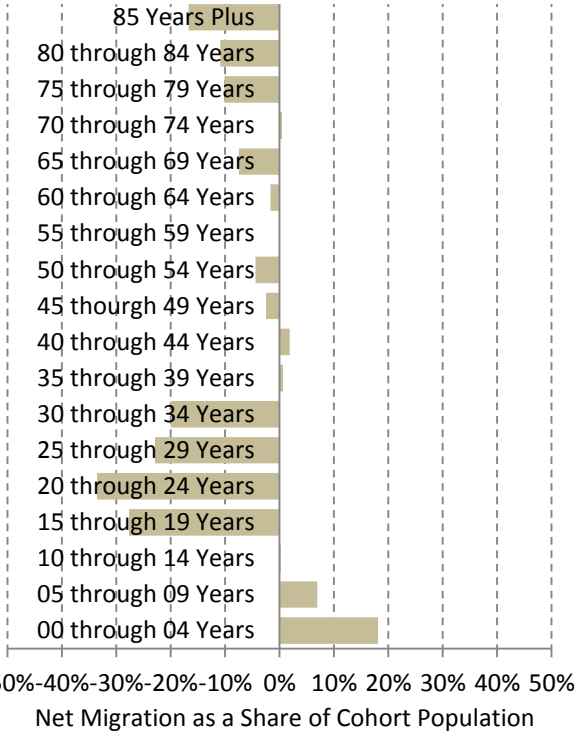
The Sources of Population Change

The anticipated population loss in the Cape and Islands is due to both the net domestic out-migration predicted in the model and the net result of more deaths than births in the region. American Community Survey PUMS data for the 2007 to 2011 period shows an annual outflow of 11,527 persons from the region compared to an inflow of just 7,546. Over a five-year period, this amounts to a net domestic loss of about 20,000 people.

[22] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

According to the ACS data, nearly all age groups are contributors to the net outflow from the region; however out-migration is particularly high among the region's youth, many of who presumably leave the region for college or job prospects while in their late teens through their twenties and mid-thirties (Figure 3.2e). Out-migration numbers will decline as the number of young residents associated with out-migration continues to shrink. Note that the *rates* of out-migration by age will be the same, according to our model; however the population of young persons in the region subject to this rate will is expected to decline over time.

Figure 3.2e
Age profile of net domestic migrants, Cape & Islands, 2007-2011, American Community Survey



When evaluating the migration component for Cape Cod, however, it should be noted that while the American Community Survey is our only *direct* source of gross-migration data by age and sex at the state or sub-state geographic level, it is based on sample survey data and therefore prone to sampling error. Because Cape Cod is the smallest region in our projection series, it can be considered the most prone to this sampling error out of all eight sub-state regions. Thus, both the migration levels and the distribution of the migration to each age group in this model are subject to dispute or revision through the analysis of other data sources when available.

Further complicating migration measurement in the Cape Cod region is the high level of seasonal, part-time, or "snowbird" residents. These populations are difficult to capture accurately in all types of direct migration data available. These data include: IRS migration data, which captures in- and out-migration for the total population down to the county level, the old Census long form (used in 2000), and the ACS survey.

Because of the variances due to measurement error as well as varying residency rules among the different sources of migration,[23] the resulting net levels of migration for this region differ significantly by source. The ACS county-to-county flow data indicates a net outflow of 4,539 per year from 2005 to 2009 and 2,437 per year during the 2007 to 2011 period.[24] This equates to 22,695 and 12,185 net out-migrants, respectively, for each of the five-year periods we use in

[23] The American Community Survey defines residency as a place where a person lives for "at least two months"; the decennial Census count defines residency as where a person lives "most of the time"; and IRS migration data is based on the filer's declared place of residence for tax purposes.

[24] Source: U.S. Census Bureau, 2005-2009 American Community Survey and 2007-2011 American Community Survey County-to-County Migration Flows. For more information see: http://www.census.gov/hhes/migration/data/acs/county-to-county.html

creating migration rates for the UMDI V2015 projection series. The ACS PUMS migration data,[25] which provides age/sex detail but which is subject to larger sample error, suggests a larger net outflow of 5,670 persons per year in 2005 to 2009 and 3,981 per year in the 2007 to 2011 period, or five-year totals of 28,350 and 19,905, respectively. In contrast, net migration estimates created by the U.S. Census Bureau for use in their annual county-level population estimates, based on IRS tax-returns and Medicare enrollment data, indicate much lower levels of net outflow: 2,871 in the 2005 to 2009 period—or 574 average per year. In the 2007 to 2011 period these estimates indicate net *positive* migration of 380 person's average per year, or 1,899 for the five-year period.[26]

As an alternative to using these direct sources of migration data, one can also estimate migration levels indirectly. One commonly used cohort-component method estimates net migration for each age/sex cohort as a residual of births, deaths, and the difference between the Census 2000 and 2010 counts. In an application of this method, we take the Census 2000 population for a given town by age and sex, age all of its cohorts forward by ten years, add the number of births in the town from 2000 to 2010, and subtract deaths from 2000 to 2010. This gives us our "anticipated" 2010 population. The difference between the "anticipated" and the actual population (the Census 2010 count) is attributed to net-migration and is converted into a migration rate that is carried forward for the rest of the time series.

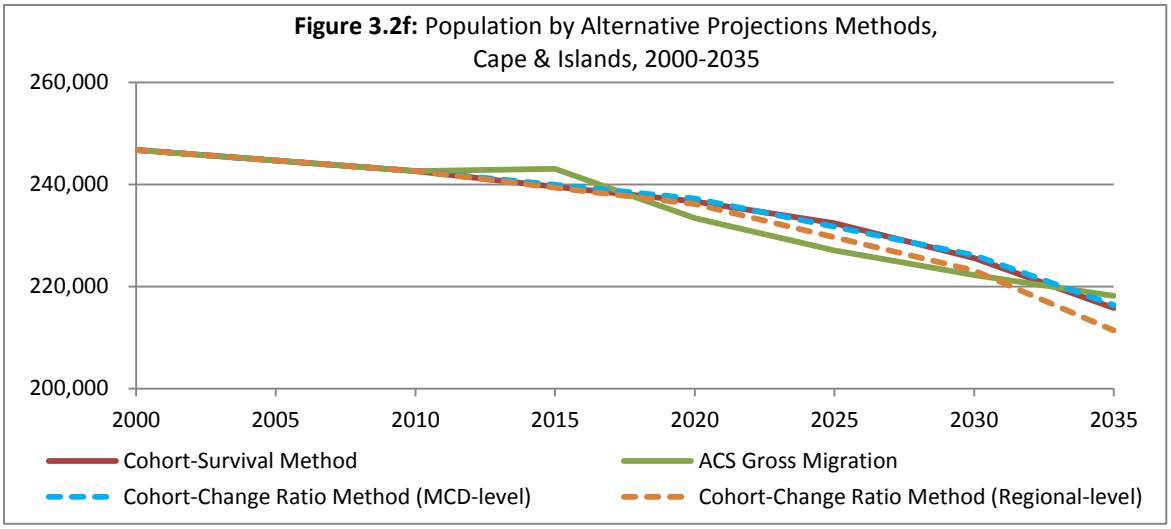
Using a residual-survival method for estimating migration, we do see a different pattern of net-migration by age than that observed in the ACS data. This method, however, also predicts population loss in the region at about the same level as the ACS-based, gross migration model that we use in this V2015 projection series. Figure 3.2f, below, shows the resulting total population projected for the region using four different methods of projecting population change: a cohort-survival method calculating net-migration, two alternate variations of a Hamilton-Perry or "cohort-change-ratio" method,[27] and the ACS-based gross-migration model that we use in the UMDI V2015 projection series.[28] For most points in the time series, the variation from the highest to the lowest result from any given model is about 4,000 to 5,000 people.

[25] Source: U.S. Census Bureau American Community Survey 5-year Public Use Microdata Sample Data 2005-2009 and 2007-2011. For additional information see: http://www.census.gov/acs/www/data_documentation/pums_data/

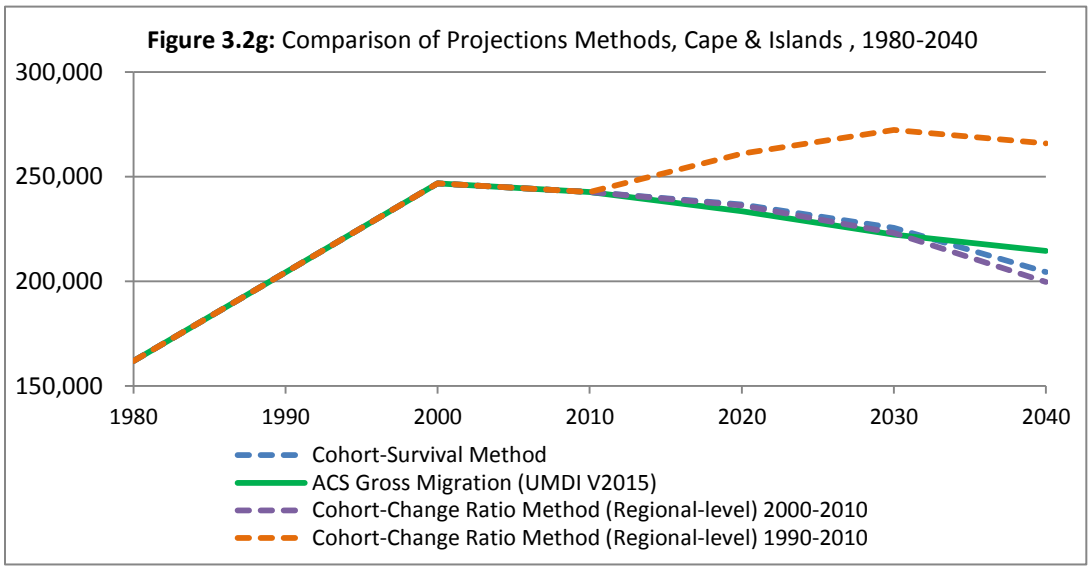
[26] Sources: U.S. Census Bureau: Cumulative Estimates of the Components of Resident Population Change for Counties of Massachusetts: April 1, 2000 to July 1, 2009 (CO-EST2009-04-25, March 2010) and Annual Resident Population Estimates, Estimated Components of Resident Population Change, and Rates of the Components of Resident Population Change for States and Counties (CO-EST2013-ALLDATA, March 2014).

[27] In our example of a cohort-change-ratio method, we take the ratio of an age/sex cohort population age (*a*) at time (*t*) to the cohort population age (*a-10*) at time (*t-10*) and apply that ratio, by age and sex, to the base and future base populations.

[28] Researchers interested in obtaining detailed results of the alternative series shown here may contact the UMDI Population Estimates Program for information.



It should be further noted that all four of the alternative models presented here are based on birth, death, and migration trends experienced in the Cape Cod region from 2000 forward. The Cape region experienced strong and steady growth for many decades leading up to 2000, with the 2000 to 2010 period representing a reversal of those trends. A projection model that based its future migration trends on a longer history of the region, for example the 1990 to 2000 period, would likely predict continued growth in this region rather than decline. Figure 3.2g below shows the example of a cohort-change-ratio model that uses the ratios observed from 1990 to 2000 averaged with the 2000 to 2010 ratios, as compared to some of the alternative models based on just the 2000 to 2010 data.



In our vintage 2015 projection series we do choose to use a migration period (2005 to 2011) that we feel is reasonably likely to reflect migration patterns over the next 20 years, and we select a source of direct migration data (ACS PUMS) that allows us to examine both in and out-migration by

age and by sex. However, it should be clear from the above discussion that these do represent choices and assumptions in our model which are subject to variation in any other given model.

While out-migration is mitigated in our model in the 2010 to2015 period, when we adjust migration rates to meet Census 2014 estimates,[29] it increases again from 2015 to 2020 before gradually diminishing when using the ACS-based rates. In-migration generally increases throughout the period, holding steady through 2020 and then increasing thereafter as the millennials in the greater U.S. start to age into the 35-44 age group now associated with slight in-flow in the Cape region according to the ACS data. These age groups further increase the inflow by bringing their children with them. While most other age-groups have been contributing to out-migration, this increased inflow, together with diminishing out-flow, is just enough to finally yield net-positive migration by 2035 (Table 3.2 and Figure 3.2h.). Finally, throughout the time series, positive international migration, at roughly 6,000 new residents in each 5-year period, steadily off-sets the losses through domestic outmigration that we predict in the region after 2015.

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	242,595	243,036	233,398	227,050	222,232
Births	10,035	10,176	9,920	9,714	9,544
Deaths	16,015	16,778	17,174	18,090	19,239
Natural Increase	*-5,980*	*-6,602*	*-7,254*	*-8,376*	*-9,695*
Domestic In-migration, MA & Border	25,852	25,729	26,224	26,573	26,890
Domestic In-migration, Rest of U.S.	16,031	15,464	16,015	16,581	17,162
Domestic Out-migration	41,435	50,161	47,252	45,508	44,359
Net Domestic Migration	*448*	*-8,968*	*-5,013*	*-2,354*	*-307*
Net International Migration	*5,973*	*5,932*	*5,919*	*5,912*	*5,904*
Ending Population	243,036	233,398	227,050	222,232	218,133

Population loss due to vital events has an even larger influence than migration on population change in the region, and its influence only increases throughout the time period. According to U.S. Census estimates, Barnstable County, which accounted for 89% of the region's population in 2010, shows the highest rate of population loss due to natural decrease (deaths over births) in the state, at 5.3 per thousand compared to 2.9 statewide.[30] From 2005 to 2010, the region experienced 11,193 births compared to 13,959 deaths.

[29] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.
[30] Source: U.S. Census Bureau Population Division, CO-EST2013-ALLDATA, March 2014 and NST_EST2013_ALLDATA, January 2014.

With the number of births essentially flat over the next twenty-five years, the gap between deaths and births will continue to widen, leading to increasing population loss through the period (Table 3.2 and Figure 3.2h). By the 2030 to2035 period, the region is projected to have a 2:1 ratio of deaths over births with 19,239 deaths compared to just 9,544 births.

Figure 3.2h
Projected levels of domestic in and out-migration, Cape & Islands, 2010-2035

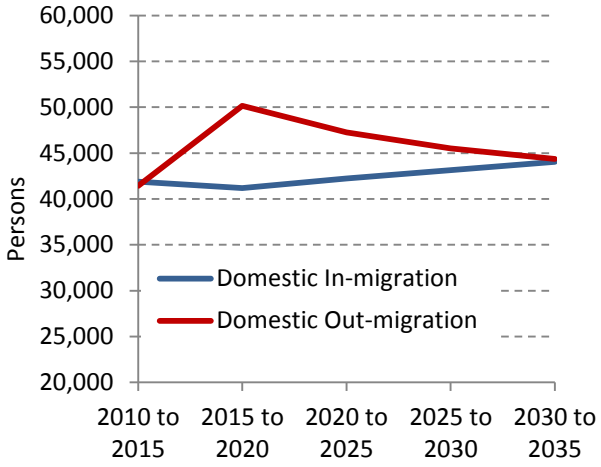
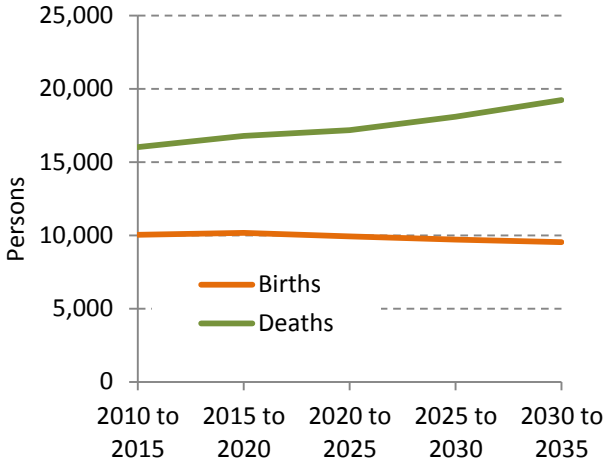


Figure 3.2i
Projected levels of births and deaths, Cape & Islands, 2010-2035



Age Profile

The increasing number of deaths over births is a trend playing out in many other parts of the Northeast and even the U.S. as the large population of baby boomers moves into their seventies and eighties, when mortality rates rise considerably. In the Cape region this effect is exacerbated by a regional age profile that is notably older than both the state and the nation. Figure 3.2j shows a sizable population mass among persons 45- 69 years old in 2010. In the Cape and Islands this group accounts for 39% of the regional population, compared to roughly 32% for the state and 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 and 10% of the state population compared to 17% in the Cape and Islands.

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 2035, roughly 35% of the population will be 65-years or older—compared to 24% in 2010. From 2010 to 2035, the region loses population in every cohort younger than 65. Of particular interest in the 2010 age profile is the near absence of the children of the baby boomers (the millennials) as a secondary bulge—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. Only some of these will to return the Cape and Islands as they approach their thirties and forties and start families of their own.

Figure 3.2j: The age and gender composition of the Cape & Islands population, 2010 (actual) vs. 2035 (forecasted)

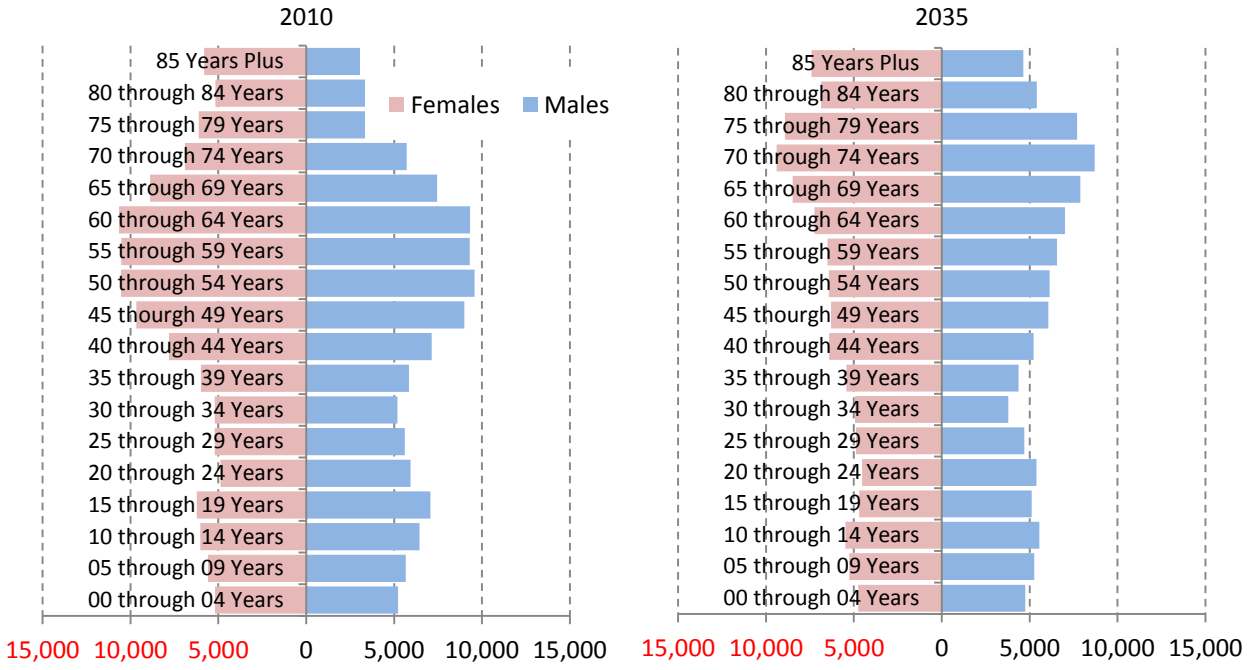
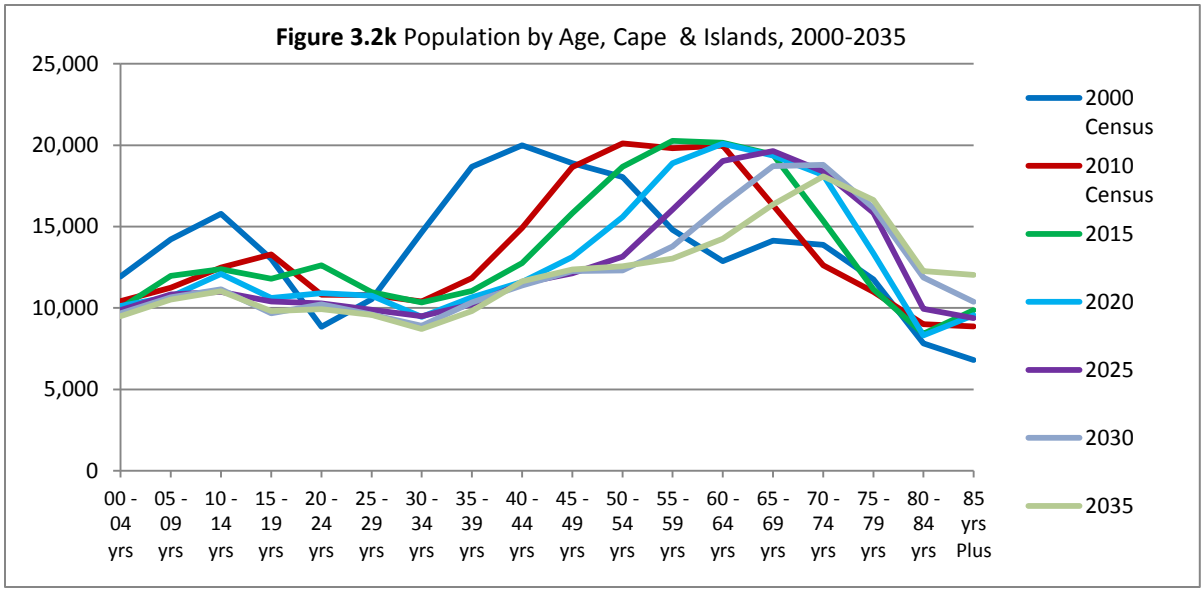


Figure 3.2k below shows the Cape and Islands population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.



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).

The Central region added just under 40,000 residents during the 2000s (Figure 3.3b), and our projections anticipate continued population growth over the next several decades with the region increasing by another 33,000 people from 2010 to 2020 and another 26,000 from 2020 to 2030. By 2035, we anticipate a population of about 760,506 in the region, as compared to 693,813 counted in the 2010 Census. The rate of population growth will slowly diminish as the number of deaths begins to rise with the aging of the regional population over time. 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 0.2% percent per year.

The Sources of Population Change

The growth of the Central region over the past decade was due primarily to natural increase, or more births than deaths in the region. 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. This reflects the age composition of the region which, as of 2010, has a fairly substantial number of residents in their later twenties and thirties and relatively few elderly residents.

Figure 3.3a:
The Central Region

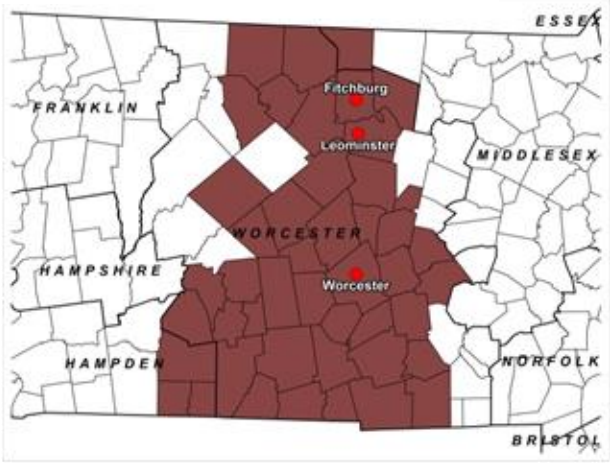


Figure 3.3b: Recent and projected population, Central Region

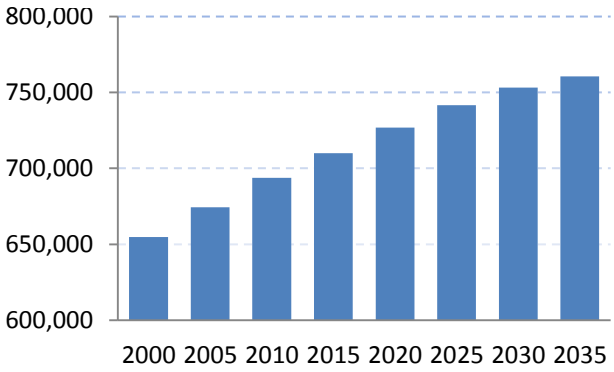
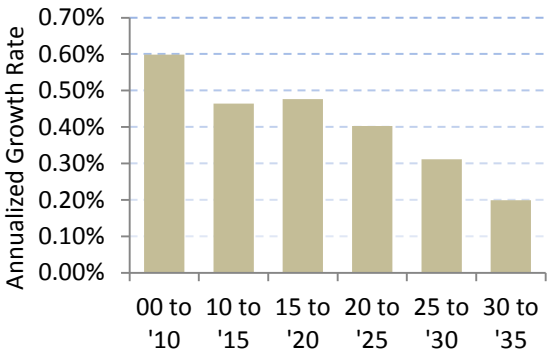


Figure 3.3c: Annualized rates of population change, Central Region



Over the next several decades, however, the gap between births and deaths is expected to narrow, leading to a slowdown in the rate of population growth (Figure 3.3e). The number of deaths is expected to rise with the aging of the population—growing from roughly 29,000 from 2005 to2010 to over 39,000 during the 2020 to2025 period. This coincides with the aging of the resident population, particularly the sizable baby boom generation, which will begin moving into its seventies by 2030. By 2025, deaths already start to outnumber births and start to cut into overall population growth.

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	693,813	709,922	726,839	741,487	753,027
Births	41,652	38,503	38,621	38,481	38,227
Deaths	32,382	35,623	39,756	44,585	49,991
Natural Increase	*9,270*	*2,880*	*-1,134*	*-6,104*	*-11,763*
Domestic In-migration, MA & Border	99,545	104,065	104,868	105,706	106,783
Domestic In-migration, Rest of U.S.	34,006	33,820	34,722	35,637	36,583
Domestic Out-migration	142,321	139,241	139,290	139,177	139,598
Net Domestic Migration	*-8,695*	*-1,389*	*298*	*2,177*	*3,797*
Net International Migration	*15,609*	*15,393*	*15,482*	*15,478*	*15,474*
Ending Population	709,922	726,839	741,487	753,027	760,506

Figure 3.3d
Projected levels of domestic in and out-migration, Central Region, 2010-2035

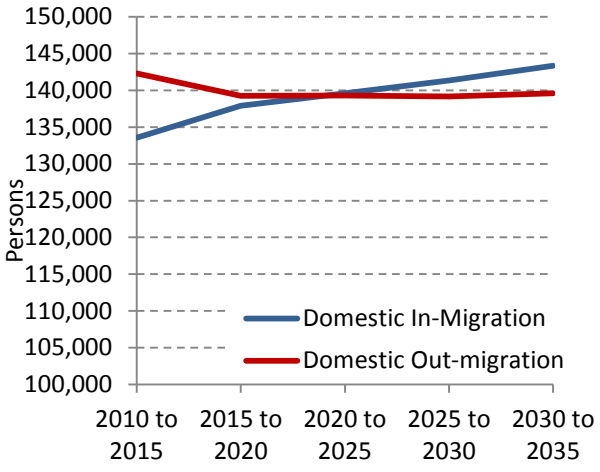
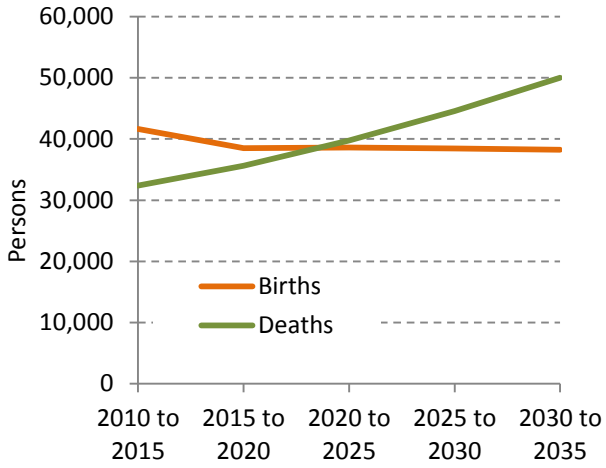
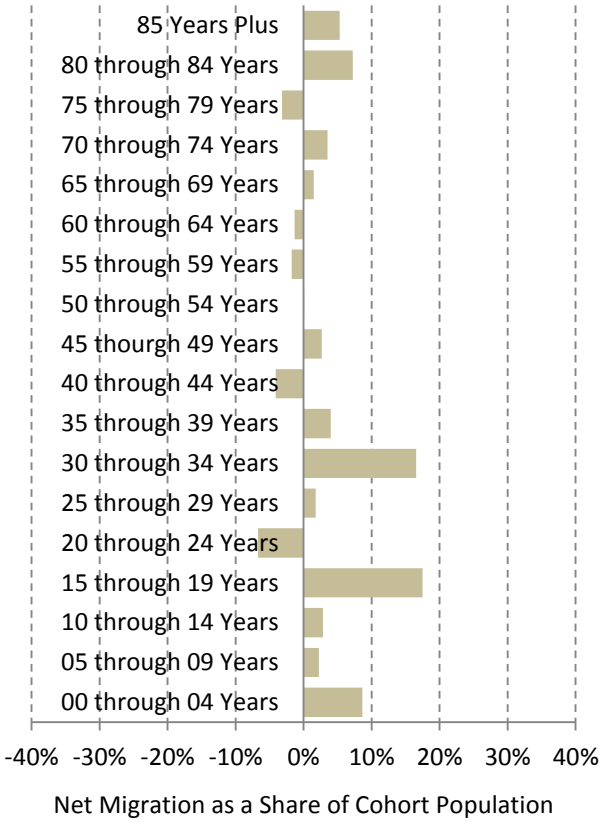


Figure 3.3e
Projected levels of births and deaths, Central Region, 2010-2035



On the positive side, ACS migration data from 2007 to 2011 suggests that the region tends to attract, on net, persons in their later twenties and thirties (Figure 3.3f). These cohorts bring their children with them and also contribute to the number of births in the region. Future projections assume that the region will continue to attract a steady stream of these young families. Accordingly, the number of births is expected to hold fairly steady over the next twenty-five years, hovering around 38,000 for each of the five-year increments from 2020 through 2035.

Figure 3.3f
Age profile of net domestic migrants,
2007-2011 American Community Survey



Home to several large colleges and universities, the Central region is also a net importer of persons in the 15- 19 age group although many in this cohort leave the region following graduation, as suggested by net negative out-migration among those in their early twenties. The region also appears to be a relatively attractive destination for some of the elderly cohorts.

As the millennial population moves into its thirties and more in-migrant baby boomers moving into their seventies and eighties, our model predicts that in-migration will increase into the region, contributing increasingly to population gain through the time series. By the 2030 to 2035 period, the number of domestic in-migrants will exceed the number of domestic out-migrants by almost 3,800 persons, while international immigrants continue to contribute to population gain in the region (Table 3.3).

Age Profile

As with other regions around the state, the Central region of the future will be home to many more elders, as the baby boomers age into the older age brackets. By 2035, 23% of the region's population will be aged 65-or older compared to just 13% in 2010. However, compared to many other regions around the state, the Central region is expected to show a relatively evenly distributed age profile, meaning that while the number of elders increases, younger adults and children are also well represented in the area (Figure 3.3g).

Figure 3.3g: The age and gender composition of the Central Region population, 2010 (actual) vs. 2035 (forecasted)

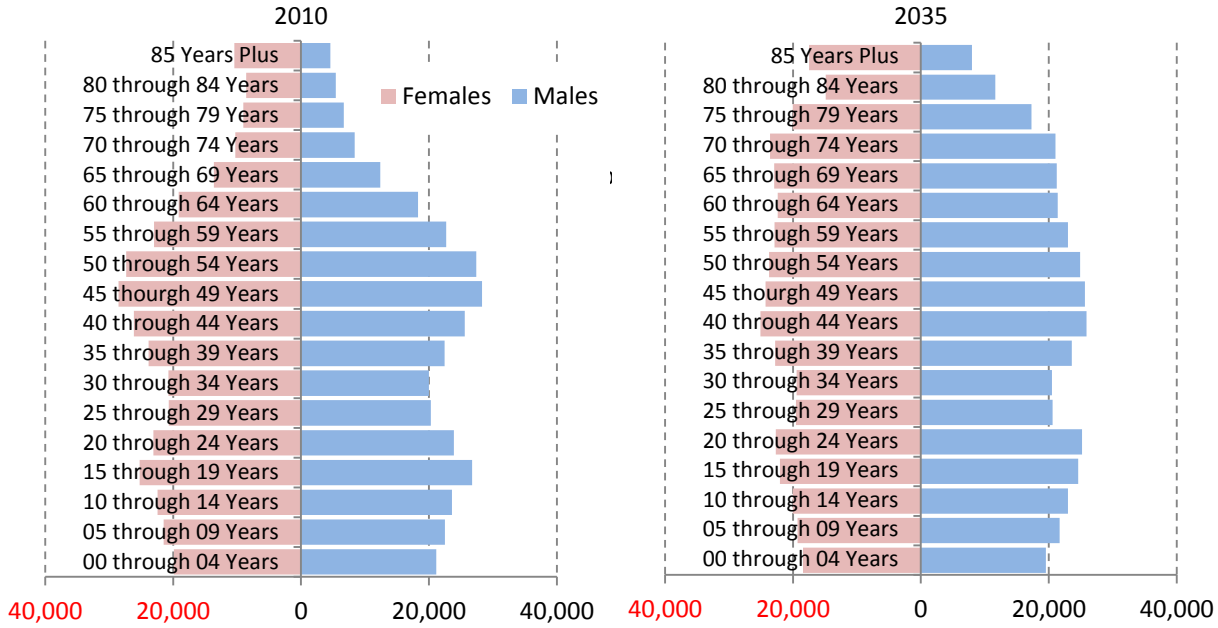
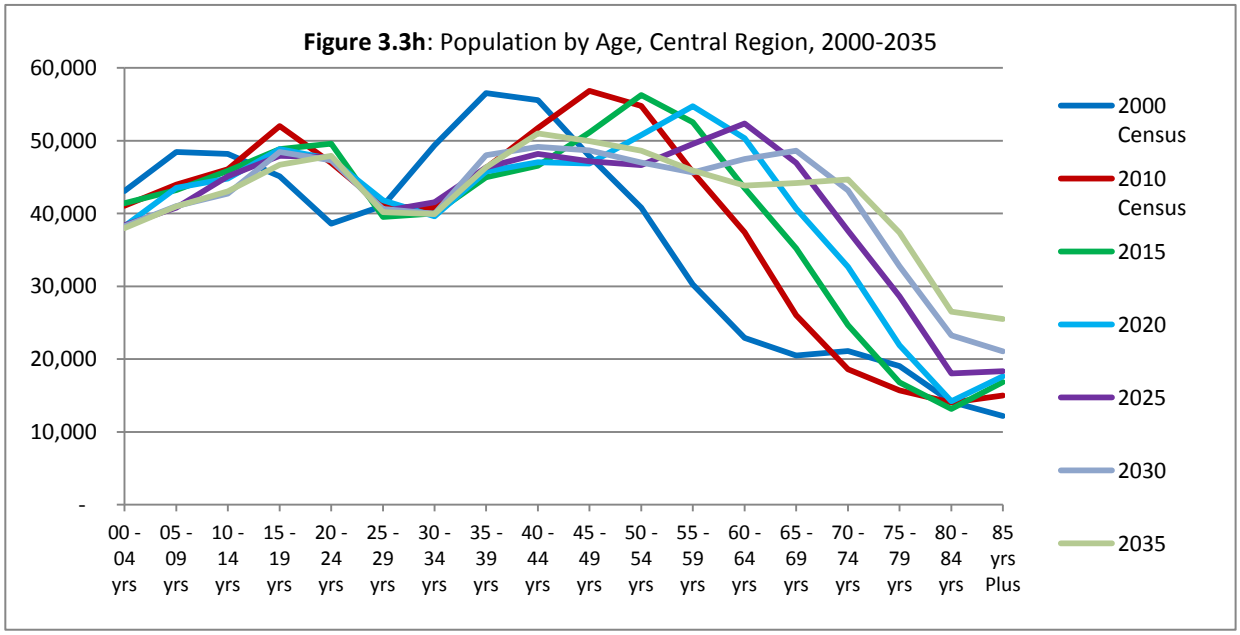


Figure 3.3h below shows the Central region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series. Because it is a college region, the number of 15-19 and 20-24 year olds is more or less maintained as other population peaks age forward over time.



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 projections predict strong growth in the Greater Boston population over the next 25 years, increasing by roughly 100,000 residents every five years through 2025, 75,000 from 2025 to 2030, and 57,000 from 2030 to 2035 (Figure 3.4b). We project growth during the 2010 to2015 period to be particularly strong, as we align our model with the level of growth estimated by the U.S. Census Bureau for the state through 2014.[31] The Bureau estimates that the Greater Boston region has been growing by about 20,000 persons per year since the 2010 Census,[32] and our model assumes that this level of growth is sustained through 2020 and beyond. By 2035, the region is expected to have a population of 2,418,770; this is 443,615 more than the 1,975,155 counted in Census 2010.

The Sources of Population Change

Population change in the Greater Boston region is driven by natural increase—the number of births over deaths—and

Figure 3.4a
The Greater Boston Region

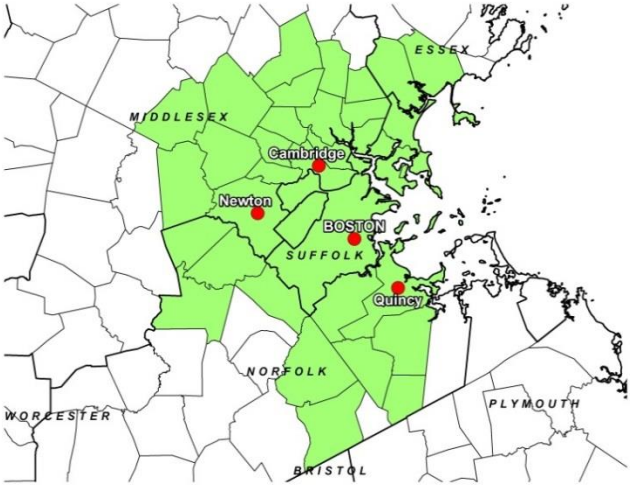


Figure 3.4b
Projected Population, Greater Boston

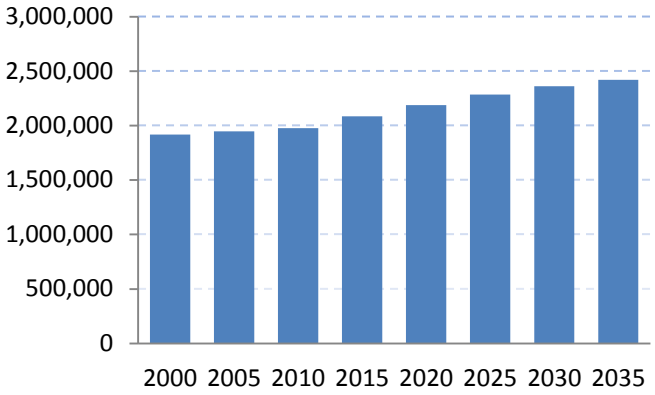
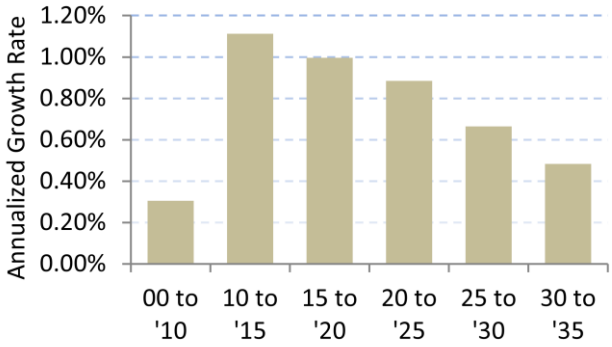


Figure 3.4c
Annualized rates of population change, Greater Boston



[31] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.
[32] Source: Sub-EST 2013: Subcounty Resident Population Estimates April 1, 2010 to July 1, 2013. U.S. Census Bureau, Population Division. May 2014.

international immigration (Table 3.4). While the region tends to lose more by out-migration than it gains by domestic in-migration, a steady stream of international immigrants more than off-sets the loss. The relatively young population of the region, including international immigrants who tend to be younger than the state on average, ensures a steady level of births over the 2010 to 2035 time period. As seen in other regions of the state, the number of deaths increases over time as a large percentage of the population ages into the elderly cohorts. In the Greater Boston region this reduces the level of natural increase over time. However, the steady number of births continues to counter this loss, and overall we continue to see positive natural increase in the region all the way through 2035.

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	1,975,155	2,085,048	2,188,890	2,285,779	2,361,771
Births	124,292	124,144	126,140	126,269	125,902
Deaths	79,063	86,933	94,904	104,605	116,069
Natural Increase	*45,229*	*37,210*	*31,236*	*21,664*	*9,833*
Domestic In-migration, MA & Border	294,330	302,018	303,394	303,350	305,272
Domestic In-migration, Rest of U.S.	215,430	217,512	222,119	225,951	229,345
Domestic Out-migration	555,938	561,694	568,820	584,110	596,612
Net Domestic Migration	*-45,013*	*-42,285*	*-43,460*	*-54,651*	*-61,666*
Net International Migration	*110,842*	*108,796*	*108,959*	*109,137*	*109,161*
Ending Population	2,085,048	2,188,890	2,285,779	2,361,771	2,418,770

Figure 3.4d
Projected levels of domestic in and out-migration, Greater Boston, 2010-2035

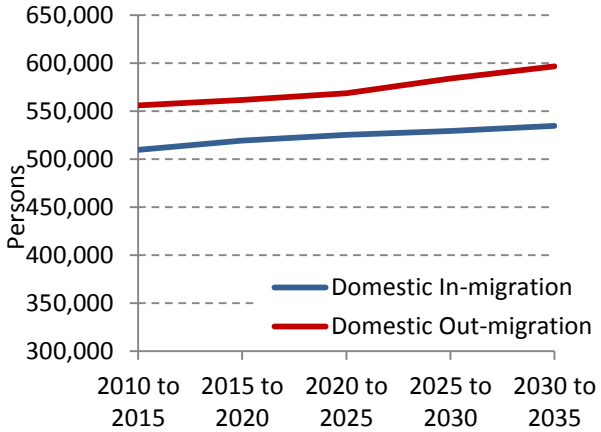
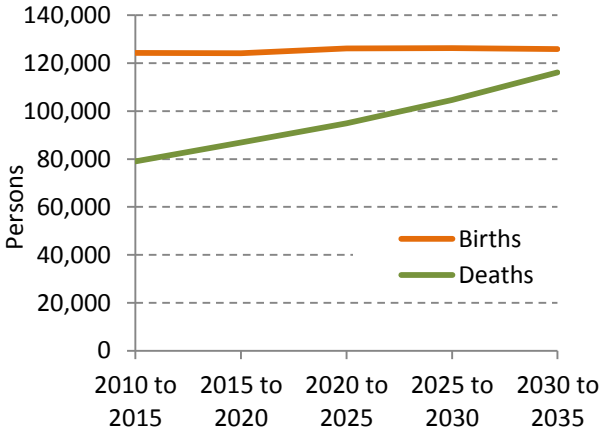
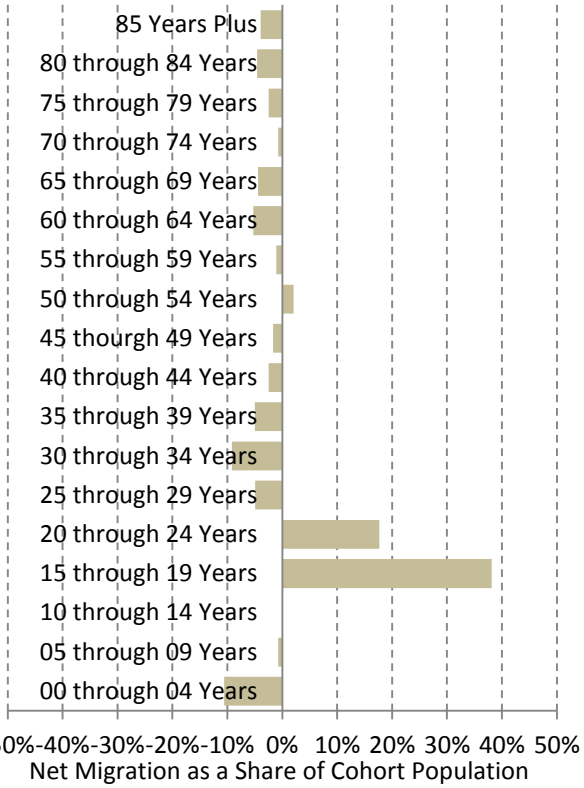


Figure 3.4e
Projected levels of births and deaths, Greater Boston, 2010-2035



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 residents as they age and taking their children with them. Figure 3.4f shows the migration-by-age patterns observed in the American Community Survey 2007 to 2011 dataset for the region. 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.

Figure 3.4f: Age profile of net domestic migrants, Greater Boston, 2007-2011 American Community Survey



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 typically represents 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. Using data from the 2007-2011 American Community Survey, we estimate that immigration contributes over 150,000 new area residents every five years. While approximately one-third of these represent college students who leave the country when their studies conclude, over 100,000 new immigrants per five-year period are expected to remain in the region.

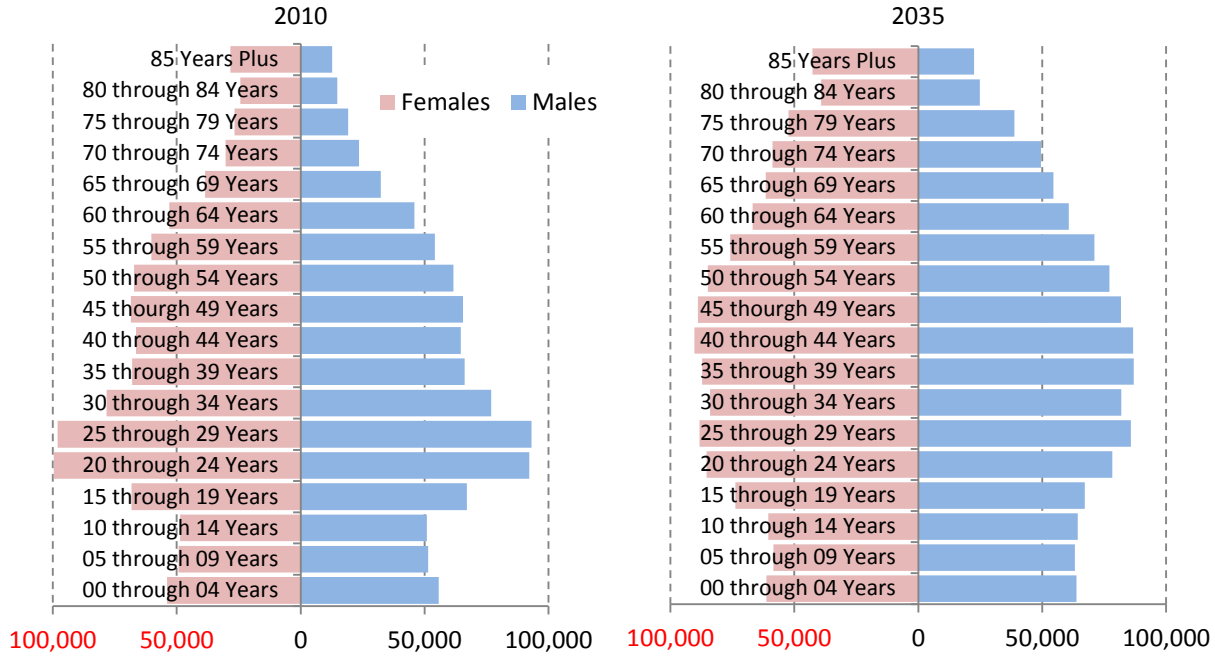
Population growth will be fastest in the next few years as the swell of millennials (the children of the baby boom generation) ages through their twenties. Because the region tends to lose residents to out-migration as they move through the family-building and retirement phases of life, we expect population 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 as international immigration and a steady number of births will

more than offset population loss associated with domestic out-migration and the gradual rise in the number of resident deaths.

Age Profile

Due to its rather unique age-specific migration patterns, the Greater Boston region is exceptionally young relative to other regions in Massachusetts. Greater Boston lacks the typical hourglass shape of the national age profile with the sizable baby boom generation (people in 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.

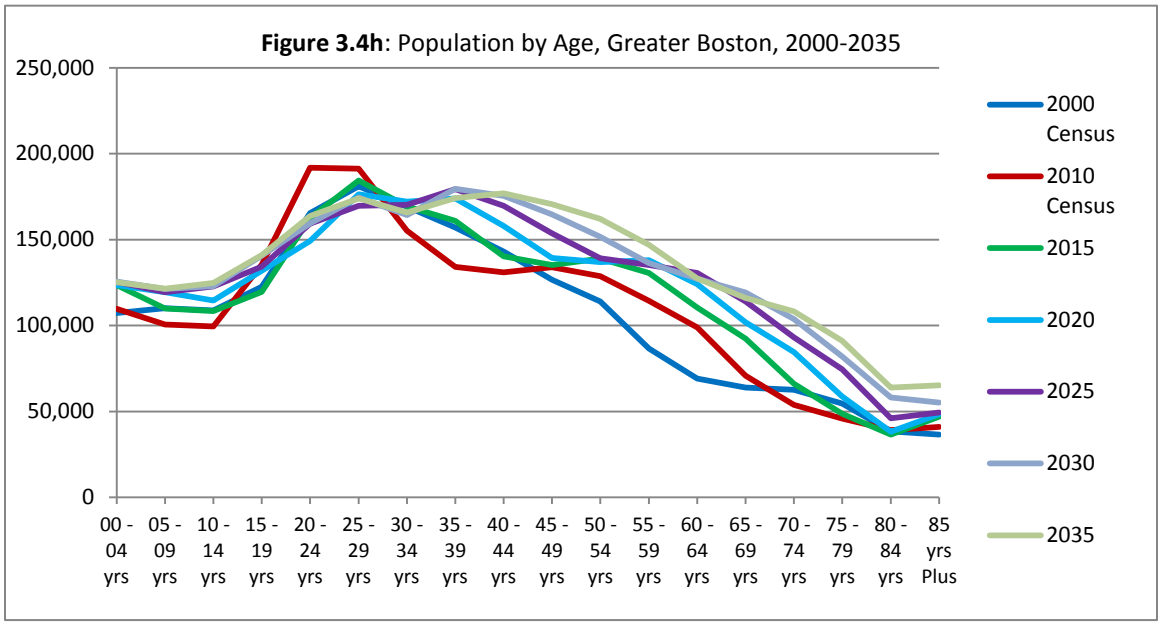
Figure 3.4g
The age and gender composition of the Greater Boston region, 2010 (actual) vs. 2035 (forecasted)



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 (Figure 3.4g). Over the near term there will be relatively more infants and pre-schoolers under the age of five, growing from 5.6% of the population in 2010 to 5.9% percent in 2015 before returning to 2010 levels again in 2020. There will also be a relatively higher share of elders aged 65 and over, coinciding with the aging in

place of the baby boomer generation, increasing from 12.7% of the population in 2010 to 18.4% in 2035. While this does represent a significant increase, it is not nearly as pronounced as in other regions of the state where the 65-and-over population of 2035 will range from 23% in younger regions like Central to 35% in older regions such as the Cape and Islands region. The relative increase in the elderly cohorts will be countered by a slight loss in the younger adult cohorts, aged 15-34, however, these losses as percentages are very small. Other cohorts are represented at roughly the same distribution in 2035 as they were in 2010 in terms of their percent of the total population.

Figure 3.4h below shows the Greater Boston region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series. Because it is a college region that includes large numbers of older graduate students, Boston's number of 20-29 year olds is more or less maintained as other population groups age forward over time.



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 County, 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, increasing by 12,372 over the ten year period, from 591,932 to 604,304 persons (Figure 3.5b). Our model anticipates that this growth will continue at a slightly increased level through 2030, with the region adding about 8,000 to 9,000 in each five-year period before falling off to about 5,000 in the 2030 to2035 period. During the 2000s, the annualized population growth rate was 0.21%. This rate will increase through 2025 to as much as to 0.31%, and then start to decline again. Our model predicts that by 2035 the region will be home to 644,975 residents, about 32,000 more than counted in the 2010 Census.

The Sources of Population Change

Population gain in the 2000 to2010 period was due primarily to natural increase—the number of births exceeding the number of deaths in the region. Natural increase is expected to contribute to population gain in the region through 2020, though at diminishing levels, after which an increase in the number of deaths in the regions will overtake births, leading to net natural

Figure 3.5a
The Lower Pioneer Valley Region

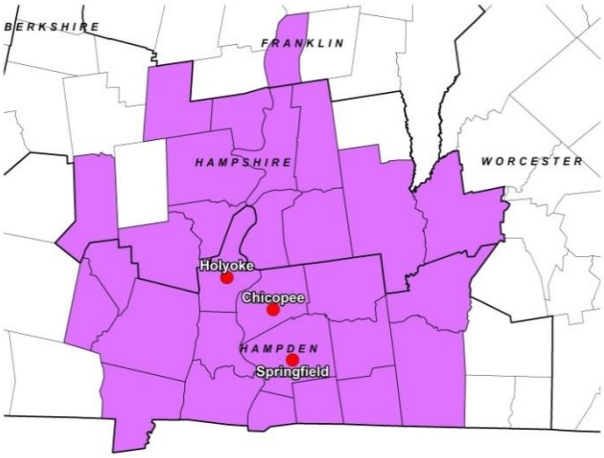


Figure 3.5b
Projected Population, Lower Pioneer Valley

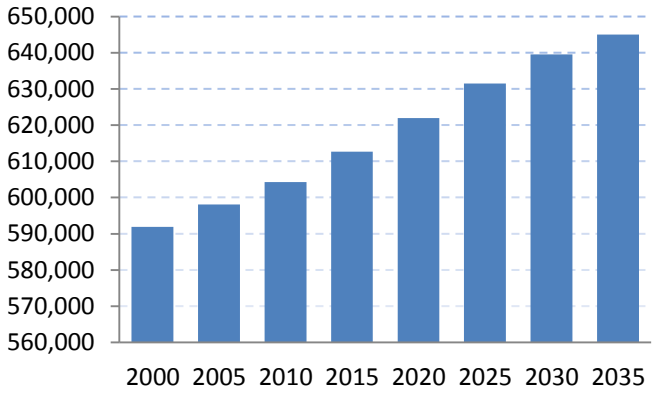
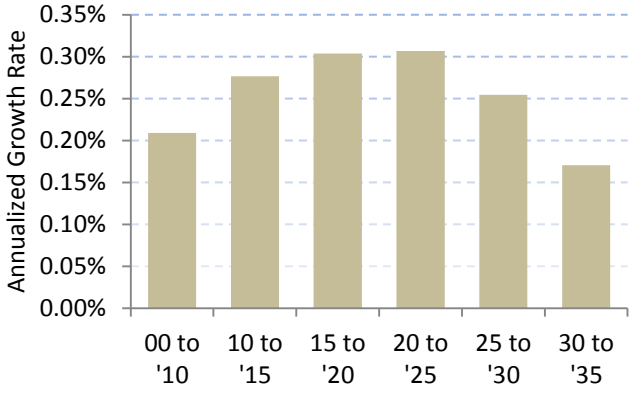


Figure 3.5c
Annualized rates of population change, Lower Pioneer Valley



decrease (Table 3.5, Figure 3.5e). On the positive side, net negative migration in the region will eventually reverse to net positive migration by the end of the time series with the number of out-migrants gradually decreasing as the number of in-migrants gradually increases over the course of the time series (Figure 3.5e).

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	604,304	612,664	621,962	631,497	639,525
Births	35,017	32,173	32,257	32,214	32,166
Deaths	29,742	31,413	33,666	36,923	40,939
Natural Increase	*5,275*	*759*	*-1,408*	*-4,709*	*-8,773*
Domestic In-migration, MA & Border	76,438	77,815	78,094	78,698	79,684
Domestic In-migration, Rest of U.S.	46,427	47,396	48,310	49,261	50,250
Domestic Out-migration	133,338	129,906	128,771	128,538	129,047
Net Domestic Migration	*-10,328*	*-4,782*	*-2,364*	*-554*	*949*
Net International Migration	*13,558*	*13,234*	*13,311*	*13,316*	*13,336*
Ending Population	612,664	621,962	631,497	639,525	644,975

Figure 3.5d
Projected levels of domestic in and out-migration, Lower Pioneer Valley, 2010-2035

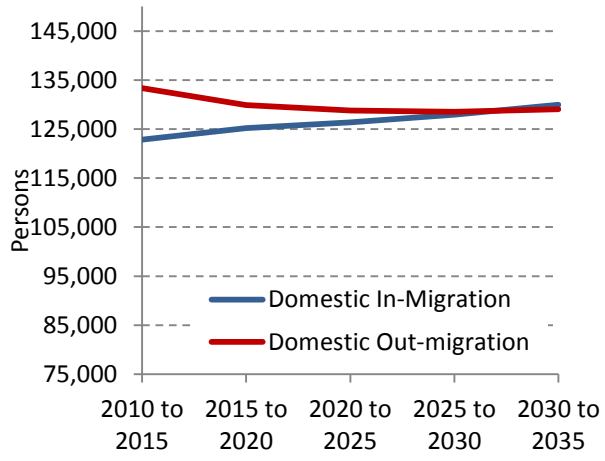
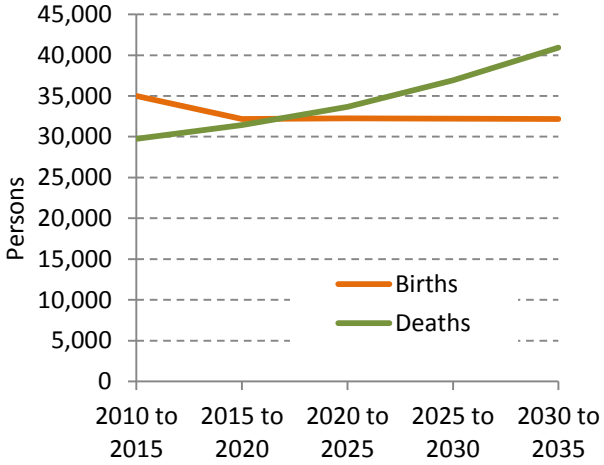


Figure 3.5e
Projected levels of births and deaths, Lower Pioneer Valley, 2010-2035



Period to period changes in each of the components are small, but together they add up to a change in relative direction. This change over time relates to the changing age structure of the region and the greater U.S. While we assume that migration-by-age rates calculated from recent ACS data will persist into the future, the migrant "pools" will vary over time as these populations age. Contributing to this dynamic is the sizable student population in the region which results in a higher portion of domestic in-migrants coming from outside the Northeast. Between 2005 and 2010, 36% of all domestic in-migrants came from outside of Massachusetts and its neighboring states. Although a minority, this share is among the lowest of all regions in the state. Thus, the future size of the region is heavily influenced not only by regional demographic trends, but also national and international ones.

Domestic migration in the Pioneer Valley is heavily concentrated among college age students. According to ACS 2007-2011 data, 15-19 year olds account for 86% of all domestic in-migrants, and these recent in-migrants represent over 40% of the resident cohort population (Figure 3.5f). However, a large number also leave the region after completing their studies, with 25-29 year olds comprising 32% of all domestic out-migrants and 58% of all domestic out-migrants falling into the 25-39 age cohorts. Looking at the non-college population only, including those that graduated college and moved out of the region, the 20-24 age group dominates the out-migrant pool, comprising 50% of all domestic out-migrants for that group. Out-migrants accounted for 30% of the region's total population of 20-24 year olds (Figure 3.5g).

In the 2010 to 2015 period, the millennials are aging up out of the 15-24 and into the 20-29 age

Figure 3.5f: Age profile of net domestic migrants, Lower Pioneer Valley, 2007-2011 American Community Survey

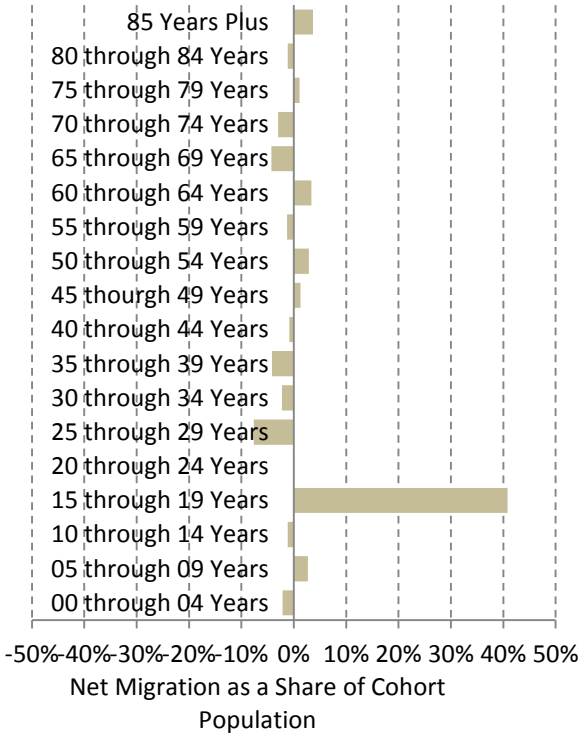
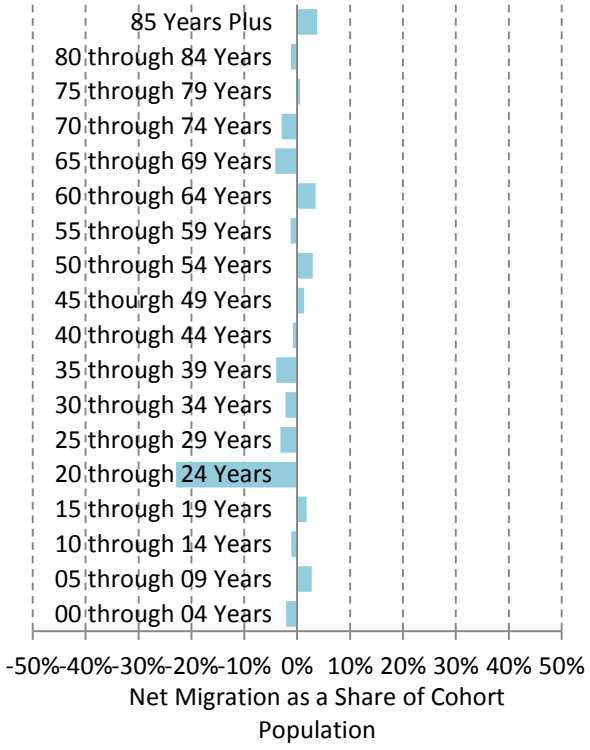


Figure 3.5g: Age profile of net domestic migrants in the **NON-COLLEGE** population, Lower Pionner Valley, 2007-2011 American Community Survey



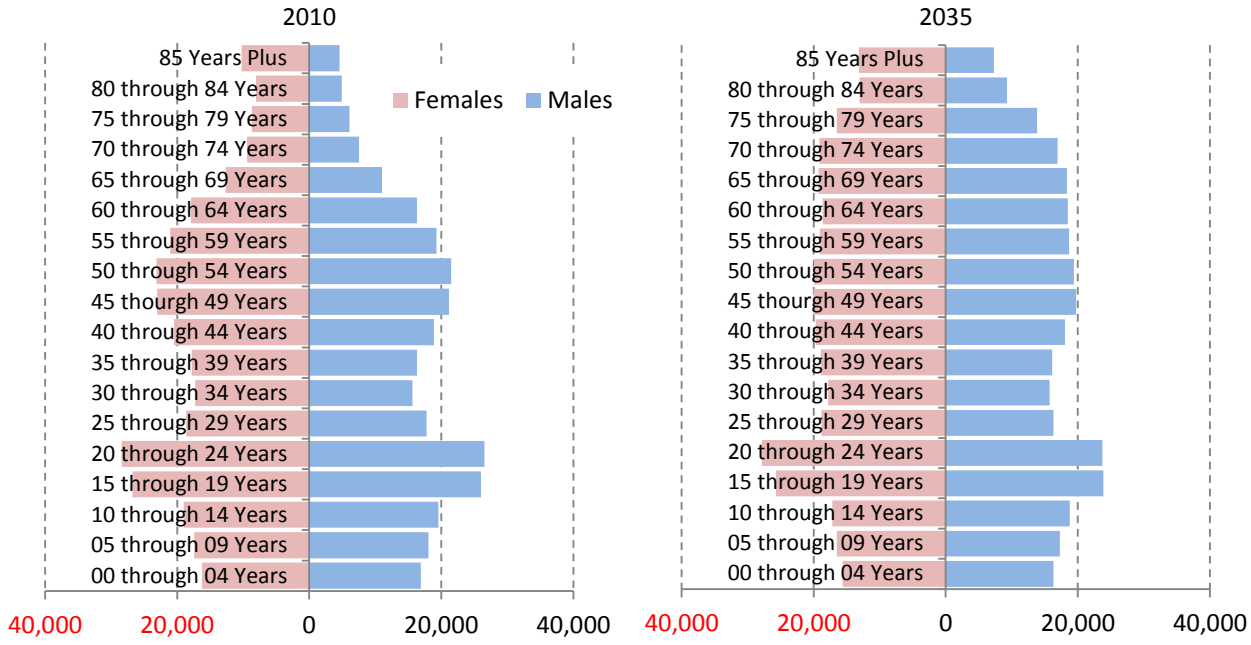
cohorts, and so we expect that out-migration in this period will be fairly high. As the group later ages through and out of the groups most prone to out-migration, the number of people leaving the region may be expected to diminish. For age groups over the age of 39, migration tends to change direction fairly frequently from one cohort to the next; making it difficult to identify other largely influential age-related migration patterns aside from those of the college and post-college cohorts.

Even though anticipated decreasing out-migration in the region supports population growth throughout the 2010 to 2035 time-series, the level of growth diminishes after 2025. While births remain nearly level from 2015 forward, an increasing number of deaths in the region due to an aging population—both in the region and statewide—will start to erode population gains. After 2020 the number of deaths is expected to overtake births, and by 2025 the region will experience a population loss of about 1,400 due to natural decline (Figure 3.5e).

Age Profile

Figure 3.5h below shows the age profile of the region in 2010 and projected to 2035, where a much larger proportion of the population reaches the elderly age-groups. In 2010, 14% of the region's population was aged 65 and over and by 2035 that percentage is expected to grow to 23%.

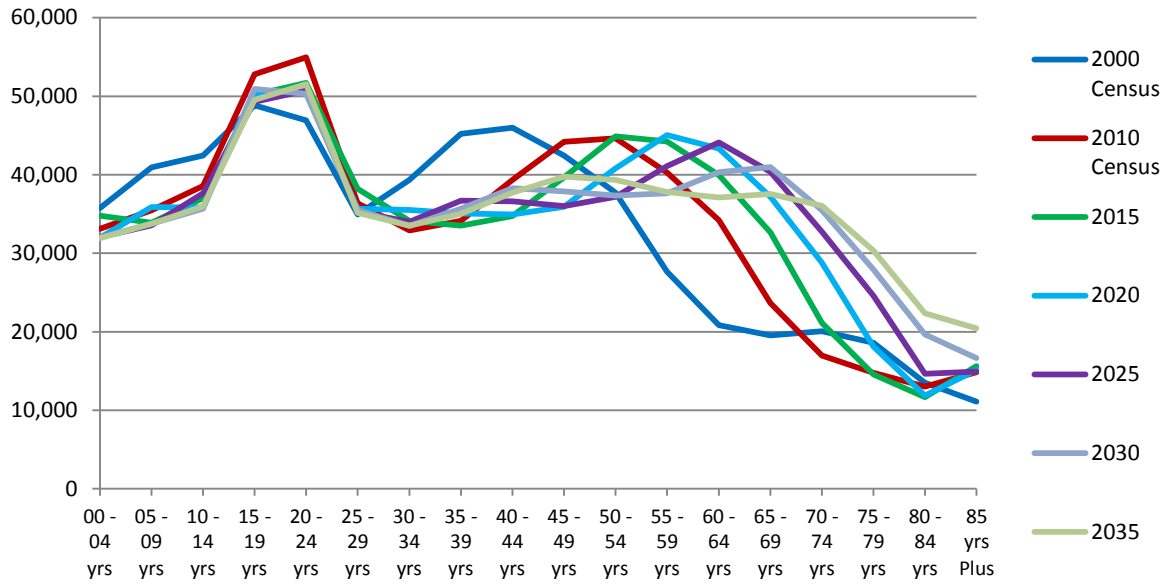
Figure 3.5h
The age and gender composition of the Lower Pioneer Valley, 2010 (actual) vs. 2035 (forecasted)



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 45-64 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 15-24-year olds. 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 stay in place and progress into older

cohorts with the passage of time, the size of the post-college age population in the Lower Pioneer Valley remains fairly constant over time; persons aged 25-39 represented 17% of the population in 2010 and are expected to comprise 16% of the population in 2035, at just over 103,000 persons in both 2010 and 2035. Likewise, the population aged 15-19 hovers around 50,000 for the entire time series, and the population aged 20-24 remains in the 50,000 to 54,000 range even when the millennials largely pass out of those age groups after 2010. Figure 3.5i below shows the Lower Pioneer Valley region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.

Figure 3.5i: Population by Age, Lower Pioneer Valley, 2000-2035



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 45 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, at increased levels through 2015, and more moderately through 2035 (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 2015, the region is expected to increase by approximately 36,000, or 1.1% per year, according to our model, which aligns the 2015 region population to U.S. Census Bureau estimates through 2014.[33] According to these Census estimates, the MetroWest region grew by about 1% per year from July 1, 2010 to July 1, 2013, increasing by 19,542 in the three-year period, or 6,514 residents per year. Our model extends this level of annual growth out to 2015, adding a total of 35,901 persons over the five-year period.

After 2015, growth is expected to slow again to between 0.25% and 0.35% annualized, increasing by an average of 11,000 persons per five-year period through 2035. By 2035, the region will have grown by 79,749 persons over the Census 2010 count of 655,126 to a new total of 734,875 persons.

Figure 3.6a
The MetroWest Region

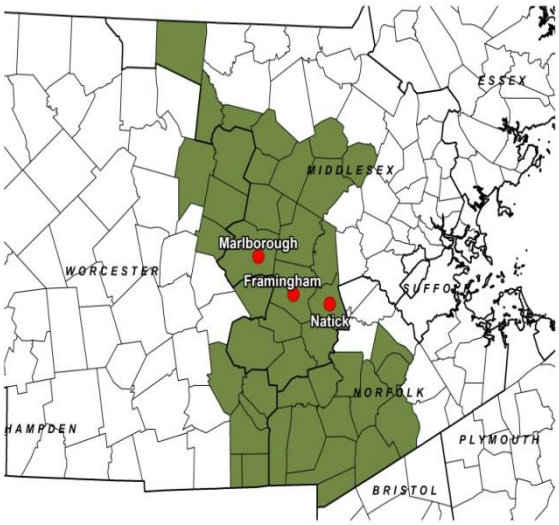


Figure 3.6b
Projected Population, MetroWest

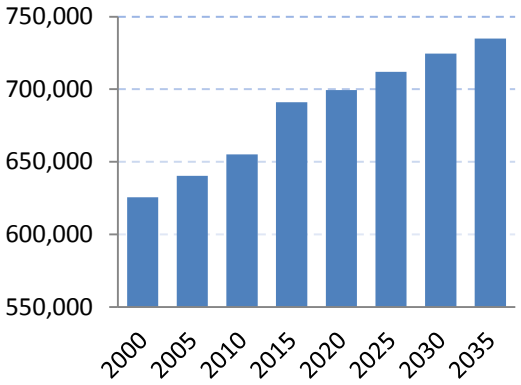
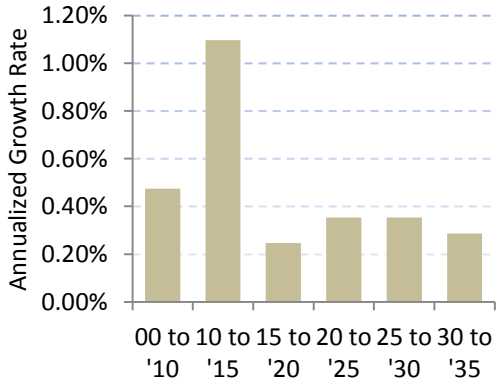


Figure 3.6c
Annualized rates of population change, MetroWest



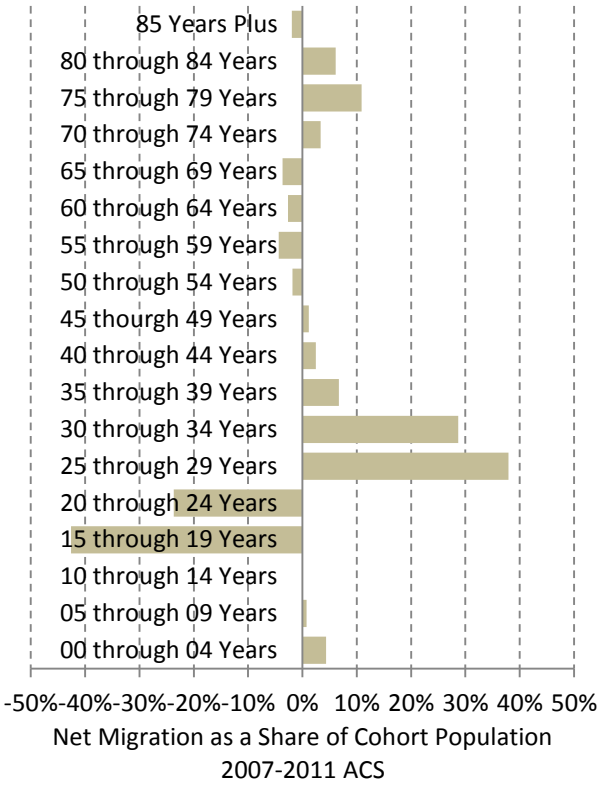
[33] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

The Sources of Population Change

The continuing growth of the MetroWest region will be the result of a combination of factors: increasing domestic in-migration coupled with slight decline in domestic out-migration from 2015 forward; continued positive net international immigration; and a slight increase in new births in the near term—with steady levels continuing throughout the period. This growth will be partly offset by a steady rise in the number of deaths, coinciding with the region's aging population.

MetroWest is a dynamic region with a significant flow of migrants moving in and out. 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 (77%) of these in-migrants come from elsewhere in Massachusetts or from neighboring states.

Figure 3.6d
Age profile of net domestic migrants, MetroWest, 2007-2011 American Community Survey



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 2015 and 2035. 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, which will more than offset any losses from domestic out-migration.

Figure 3.6e
Projected levels of domestic in and out-migration, MetroWest, 2010-2035

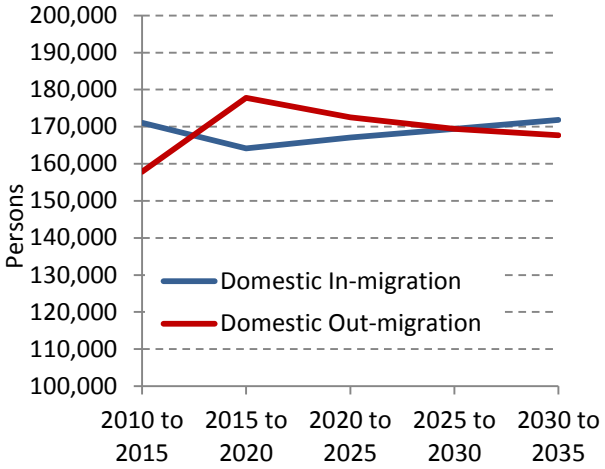
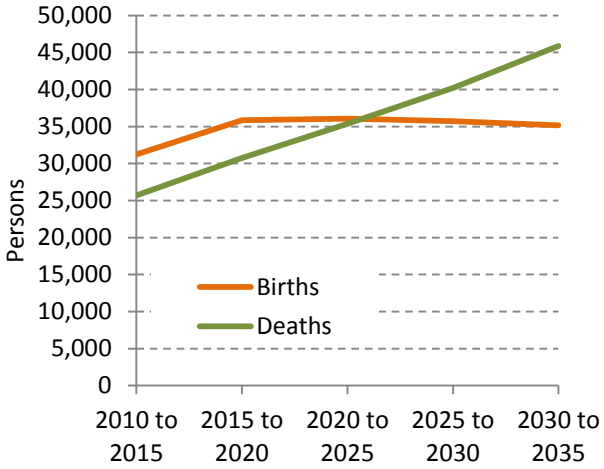


Figure 3.6f
Projected levels of births and deaths, MetroWest, 2010-2035



In-migration in the region during 2010 to 2015 is increased in our model to catch up to 2014 Census Bureau estimates[34] before returning to historic 2005 to 2011 rates-by-age for the 2015 to 2020 period and beyond. Out-migration peaks in the 2015 to 2020 period, most of this driven by large number of persons in their late teens and early twenties leaving the region. The 15-19 year old population is peaking in in 2010 and 2015, while the 20-24 and 25-29 year old groups in the region peak in 2015. This means that the pool of persons in the groups most prone to out-migration is at a maximized level and thus the number of out-migrants increases.

The age groups contributing the largest number of domestic in-migrants, persons in their late twenties and early thirties, have the largest effect on in-migration levels during the 2015 to 2035 time period. The number of in-migrants from the largest contributing age group, the 25-29 year olds, peaks in the 2020 to 2025 period, corresponding to the swell of millennials passing through this cohort starting around 2015. Many of the older cohorts also contribute to modest increases in the number of in-migrants as the region moves towards 2035, so that net domestic migration gradually increases to a positive over the 2015 to 2035 period. By the 2030 to 2035 period, there will be an estimated 4,088 more people coming into the region than leaving it.

The numbers of births and deaths largely follow changes in the age composition of the population, with a considerably larger share of the population moving through their twenties and thirties and relatively few elderly residents (see Figure 3.6g). While large numbers of in-migrants in their late twenties enter the area after 2015, and the 30-34 age cohort peaks from 2015 through 2025, the number of births in the region also increases after 2015 and remains strong throughout the 2015 to 2035 time period (Figure 3.6g). However, an aging population at the top end of the distribution suggests that the number of deaths in the region also increases after 2015 and at a stronger pace. The number of deaths increases as the population ages, particularly so when residents age into

[34] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

cohorts of 70 years and older when mortality rates begin to show a marked increase. The baby boom population will only begin to move into these higher-mortality cohorts by 2030. Over time, the number of deaths starts to catch up to and then exceed the number of births, slowing population growth in the region. By 2035, the region is expected to experience 10,734 more deaths than births (Table 3.6).

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

	2010 -2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	655,126	691,027	699,520	711,909	724,504
Births	31,231	35,854	36,077	35,703	35,158
Deaths	25,674	30,753	35,385	40,202	45,892
Natural Increase	*5,557*	*5,101*	*692*	*-4,499*	*-10,734*
Domestic In-migration, MA & Border	132,324	126,483	128,041	129,127	130,502
Domestic In-migration, Rest of U.S.	38,735	37,683	39,078	40,314	41,305
Domestic Out-migration	157,848	177,788	172,483	169,386	167,719
Net Domestic Migration	*13,210*	*-13,622*	*-5,363*	*54*	*4,088*
Net International Migration	*17,133*	*17,014*	*17,060*	*17,039*	*17,016*
Ending Population	691,027	699,520	711,909	724,504	734,875

Age Profile

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 2035, the population aged 65 and over will have doubled its share of the regional total, comprising 26% of the region's population compared to just 13% in 2010. At the same time, however, the population profile will also become more evenly distributed among retirees, middle-aged households, and young families with school-aged children. The massive concentration of the baby boomer generation found in 2010 is far less evident in 2035. This is, in part, because MetroWest residents are somewhat prone to leaving 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-aged cohorts than found in other regions.

Figure 3.6g
The age and gender composition of the MetroWest region, 2010 (actual) vs. 2035 (forecasted)

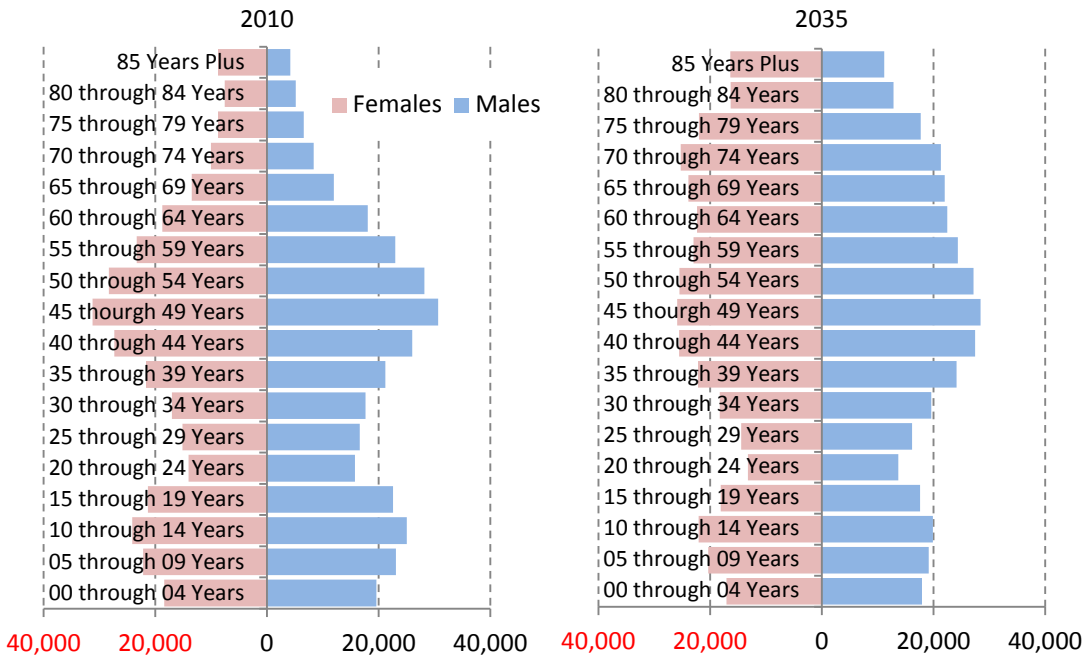
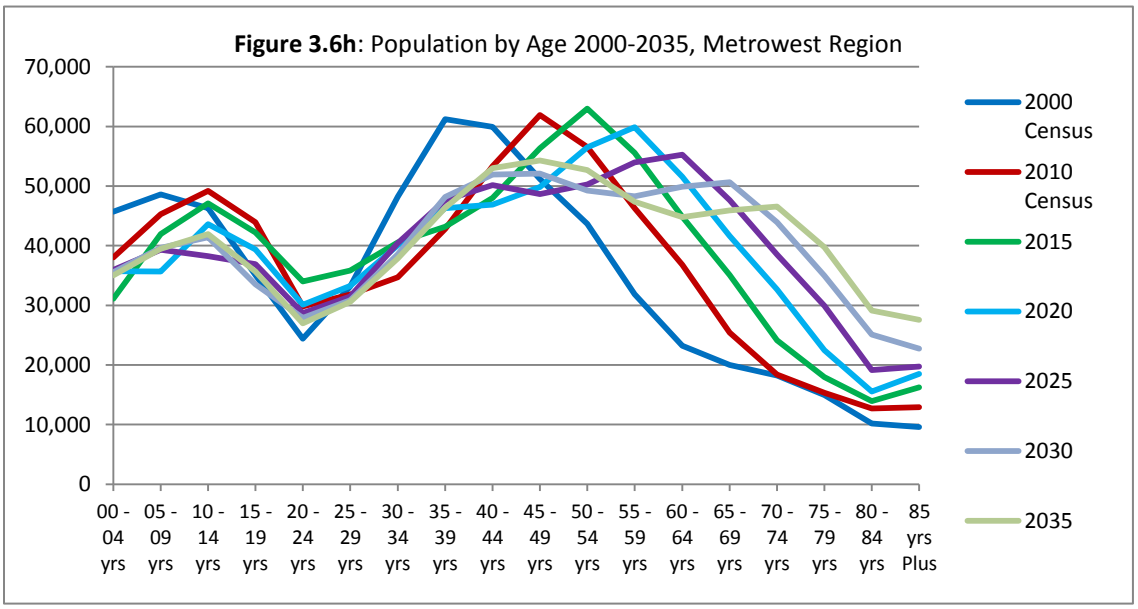


Figure 3.6h below shows the MetroWest region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.



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.

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 (Figures 3.7b and 3.7c). Since that time, the U.S. Census Bureau estimates that the region has been growing at an even faster pace.[35] According to Census estimates, the Northeast region grew by an average of 0.9% per year from July 1, 2010 to July 1, 2013, increasing by 29,096 persons in the three year period, or 9,365 per year. In aligning future projections to these recent estimates,[36] our model anticipates a 52,423 person increase in the region from 2010 to 2015. The annualized growth rate is accelerated to 1.02% in the near-term to 2015 before slowing down to levels more consistent with the 2000 to 2010 period. After 2015, our model predicts that annualized growth will slow to about 0.2% per year through 2025, gradually diminishing to just under 0.1% in the 2030 to 2035 period. (Figure 3.7c).

Figure 3.7a
The Northeast Region

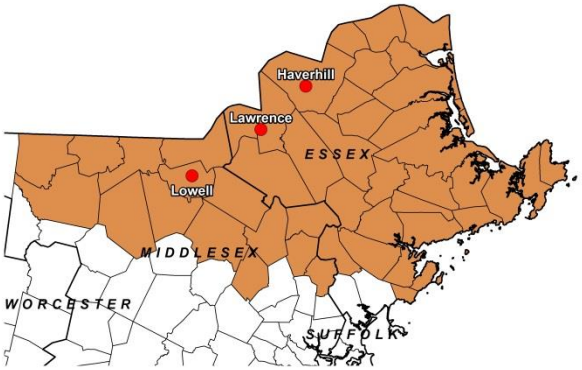


Figure 3.7b
Projected Population, Northeast

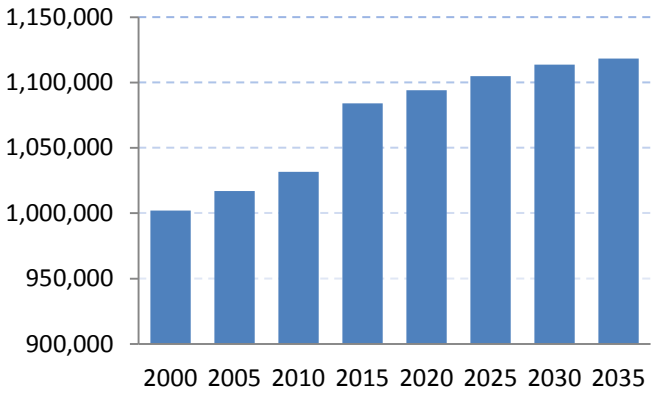
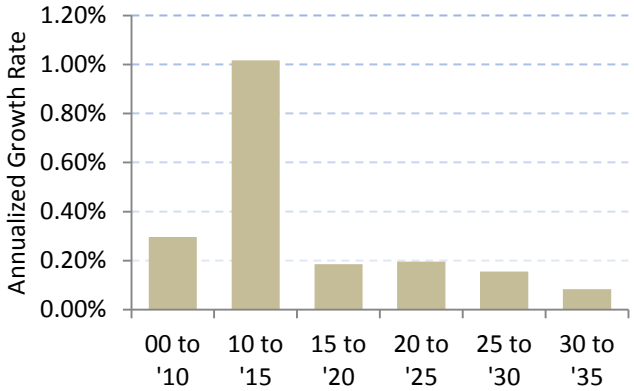


Figure 3.7c
Annualized rates of population change, Northeast



[35] Source: Sub-EST 2013: Subcounty Resident Population Estimates April 1, 2010 to July 1, 2013. U.S. Census Bureau, Population Division. May 2014.
[36] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

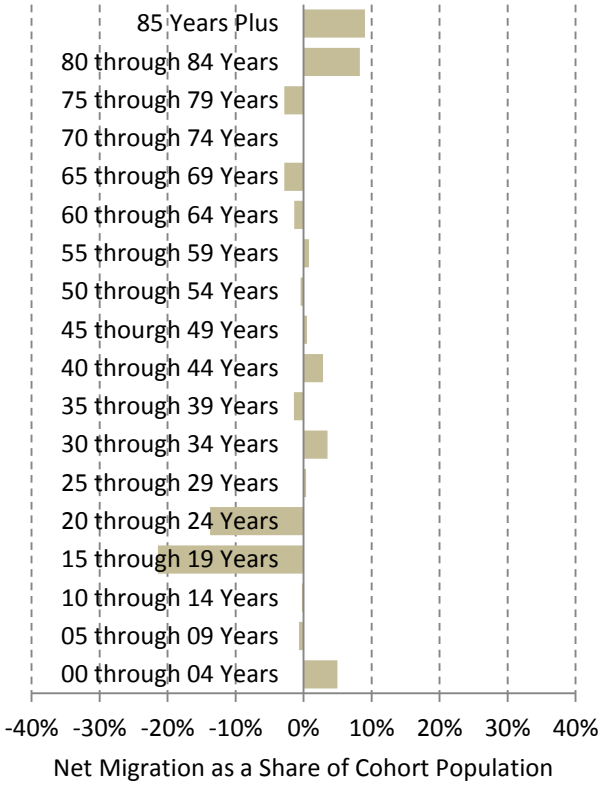
Table 3.7
Summary Results: Estimated Components of Population Change, Northeast Region

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030	2030 to 2035
Starting Population	1,031,733	1,084,156	1,094,196	1,104,923	1,113,554
Births	57,389	60,988	60,272	58,691	57,246
Deaths	46,396	54,147	60,213	67,344	75,790
Natural Increase	*10,993*	*6,840*	*59*	*-8,653*	*-18,543*
Domestic In-migration, MA & Border	132,930	130,673	131,306	132,228	133,653
Domestic In-migration, Rest of U.S.	54,844	50,060	52,033	53,833	55,668
Domestic Out-migration	165,818	196,874	192,144	188,226	185,501
Net Domestic Migration	*21,956*	*-16,141*	*-8,805*	*-2,165*	*3,821*
Net International Migration	*19,475*	*19,341*	*19,472*	*19,449*	*19,423*
Ending Population	1,084,156	1,094,196	1,104,923	1,113,554	1,118,254

In recent years, the Northeast region has lost more residents to domestic migration than it has gained. In our model, we adjust migration rates in the 2010 to 2015 period so that population totals catch up to Census Bureau estimates through 2013, resulting in net domestic in-migration during that period. After 2015, our model reverts to migration patterns observed in the 2005 to 2011 American Community Survey, and the region once again shows more outflow than inflow from other parts of the U.S. (Table 3.7).

The largest cohorts of out-migrants are the 15- to 24-year olds, many of who head 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 also a net attractor of young families and others in their early thirties,

Figure 3.7d: Age profile of net domestic migrants, Northeast, 2007-2011, American Community Survey



some of which bring their young children with them.

Over the next two decades, the aging of the large millennial generation into its thirties will lead to a slight increase in domestic in-migration—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, Northeast, 2010-2035

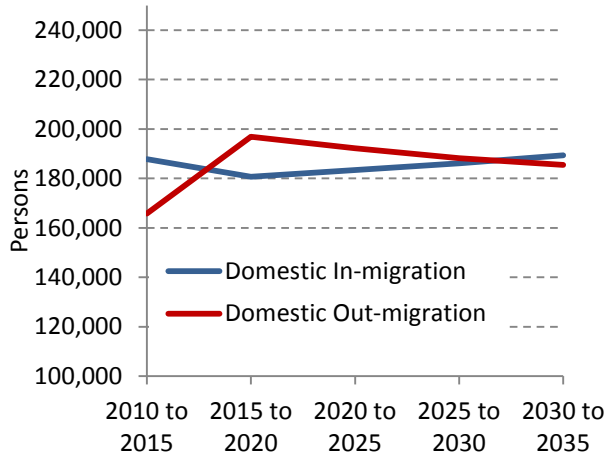
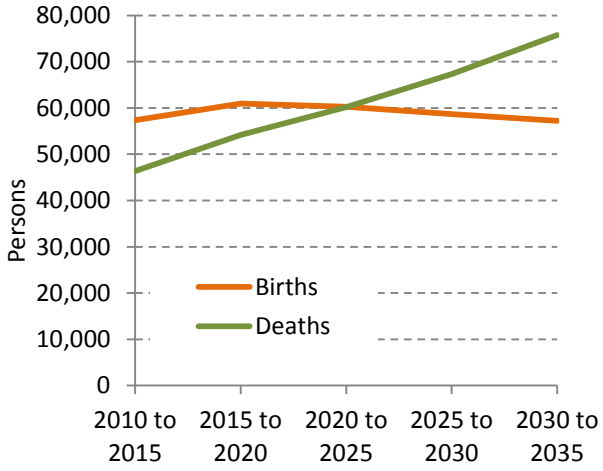


Figure 3.7f
Projected levels of births and deaths, Northeast, 2010-2035



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 2010 and 2015, we estimate that the region will add 19,000 new residents due to net international immigration—a level that is expected to carry forward for the next several decades. This international immigration more than offsets the domestic loss experienced in 2015 through 2030.

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 2010 and 2035, from about 46,000 every five years to almost 76,000 in the 2030 to 2035 period. 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 2035, but by 2025 the number of deaths catches up to the number of births. By 2030 the number of deaths in the region is expected to outnumber births by over 8,000, significantly slowing growth in the region.

Age Profile

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 2035 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 25% of the region's residents age 65-and older by 2035—compared to the 14% 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 forties by 2035, many with school age children. Children aged 0 through 14 will make up 16% of the regions population in 2035 compared to 19% in 2010.

Figure 3.7g
The age and gender composition of the Northeast Region, 2010 (actual) vs. 2035 (forecasted)

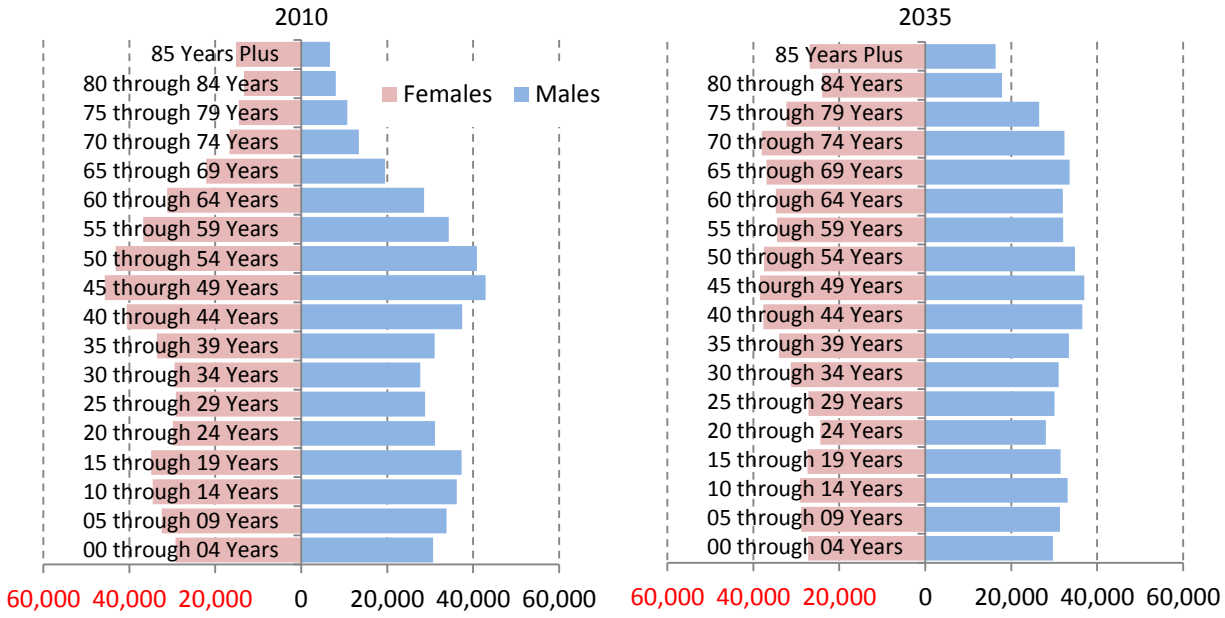


Figure 3.7h below shows the Northeast region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.

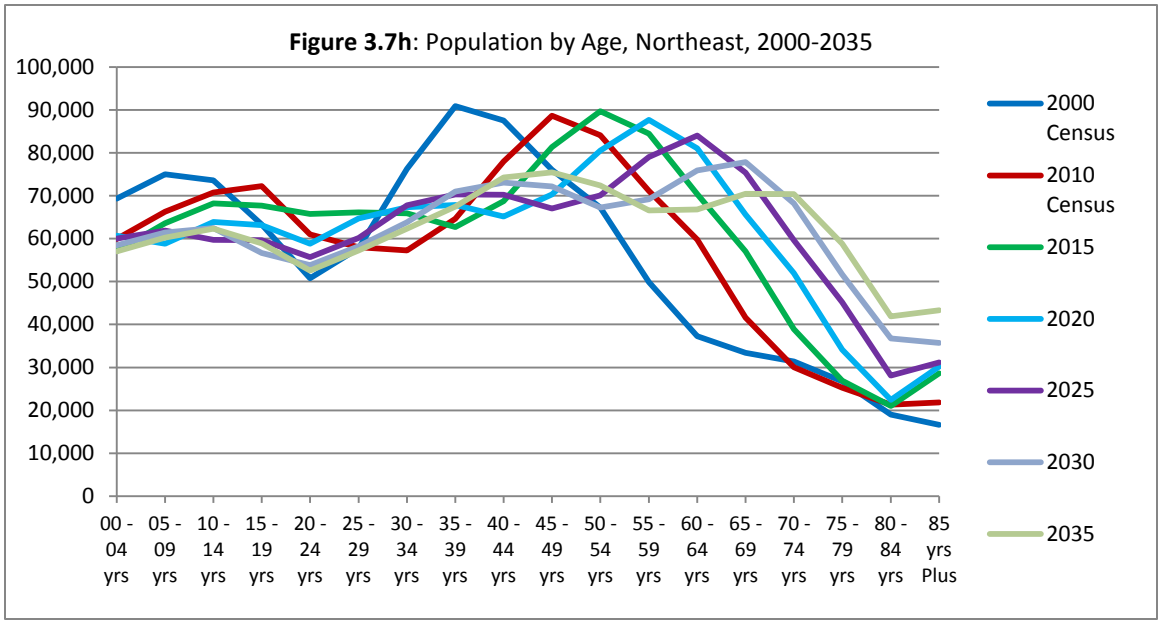


Figure 3.7h: Population by Age, Northeast, 2000-2035
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
00 - 04 yrs
05 - 09 yrs
10 - 14 yrs
15 - 19 yrs
20 - 24 yrs
25 - 29 yrs
30 - 34 yrs
35 - 39 yrs
40 - 44 yrs
45 - 49 yrs
50 - 54 yrs
55 - 59 yrs
60 - 64 yrs
65 - 69 yrs
70 - 74 yrs
75 - 79 yrs
80 - 84 yrs
85 yrs Plus
2000 Census
2010 Census
2015
2020
2025
2030
2035

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, adding 37,633 persons and with an annualized population growth rate of 0.35% between 2000 and 2010. The region should expect to see continued population growth over the next twenty five years, although at an increasingly slower rate as time moves on (Figures 3.8b and 3.8c). Our model anticipates that the region will add another 39,490 residents between 2010 and 2020, after which levels of growth start to diminish, with fewer than 28,000 residents gained from 2020 to 2030. By 2035, the population of the Southeast region will approach 1.19 million persons, a gain of almost 75,000 residents over the 2010 Decennial Census.

The Sources of Population Change

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 2025.

Figure 3.8a
The Southeast Region

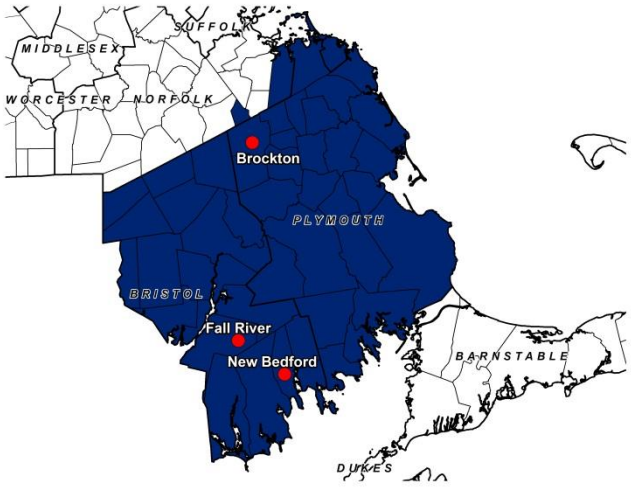


Figure 3.8b
Projected Population, Southeast

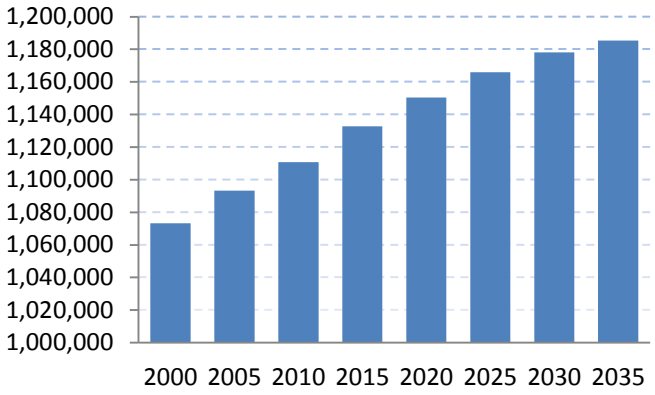


Figure 3.8c
Annualized rates of population change, Southeast

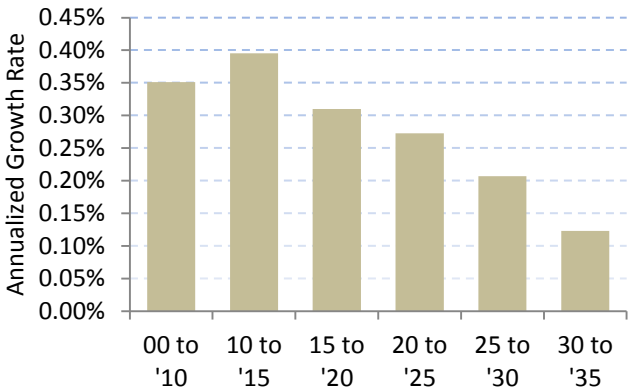


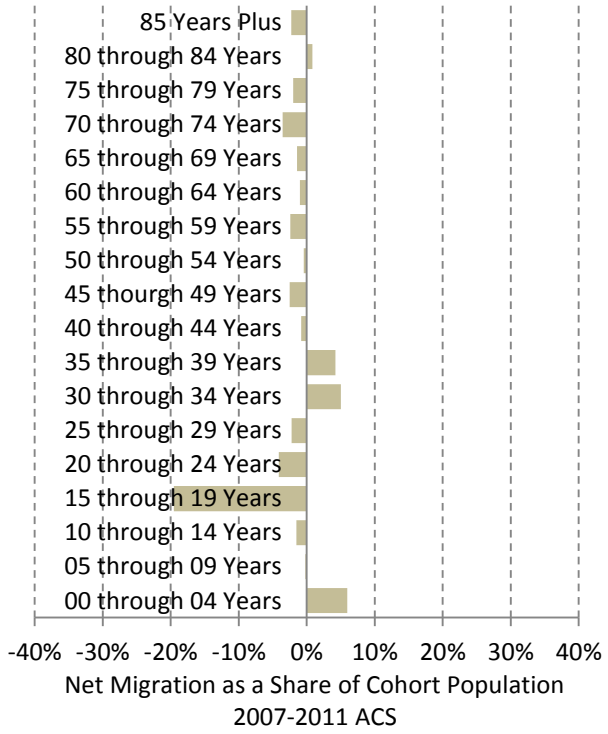
Table 3.8 Summary Results: Estimated Components of Population Change, Southeast

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	1,108,845	1,132,805	1,150,345	1,166,038	1,178,095
Births	58,476	60,541	61,219	60,694	59,810
Deaths	52,082	57,177	62,674	69,403	76,810
Natural Increase	*6,394*	*3,364*	*-1,455*	*-8,709*	*-17,000*
Domestic In-Migration, MA & Border	125,472	133,625	134,316	135,015	136,109
Domestic In-Migration, Rest of U.S.	43,962	45,425	46,925	48,369	49,645
Domestic Out-migration	171,223	184,097	183,331	181,833	180,706
Net Domestic Migration	*-1,789*	*-5,048*	*-2,089*	*1,552*	*5,048*
Net International Migration	*19,356*	*19,223*	*19,238*	*19,214*	*19,188*
Ending Population	1,132,805	1,150,345	1,166,038	1,178,095	1,185,331

In recent years, the Southeast region has tended to lose residents due to domestic out-migration, and this trend is expected to continue through 2025 (Table 3.8). At the same time, international migration offsets this net domestic loss, with gains of over 19,000 each five years expected to continue through the time-series such that the region continues to increase in population size.

Domestic out-migration is heavily concentrated among the college-age population and, to a lesser extent, older residents in the 55-and older cohorts (Figure 3.8d). However, the region tends to import residents in their thirties, as well as their school-age children. In the near future, the large population of millennials move out of their teens and twenties (age-groups prone to leaving the region) and into their thirties (the groups that tend to move in). This, together with only modest levels of out-migration among boomers, will result in decreasing

Figure 3.8d
Age profile of net domestic migrants, Southeast, 2007-2011 American Community Survey



levels of out-migration and increasing levels of domestic in-migration. Domestic in-migration will catch up to out-migration by 2025 to 2030 and start contributing to population gain in the region (Figure 3.8e).

Figure 3.8e
Projected levels of domestic in and out-migration, Southeast, 2010-2035

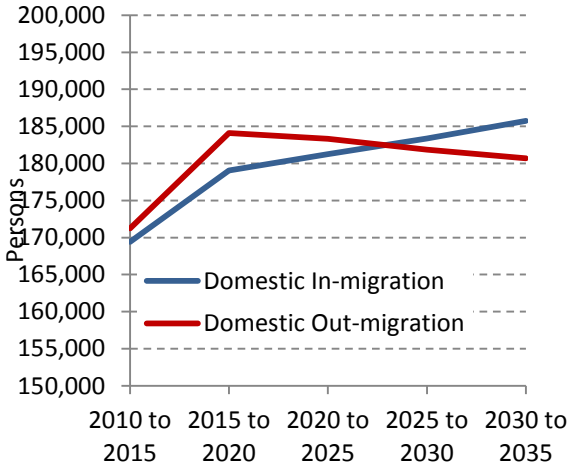
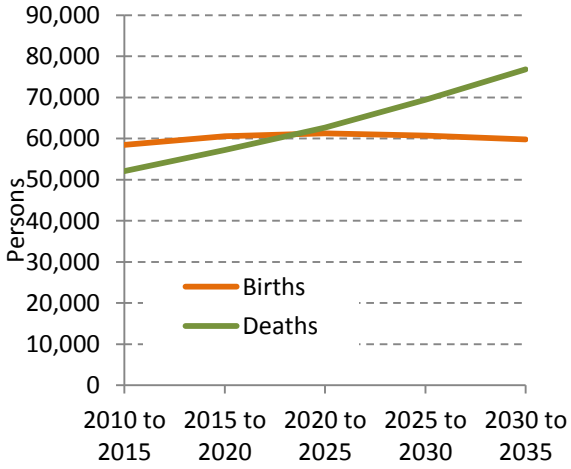


Figure 3.8f
Projected levels of births and deaths, Southeast, 2010-2035



Growth in the Southeast region will be partially constrained, however, 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 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 begin to move into these high-mortality cohorts by 2025, and by that time the number of deaths in the region will start to exceed the number of births, subtracting from the population gained by migration.

Age Profile

By 2030, baby boomers will have moved into the retirement phase of their life cycles. Although some older residents will retire outside the region, they will be eclipsed by those deciding to age in place, shifting the entire population distribution upward (Figure 3.8g). By 2035, 24% of the region's population will be over the age of 65, compared to 14% in 2010. Yet the Southeast will continue to attract young families, including many from the millennial generation, who will be moving into their forties by 2035. The result will be a regional age profile that, while older, will be more evenly distributed among the different age groups (Figure 3.8g.)

Figure 3.8g: The age and gender composition of the Southeast Region, 2010 (actual) vs. 2035 (forecasted)

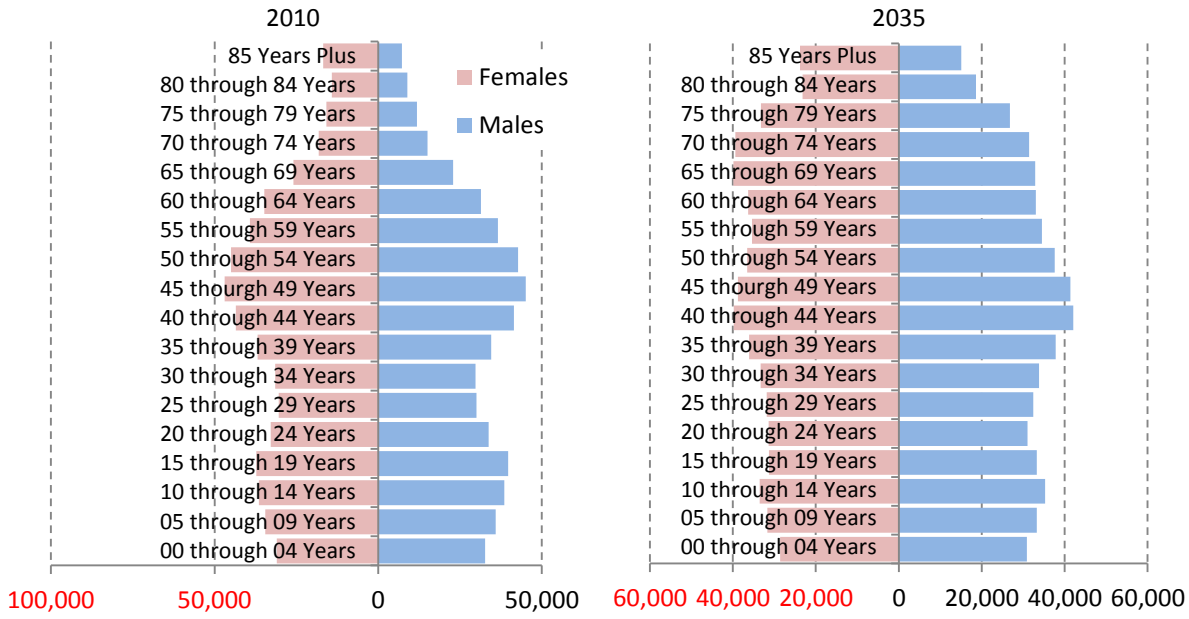
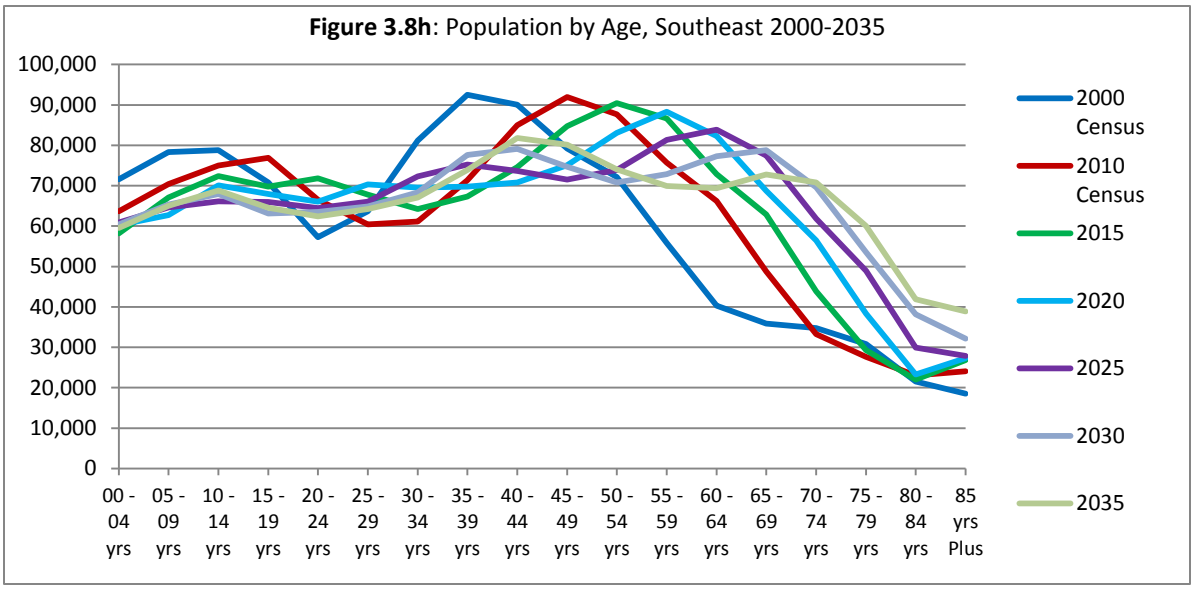


Figure 3.8h below shows the Southeast region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.



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 projections developed for eight sub-state regions 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 or regional planning areas.

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 Massachusetts 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 70-years

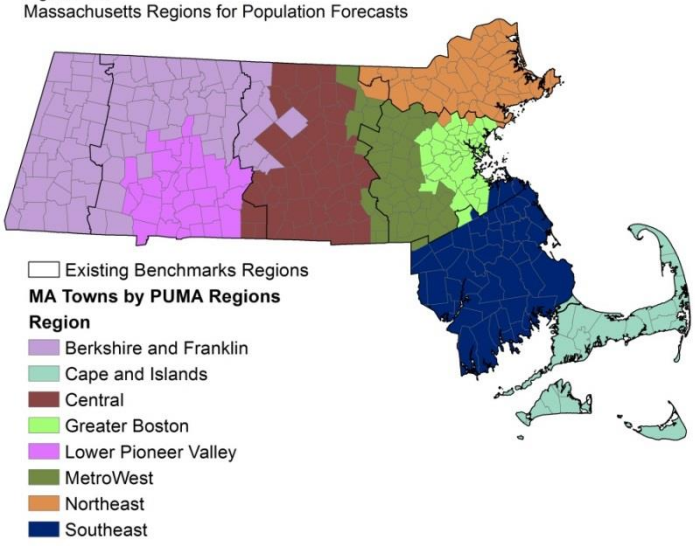
and older, such that an area with a large concentration of elderly residents will experience more deaths in decades to come.

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 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- 4 years old, 5- 9,… 80-84, and 85- and 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 (2013). 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 the 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[37]. 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[38]. Sample sizes can be particularly small when distributed by age and sex cohorts for different types of migrants, especially in small regions. For this reason, the Berkshire/Franklin and Cape & Islands are two regions that can be treated with more skepticism in our projections results and which lend themselves to greater cross-examination

[37] To account for small or missing samples in some cohorts in some regions, we make some limited adjustments to the ACS PUMS data before calculating migration rates based on the data. In the Cape and Berkshire/Franklin regions, male and female migrants under the age of 15 are assigned the male/female average number of migrants before a rate is calculated in order to smooth out male/female ratios resulting from small sample sizes. In other regions, cohorts under age 75 with a sample size of zero in the ACS data are assigned values from the opposite gender when it is available to reduce instances of rates calculated from a null value.

[38] While we are aware of the potential for sampling error in using ACS PUMS data for these small regions, it is the only direct source of gross migration by age available to us at this time. IRS data on migration does include gross migration data for tax-filers at the county level; however the released data does not include age detail. The Current Population Survey, another sample survey product from the U.S. Census Bureau, provides migration data by age, but only down to the U.S. regional level of geography. Other methods commonly used to estimate migration do so using an indirect method of calculating net migration by age as a residual of a cohort-survival method

by alternative methods[39]. These two regions were counted at fewer than 250,000 persons each in the 2010 Census and are subject to larger sampling error than the other six sub-state regions which all number more than 600,000 persons, and sometimes over 1 million. In our model, we develop migration rates using data from the 2005 to 2009 ACS PUMS as well as the 2007 to 2011 ACS PUMS, the most recent five-year dataset available at the PUMA level of geography. [40]

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:

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

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.[41] 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:

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

[39] For information on alternative projections methods and results for the Berkshire/Franklin and Cape & Islands regions, researchers may contact the Population Estimates Program of the UMass Donahue Institute.

[40] To account for small or missing samples in some cohorts in some regions, we make some limited adjustments to the ACS PUMS data before calculating migration rates based on the data. In the Cape and Berkshire/Franklin regions, male and female migrants under the age of 15 are assigned the male/female average number of migrants before a rate is calculated in order to smooth out male/female ratios resulting from small sample sizes. In other regions, cohorts under age 75 with a sample size of zero in the ACS data are assigned values from the opposite gender when it is available to reduce instances of rates calculated from a null value.

[41] 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.

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

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.

College Migration

Tracking the migration of college students is often problematic for researchers, as neither the ACS nor conventional tax-return migration data seems to capture their movement comprehensively or accurately. For this reason, the U.S. Census Bureau applies a "college fix" in their annual county-level population estimates to areas that meet their criteria for percent of population enrolled in college and other population thresholds[42]. In the basic application of the "college fix", the college-enrolled population in a region is held back from aging and migration experienced by the non-college population over the specified time period, and is then restored to the region at the end of the period. In this way, the college-enrolled population remains more or less fixed for a region while other cohorts migrate and age over time.

In the UMDI Vintage 2015 projections model, we apply a "college fix" method to the 15-19, 20-24, and 25-29 age cohorts in three regions: Greater Boston, Lower Pioneer Valley, and the Central Region. According to ACS 20072011 data, these regions all show significant percentages of college enrollment as follows:

ACS 2007-2011 Population Enrolled in College or Graduate School by Region						
UMDI Region	Greater Boston		Lower Pioneer Valley		Central Region	
Age cohort	# enrolled	% of cohort	# enrolled	% of cohort	# enrolled	% of cohort
15-19	55,018	39%	19,565	36%	14,207	27%
20-24	97,496	54%	30,255	57%	22,624	49%
25-29	44,479	24%	5,557	15%	5,613	14%

The UMDI college fix method, like the Census Bureau's, holds out the college enrolled portion of these three cohorts from aging and migration and then adds it back into its original cohort five years later. For each of the "College Fix" regions, we use 2007-2011 ACS data to determine the share of population enrolled in college or graduate school in each of the age cohorts. The share is based on the region's enrolled cohort as a percent of the total U.S. cohort. We apply this share by

[42] *The "College Fix": Overcoming Issues in the Age Distribution of Population in College Counties*. Ortman, Sink, King. Population Division, U.S. Census Bureau. October 2014.

age and sex to the base year population in order to estimate the regional college population and then subtract this from the total regional population. The difference is the estimated "non-college" population. This non-college population is subject to the same migration method described in the domestic migration section above, except that the migration rates are based solely on the non-college population and migrants in the ACS data. The resulting net number of non-college domestic migrants is added to each non-college cohort, which is then aged forward by five years. Finally, the enrollment share for each cohort is applied to the latest U.S. cohort total to determine a new estimate of the college-enrolled population for the region. This updated college estimate is added to the projected population. Below is an example for the 2010 to 2015 period.

2010		2015
non college pop 10-14	*age 5 years and add net migrants 2010-2015→*	non-college pop 15-19
college pop 15-19	*not aged; apply % enrolled to 2015 U.S. population 15-19→*	college pop 15-19
non college pop 15-19	*age 5 years and add net migrants 2010-2015→*	non-college pop 20-24
college pop 20-24	*not aged; apply % enrolled to 2015 U.S. population 20-24→*	college pop 20-24
non college pop 20-24	*age 5 years and add net migrants 2010-2015→*	non college pop 25-29
college pop 25-29	*not aged; apply % enrolled to 2015 U.S. population 25-29→*	college pop 25-29
non college pop 25-29	*age 5 years and add net migrants 2010-2015→*	non college pop 30-34

Because the college population is held out of the aging process, and because migration is only captured for the non-college population, we had to make two additional adjustments to our model. First, we allow portions of the college-enrolled population aged 20-24 and 25-29 to age forward into the non-college population[43]. This accounts for the college-enrolled population that ages in place into the non-college population (i.e. those that come for college or graduate and stay). Additionally, we account for the region's non-college population that joins the college population upon migrating out of the region (i.e. those who leave their homes in Massachusetts to attend college elsewhere in the U.S.) by capturing them as out-migrants[44].

International Migration (immigration and emigration)

International immigration in our model is estimated according to the number of international migrants, by age and sex, indicated for each region by the ACS 2007-2011 PUMS dataset. Unlike domestic migration in our model, however, the estimates of international immigrants from the ACS are not then converted to rates. With domestic migration, we can more comfortably make the assumption that there is a relationship between the number of migrants (our numerator) and another region (our denominator) that might be expected to remain relatively constant over time - for example the number of out-migrants relative to the region's population or the number of in-migrants relative to the U.S. population. In the case of international migration, it is harder to make an assumption that, for example, as the world population by age increases, the region's immigrants will increase at the same rate. In reality, a great number of factors not related to any particular

[43] To determine this proportion we applied a residual survival method using estimates of the college-enrolled and total populations by age in 2005 and 2010, based on enrollment levels by age indicated in the ACS 2005-2009 PUMS data.
[44] Out-migrants that are enrolled in college in regions outside of the study area, as captured in the ACS PUMS datasets.

region's current population will influence future immigration levels, including federal immigration policy change, college recruitment policies, and labor needs, to name just a few. Instead of trying to guess at which way these changes will affect immigration to each region, we assume that the levels experienced in recent history, in this case the 2007 to 2011 period, will be sustained, and in our Vintage 2015 model the number of immigrants by cohort remain constant over the time period.

There is no consensus on how best to deal with emigration in a gross-migration context. 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.

But, while we cannot directly estimate the number of emigrants in a five-year period using regional level ACS data, there are alternative methods that can be borrowed to at least approximate the a number for each region. The U.S. Census Bureau developed emigration rates for the foreign born population -- the population most prone to emigration -- for a demographic analysis of net international migration. The rates were developed using a residual method and data from Census 2000, the American Community Survey, and life tables from the National Center for Health Statistics[45]. They estimated emigration rates ranging from of 12.8 to 15.5 per 1,000 among the population of recently arrived foreign born (those entering the U.S. within 10 years prior to the survey) and rates of just 1.7 to 3.5 per 1,000 for the foreign born population with longer residency – (those arriving more than ten years prior to the survey).

To estimate emigration in our model, we first use ACS 2007-2011 information on the foreign born population by age and by decade of entry to create two estimates of the foreign born population for each state region: one recent-arrival group and one longer-residency group. Using a simplified survival method, we age these two populations forward every five years, decreasing them by letting the 85-and older population fall out (a rough proxy for mortality) and increasing them by the addition of new immigrants (using ACS 2007-2011 levels). After 10 years, new immigrants are moved into the longer-residency group. We apply the Census Bureau's middle-range rates for recently-arrived and longer-residency distinctly to each group in order to estimate the total number of emigrants by cohort in each time period.

It should be noted that in the Greater Boston, Central, and Lower Pioneer Valley regions, emigrating international students are already accounted for by the "revolving-door" approach of the college-fix method. In these three regions, we calculate international immigration and emigration only for the non-college population. College students in our model are withheld from the population at-risk for migration and aging. As such, they are not being counted as "immigrants" in the conventional sense, but instead are lumped in with all other college students, as a constant relative to the entire national population. In the Greater Boston region, college-enrolled immigrants ages 15-29 account for 30% of all international immigrants in the 2007-2011 ACS period, while in the Lower Pioneer Valley, they account for about 36%. These proportions can be thought of in our model as now

[45] Source: Population Division Working Paper No. 97: *Estimating Net International Migration for 2010 Demographic Analysis: An Overview of Methods and Results,* U.S. Census Bureau, February 2013.

removed from the foreign born population that would typically drive both immigration and emigration numbers, and so reduces the effect of any error in estimating emigration based on foreign born population estimates.

Finally, international immigrants who become part of the resident population are then subject to the same out-migration rates as the general population. If they move on to other parts of the U.S., they are captured as out-migrants in the next five-year period.

The final step of the migration model adds the estimated net number of domestic migrations (in-migrants minus out-migrants) and the estimated international migrants 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 last component in our regional cohort-component model 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 to2009). 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 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:

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

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 next 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- 4) and final (85+) cohorts are treated differently. The number of anticipated babies estimated in the previous step becomes the number of 0- 4 year olds in 2015. The number of persons in the 85+ cohort in 2015 is the number of surviving stayers in the 80- 84 age cohort (in 2010) added to the number of surviving stayers in the 85 and older cohort. As we made separate estimates 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 estimating population 'at-risk' of domestic in-migration. The U.S. Census Bureau regularly generates highly detailed national population forecasts.[46] We use the latest release of national forecasts (release date December 2014) which are based on information from the 2010 Decennial Census. Unfortunately, the Census Bureau no longer generates detailed state-level long-term projections; their last state-level projections were developed in 2005. So for estimating future in-migrants from neighboring Northeast states, we use the state-level age/sex projections developed by the University of Virginia's Weldon Cooper Center for Public Service[47] (release 2013).

Reconciliation to Current Population Estimates

As a final step in the regional model, we align our projections to the most current population estimates from the U.S. Census Bureau at the state and regional levels. We aggregate the vintage 2013 sub-county estimates[48] to the UMDI regions and then calculate the annual percent change in population from 2010 to 2013 for each region. This annual percent change is applied to the 2013 population to create a 2014 estimate for each region. The 2014 regional totals are then controlled to the Census Bureau's vintage 2014 state-level population estimate[49] to create updated regional totals to 2014. For each region, the resulting annual percent growth from 2010 to 2014 is calculated and then applied to the 2014 total to create a 2015 "target" population.

In the first five-year period of our projection series, 2010 to 2015, migration rates are adjusted across all age/sex cohorts by a fixed percentage so that the 2015 projection now matches this 2015 target. In regions where our unadjusted 2015 projection is less than the 2015 target, in-migration was adjusted upward and out-migration downward. In regions that were over-projected, in-migration was adjusted downward and out-migration upward. Adjustment factors varied by region from 0.00 to 0.13 (where adjustment = original rate x [1 + adjustment factor]). Because the adjustment is applied as a percentage of the original cohort rate, the effect is that high-migratory age groups are affected to a greater degree than the groups with less migration activity, in terms of resulting number of migrants. These final migration rates for the 2010 to 2015 period are essentially "synthesized" age/sex rates that capture the 2010 to 2014 population change trend while conforming to the to the age/sex distribution of migration found in the 2007-2011 ACS, the latest five-year set of age/sex migration data available at the PUMA level.

[46] Source: http://www.census.gov/population/projections/

[47] Source: *Population Projections by Age for the U.S. and States*. Updated August 9, 2013. Weldon Cooper Center for Public Service, University of Virginia. http://www.coopercenter.org/demographics/national-population-projections

[48] Source: Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013, U.S. Census Bureau, Population Division, May 2014.

[49] Source: Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013, U.S. Census Bureau, Population Division, December 2014.

Rates for subsequent projection periods – 2015 to 2020, 2020 to 2025, and so on – use an average of rates calculated from the 2005-2009 and 2007-2011 ACS datasets. The two sets are averaged in order to capture the longest recent time-span available in the ACS PUMS five-year datasets. This averaging also helps to reduce sample error for age/sex migration rates that occurs with sample survey data. While averaging these two overlapping periods effectively centers the migration rates on the 2007-2009 period, according to Census Bureau state-level component estimates[50], the centered average of these two overlapping periods is nearly identical to the average net migration estimated by Census for the most recent ten-year period, 2005 to 2014.

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.[51] 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 aged five 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 2035 using the previous projection as the new launch population. Projections for eighteen five-year age groups (0-4, 5-9 …80-84, and 85–and older) are reported for males and females. (Throughout this document, the term "age" refers to a five-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

[50] Source: ST-2000-7; CO-EST2010-ALLDATA; and NST-EST2013-ALLDATA, U.S. Census Bureau Population Division.
[51] 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.

Data Sources

The launch populations by sex, age cohort, and MCD were obtained from U.S. Census 2010 data[52]. 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.

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[53]. 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.

Five-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 2035). 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 five-year period. The 85-and older cohort's survival rate was used as-is, since there was no older cohort to average.

[52] An exception is made in our model for the town of Lincoln, Massachusetts. For the Lincoln base we have instead created 2010 age/sex estimates using cohort-change ratios observed in the 1990-2000 period applied to the Census 2000 age/sex base. We do this because Lincoln was counted in Census 2010 with a significantly reduced population. This happened because, at the time of the Census count, a large number of the housing units at a military base had been demolished, with their replacement happening only later in 2011. This gave the town a Census 2010 base count that was out of trend with its population in the years right before and again shortly after, with population reduced by as much as 21%. While the 2010 Census may be considered as a relatively accurate point-in-time count, using it as a point of reference in a residual net migration model will create drastically altered migration rates for the town, and using it as the population base for future years will also produce unreasonably low projections.

[53] See footnote (above) on exception in the town of Lincoln.

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 to 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 five-year projection by applying the corresponding averaged five-year survival rates by age/sex.

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 25 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 ages five and older. 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 to 2009. In order to calculate five-year net migration by age, sex and MCD, natural increase (births minus deaths) by age/ sex for 2000 to 2005 is added to the 2000 population by age/ sex for each MCD. The results are then subtracted from the interpolated 2005 population by age/ sex for each MCD to estimate net migration by age/ sex and MCD for 2000 to 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 four males aged 70-74 and net migration shows four 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 projection 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 to 2005 and 2005 to 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[54]. We calculated regional rates using the same MCD-based vital statistics data from 2000 to 2009 as we used in calculating the MCD rates.

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.

[54] While MCDs with populations less than 10,000 are given the regional rate in this model, we make exception for "college bedroom" towns. Because fertility rates are generally lower among females enrolled in college compared to the general population of the same age group, applying regional fertility rates to small towns with high percentages of college-enrolled population resulted in inflated births. We developed criteria for identifying "college bedroom" towns and applied town-specific fertility rates to these instead of the regional rates. Criteria is: population under 10,000 in 2010; >20% of 18 and over female population is enrolled in college or graduate school according to 2008-2012 ACS; and use of regional fertility rate resulted in a ≥25% Increase in the 0-4 age group from 2010 to 2015. The three MCDs subject to the "college bedroom" exception include Wenham, Sunderland, and Williamstown.

Sources:

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UMASS DONAHUE INSTITUTE

Section II. State-Level Summary

excerpt from:

***Long-term Population Projections for Massachusetts Regions and Municipalities*:**

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

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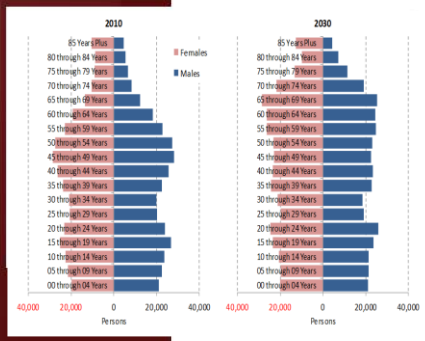

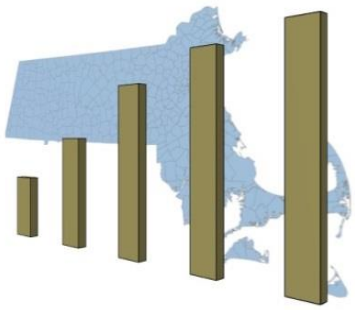

March 2015

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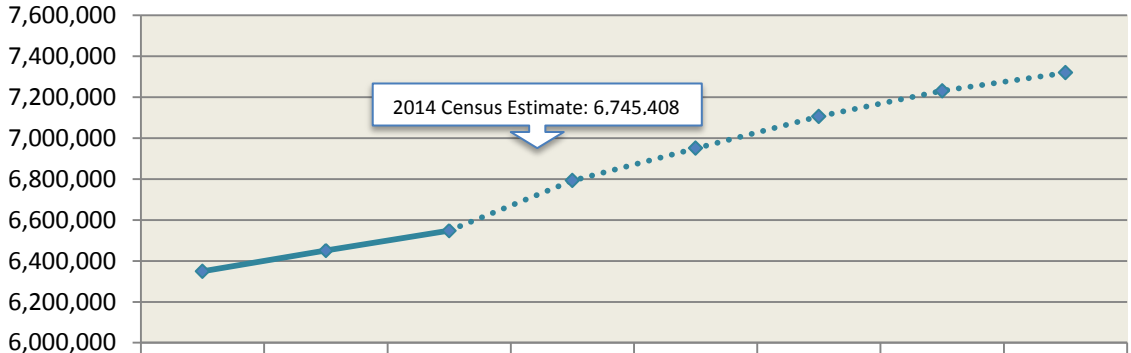
A. Massachusetts Growth: 2000 to 2035

The UMass Donahue Institute projections anticipate that the Massachusetts population will grow by 11.8% from 2010 to 2035, with population increasing by 771,840 over the 25-year term to a new total of 7,319,469. This projection picks up on the recent rapid growth experienced in Massachusetts through 2014, estimated at 3% cumulatively since the 2010 Census and averaging 46,492 persons per year according to U.S. Census estimates.[1] In this projection series, growth will continue at about this same rate through 2015, adding about 245,000 persons in the first five-year period, and then gradually diminish over the following time periods, slowing to about 1.2% growth in the 2030 to 2035 period. By comparison, Massachusetts grew 3.1% in the ten years from 2000 to 2010, increasing just 0.9% from 2000 to 2005 and then accelerating to 2.3% from 2005 to 2010 (Figure 2.1[2]).

Figure 2.1: Massachusetts Actual and Projected Population, 2000-2035



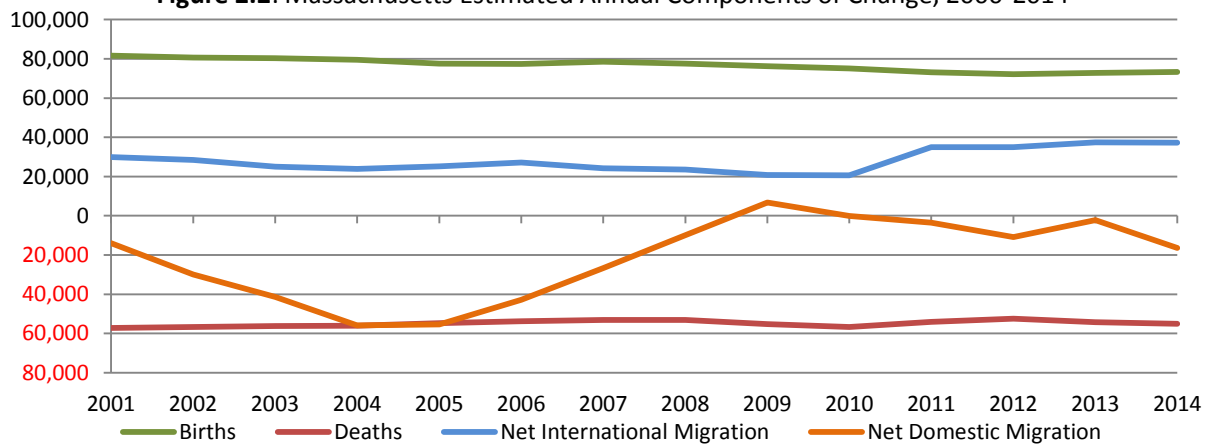
	2000	2005	2010	2015	2020	2025	2030	2035
Population	6,349,097	6,450,755	6,547,629	6,792,591	6,950,668	7,105,878	7,231,126	7,319,469
Numeric Change		101,658	96,874	244,962	158,077	155,210	125,248	88,343
5-Year % Change		1.6%	1.5%	3.7%	2.3%	2.2%	1.8%	1.2%

[1] Source: U.S. Census Bureau Population Division, Cumulative Estimates of the Resident Population Change for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014 (NST-EST2014-02), December 23, 2014.
[2] Sources: U.S. Census Bureau: Census 2000; 2005 Interim State Population Projections; Census 2010; 2014 Estimates; and UMass Donahue Institute Population Projections, 2015.

B. Factors Affecting Growth Rates

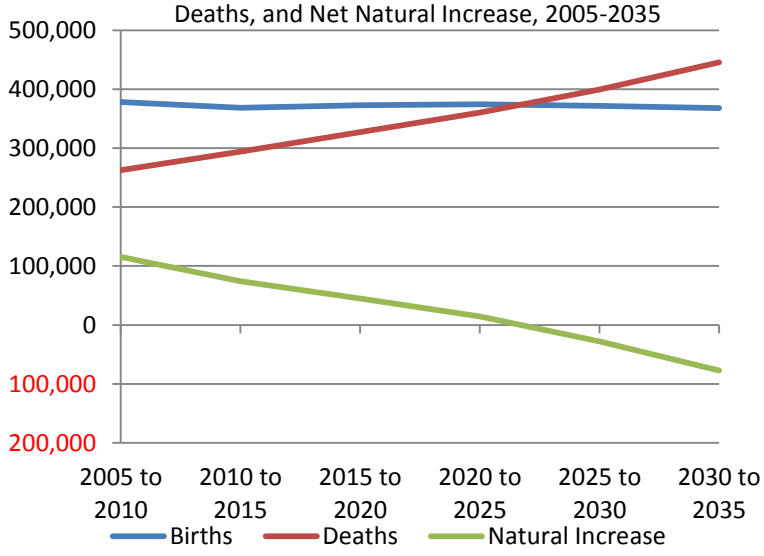
Recent rapid growth in Massachusetts is attributed to a combination of natural increase – more births than deaths, and positive total migration, which is the sum of slightly negative domestic migration to other parts of the U.S. offset by positive international immigration into the state (Figure 2.2).

Figure 2.2: Massachusetts Estimated Annual Components of Change, 2000-2014



Sources: U.S. Census Bureau, Population Division Tables ST-2000-7, CO-EST2010-ALLDATA, and NST-EST2014-ALLDATA.

Figure 2.3: Massachusetts Actual and Projected Births, Deaths, and Net Natural Increase, 2005-2035



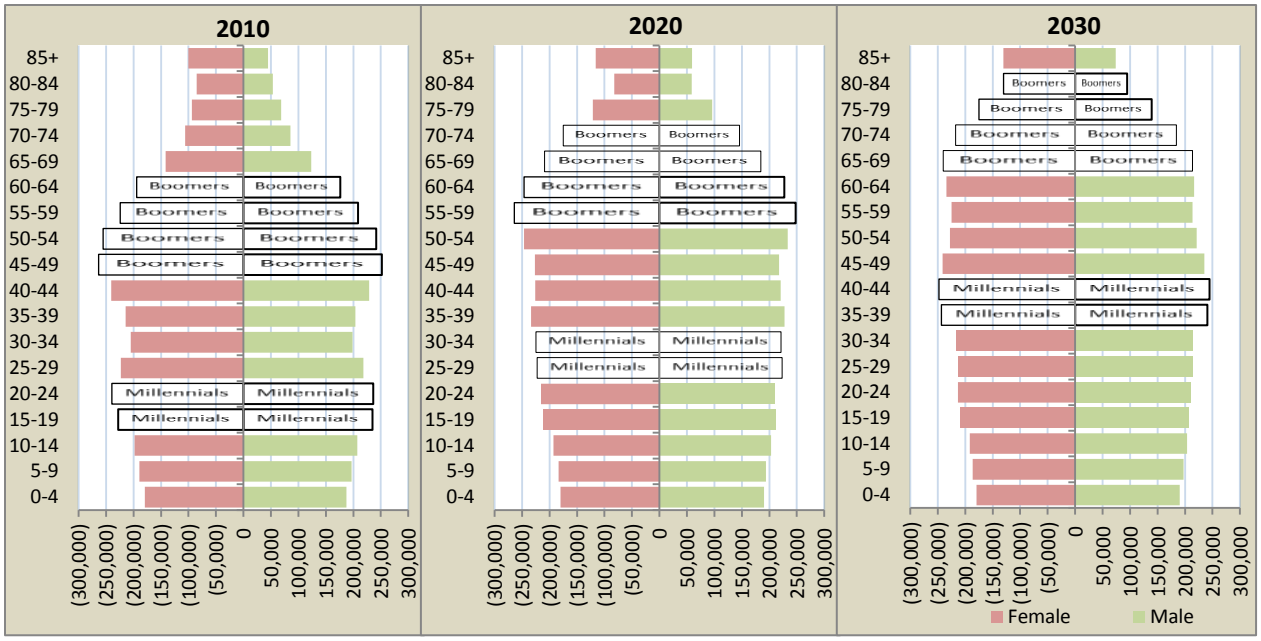
In recent years, Massachusetts has stood out as the fastest grower in the Northeast due to its relatively low domestic outflow and high immigration,[3] and this projection series anticipates that future migration in Massachusetts will carry forward at rates that reflect these recent trends. The eventual slow-down in growth, on the other hand, is attributable to the age profiles of Massachusetts and the United States overall, both directly impacting future numbers of births and deaths. As the United States grows older, the bulk of its population ages out of childbearing years and eventually into higher mortality cohorts—factors that will contribute to slower 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

[3]Source: U.S. Census Bureau Population Division, NST_EST2014. For a full summary of Massachusetts' recent growth and components of change, see *UMass Donahue Institute Summary of The U.S. Census Bureau's 2014 State-Level Population Estimates*, December 23, 2014 at http://www.massbenchmarks.org/statedata/data/UMDIsumStatePop2014.12.23.pdf.

share of its population in the older age-groups and a smaller share in the younger.[4] So while the population continues to grow, with births declining only slightly, the increasing number of deaths in an aging population starts to erode the net natural increase in Massachusetts. By 2030 the number of deaths is expected to outnumber new births in the state (Figure 2.3). 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 an aging baby boom population results in diminishing population growth over time, the effect is offset in part by a large "millennial" generation in the United States overall. By 2010 this group was 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, additionally increasing 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-boomer. 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 2.4), 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: an age-span associated with both high fertility and high levels of migration.

Figure 2.4: Massachusetts Actual and Projected Population by Cohort 2010, 2020, and 2030

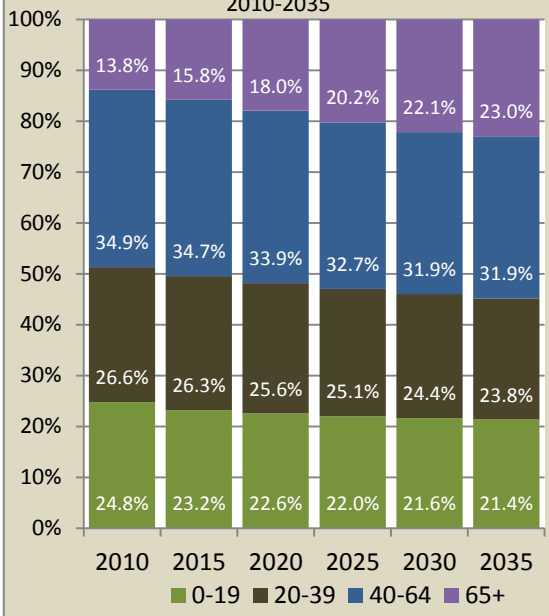


Sources: U.S. Census Bureau 2010 Census Summary File 1; UMass Donahue Institute Population Projections, 2015

[4] 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: 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 2025. Looking across the 25-year period, the swell in the percent of population aged 20-39 experienced in 2010 and 2015 (representing the millennial bulge) starts to falls off somewhat in 2020 and increasingly so thereafter (Figure 2.5). Meanwhile, the population of persons in their 40s and 50s steadily decreases from about 35% of the state's population in 2010 to 31.9% by 2035. The 0-19 age group also decreases over time, roughly following the pattern of their parents, and changing from almost 25% of the 2010 Massachusetts population to 21.4% by 2035. In sharp contrast, the population aged 65 and over in the state increases from about 14% to almost 16% in the first five-year period, and then increases even more in the second. By 2035, the 65-and-over population will represent 23% of the state's population.

Figure 2.5: Massachusetts Projected Population Distribution by Age Group, 2010-2035

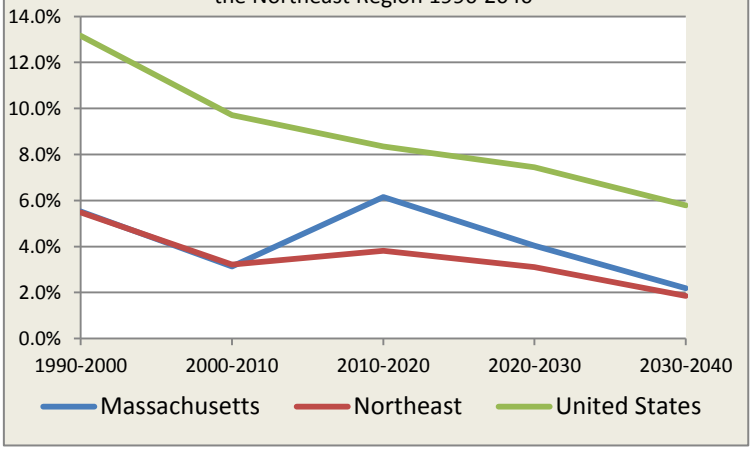


Source Data: U.S. Census Bureau, 2010 Census Summary File 1; UMass Donahue Institute Population Projections 2015.

C. Massachusetts and United States Growth Comparison

Although Massachusetts will continue to grow in population through 2035 and even outpace the Northeast Region as in recent years, its growth will still lag that of the United States as a whole (Figure 2.6[5]). While Massachusetts is projected to grow by 6.2% from 2010 to 2020, the Northeast will grow by just 3.8%[6] and the U.S. by a projected 8.3%.[7] From 2020 to 2030, Massachusetts growth will slow to 4.0%, still ahead of the Northeast at just 3.1%, while the U.S. average also slows to 7.4% yet remains higher than Massachusetts.

Figure 2.6: Actual and Projected Percentage Growth by 10-Year Period for Massachusetts, the United States, and the Northeast Region 1990-2040



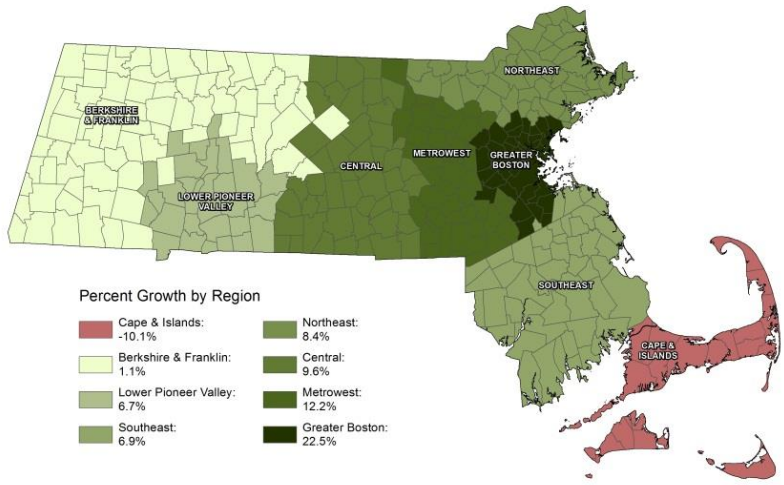
[5] Sources: U.S. Census Bureau, Census 2000 and Census 2010; 1990 Census, Population and Housing Unit Counts, United States (1990 CPH-2-1); *Observed and Total Population for the U.S. and the States, 2010-2040, Weldon Cooper Center for Public Service, University of Virginia, August 2013* and UMass Donahue Institute Population Projections, January 2015.
[6] Source: ibid, Weldon Cooper Center August 2013 and UMass Donahue Institute Population Projections, January 2015.
[7] Source: Projected Population by Single Year of Age, Sex, Race, and Hispanic Origin for the United States: 2014 to 2060. U.S. Census Bureau, Population Division. Release Date: December 2014.

One of the reasons why Massachusetts will continue to grow more slowly than the U.S. average is because it has an older age distribution than the national average. Although some parts of the state—particularly the Boston area—attract college-aged students, the Southern and Western regions of the U.S. start out with much higher percentages of younger cohorts in their resident populations, especially in the 0-18 year old age groups.[8] Younger populations in these regions ensure a greater number of births and fewer deaths in future years as compared to Massachusetts and the Northeast. Areas of the South and West also continue to experience positive net domestic migration while the Northeast tends to experience net domestic out-migration. That said, Massachusetts is affected by these components to a much lesser degree than other states in the Northeast. Its outmigration in recent years has tended to be minimal compared to other Northeast states, and the small domestic loss has been offset by strong positive international immigration. In 2013 Massachusetts' annual percent growth actually caught up with the U.S. rate for the first time since 1968.[9] Massachusetts has also consistently led the rest of the Northeast states in growth since the last Census in 2010. By the 2030 to 2040 period, an aging U.S. profile means that all comparison regions slow in growth significantly, the U.S. to 5.8%, Massachusetts to 2.2% and the Northeast region to 1.9%.

D. Projected Geographic Distribution of Population Growth

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 11.8% anticipated for the state by 2035 (Figure 2.7). The Greater Boston region, which has been growing at an estimated 1.1% per year since 2010,[10] is expected to increase by 22.5% in the 2010 to 2035 period. Concurrently, most other regions around the state are expected to experience strong but more moderate levels of growth. The Metrowest region is expected to increase 12.2% by 2035, the

Figure 2.7:
Projected % Growth by Massachusetts Region 2010-2035



[8] Source: U.S. Census Bureau, 2010 Census Summary File 1.
[9] Sources: U.S. Census Bureau Annual Estimates of the Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2013 (NST-EST2013-01). Release Date: December 30, 2013, Population Division; and Intercensal Estimates of the Total Resident Population of States: 1960 to 1970. Release date: Aug. 1996. Population Distribution Branch. Both: U.S. Census Bureau.
[10] Source: U.S. Census Bureau NST-EST2013-01.

Central region by 9.6%, the Northeast by 8.4%, the Southeast by 6.9%, and the Lower Pioneer Valley by 6.7%. At the other end of the spectrum, the Cape and Islands region is predicted to decrease in population by 10.1% over 25 years if recent trends in migration, fertility, and mortality continue, while the Berkshire and Franklin region will remain nearly level, with a slight increase of just 1.1% during that same period. Both of these regions stand apart from the Massachusetts average due to their older population structure compared to other regions around the state. Further analysis on why growth varies significantly by region is presented in more detail in Section III of this report.

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Section III. Long-Term Regional Population Projections

excerpt from:

Long-term Population Projections for Massachusetts Regions and Municipalities

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

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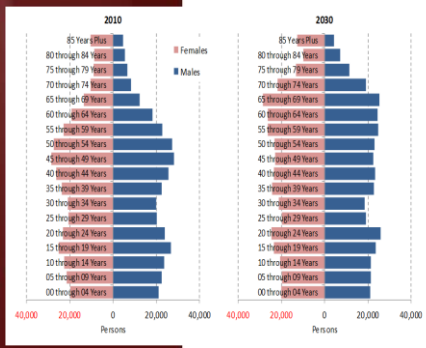

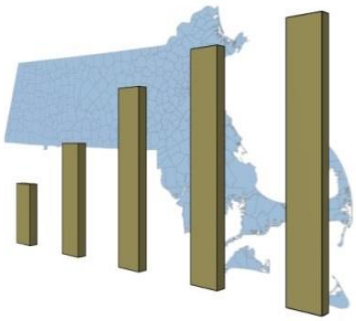

March 2015

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III. Long-Term Regional Population Projections

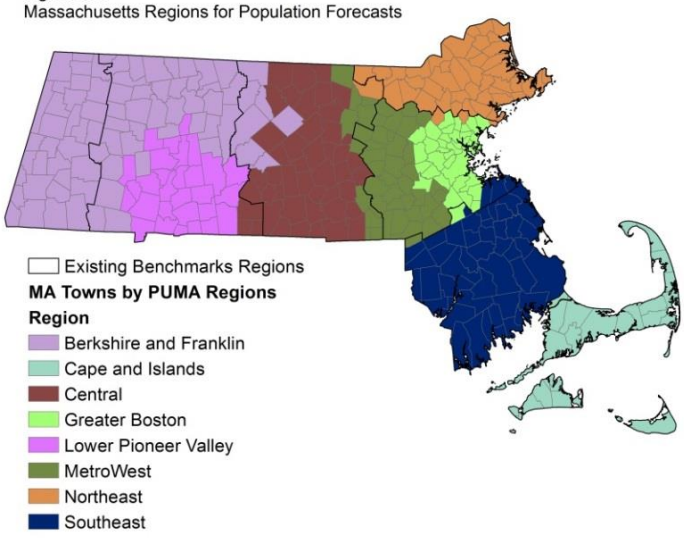
A. Introduction

This section presents long-term regional population projections for eight Massachusetts regions for years 2010 through 2035. 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. 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.[1]

Figure 3.1:
Massachusetts Regions for Population Forecasts



[1] 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.[2] 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. ages 0-4, 5- 9,… 80- 84, and 85 and 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 series 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.[3] 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.

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 norms and lifestyle preferences, regional differences in climate change, even state and federal

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

[3] 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.

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 or 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 ones 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

Summary

The Berkshire/Franklin county region consists of 76 communities spanning the Commonwealth's western and northwestern borders (Figure 3.1a). It is predominantly rural with its primary population and employment centers in 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 -0.1%. Our model predicts that recent trends of slow decline will continue through 2015 and then temporarily reverse between 2015 and 2030, with more in-migration from retiring baby boomers coupled with a reduction in domestic out-migration, as the region includes fewer persons in the younger cohorts more prone to leave the region. The effect of retirement-fueled growth will be only temporary however, as increasing deaths associated with an aging population will eventually erode all gains. The regional population is expected to peak in 2030 at 238,425 residents—about 2,300 more than were counted in the 2010 Census—and then start to slowly decline again towards 2035. (Figures 3.1b & 3.1c). This said, the region may be thought of as very stable over the time series in terms of total population. The population varies by less than 5,000 from the highest to lowest point in the 2010 to 2035 time series with a 25-year increase of just 1.1%.

Figure 3.1a
The Berkshire/Franklin Region

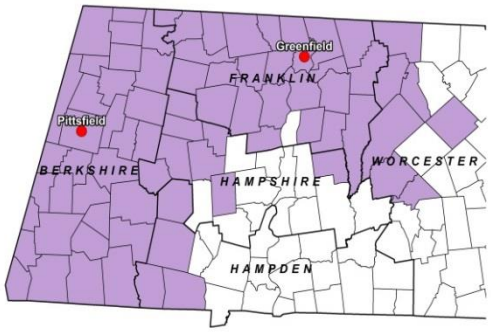


Figure 3.1b
Recent and projected population, Berkshire/Franklin

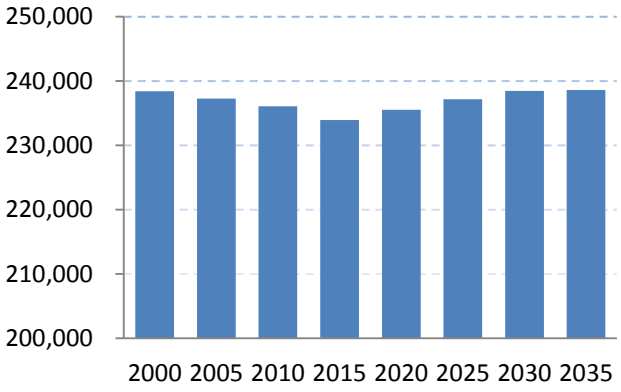


Figure 3.1c
Annualized rates of population change, Berkshire/Franklin

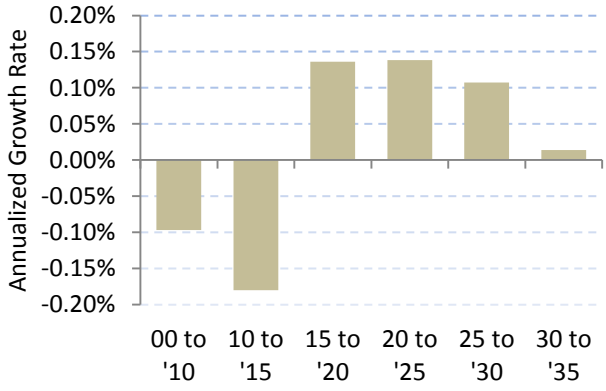


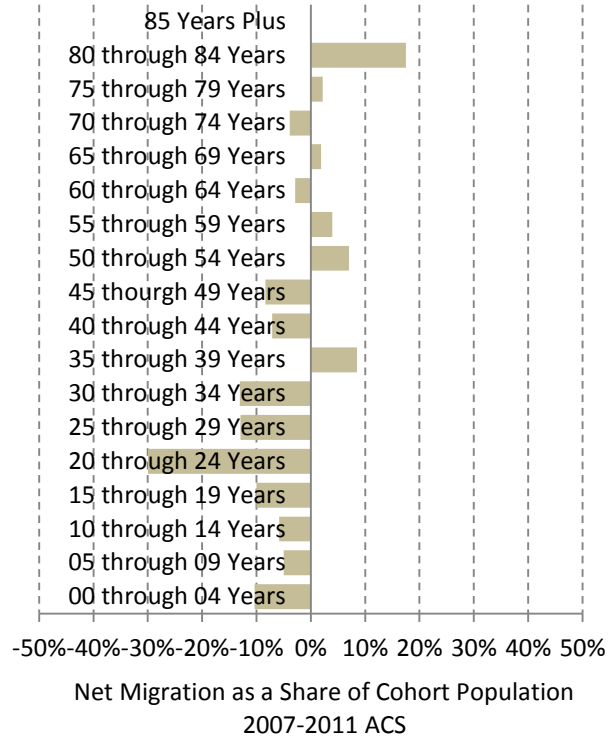
Table 3.1
Summary Results: Estimated Components of Population Change, Berkshire/Franklin

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	236,058	233,932	235,525	237,153	238,425
Births	10,577	10,166	10,079	9,900	9,781
Deaths	12,886	14,582	16,415	18,386	20,633
Natural Increase	*-2,310*	*-4,416*	*-6,336*	*-8,485*	*-10,851*
Domestic In-migration, MA & Border	31,141	33,300	33,393	33,885	34,467
Domestic In-migration, Rest of U.S.	12,681	13,571	14,068	14,546	14,948
Domestic Out-migration	48,113	45,305	43,924	43,096	42,814
Net Domestic Migration	*-4,292*	*1,566*	*3,536*	*5,335*	*6,601*
Net International Migration	*4,475*	*4,444*	*4,428*	*4,422*	*4,416*
Ending Population	233,932	235,525	237,153	238,425	238,592

Table 3.1 above shows future estimated components of population change for the region. While births decrease over time, the number of deaths will increase, leading to decreasing net population change due to natural events. At the same time, the number of in-migrants increases over time while the number of out-migrants decreases: resulting in increasing population due to migration. Together, these sum to the population variations anticipated from one period to the next. In the case of all components, the predicted trends are very much related to the age structure of the region and how recent trends in migration-by-age will affect future populations.

Domestic out-migration has been the Berkshire/Franklin region's major source of population loss in recent years. ACS data for the 2007-2011 period indicates that the region lost 57,435 residents due to domestic out-migration, while gaining only 43,995 new residents from other regions in the state

Figure 3.1d: Age profile of net domestic migrants, Berkshire/Franklin, 2007-2011, American Community Survey



and the U.S. The region has gained some new residents in the 35- 39 age group, however all other in-migrants have been in the older cohorts aged 50 and above. 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).

Age Profile

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 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 15-29 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 decrease 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.

Figure 3.1e: Projected levels of domestic in and out-migration, Berkshire/Franklin, 2010-2035

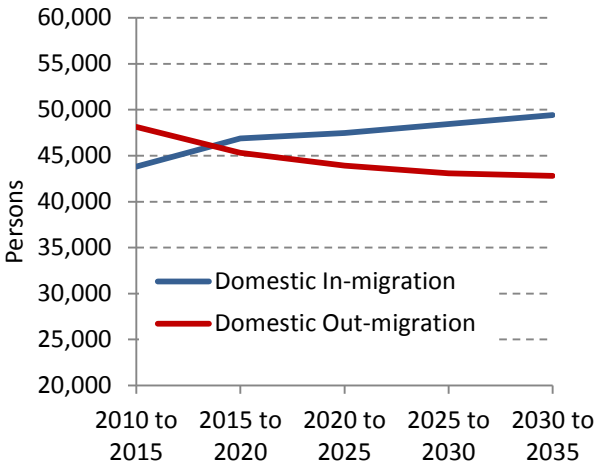
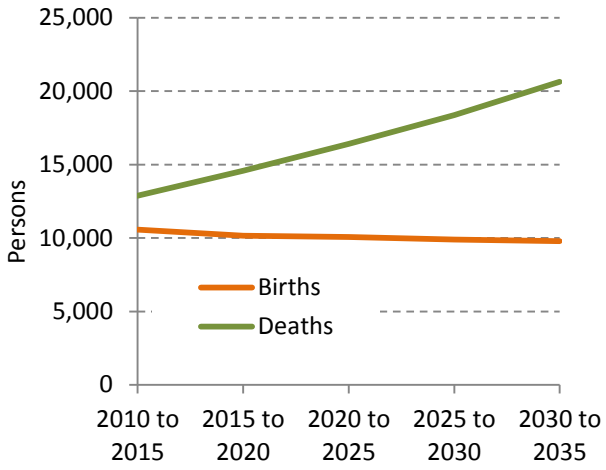


Figure 3.1f: Projected levels of births and deaths, Berkshire/Franklin, 2010-2035



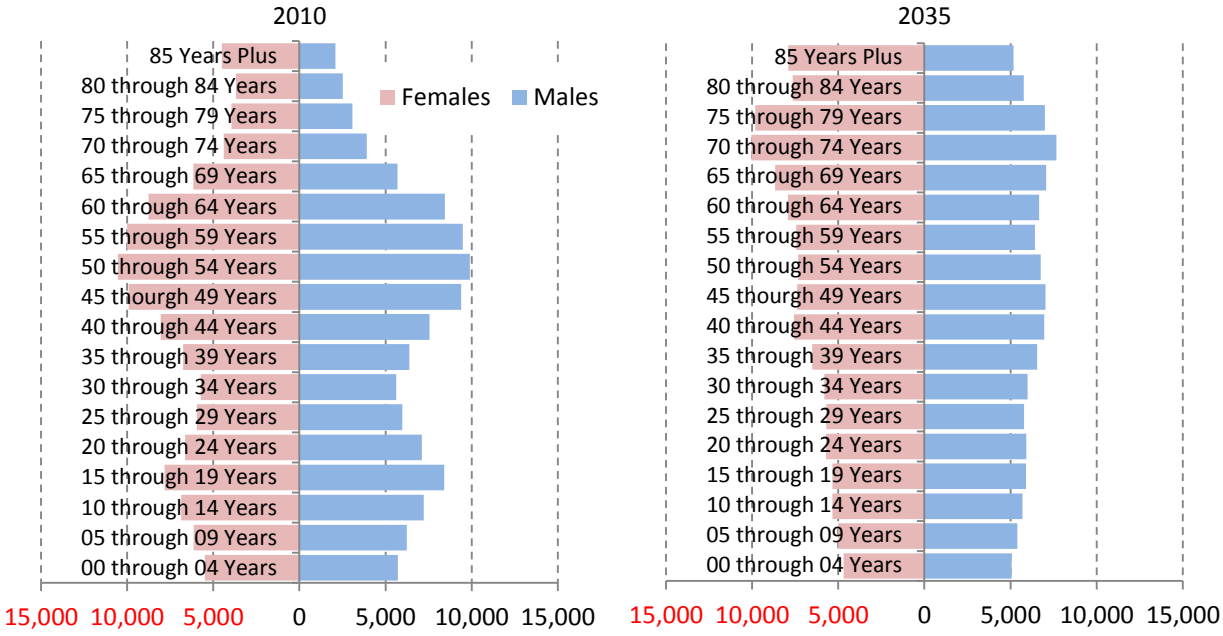
A smaller portion of the region's recent population loss has been due to natural decline, i.e. more deaths than births; however, this is expected to play a much larger role in population loss in the years ahead. Between 2005 and 2010, there were 10,833 births in the region compared to 11,513 deaths, 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, growing population 70 years and older—ages when mortality rates begin to show a marked increase.

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- 64—cohorts roughly analogous to the baby boomer generation. We also find a secondary concentration (21%) between the ages of 10-25—ages associated with the millennial generation or echo boomers (Figure 3.1g). By 2030, the baby boomers will have moved into 65-years 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 the ages of 20 and 30 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 25 years will be considerably older than today. In 2010, roughly 32% of the region's population was 55-years or older. By 2035, this share will increase to 44%. In the next twenty-five years, we expect stagnancy or a relative decline in the population share of nearly all cohorts except those over 65. Figure 3.1g, below, shows the change in the age and gender composition of the region anticipated by 2035 compared to 2010. Figure 3.1h shows the population by age at 2000, 2010 and then projected at 5-year intervals through 2035, demonstrating how the population ages forward through the time-series.

Figure 3.1g
The age and gender composition of the Berkshire/Franklin population, 2010 (actual) vs. 2035 (forecasted)



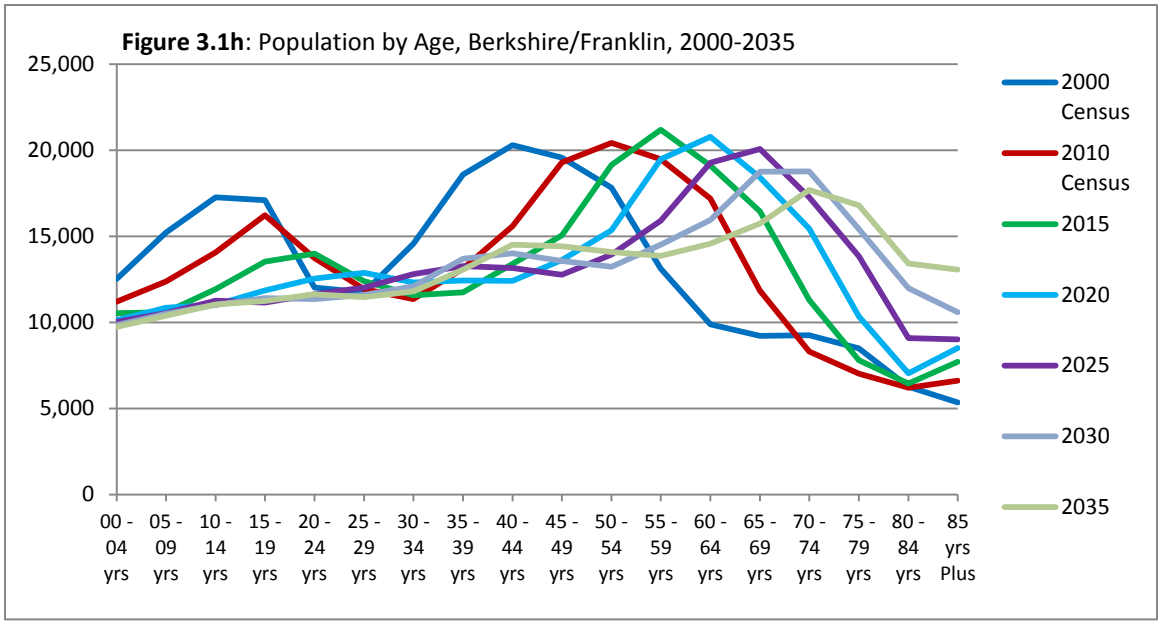


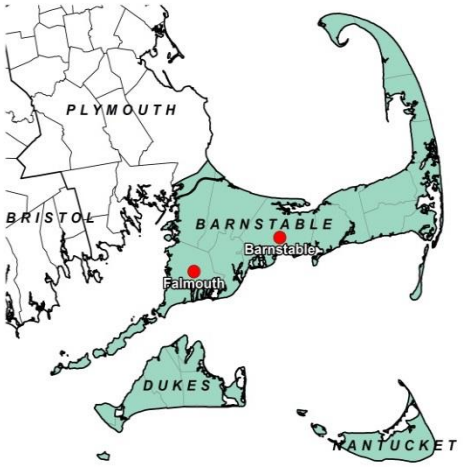
Figure 3.1h: Population by Age, Berkshire/Franklin, 2000-2035
25,000
20,000
15,000
10,000
5,000
0
00 - 04 yrs
05 - 09 yrs
10 - 14 yrs
15 - 19 yrs
20 - 24 yrs
25 - 29 yrs
30 - 34 yrs
35 - 39 yrs
40 - 44 yrs
45 - 49 yrs
50 - 54 yrs
55 - 59 yrs
60 - 64 yrs
65 - 69 yrs
70 - 74 yrs
75 - 79 yrs
80 - 84 yrs
85 yrs Plus
2000 Census
2010 Census
2015
2020
2025
2030
2035

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).

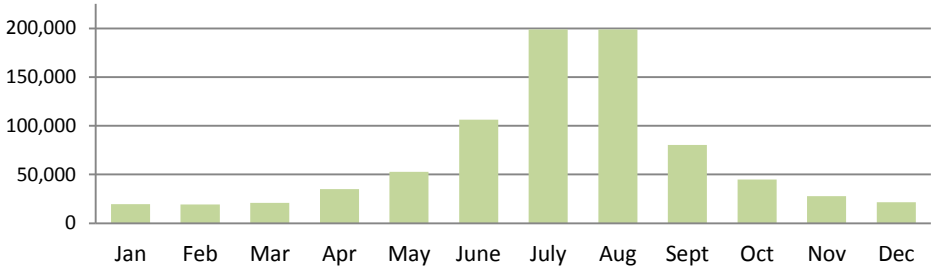
Figure 3.2a
The Cape & Islands Region



Before describing population and population change in the Cape and Islands region, it is important to first note that our projection series accounts only for the "resident" population of the region, as captured by the U.S. Census Bureau. During significant portions of any given year, however, the region is also home to a large number of "seasonal" residents not counted by the Census Bureau and, likewise, not considered in the scope of this projection series.

Estimates produced by the Cape Cod Commission, using survey data on second homes indicate that the seasonal population on Cape Cod, when averaged over a full year, is equivalent to 68,856 full-time residents in addition to the 215,888 counted by the U.S. Census Bureau in 2010 (Figure 3.2b).[4] The extent of this seasonal population is also apparent in Census Bureau housing unit data. Out of 3,221 U.S. counties tallied in Census 2010, the three Cape and Island counties all rank in the top 100 in terms of vacant/seasonal units as a percent of all housing units. Nantucket County ranks 9th at 58%; Dukes County ranks 14th at 54%; and Barnstable County is 75th at 36%. In terms of the total number of vacant/seasonal housing units, Barnstable County, with 56,918 units, has the 4th largest number in of all counties in the United States, just behind Maricopa County Arizona and Lee and Palm Beach counties in Florida.[5]

Figure 3.2b: Second Home Population Estimate , Cape Cod, 2010

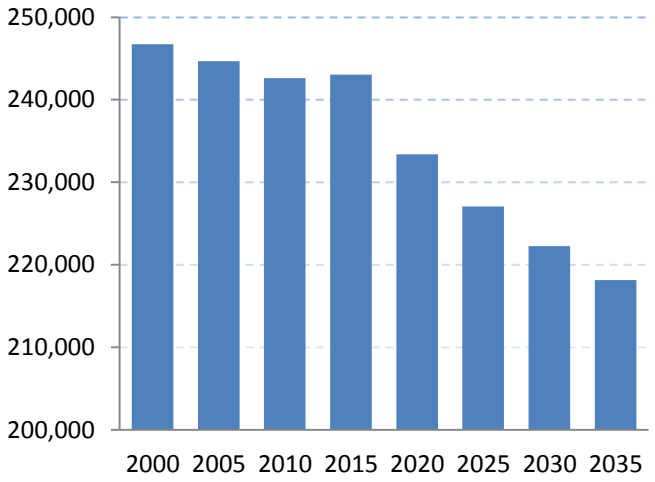


Source Data: Cape Cod Commission 2015. Calculations based on UMass Donahue Institute's *Second Home Owner Survey* 2008 and 2010 U.S. Census.

[4] For more information on the estimate of full-time resident equivalency, contact the Economic Development Department of the Cape Cod Commission in Barnstable, MA at http://www.capecodcommission.org.
[5] Source: U.S. Census Bureau, DP-1: Profile of General Population and Housing Characteristics, 2010 Census.

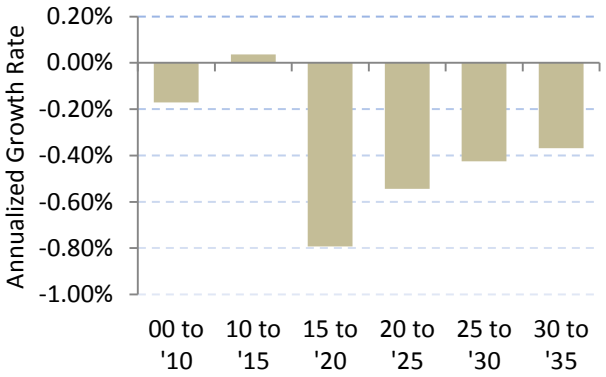
Between 2000 and 2010, the Cape and Islands region experienced a net loss of just over 4,000 residents, much of which was due to the out-migration of youth and a large number of deaths characteristic of an older resident population. Our model shows a slight increase in population from 2010 to 2015 to align the region with recent U.S. Census Bureau estimates for the area,[6] but the recent trend of population loss continues for the rest of the time period. From 2010 to 2015, the population increases to just over 243,000 persons, but then starts to lose population again at a level of about 6,225 persons on average every five years through 2035 (Figure 3.2c).

Figure 3.2c
Recent and projected population, Cape & Islands



Annualized growth from 2010 to 2015 is minimal—just 0.04%—and is followed by a decrease of -0.8% from 2015 to 2020 (Figure 3.2d). From 2000 to 2010, the region decreased by -0.17%. In the 2015 to 2020 period, decreasing population in the region is driven largely by the outflow of young people from the region. After 2020, the decrease is due largely to vital events as the number of deaths increasingly outnumbers the number of births in an aging region.

Figure 3.2d
Annualized rates of population change, Cape & Islands



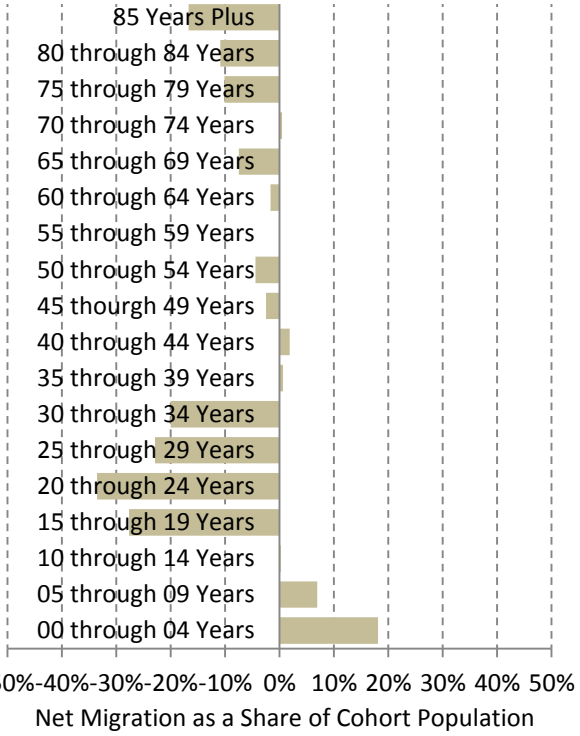
The Sources of Population Change

The anticipated population loss in the Cape and Islands is due to both the net domestic out-migration predicted in the model and the net result of more deaths than births in the region. American Community Survey PUMS data for the 2007 to 2011 period shows an annual outflow of 11,527 persons from the region compared to an inflow of just 7,546. Over a five-year period, this amounts to a net domestic loss of about 20,000 people.

[6] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

According to the ACS data, nearly all age groups are contributors to the net outflow from the region; however out-migration is particularly high among the region's youth, many of who presumably leave the region for college or job prospects while in their late teens through their twenties and mid-thirties (Figure 3.2e). Out-migration numbers will decline as the number of young residents associated with out-migration continues to shrink. Note that the *rates* of out-migration by age will be the same, according to our model; however the population of young persons in the region subject to this rate will is expected to decline over time.

Figure 3.2e
Age profile of net domestic migrants, Cape & Islands, 2007-2011, American Community Survey



When evaluating the migration component for Cape Cod, however, it should be noted that while the American Community Survey is our only *direct* source of gross-migration data by age and sex at the state or sub-state geographic level, it is based on sample survey data and therefore prone to sampling error. Because Cape Cod is the smallest region in our projection series, it can be considered the most prone to this sampling error out of all eight sub-state regions. Thus, both the migration levels and the distribution of the migration to each age group in this model are subject to dispute or revision through the analysis of other data sources when available.

Further complicating migration measurement in the Cape Cod region is the high level of seasonal, part-time, or "snowbird" residents. These populations are difficult to capture accurately in all types of direct migration data available. These data include: IRS migration data, which captures in- and out-migration for the total population down to the county level, the old Census long form (used in 2000), and the ACS survey.

Because of the variances due to measurement error as well as varying residency rules among the different sources of migration,[7] the resulting net levels of migration for this region differ significantly by source. The ACS county-to-county flow data indicates a net outflow of 4,539 per year from 2005 to 2009 and 2,437 per year during the 2007 to 2011 period.[8] This equates to 22,695 and 12,185 net out-migrants, respectively, for each of the five-year periods we use in creating

[7] The American Community Survey defines residency as a place where a person lives for "at least two months"; the decennial Census count defines residency as where a person lives "most of the time"; and IRS migration data is based on the filer's declared place of residence for tax purposes.

[8] Source: U.S. Census Bureau, 2005-2009 American Community Survey and 2007-2011 American Community Survey County-to-County Migration Flows. For more information see: http://www.census.gov/hhes/migration/data/acs/county-to-county.html

migration rates for the UMDI V2015 projection series. The ACS PUMS migration data,[9] which provides age/sex detail but which is subject to larger sample error, suggests a larger net outflow of 5,670 persons per year in 2005 to 2009 and 3,981 per year in the 2007 to 2011 period, or five-year totals of 28,350 and 19,905, respectively. In contrast, net migration estimates created by the U.S. Census Bureau for use in their annual county-level population estimates, based on IRS tax-returns and Medicare enrollment data, indicate much lower levels of net outflow: 2,871 in the 2005 to 2009 period—or 574 average per year. In the 2007 to 2011 period these estimates indicate net *positive* migration of 380 person's average per year, or 1,899 for the five-year period.[10]

As an alternative to using these direct sources of migration data, one can also estimate migration levels indirectly. One commonly used cohort-component method estimates net migration for each age/sex cohort as a residual of births, deaths, and the difference between the Census 2000 and 2010 counts. In an application of this method, we take the Census 2000 population for a given town by age and sex, age all of its cohorts forward by ten years, add the number of births in the town from 2000 to 2010, and subtract deaths from 2000 to 2010. This gives us our "anticipated" 2010 population. The difference between the "anticipated" and the actual population (the Census 2010 count) is attributed to net-migration and is converted into a migration rate that is carried forward for the rest of the time series.

Using a residual-survival method for estimating migration, we do see a different pattern of net-migration by age than that observed in the ACS data. This method, however, also predicts population loss in the region at about the same level as the ACS-based, gross migration model that we use in this V2015 projection series. Figure 3.2f, below, shows the resulting total population projected for the region using four different methods of projecting population change: a cohort-survival method calculating net-migration, two alternate variations of a Hamilton-Perry or "cohort-change-ratio" method,[11] and the ACS-based gross-migration model that we use in the UMDI V2015 projection series.[12] For most points in the time series, the variation from the highest to the lowest result from any given model is about 4,000 to 5,000 people.

[9] Source: U.S. Census Bureau American Community Survey 5-year Public Use Microdata Sample Data 2005-2009 and 2007-2011. For additional information see: http://www.census.gov/acs/www/data_documentation/pums_data/

[10] Sources: U.S. Census Bureau: Cumulative Estimates of the Components of Resident Population Change for Counties of Massachusetts: April 1, 2000 to July 1, 2009 (CO-EST2009-04-25, March 2010) and Annual Resident Population Estimates, Estimated Components of Resident Population Change, and Rates of the Components of Resident Population Change for States and Counties (CO-EST2013-ALLDATA, March 2014).

[11] In our example of a cohort-change-ratio method, we take the ratio of an age/sex cohort population age (*a*) at time (*t*) to the cohort population age (*a-10*) at time (*t-10*) and apply that ratio, by age and sex, to the base and future base populations.

[12] Researchers interested in obtaining detailed results of the alternative series shown here may contact the UMDI Population Estimates Program for information.

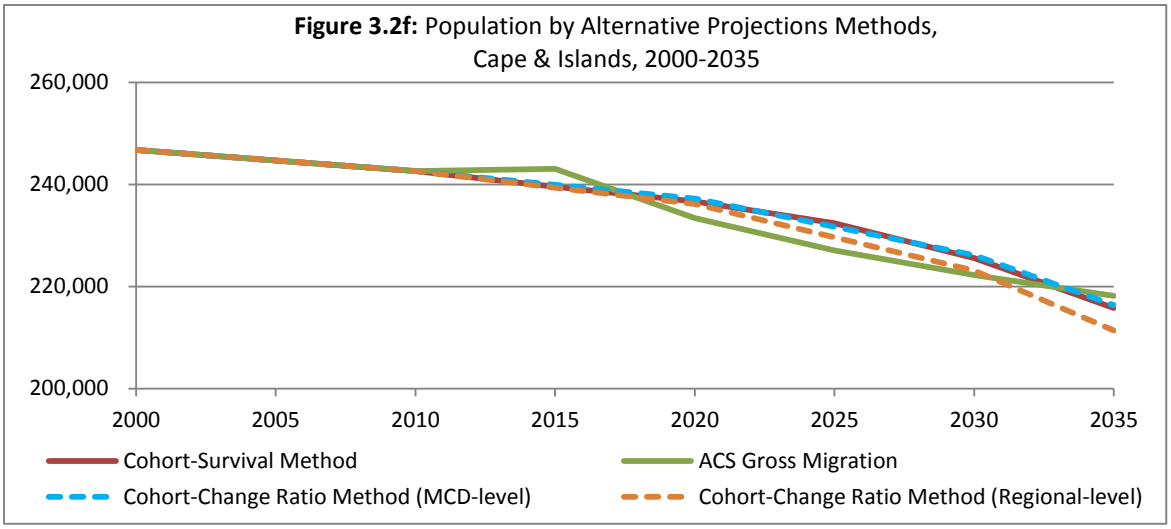


Figure 3.2f: Population by Alternative Projections Methods, Cape & Islands, 2000-2035

It should be further noted that all four of the alternative models presented here are based on birth, death, and migration trends experienced in the Cape Cod region from 2000 forward. The Cape region experienced strong and steady growth for many decades leading up to 2000, with the 2000 to 2010 period representing a reversal of those trends. A projection model that based its future migration trends on a longer history of the region, for example the 1990 to 2000 period, would likely predict continued growth in this region rather than decline. Figure 3.2g below shows the example of a cohort-change-ratio model that uses the ratios observed from 1990 to 2000 averaged with the 2000 to 2010 ratios, as compared to some of the alternative models based on just the 2000 to 2010 data.

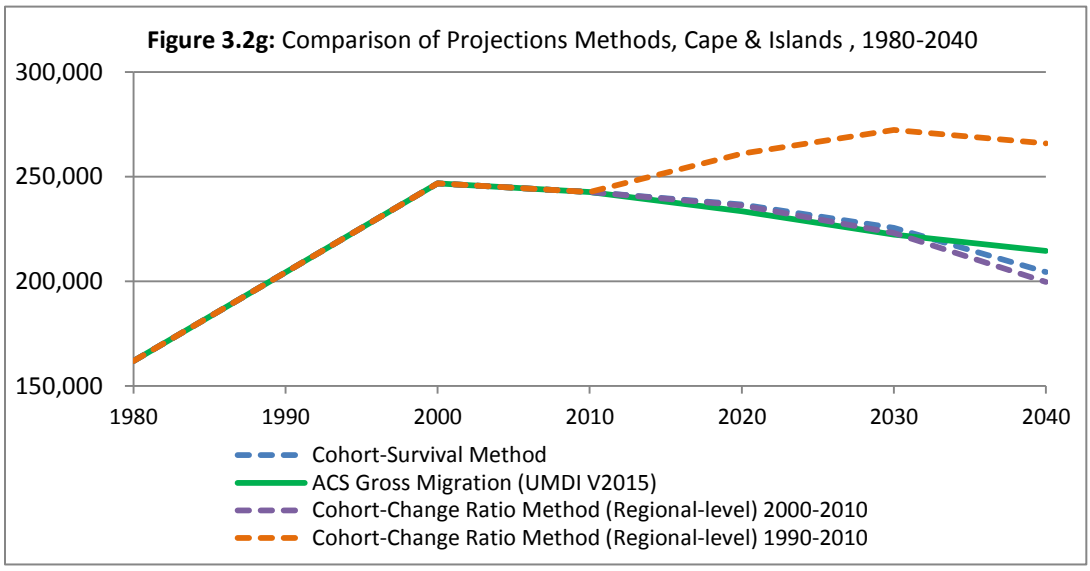


Figure 3.2g: Comparison of Projections Methods, Cape & Islands , 1980-2040

In our vintage 2015 projection series we do choose to use a migration period (2005 to 2011) that we feel is reasonably likely to reflect migration patterns over the next 20 years, and we select a source of direct migration data (ACS PUMS) that allows us to examine both in and out-migration by

age and by sex. However, it should be clear from the above discussion that these do represent choices and assumptions in our model which are subject to variation in any other given model.

While out-migration is mitigated in our model in the 2010 to2015 period, when we adjust migration rates to meet Census 2014 estimates,[13] it increases again from 2015 to 2020 before gradually diminishing when using the ACS-based rates. In-migration generally increases throughout the period, holding steady through 2020 and then increasing thereafter as the millennials in the greater U.S. start to age into the 35-44 age group now associated with slight in-flow in the Cape region according to the ACS data. These age groups further increase the inflow by bringing their children with them. While most other age-groups have been contributing to out-migration, this increased inflow, together with diminishing out-flow, is just enough to finally yield net-positive migration by 2035 (Table 3.2 and Figure 3.2h.). Finally, throughout the time series, positive international migration, at roughly 6,000 new residents in each 5-year period, steadily off-sets the losses through domestic outmigration that we predict in the region after 2015.

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	242,595	243,036	233,398	227,050	222,232
Births	10,035	10,176	9,920	9,714	9,544
Deaths	16,015	16,778	17,174	18,090	19,239
Natural Increase	*-5,980*	*-6,602*	*-7,254*	*-8,376*	*-9,695*
Domestic In-migration, MA & Border	25,852	25,729	26,224	26,573	26,890
Domestic In-migration, Rest of U.S.	16,031	15,464	16,015	16,581	17,162
Domestic Out-migration	41,435	50,161	47,252	45,508	44,359
Net Domestic Migration	*448*	*-8,968*	*-5,013*	*-2,354*	*-307*
Net International Migration	*5,973*	*5,932*	*5,919*	*5,912*	*5,904*
Ending Population	243,036	233,398	227,050	222,232	218,133

Population loss due to vital events has an even larger influence than migration on population change in the region, and its influence only increases throughout the time period. According to U.S. Census estimates, Barnstable County, which accounted for 89% of the region's population in 2010, shows the highest rate of population loss due to natural decrease (deaths over births) in the state, at 5.3 per thousand compared to 2.9 statewide.[14] From 2005 to 2010, the region experienced 11,193 births compared to 13,959 deaths.

[13] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.
[14] Source: U.S. Census Bureau Population Division, CO-EST2013-ALLDATA, March 2014 and NST_EST2013_ALLDATA, January 2014.

With the number of births essentially flat over the next twenty-five years, the gap between deaths and births will continue to widen, leading to increasing population loss through the period (Table 3.2 and Figure 3.2h). By the 2030 to2035 period, the region is projected to have a 2:1 ratio of deaths over births with 19,239 deaths compared to just 9,544 births.

Figure 3.2h
Projected levels of domestic in and out-migration, Cape & Islands, 2010-2035

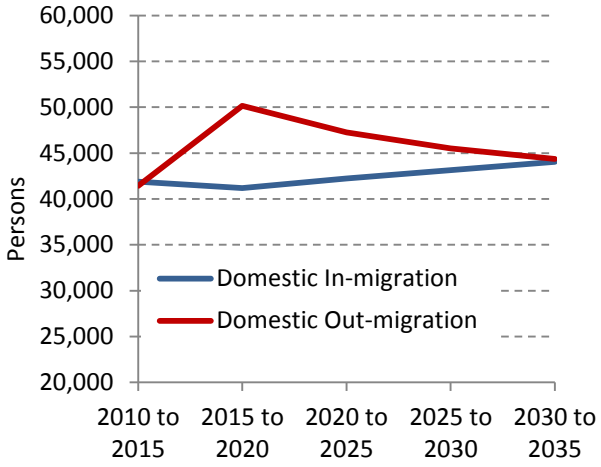
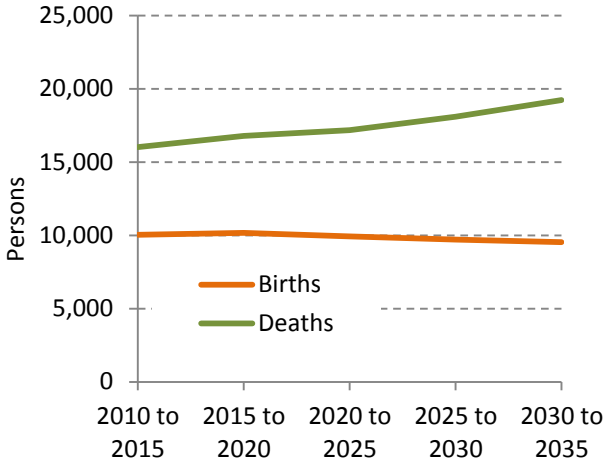


Figure 3.2i
Projected levels of births and deaths, Cape & Islands, 2010-2035



Age Profile

The increasing number of deaths over births is a trend playing out in many other parts of the Northeast and even the U.S. as the large population of baby boomers moves into their seventies and eighties, when mortality rates rise considerably. In the Cape region this effect is exacerbated by a regional age profile that is notably older than both the state and the nation. Figure 3.2j shows a sizable population mass among persons 45- 69 years old in 2010. In the Cape and Islands this group accounts for 39% of the regional population, compared to roughly 32% for the state and 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 and 10% of the state population compared to 17% in the Cape and Islands.

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 2035, roughly 35% of the population will be 65-years or older—compared to 24% in 2010. From 2010 to 2035, the region loses population in every cohort younger than 65. Of particular interest in the 2010 age profile is the near absence of the children of the baby boomers (the millennials) as a secondary bulge—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. Only some of these will to return the Cape and Islands as they approach their thirties and forties and start families of their own.

Figure 3.2j: The age and gender composition of the Cape & Islands population, 2010 (actual) vs. 2035 (forecasted)

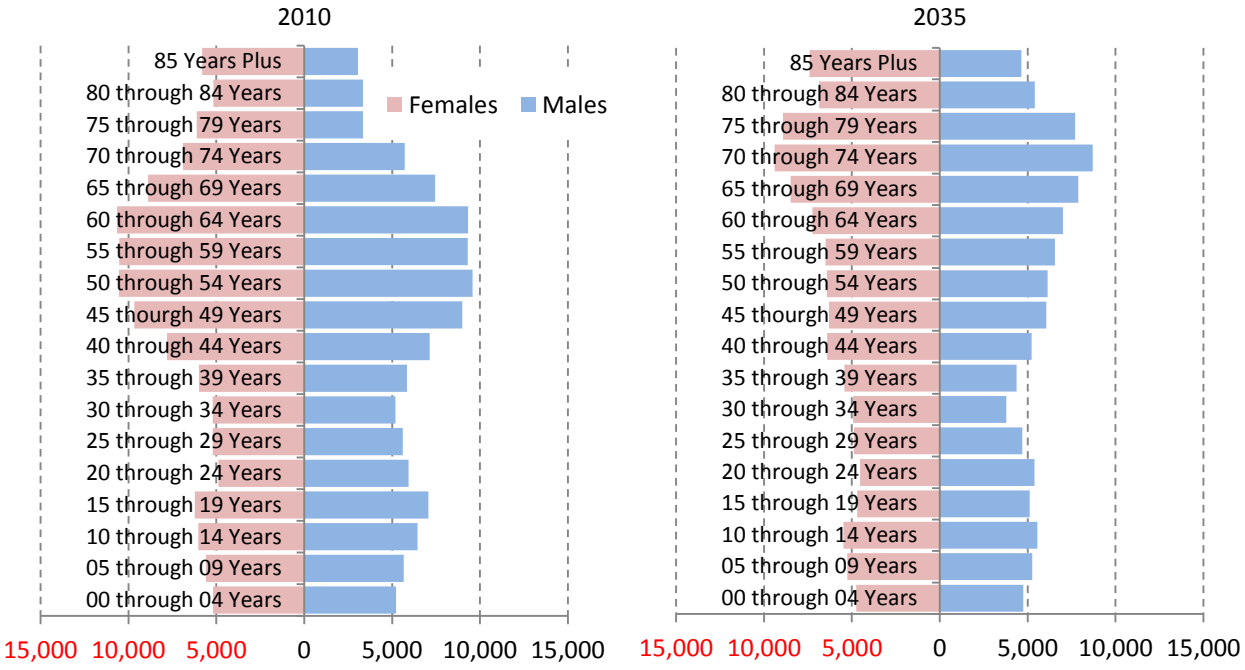
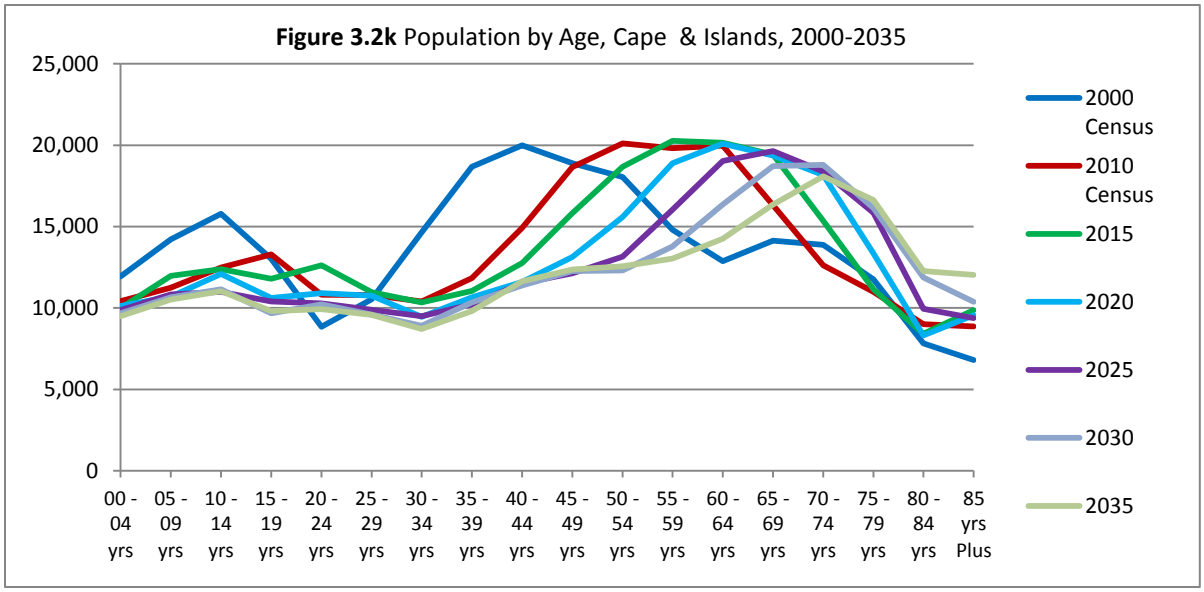


Figure 3.2k below shows the Cape and Islands population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.

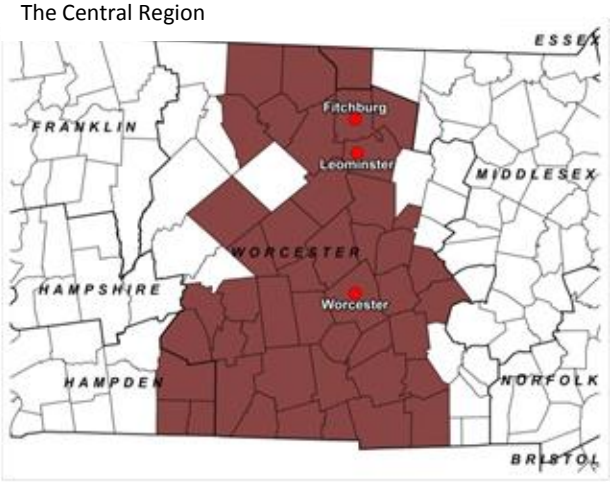


3. Central Region

Summary

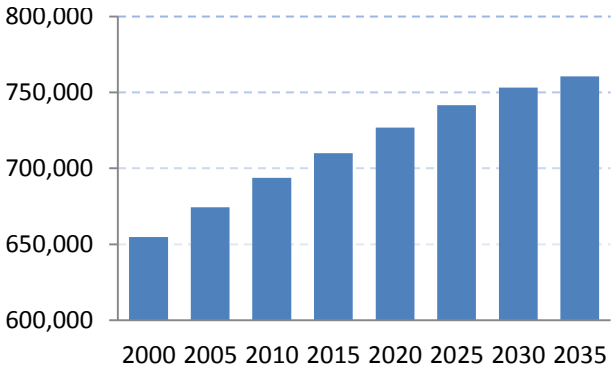
The Central region lies on the western fringe of the 495 Corridor. It includes 46 communities anchored by the city of Worcester, with secondary industrial/population centers, Leominster and Fitchburg, to the north (Figure 3.3a).

Figure 3.3a:
The Central Region



The Central region added just under 40,000 residents during the 2000s (Figure 3.3b), and our projections anticipate continued population growth over the next several decades with the region increasing by another 33,000 people from 2010 to 2020 and another 26,000 from 2020 to 2030. By 2035, we anticipate a population of about 760,506 in the region, as comp

Figure 3.3b: Recent and projected population, Central Region

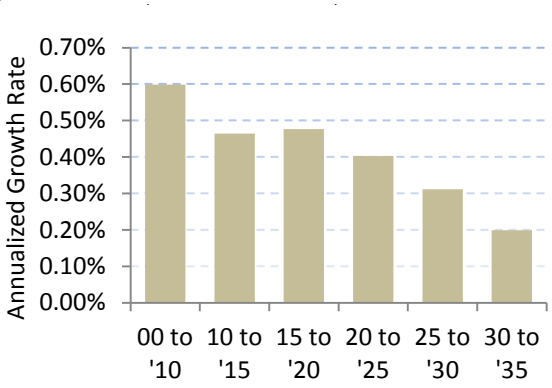


The rate of population growth will slowly diminish as the number of deaths begins to rise with the aging of the regional population over time. Between 2000 and 2010, the Central region experienced a relatively robust annualized population growth rate of 0.6% per year (Figure 3.3c). By the end of our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

The Sources of Population Change

The growth of the Central region over the past deca more births than deaths in the region. Between 200 region, compared to 28,966 deaths, resulting in a natural increase of just over 13,000. This reflects the age composition of the region which, as of 2010, has a fairly substantial number of residents in their later twenties and thirties and relatively few elderly residents.

Figure 3.3c: Annualized rates of population change, Central Region



Over the next several decades, however, the gap between births and deaths is expected to narrow, leading to a slowdown in the rate of population growth (Figure 3.3e). The number of deaths is expected to rise with the aging of the population—growing from roughly 29,000 from

2005 to2010 to over 39,000 during the 2020 to2025 period. This coincides with the aging of the resident population, particularly the sizable baby boom generation, which will begin moving into its seventies by 2030. By 2025, deaths already start to outnumber births and start to cut into overall population growth.

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	693,813	709,922	726,839	741,487	753,027
Births	41,652	38,503	38,621	38,481	38,227
Deaths	32,382	35,623	39,756	44,585	49,991
Natural Increase	*9,270*	*2,880*	*-1,134*	*-6,104*	*-11,763*
Domestic In-migration, MA & Border	99,545	104,065	104,868	105,706	106,783
Domestic In-migration, Rest of U.S.	34,006	33,820	34,722	35,637	36,583
Domestic Out-migration	142,321	139,241	139,290	139,177	139,598
Net Domestic Migration	*-8,695*	*-1,389*	*298*	*2,177*	*3,797*
Net International Migration	*15,609*	*15,393*	*15,482*	*15,478*	*15,474*
Ending Population	709,922	726,839	741,487	753,027	760,506

Figure 3.3d
Projected levels of domestic in and out-migration, Central Region, 2010-2035

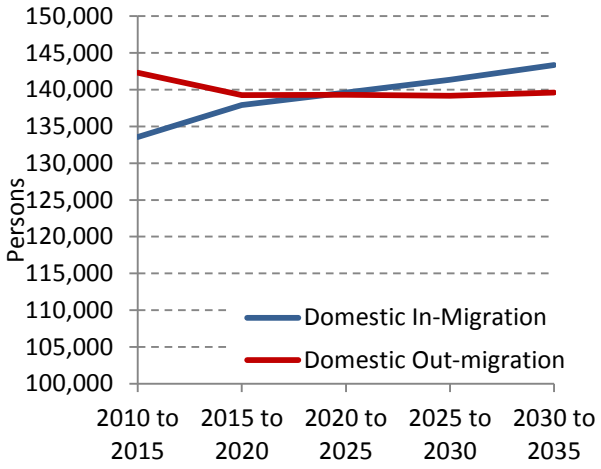
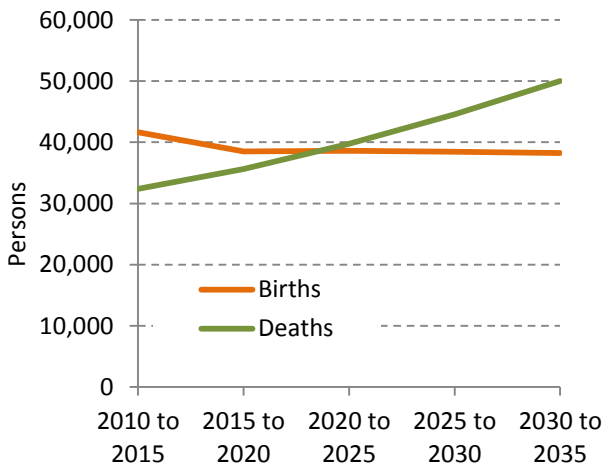
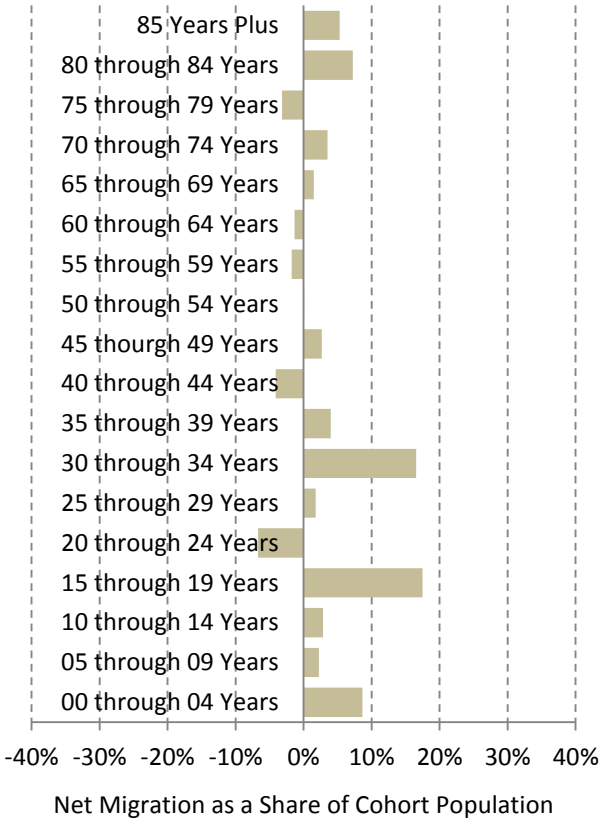


Figure 3.3e
Projected levels of births and deaths, Central Region, 2010-2035



On the positive side, ACS migration data from 2007 to 2011 suggests that the region tends to attract, on net, persons in their later twenties and thirties (Figure 3.3f). These cohorts bring their children with them and also contribute to the number of births in the region. Future projections assume that the region will continue to attract a steady stream of these young families. Accordingly, the number of births is expected to hold fairly steady over the next twenty-five years, hovering around 38,000 for each of the five-year increments from 2020 through 2035.

Figure 3.3f
Age profile of net domestic migrants,
2007-2011 American Community Survey



Home to several large colleges and universities, the Central region is also a net importer of persons in the 15- 19 age group although many in this cohort leave the region following graduation, as suggested by net negative out-migration among those in their early twenties. The region also appears to be a relatively attractive destination for some of the elderly cohorts.

As the millennial population moves into its thirties and more in-migrant baby boomers moving into their seventies and eighties, our model predicts that in-migration will increase into the region, contributing increasingly to population gain through the time series. By the 2030 to 2035 period, the number of domestic in-migrants will exceed the number of domestic out-migrants by almost 3,800 persons, while international immigrants continue to contribute to population gain in the region (Table 3.3).

Age Profile

As with other regions around the state, the Central region of the future will be home to many more elders, as the baby boomers age into the older age brackets. By 2035, 23% of the region's population will be aged 65-or older compared to just 13% in 2010. However, compared to many other regions around the state, the Central region is expected to show a relatively evenly distributed age profile, meaning that while the number of elders increases, younger adults and children are also well represented in the area (Figure 3.3g).

Figure 3.3g: The age and gender composition of the Central Region population, 2010 (actual) vs. 2035 (forecasted)

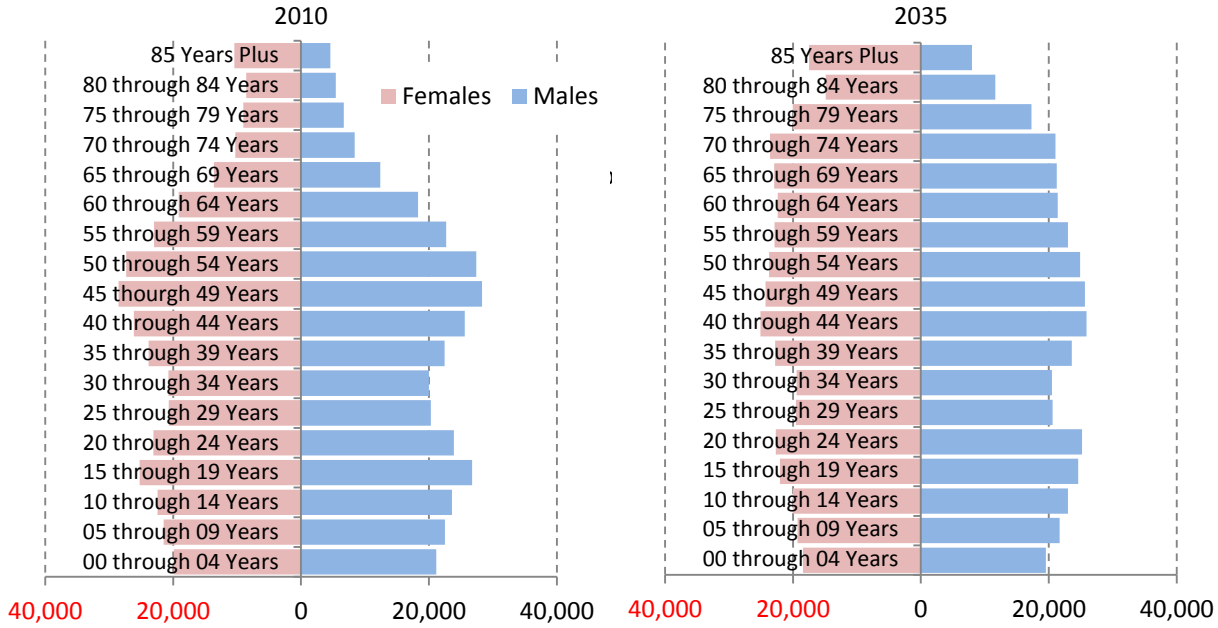
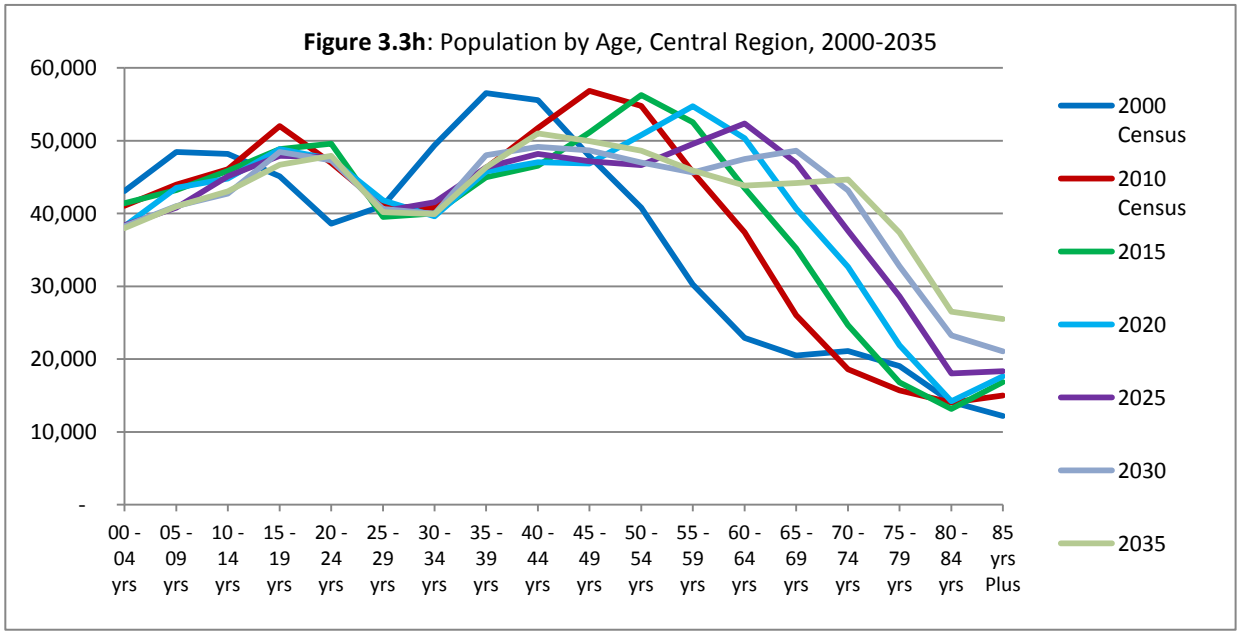


Figure 3.3h below shows the Central region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series. Because it is a college region, the number of 15-19 and 20-24 year olds is more or less maintained as other population peaks age forward over time.



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 projections predict strong growth in the Greater Boston population over the next 25 years, increasing by roughly 100,000 residents every five years through 2025, 75,000 from 2025 to 2030, and 57,000 from 2030 to 2035 (Figure 3.4b). We project growth during the 2010 to2015 period to be particularly strong, as we align our model with the level of growth estimated by the U.S. Census Bureau for the state through 2014.[15] The Bureau estimates that the Greater Boston region has been growing by about 20,000 persons per year since the 2010 Census,[16] and our model assumes that this level of growth is sustained through 2020 and beyond. By 2035, the region is expected to have a population of 2,418,770; this is 443,615 more than the 1,975,155 counted in Census 2010.

The Sources of Population Change

Population change in the Greater Boston region is driven by natural increase—the number of births over deaths—and

Figure 3.4a
The Greater Boston Region

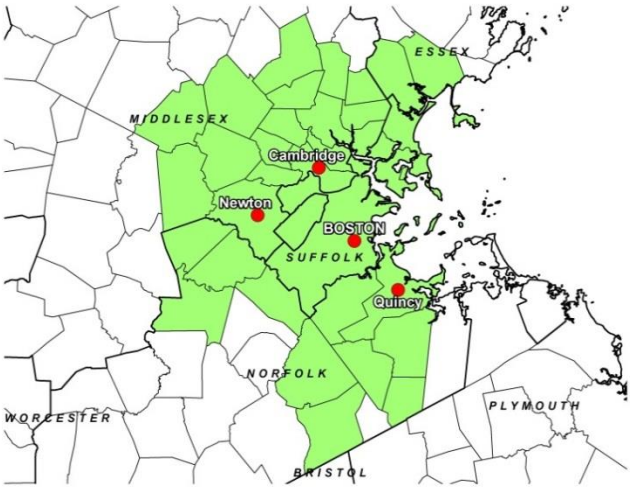


Figure 3.4b
Projected Population, Greater Boston

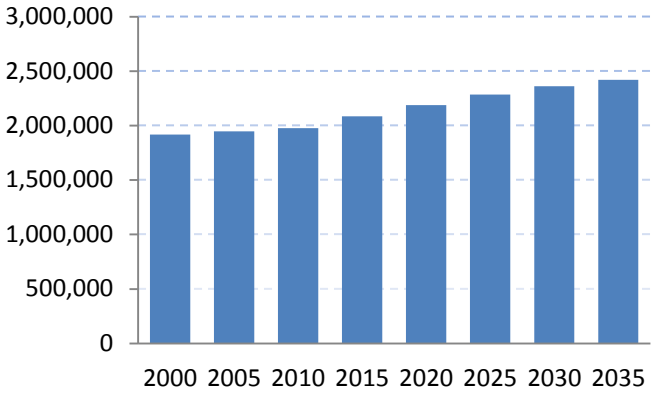
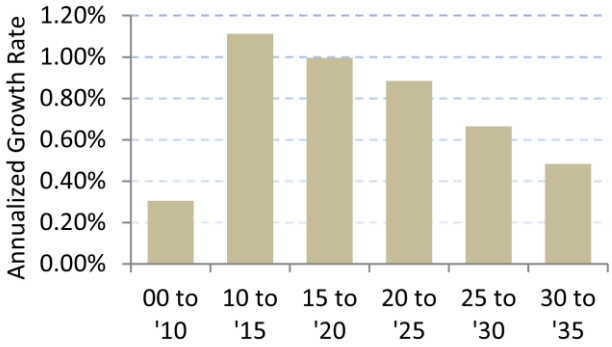


Figure 3.4c
Annualized rates of population change, Greater Boston



[15] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.
[16] Source: Sub-EST 2013: Subcounty Resident Population Estimates April 1, 2010 to July 1, 2013. U.S. Census Bureau, Population Division. May 2014.

international immigration (Table 3.4). While the region tends to lose more by out-migration than it gains by domestic in-migration, a steady stream of international immigrants more than off-sets the loss. The relatively young population of the region, including international immigrants who tend to be younger than the state on average, ensures a steady level of births over the 2010 to 2035 time period. As seen in other regions of the state, the number of deaths increases over time as a large percentage of the population ages into the elderly cohorts. In the Greater Boston region this reduces the level of natural increase over time. However, the steady number of births continues to counter this loss, and overall we continue to see positive natural increase in the region all the way through 2035.

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	1,975,155	2,085,048	2,188,890	2,285,779	2,361,771
Births	124,292	124,144	126,140	126,269	125,902
Deaths	79,063	86,933	94,904	104,605	116,069
Natural Increase	*45,229*	*37,210*	*31,236*	*21,664*	*9,833*
Domestic In-migration, MA & Border	294,330	302,018	303,394	303,350	305,272
Domestic In-migration, Rest of U.S.	215,430	217,512	222,119	225,951	229,345
Domestic Out-migration	555,938	561,694	568,820	584,110	596,612
Net Domestic Migration	*-45,013*	*-42,285*	*-43,460*	*-54,651*	*-61,666*
Net International Migration	*110,842*	*108,796*	*108,959*	*109,137*	*109,161*
Ending Population	2,085,048	2,188,890	2,285,779	2,361,771	2,418,770

Figure 3.4d
Projected levels of domestic in and out-migration, Greater Boston, 2010-2035

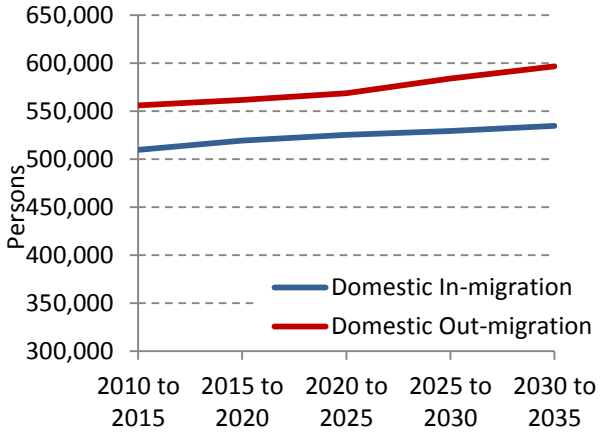
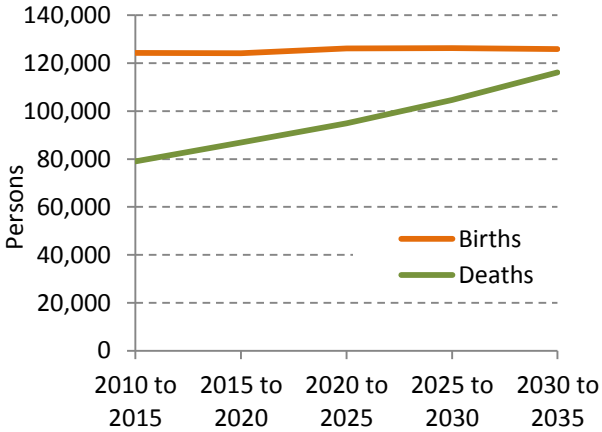
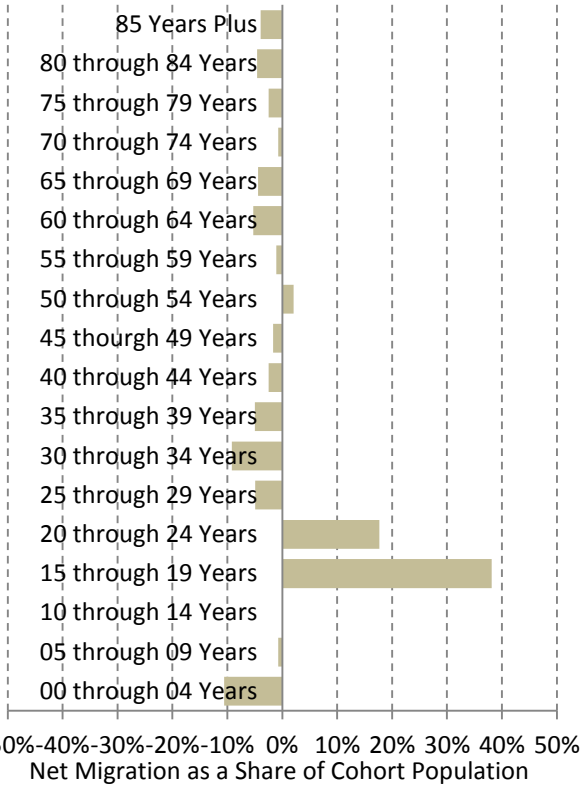


Figure 3.4e
Projected levels of births and deaths, Greater Boston, 2010-2035



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 residents as they age and taking their children with them. Figure 3.4f shows the migration-by-age patterns observed in the American Community Survey 2007 to 2011 dataset for the region. 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.

Figure 3.4f: Age profile of net domestic migrants, Greater Boston, 2007-2011 American Community Survey



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 typically represents 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. Using data from the 2007-2011 American Community Survey, we estimate that immigration contributes over 150,000 new area residents every five years. While approximately one-third of these represent college students who leave the country when their studies conclude, over 100,000 new immigrants per five-year period are expected to remain in the region.

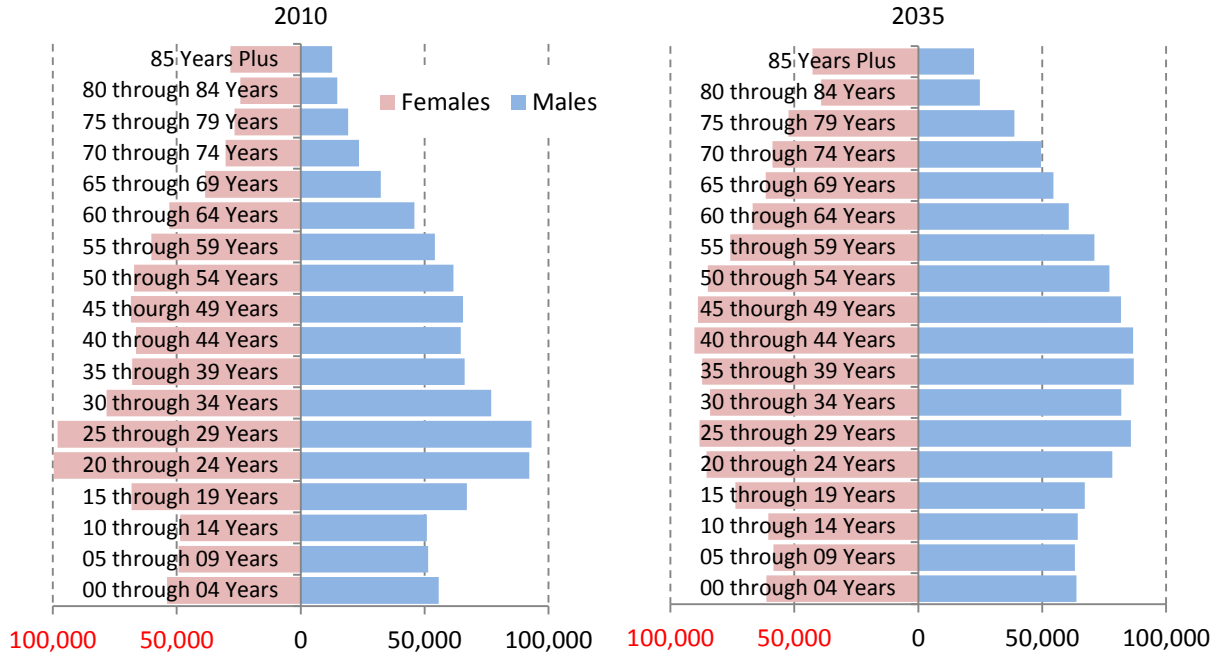
Population growth will be fastest in the next few years as the swell of millennials (the children of the baby boom generation) ages through their twenties. Because the region tends to lose residents to out-migration as they move through the family-building and retirement phases of life, we expect population 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 as international immigration and a steady number of births will

more than offset population loss associated with domestic out-migration and the gradual rise in the number of resident deaths.

Age Profile

Due to its rather unique age-specific migration patterns, the Greater Boston region is exceptionally young relative to other regions in Massachusetts. Greater Boston lacks the typical hourglass shape of the national age profile with the sizable baby boom generation (people in 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.

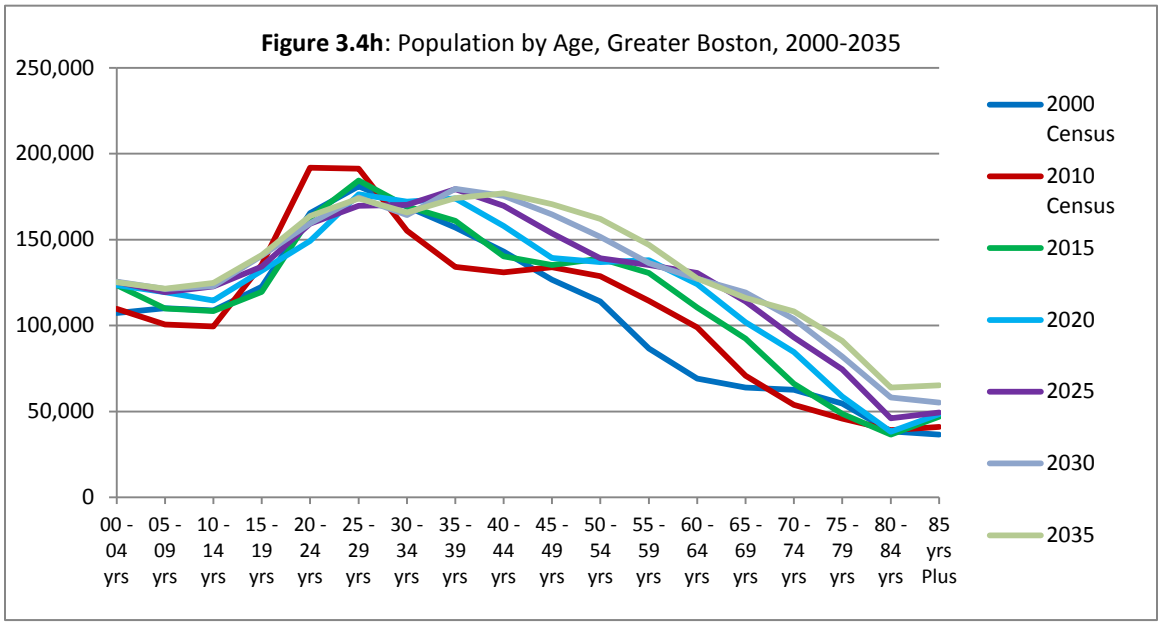
Figure 3.4g
The age and gender composition of the Greater Boston region, 2010 (actual) vs. 2035 (forecasted)



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 (Figure 3.4g). Over the near term there will be relatively more infants and pre-schoolers under the age of five, growing from 5.6% of the population in 2010 to 5.9% percent in 2015 before returning to 2010 levels again in 2020. There will also be a relatively higher share of elders aged 65 and over, coinciding with the aging in

place of the baby boomer generation, increasing from 12.7% of the population in 2010 to 18.4% in 2035. While this does represent a significant increase, it is not nearly as pronounced as in other regions of the state where the 65-and-over population of 2035 will range from 23% in younger regions like Central to 35% in older regions such as the Cape and Islands region. The relative increase in the elderly cohorts will be countered by a slight loss in the younger adult cohorts, aged 15-34, however, these losses as percentages are very small. Other cohorts are represented at roughly the same distribution in 2035 as they were in 2010 in terms of their percent of the total population.

Figure 3.4h below shows the Greater Boston region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series. Because it is a college region that includes large numbers of older graduate students, Boston's number of 20-29 year olds is more or less maintained as other population groups age forward over time.



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 County, 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, increasing by 12,372 over the ten year period, from 591,932 to 604,304 persons (Figure 3.5b). Our model anticipates that this growth will continue at a slightly increased level through 2030, with the region adding about 8,000 to 9,000 in each five-year period before falling off to about 5,000 in the 2030 to2035 period. During the 2000s, the annualized population growth rate was 0.21%. This rate will increase through 2025 to as much as to 0.31%, and then start to decline again. Our model predicts that by 2035 the region will be home to 644,975 residents, about 32,000 more than counted in the 2010 Census.

The Sources of Population Change

Population gain in the 2000 to2010 period was due primarily to natural increase—the number of births exceeding the number of deaths in the region. Natural increase is expected to contribute to population gain in the region through 2020, though at diminishing levels, after which an increase in the number of deaths in the regions will overtake births, leading to net natural

Figure 3.5a
The Lower Pioneer Valley Region

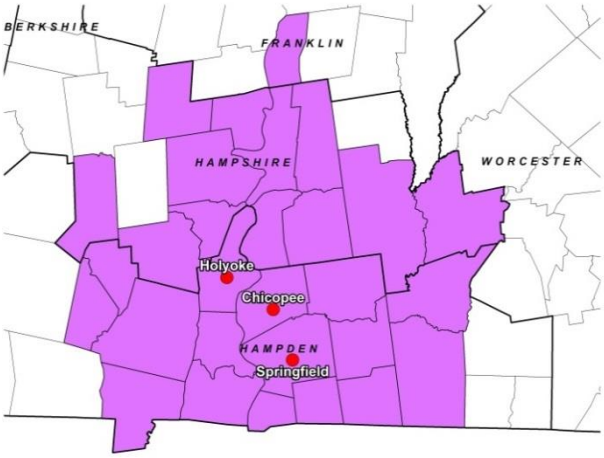


Figure 3.5b
Projected Population, Lower Pioneer Valley

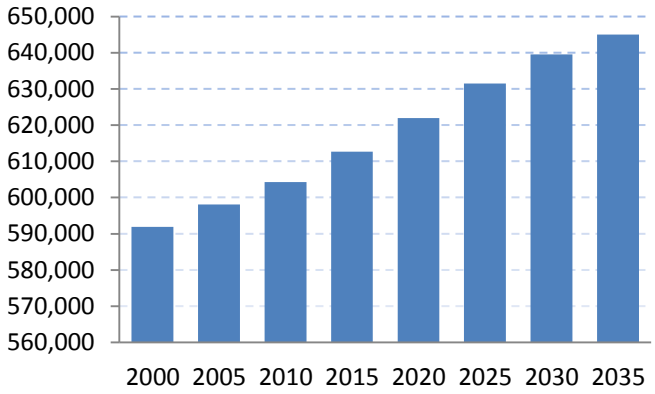
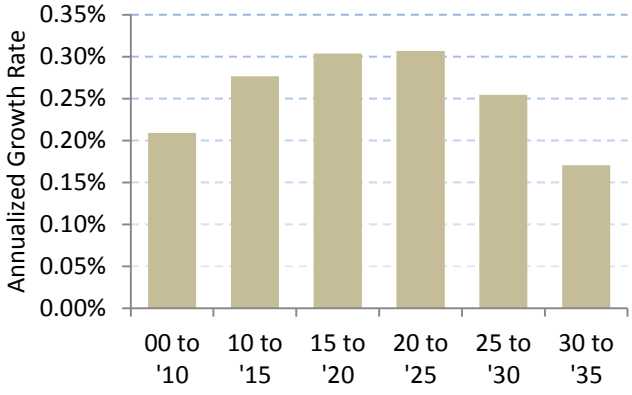


Figure 3.5c
Annualized rates of population change, Lower Pioneer Valley



decrease (Table 3.5, Figure 3.5e). On the positive side, net negative migration in the region will eventually reverse to net positive migration by the end of the time series with the number of out-migrants gradually decreasing as the number of in-migrants gradually increases over the course of the time series (Figure 3.5e).

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

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	604,304	612,664	621,962	631,497	639,525
Births	35,017	32,173	32,257	32,214	32,166
Deaths	29,742	31,413	33,666	36,923	40,939
Natural Increase	*5,275*	*759*	*-1,408*	*-4,709*	*-8,773*
Domestic In-migration, MA & Border	76,438	77,815	78,094	78,698	79,684
Domestic In-migration, Rest of U.S.	46,427	47,396	48,310	49,261	50,250
Domestic Out-migration	133,338	129,906	128,771	128,538	129,047
Net Domestic Migration	*-10,328*	*-4,782*	*-2,364*	*-554*	*949*
Net International Migration	*13,558*	*13,234*	*13,311*	*13,316*	*13,336*
Ending Population	612,664	621,962	631,497	639,525	644,975

Figure 3.5d
Projected levels of domestic in and out-migration, Lower Pioneer Valley, 2010-2035

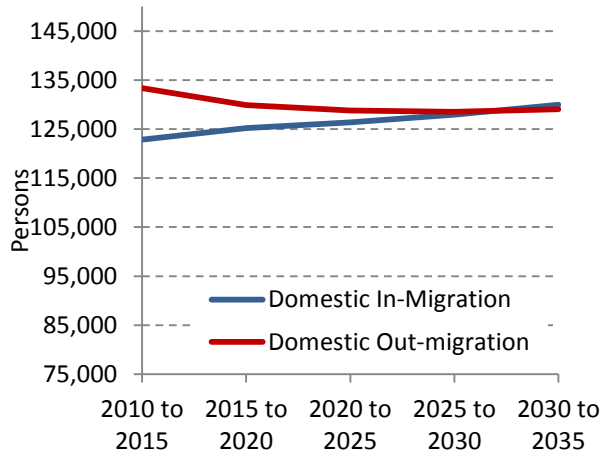
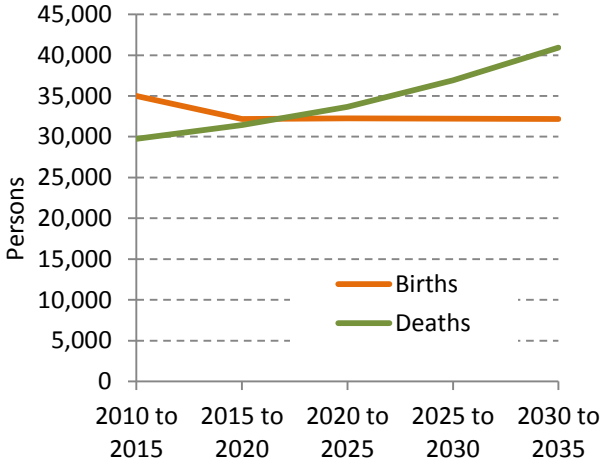


Figure 3.5e
Projected levels of births and deaths, Lower Pioneer Valley, 2010-2035



Period to period changes in each of the components are small, but together they add up to a change in relative direction. This change over time relates to the changing age structure of the region and the greater U.S. While we assume that migration-by-age rates calculated from recent ACS data will persist into the future, the migrant "pools" will vary over time as these populations age. Contributing to this dynamic is the sizable student population in the region which results in a higher portion of domestic in-migrants coming from outside the Northeast. Between 2005 and 2010, 36% of all domestic in-migrants came from outside of Massachusetts and its neighboring states. Although a minority, this share is among the lowest of all regions in the state. Thus, the future size of the region is heavily influenced not only by regional demographic trends, but also national and international ones.

Domestic migration in the Pioneer Valley is heavily concentrated among college age students. According to ACS 2007-2011 data, 15-19 year olds account for 86% of all domestic in-migrants, and these recent in-migrants represent over 40% of the resident cohort population (Figure 3.5f). However, a large number also leave the region after completing their studies, with 25-29 year olds comprising 32% of all domestic out-migrants and 58% of all domestic out-migrants falling into the 25-39 age cohorts. Looking at the non-college population only, including those that graduated college and moved out of the region, the 20-24 age group dominates the out-migrant pool, comprising 50% of all domestic out-migrants for that group. Out-migrants accounted for 30% of the region's total population of 20-24 year olds (Figure 3.5g).

In the 2010 to 2015 period, the millennials are

Figure 3.5f: Age profile of net domestic migrants, Lower Pioneer Valley, 2007-2011 American Community Survey

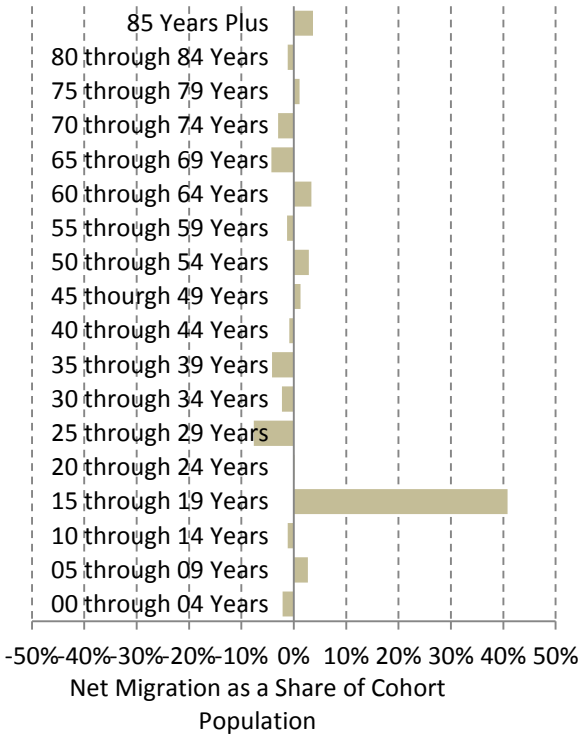
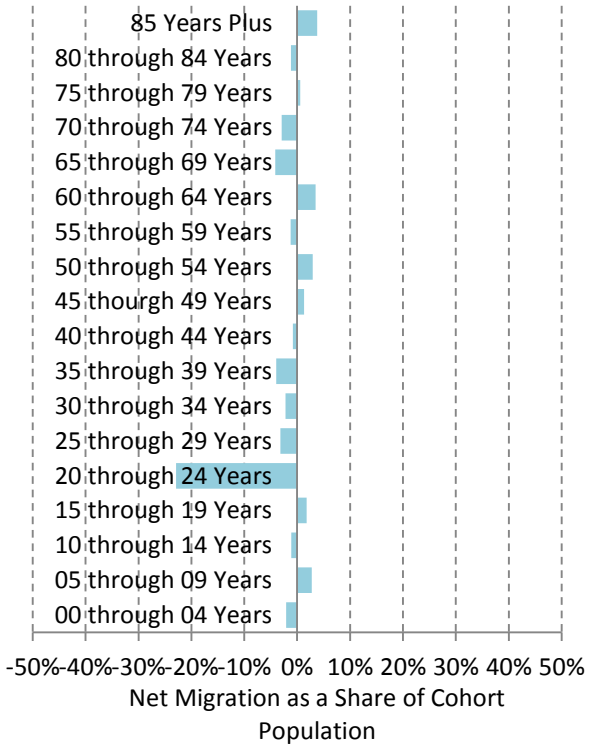


Figure 3.5g: Age profile of net domestic migrants in the **NON-COLLEGE** population, Lower Pionner Valley, 2007-2011 American Community Survey



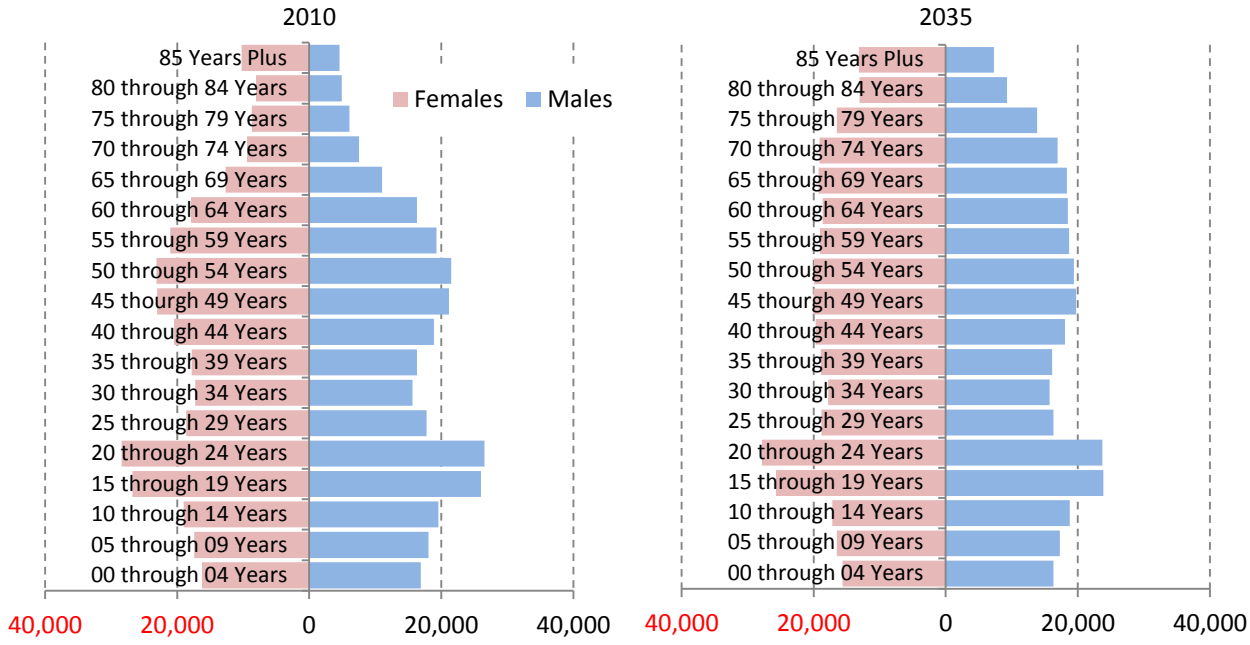
aging up out of the 15-24 and into the 20-29 age cohorts, and so we expect that out-migration in this period will be fairly high. As the group later ages through and out of the groups most prone to out-migration, the number of people leaving the region may be expected to diminish. For age groups over the age of 39, migration tends to change direction fairly frequently from one cohort to the next; making it difficult to identify other largely influential age-related migration patterns aside from those of the college and post-college cohorts.

Even though anticipated decreasing out-migration in the region supports population growth throughout the 2010 to 2035 time-series, the level of growth diminishes after 2025. While births remain nearly level from 2015 forward, an increasing number of deaths in the region due to an aging population—both in the region and statewide—will start to erode population gains. After 2020 the number of deaths is expected to overtake births, and by 2025 the region will experience a population loss of about 1,400 due to natural decline (Figure 3.5e).

Age Profile

Figure 3.5h below shows the age profile of the region in 2010 and projected to 2035, where a much larger proportion of the population reaches the elderly age-groups. In 2010, 14% of the region's population was aged 65 and over and by 2035 that percentage is expected to grow to 23%.

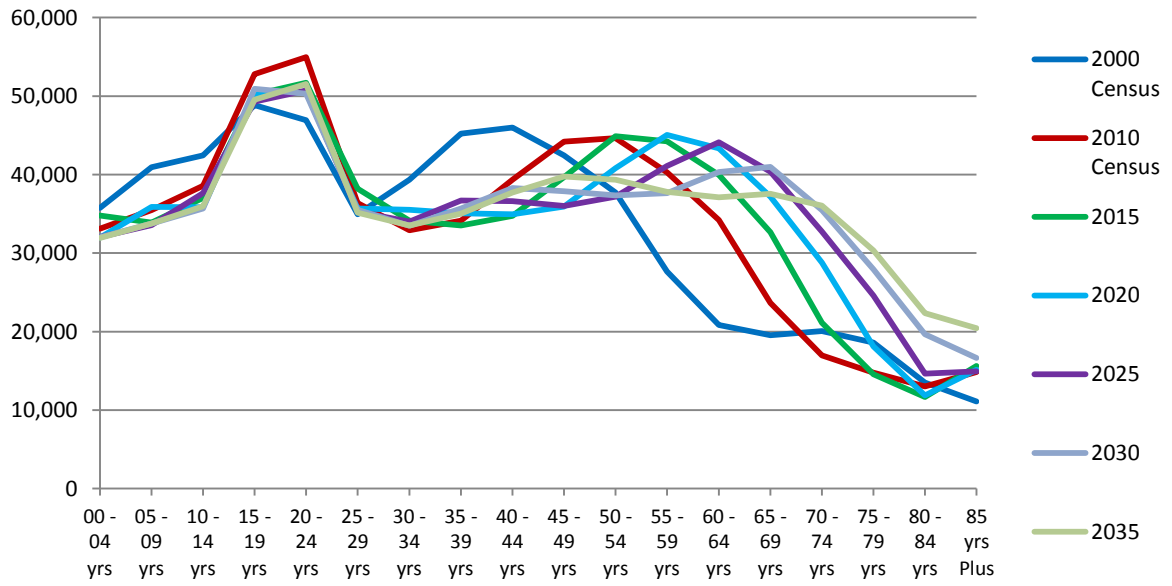
Figure 3.5h
The age and gender composition of the Lower Pioneer Valley, 2010 (actual) vs. 2035 (forecasted)



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 45-64 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

15-24-year olds. 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 stay in place and progress into older cohorts with the passage of time, the size of the post-college age population in the Lower Pioneer Valley remains fairly constant over time; persons aged 25-39 represented 17% of the population in 2010 and are expected to comprise 16% of the population in 2035, at just over 103,000 persons in both 2010 and 2035. Likewise, the population aged 15-19 hovers around 50,000 for the entire time series, and the population aged 20-24 remains in the 50,000 to 54,000 range even when the millennials largely pass out of those age groups after 2010. Figure 3.5i below shows the Lower Pioneer Valley region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.

Figure 3.5i: Population by Age, Lower Pioneer Valley, 2000-2035



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 45 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, at increased levels through 2015, and more moderately through 2035 (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 2015, the region is expected to increase by approximately 36,000, or 1.1% per year, according to our model, which aligns the 2015 region population to U.S. Census Bureau estimates through 2014.[17] According to these Census estimates, the MetroWest region grew by about 1% per year from July 1, 2010 to July 1, 2013, increasing by 19,542 in the three-year period, or 6,514 residents per year. Our model extends this level of annual growth out to 2015, adding a total of 35,901 persons over the five-year period.

After 2015, growth is expected to slow again to between 0.25% and 0.35% annualized, increasing by an average of 11,000 persons per five-year period through 2035. By 2035, the region will have grown by 79,749 persons over the Census 2010 count of 655,126 to a new total of 734,875 persons.

Figure 3.6a
The MetroWest Region

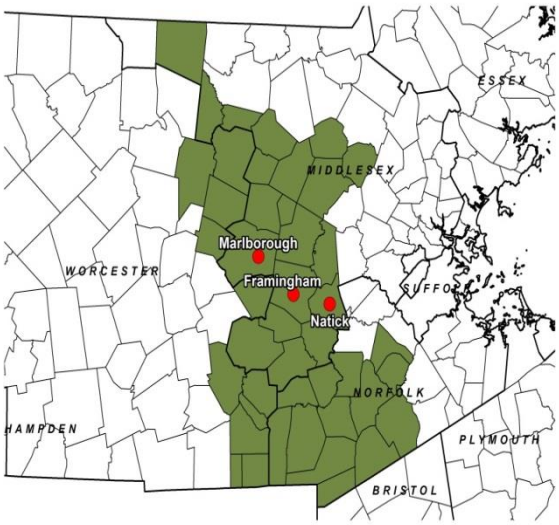


Figure 3.6b
Projected Population, MetroWest

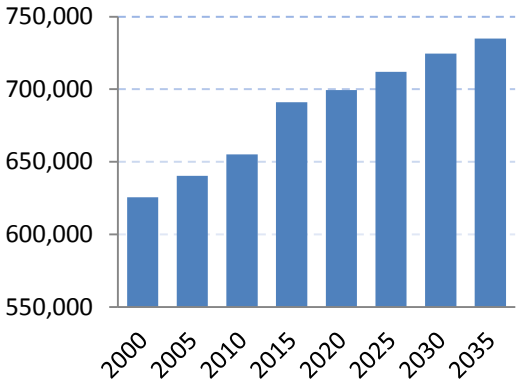
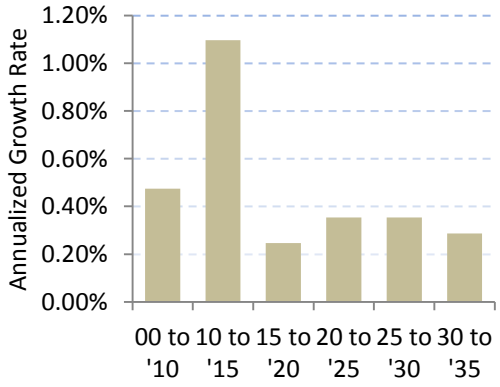


Figure 3.6c
Annualized rates of population change, MetroWest

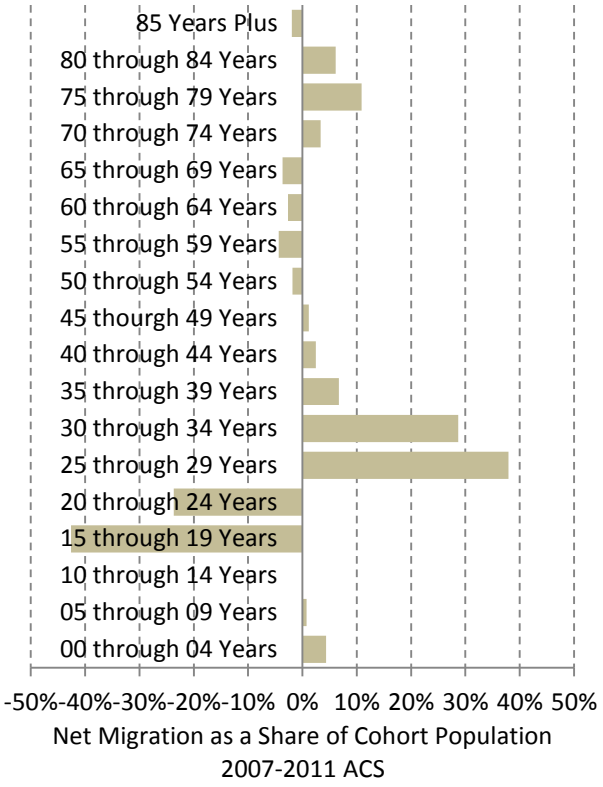


[17] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

The Sources of Population Change

Figure 3.6d
Age profile of net domestic migrants, MetroWest, 2007-2011 American Community Survey

The continuing growth of the MetroWest region will be the result of a combination of factors: increasing domestic in-migration coupled with slight decline in domestic out-migration from 2015 forward; continued positive net international immigration; and a slight increase in new births in the near term—with steady levels continuing throughout the period. This growth will be partly offset by a steady rise in the number of deaths, coinciding with the region's aging population.



MetroWest is a dynamic region with a significant flow of migrants moving in and out. 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 (77%) of these in-migrants come from elsewhere in Massachusetts or from neighboring states.

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 2015 and 2035. 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, which will more than offset any losses from domestic out-migration.

Figure 3.6e
Projected levels of domestic in and out-migration, MetroWest, 2010-2035

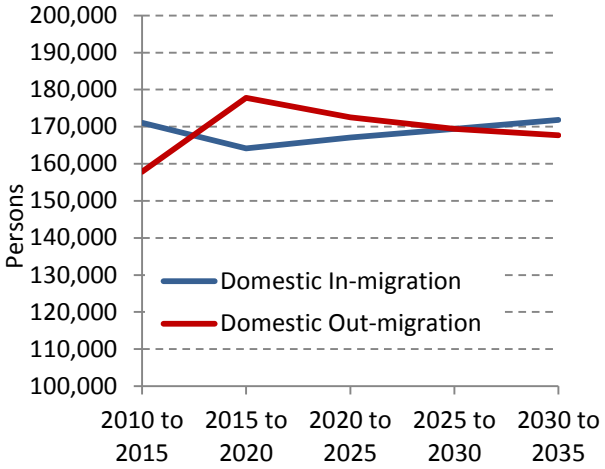
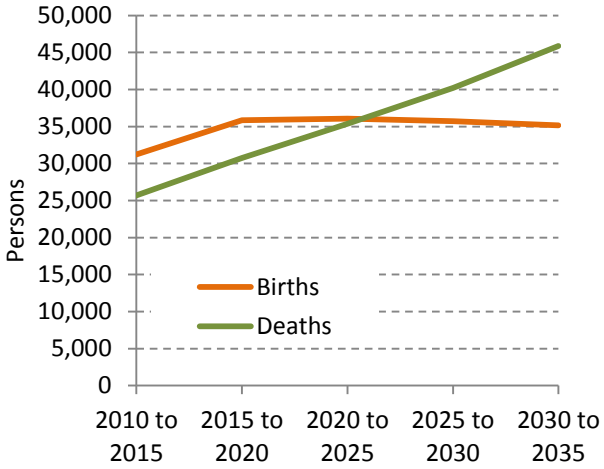


Figure 3.6f
Projected levels of births and deaths, MetroWest, 2010-2035



In-migration in the region during 2010 to 2015 is increased in our model to catch up to 2014 Census Bureau estimates[18] before returning to historic 2005 to 2011 rates-by-age for the 2015 to 2020 period and beyond. Out-migration peaks in the 2015 to 2020 period, most of this driven by large number of persons in their late teens and early twenties leaving the region. The 15-19 year old population is peaking in in 2010 and 2015, while the 20-24 and 25-29 year old groups in the region peak in 2015. This means that the pool of persons in the groups most prone to out-migration is at a maximized level and thus the number of out-migrants increases.

The age groups contributing the largest number of domestic in-migrants, persons in their late twenties and early thirties, have the largest effect on in-migration levels during the 2015 to 2035 time period. The number of in-migrants from the largest contributing age group, the 25-29 year olds, peaks in the 2020 to 2025 period, corresponding to the swell of millennials passing through this cohort starting around 2015. Many of the older cohorts also contribute to modest increases in the number of in-migrants as the region moves towards 2035, so that net domestic migration gradually increases to a positive over the 2015 to 2035 period. By the 2030 to 2035 period, there will be an estimated 4,088 more people coming into the region than leaving it.

The numbers of births and deaths largely follow changes in the age composition of the population, with a considerably larger share of the population moving through their twenties and thirties and relatively few elderly residents (see Figure 3.6g). While large numbers of in-migrants in their late twenties enter the area after 2015, and the 30-34 age cohort peaks from 2015 through 2025, the number of births in the region also increases after 2015 and remains strong throughout the 2015 to 2035 time period (Figure 3.6g). However, an aging population at the top end of the distribution suggests that the number of deaths in the region also increases after 2015 and at a stronger pace. The number of deaths increases as the population ages, particularly so when residents age into

[18] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

cohorts of 70 years and older when mortality rates begin to show a marked increase. The baby boom population will only begin to move into these higher-mortality cohorts by 2030. Over time, the number of deaths starts to catch up to and then exceed the number of births, slowing population growth in the region. By 2035, the region is expected to experience 10,734 more deaths than births (Table 3.6).

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

	2010 -2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	655,126	691,027	699,520	711,909	724,504
Births	31,231	35,854	36,077	35,703	35,158
Deaths	25,674	30,753	35,385	40,202	45,892
Natural Increase	*5,557*	*5,101*	*692*	*-4,499*	*-10,734*
Domestic In-migration, MA & Border	132,324	126,483	128,041	129,127	130,502
Domestic In-migration, Rest of U.S.	38,735	37,683	39,078	40,314	41,305
Domestic Out-migration	157,848	177,788	172,483	169,386	167,719
Net Domestic Migration	*13,210*	*-13,622*	*-5,363*	*54*	*4,088*
Net International Migration	*17,133*	*17,014*	*17,060*	*17,039*	*17,016*
Ending Population	691,027	699,520	711,909	724,504	734,875

Age Profile

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 2035, the population aged 65 and over will have doubled its share of the regional total, comprising 26% of the region's population compared to just 13% in 2010. At the same time, however, the population profile will also become more evenly distributed among retirees, middle-aged households, and young families with school-aged children. The massive concentration of the baby boomer generation found in 2010 is far less evident in 2035. This is, in part, because MetroWest residents are somewhat prone to leaving 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-aged cohorts than found in other regions.

Figure 3.6g
The age and gender composition of the MetroWest region, 2010 (actual) vs. 2035 (forecasted)

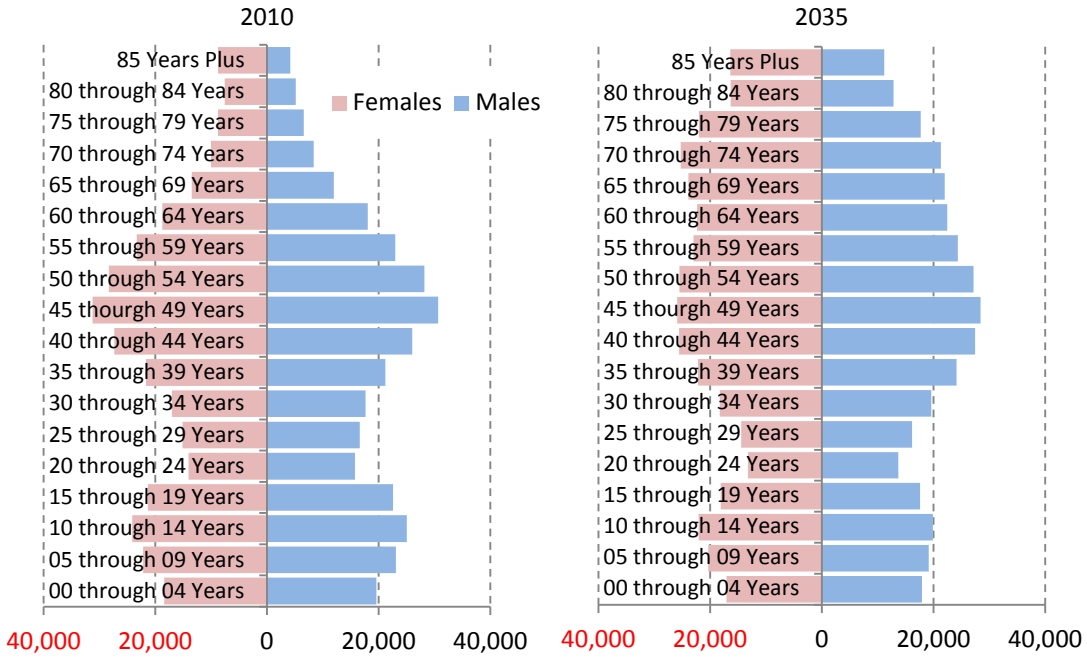
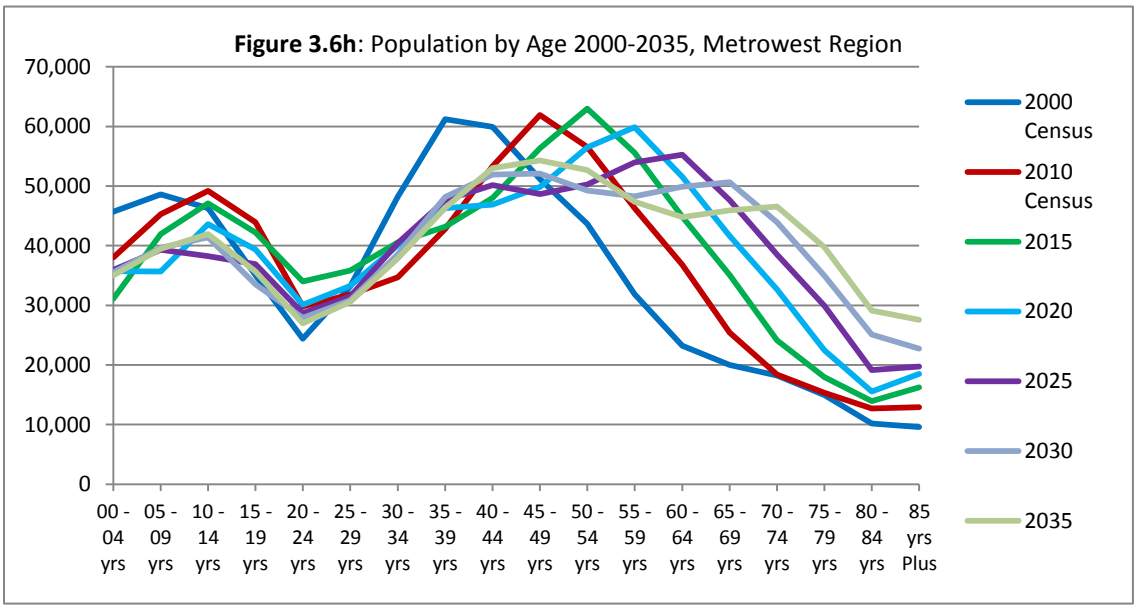


Figure 3.6h below shows the MetroWest region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.



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.

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 (Figures 3.7b and 3.7c). Since that time, the U.S. Census Bureau estimates that the region has been growing at an even faster pace.[19] According to Census estimates, the Northeast region grew by an average of 0.9% per year from July 1, 2010 to July 1, 2013, increasing by 29,096 persons in the three year period, or 9,365 per year. In aligning future projections to these recent estimates,[20] our model anticipates a 52,423 person increase in the region from 2010 to 2015. The annualized growth rate is accelerated to 1.02% in the near-term to 2015 before slowing down to levels more consistent with the 2000 to 2010 period. After 2015, our model predicts that annualized growth will slow to about 0.2% per year through 2025, gradually diminishing to just under 0.1% in the 2030 to 2035 period. (Figure 3.7c).

Figure 3.7a
The Northeast Region

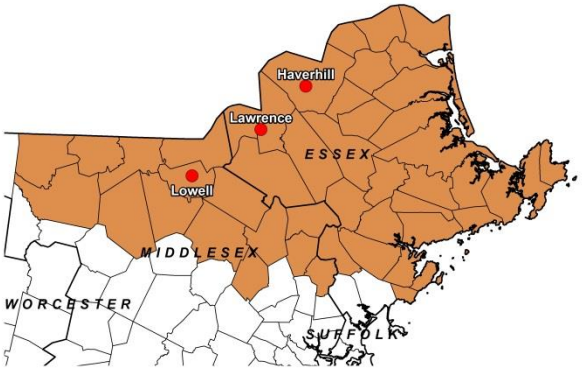


Figure 3.7b
Projected Population, Northeast

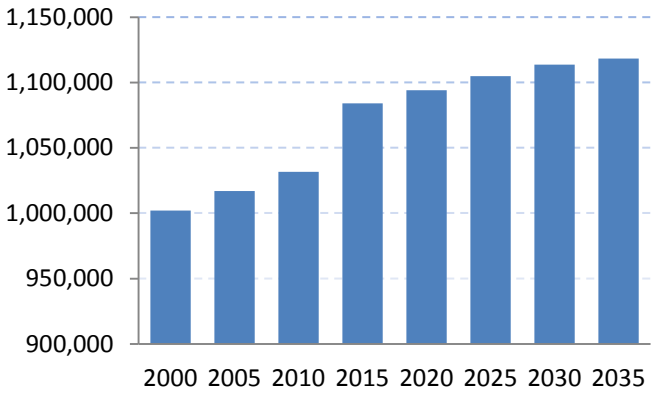
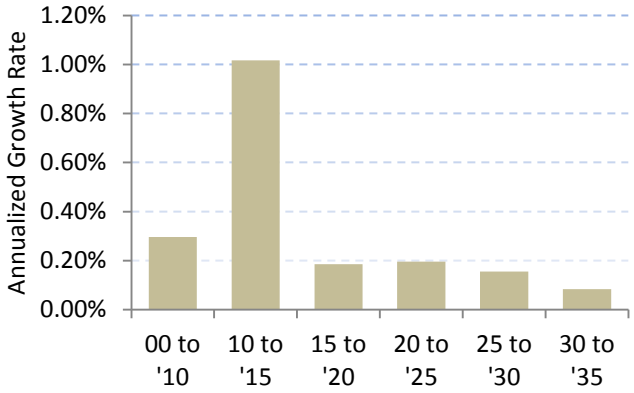


Figure 3.7c
Annualized rates of population change, Northeast



[19] Source: Sub-EST 2013: Subcounty Resident Population Estimates April 1, 2010 to July 1, 2013. U.S. Census Bureau, Population Division. May 2014.
[20] See Methods section of this report for details on how 2015 population for each region is aligned to U.S. Census Bureau population estimates through 2013 and 2014.

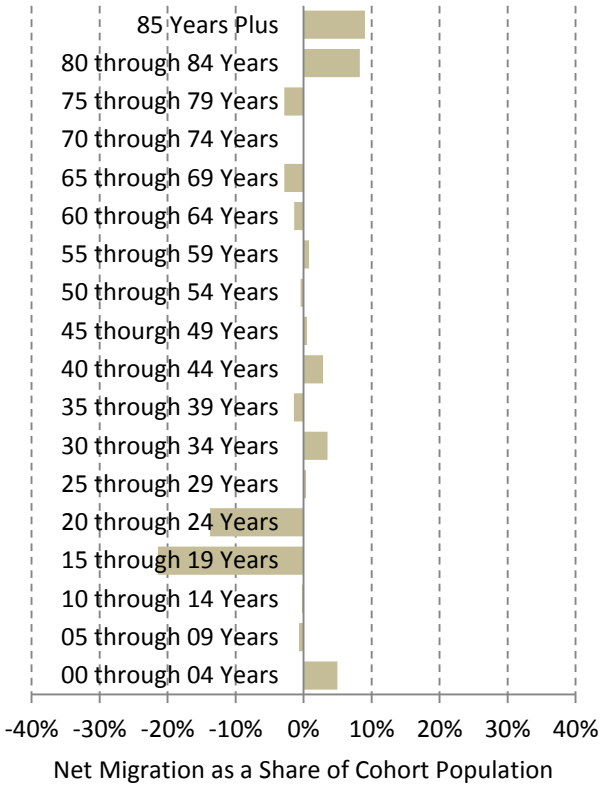
Table 3.7
Summary Results: Estimated Components of Population Change, Northeast Region

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030	2030 to 2035
Starting Population	1,031,733	1,084,156	1,094,196	1,104,923	1,113,554
Births	57,389	60,988	60,272	58,691	57,246
Deaths	46,396	54,147	60,213	67,344	75,790
Natural Increase	*10,993*	*6,840*	*59*	*-8,653*	*-18,543*
Domestic In-migration, MA & Border	132,930	130,673	131,306	132,228	133,653
Domestic In-migration, Rest of U.S.	54,844	50,060	52,033	53,833	55,668
Domestic Out-migration	165,818	196,874	192,144	188,226	185,501
Net Domestic Migration	*21,956*	*-16,141*	*-8,805*	*-2,165*	*3,821*
Net International Migration	*19,475*	*19,341*	*19,472*	*19,449*	*19,423*
Ending Population	1,084,156	1,094,196	1,104,923	1,113,554	1,118,254

In recent years, the Northeast region has lost more residents to domestic migration than it has gained. In our model, we adjust migration rates in the 2010 to 2015 period so that population totals catch up to Census Bureau estimates through 2013, resulting in net domestic in-migration during that period. After 2015, our model reverts to migration patterns observed in the 2005 to 2011 American Community Survey, and the region once again shows more outflow than inflow from other parts of the U.S. (Table 3.7).

The largest cohorts of out-migrants are the 15- to 24-year olds, many of who head 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 also a net attractor of young families and others in their early thirties,

Figure 3.7d: Age profile of net domestic migrants, Northeast, 2007-2011, American Community Survey



some of which bring their young children with them.

Over the next two decades, the aging of the large millennial generation into its thirties will lead to a slight increase in domestic in-migration—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, Northeast, 2010-2035

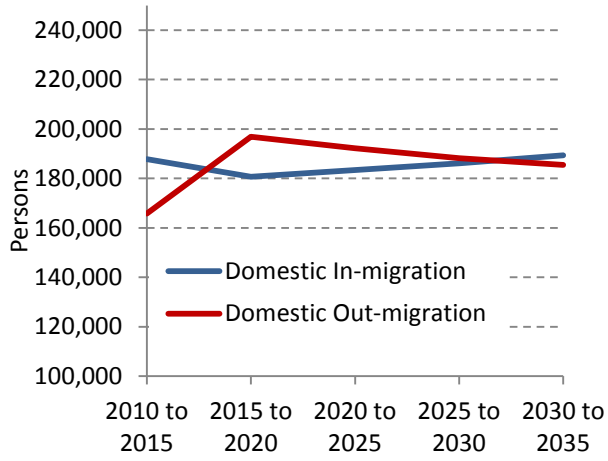
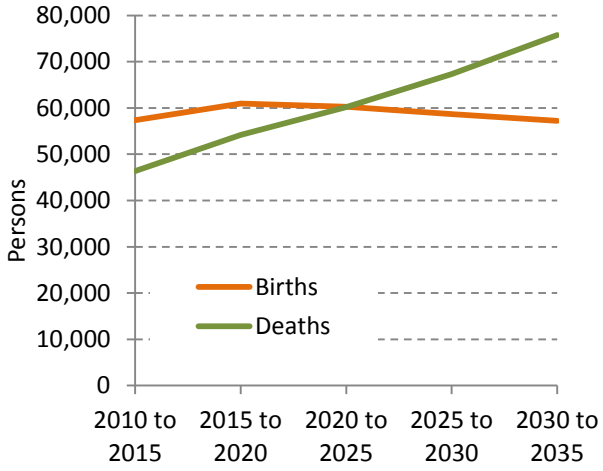


Figure 3.7f
Projected levels of births and deaths, Northeast, 2010-2035



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 2010 and 2015, we estimate that the region will add 19,000 new residents due to net international immigration—a level that is expected to carry forward for the next several decades. This international immigration more than offsets the domestic loss experienced in 2015 through 2030.

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 2010 and 2035, from about 46,000 every five years to almost 76,000 in the 2030 to 2035 period. 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 2035, but by 2025 the number of deaths catches up to the number of births. By 2030 the number of deaths in the region is expected to outnumber births by over 8,000, significantly slowing growth in the region.

Age Profile

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 2035 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 25% of the region's residents age 65-and older by 2035—compared to the 14% 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 forties by 2035, many with school age children. Children aged 0 through 14 will make up 16% of the regions population in 2035 compared to 19% in 2010.

Figure 3.7g
The age and gender composition of the Northeast Region, 2010 (actual) vs. 2035 (forecasted)

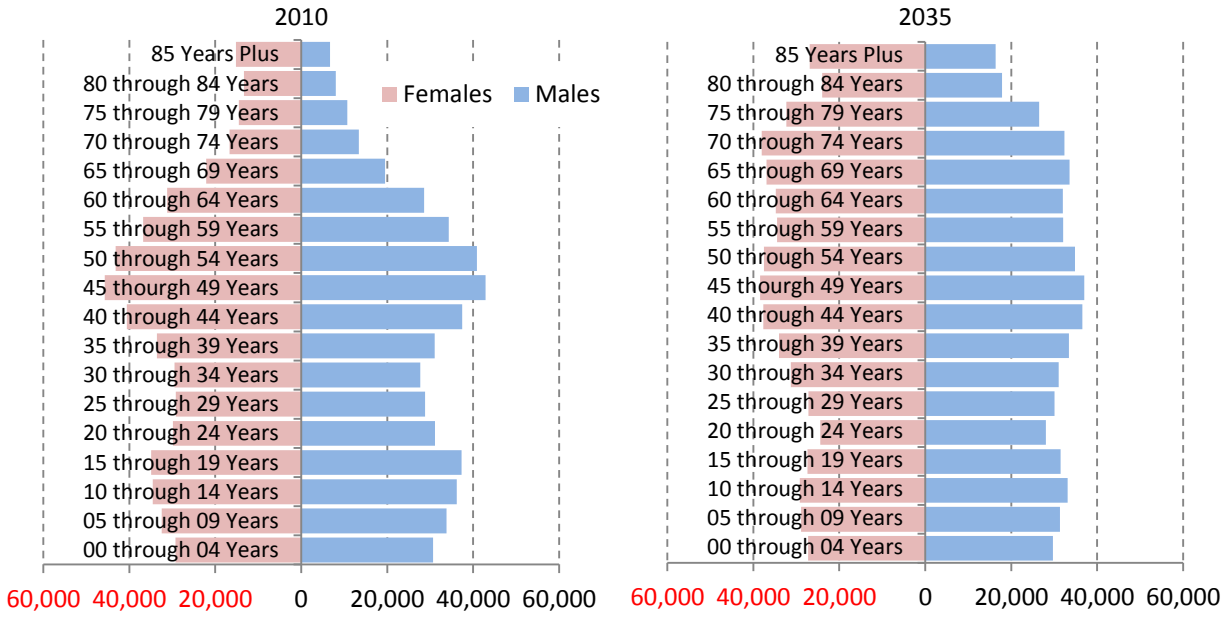


Figure 3.7h below shows the Northeast region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.

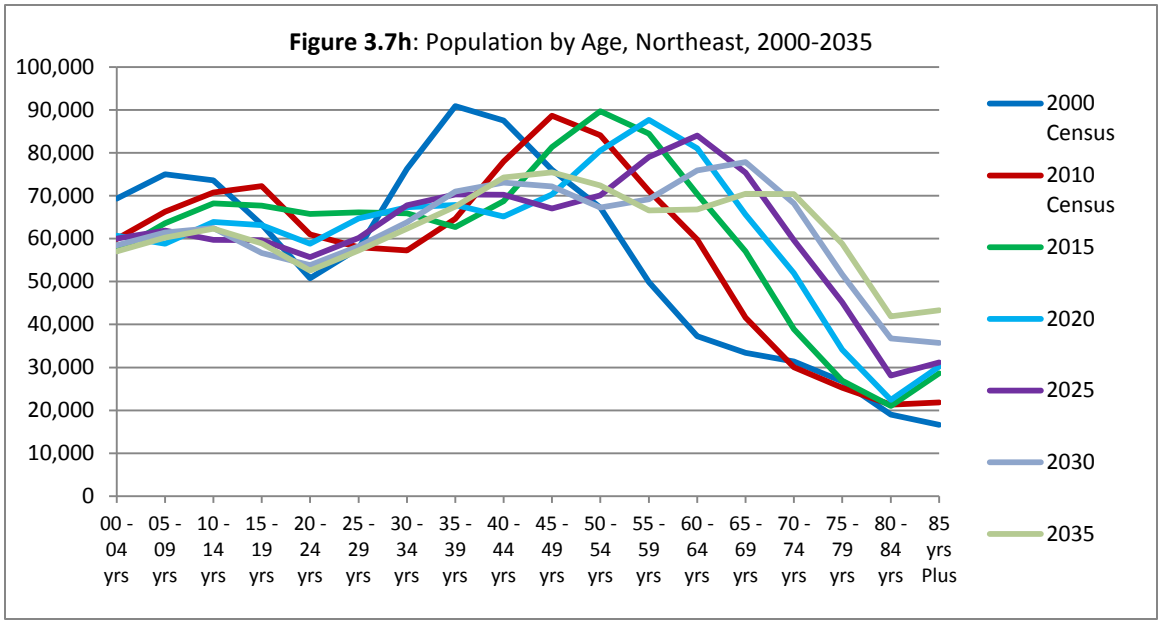


Figure 3.7h: Population by Age, Northeast, 2000-2035
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
00 - 04 yrs
05 - 09 yrs
10 - 14 yrs
15 - 19 yrs
20 - 24 yrs
25 - 29 yrs
30 - 34 yrs
35 - 39 yrs
40 - 44 yrs
45 - 49 yrs
50 - 54 yrs
55 - 59 yrs
60 - 64 yrs
65 - 69 yrs
70 - 74 yrs
75 - 79 yrs
80 - 84 yrs
85 yrs Plus
2000 Census
2010 Census
2015
2020
2025
2030
2035

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, adding 37,633 persons and with an annualized population growth rate of 0.35% between 2000 and 2010. The region should expect to see continued population growth over the next twenty five years, although at an increasingly slower rate as time moves on (Figures 3.8b and 3.8c). Our model anticipates that the region will add another 39,490 residents between 2010 and 2020, after which levels of growth start to diminish, with fewer than 28,000 residents gained from 2020 to 2030. By 2035, the population of the Southeast region will approach 1.19 million persons, a gain of almost 75,000 residents over the 2010 Decennial Census.

The Sources of Population Change

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 2025.

Figure 3.8a
The Southeast Region

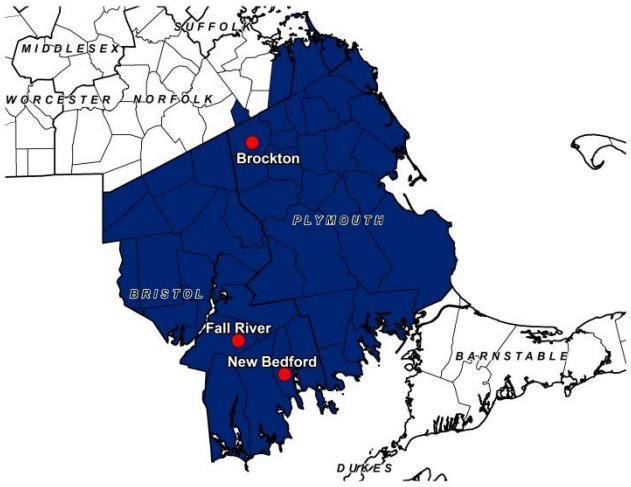


Figure 3.8b
Projected Population, Southeast

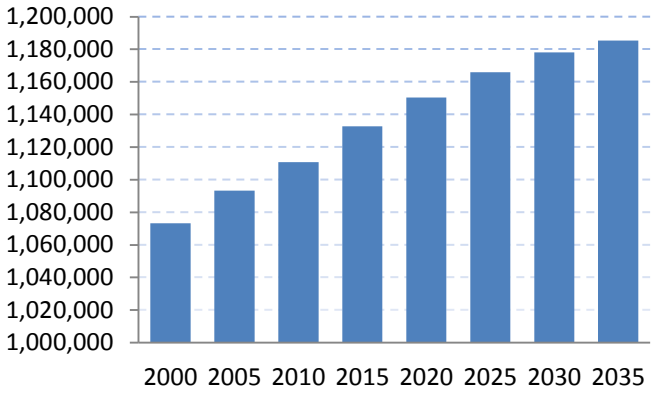


Figure 3.8c
Annualized rates of population change, Southeast

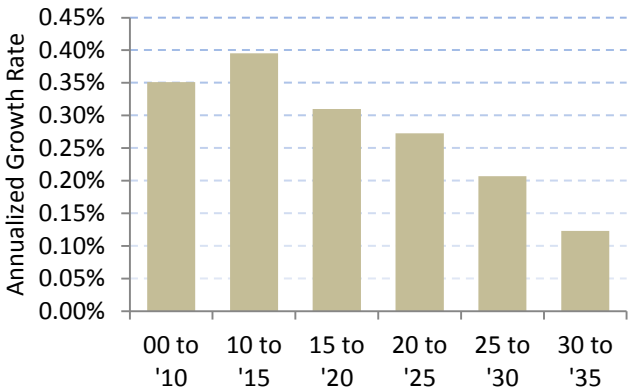


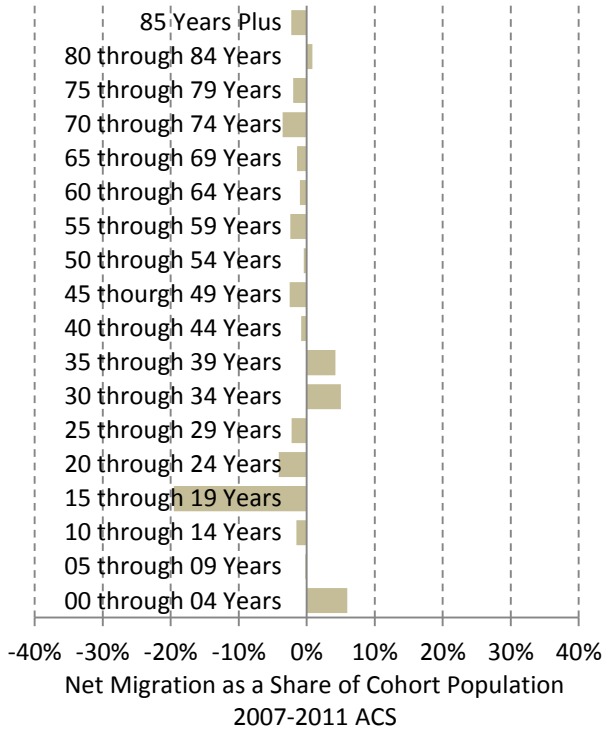
Table 3.8 Summary Results: Estimated Components of Population Change, Southeast

	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Starting Population	1,108,845	1,132,805	1,150,345	1,166,038	1,178,095
Births	58,476	60,541	61,219	60,694	59,810
Deaths	52,082	57,177	62,674	69,403	76,810
Natural Increase	*6,394*	*3,364*	*-1,455*	*-8,709*	*-17,000*
Domestic In-Migration, MA & Border	125,472	133,625	134,316	135,015	136,109
Domestic In-Migration, Rest of U.S.	43,962	45,425	46,925	48,369	49,645
Domestic Out-migration	171,223	184,097	183,331	181,833	180,706
Net Domestic Migration	*-1,789*	*-5,048*	*-2,089*	*1,552*	*5,048*
Net International Migration	*19,356*	*19,223*	*19,238*	*19,214*	*19,188*
Ending Population	1,132,805	1,150,345	1,166,038	1,178,095	1,185,331

In recent years, the Southeast region has tended to lose residents due to domestic out-migration, and this trend is expected to continue through 2025 (Table 3.8). At the same time, international migration offsets this net domestic loss, with gains of over 19,000 each five years expected to continue through the time-series such that the region continues to increase in population size.

Domestic out-migration is heavily concentrated among the college-age population and, to a lesser extent, older residents in the 55-and older cohorts (Figure 3.8d). However, the region tends to import residents in their thirties, as well as their school-age children. In the near future, the large population of millennials move out of their teens and twenties (age-groups prone to leaving the region) and into their thirties (the groups that tend to move in). This, together with only modest levels of out-migration among boomers, will result in decreasing

Figure 3.8d
Age profile of net domestic migrants, Southeast, 2007-2011 American Community Survey



levels of out-migration and increasing levels of domestic in-migration. Domestic in-migration will catch up to out-migration by 2025 to 2030 and start contributing to population gain in the region (Figure 3.8e).

Figure 3.8e
Projected levels of domestic in and out-migration, Southeast, 2010-2035

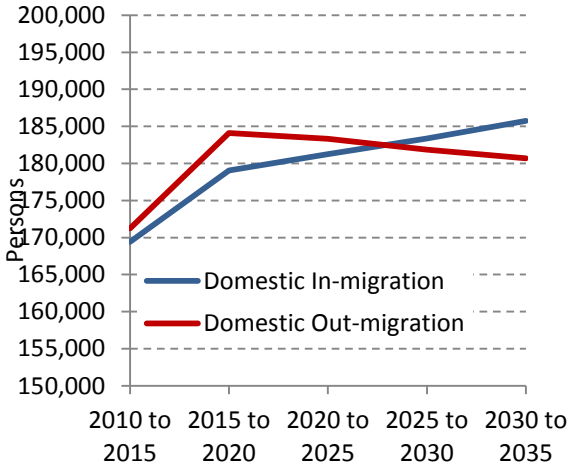
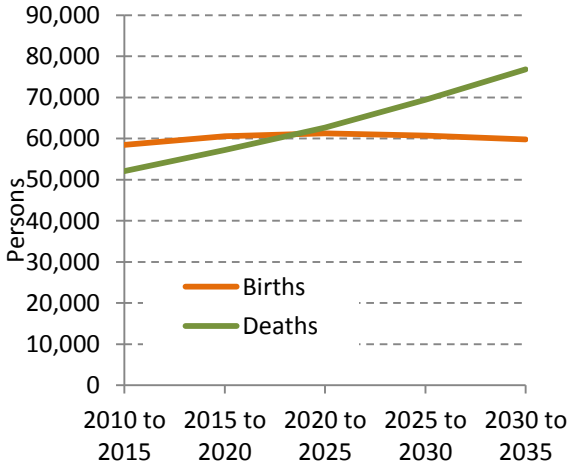


Figure 3.8f
Projected levels of births and deaths, Southeast, 2010-2035



Growth in the Southeast region will be partially constrained, however, 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 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 begin to move into these high-mortality cohorts by 2025, and by that time the number of deaths in the region will start to exceed the number of births, subtracting from the population gained by migration.

Age Profile

By 2030, baby boomers will have moved into the retirement phase of their life cycles. Although some older residents will retire outside the region, they will be eclipsed by those deciding to age in place, shifting the entire population distribution upward (Figure 3.8g). By 2035, 24% of the region's population will be over the age of 65, compared to 14% in 2010. Yet the Southeast will continue to attract young families, including many from the millennial generation, who will be moving into

their forties by 2035. The result will be a regional age profile that, while older, will be more evenly distributed among the different age groups (Figure 3.8g.)

Figure 3.8g: The age and gender composition of the Southeast Region, 2010 (actual) vs. 2035 (forecasted)

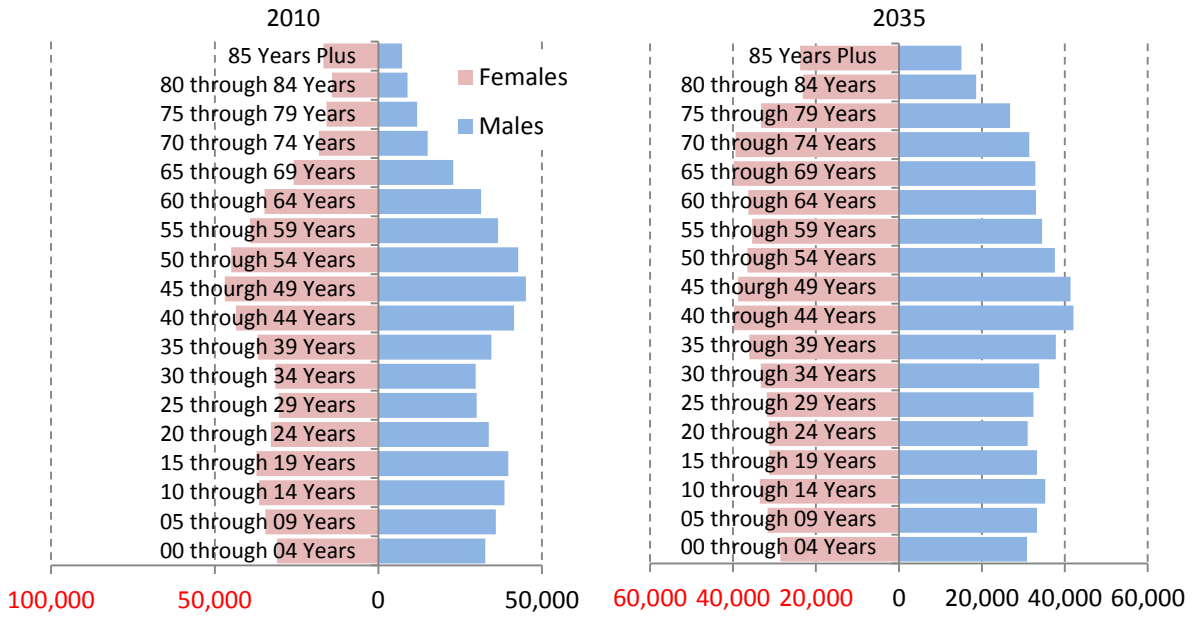
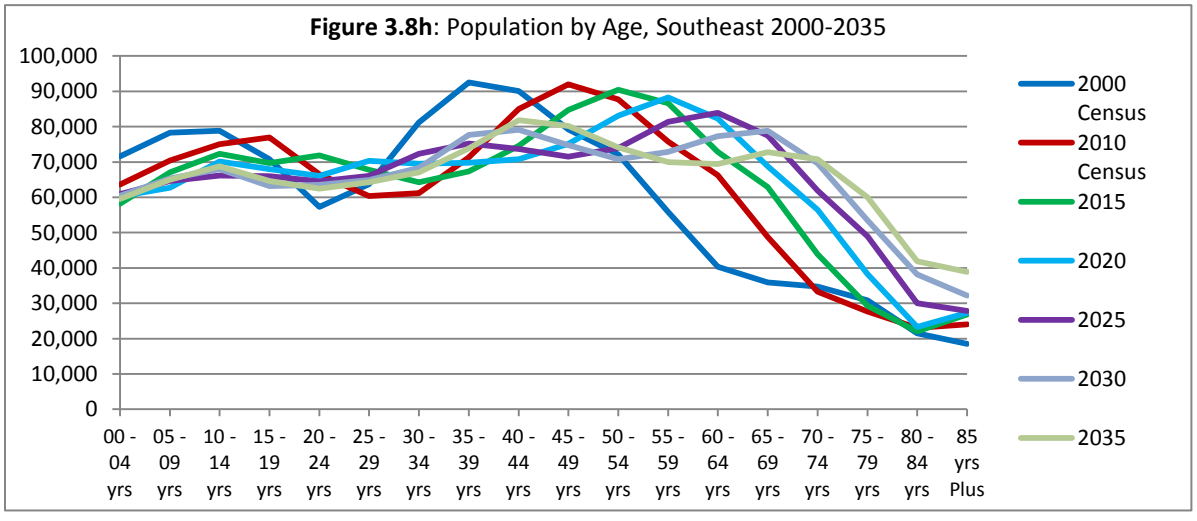


Figure 3.8h below shows the Southeast region population by age at 2000, 2010 and then projected at five-year intervals through 2035, demonstrating how the population ages forward through the time-series.



UMASS DONAHUE INSTITUTE

Section IV. Technical Discussion of Methods and Assumptions

excerpt from:

Long-term Population Projections for Massachusetts Regions and Municipalities

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

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Department of Landscape Architecture and Regional Planning

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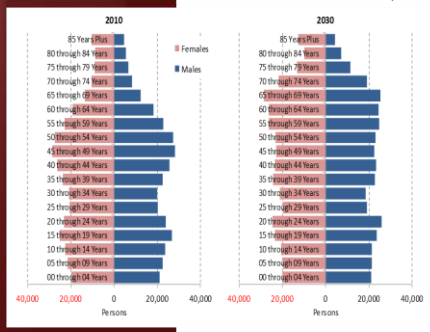
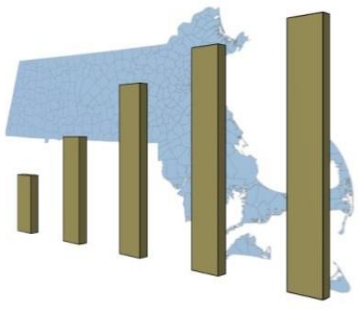
Katherine Paik, Research Analyst
Steffen Herter, Research Assistant





March 2015

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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 projections developed for eight sub-state regions 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 or regional planning areas.

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 Massachusetts 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 70-years

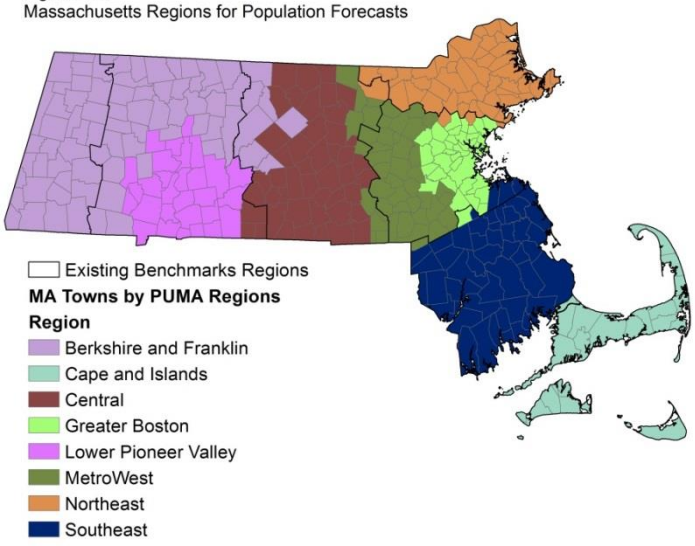
and older, such that an area with a large concentration of elderly residents will experience more deaths in decades to come.

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 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- 4 years old, 5- 9,… 80-84, and 85- and 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 (2013). 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 the 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[1]. 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[2]. Sample sizes can be particularly small when distributed by age and sex cohorts for different types of migrants, especially in small regions. For this reason, the Berkshire/Franklin and Cape & Islands are two regions that can be treated with more skepticism in our projections results and which lend themselves to greater cross-examination

[1] To account for small or missing samples in some cohorts in some regions, we make some limited adjustments to the ACS PUMS data before calculating migration rates based on the data. In the Cape and Berkshire/Franklin regions, male and female migrants under the age of 15 are assigned the male/female average number of migrants before a rate is calculated in order to smooth out male/female ratios resulting from small sample sizes. In other regions, cohorts under age 75 with a sample size of zero in the ACS data are assigned values from the opposite gender when it is available to reduce instances of rates calculated from a null value.

[2] While we are aware of the potential for sampling error in using ACS PUMS data for these small regions, it is the only direct source of gross migration by age available to us at this time. IRS data on migration does include gross migration data for tax-filers at the county level; however the released data does not include age detail. The Current Population Survey, another sample survey product from the U.S. Census Bureau, provides migration data by age, but only down to the U.S. regional level of geography. Other methods commonly used to estimate migration do so using an indirect method of calculating net migration by age as a residual of a cohort-survival method

by alternative methods[3]. These two regions were counted at fewer than 250,000 persons each in the 2010 Census and are subject to larger sampling error than the other six sub-state regions which all number more than 600,000 persons, and sometimes over 1 million. In our model, we develop migration rates using data from the 2005 to 2009 ACS PUMS as well as the 2007 to 2011 ACS PUMS, the most recent five-year dataset available at the PUMA level of geography. [4]

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:

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

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.[5] 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:

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

[3] For information on alternative projections methods and results for the Berkshire/Franklin and Cape & Islands regions, researchers may contact the Population Estimates Program of the UMass Donahue Institute.

[4] To account for small or missing samples in some cohorts in some regions, we make some limited adjustments to the ACS PUMS data before calculating migration rates based on the data. In the Cape and Berkshire/Franklin regions, male and female migrants under the age of 15 are assigned the male/female average number of migrants before a rate is calculated in order to smooth out male/female ratios resulting from small sample sizes. In other regions, cohorts under age 75 with a sample size of zero in the ACS data are assigned values from the opposite gender when it is available to reduce instances of rates calculated from a null value.

[5] 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.

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

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.

College Migration

Tracking the migration of college students is often problematic for researchers, as neither the ACS nor conventional tax-return migration data seems to capture their movement comprehensively or accurately. For this reason, the U.S. Census Bureau applies a "college fix" in their annual county-level population estimates to areas that meet their criteria for percent of population enrolled in college and other population thresholds[6]. In the basic application of the "college fix", the college-enrolled population in a region is held back from aging and migration experienced by the non-college population over the specified time period, and is then restored to the region at the end of the period. In this way, the college-enrolled population remains more or less fixed for a region while other cohorts migrate and age over time.

In the UMDI Vintage 2015 projections model, we apply a "college fix" method to the 15-19, 20-24, and 25-29 age cohorts in three regions: Greater Boston, Lower Pioneer Valley, and the Central Region. According to ACS 20072011 data, these regions all show significant percentages of college enrollment as follows:

ACS 2007-2011 Population Enrolled in College or Graduate School by Region						
UMDI Region	Greater Boston		Lower Pioneer Valley		Central Region	
Age cohort	# enrolled	% of cohort	# enrolled	% of cohort	# enrolled	% of cohort
15-19	55,018	39%	19,565	36%	14,207	27%
20-24	97,496	54%	30,255	57%	22,624	49%
25-29	44,479	24%	5,557	15%	5,613	14%

The UMDI college fix method, like the Census Bureau's, holds out the college enrolled portion of these three cohorts from aging and migration and then adds it back into its original cohort five years later. For each of the "College Fix" regions, we use 2007-2011 ACS data to determine the share of population enrolled in college or graduate school in each of the age cohorts. The share is based on the region's enrolled cohort as a percent of the total U.S. cohort. We apply this share by

[6] *The "College Fix": Overcoming Issues in the Age Distribution of Population in College Counties*. Ortman, Sink, King. Population Division, U.S. Census Bureau. October 2014.

age and sex to the base year population in order to estimate the regional college population and then subtract this from the total regional population. The difference is the estimated "non-college" population. This non-college population is subject to the same migration method described in the domestic migration section above, except that the migration rates are based solely on the non-college population and migrants in the ACS data. The resulting net number of non-college domestic migrants is added to each non-college cohort, which is then aged forward by five years. Finally, the enrollment share for each cohort is applied to the latest U.S. cohort total to determine a new estimate of the college-enrolled population for the region. This updated college estimate is added to the projected population. Below is an example for the 2010 to 2015 period.

2010		2015
non college pop 10-14	*age 5 years and add net migrants 2010-2015→*	non-college pop 15-19
college pop 15-19	*not aged; apply % enrolled to 2015 U.S. population 15-19→*	college pop 15-19
non college pop 15-19	*age 5 years and add net migrants 2010-2015→*	non-college pop 20-24
college pop 20-24	*not aged; apply % enrolled to 2015 U.S. population 20-24→*	college pop 20-24
non college pop 20-24	*age 5 years and add net migrants 2010-2015→*	non college pop 25-29
college pop 25-29	*not aged; apply % enrolled to 2015 U.S. population 25-29→*	college pop 25-29
non college pop 25-29	*age 5 years and add net migrants 2010-2015→*	non college pop 30-34

Because the college population is held out of the aging process, and because migration is only captured for the non-college population, we had to make two additional adjustments to our model. First, we allow portions of the college-enrolled population aged 20-24 and 25-29 to age forward into the non-college population[7]. This accounts for the college-enrolled population that ages in place into the non-college population (i.e. those that come for college or graduate and stay). Additionally, we account for the region's non-college population that joins the college population upon migrating out of the region (i.e. those who leave their homes in Massachusetts to attend college elsewhere in the U.S.) by capturing them as out-migrants[8].

International Migration (immigration and emigration)

International immigration in our model is estimated according to the number of international migrants, by age and sex, indicated for each region by the ACS 2007-2011 PUMS dataset. Unlike domestic migration in our model, however, the estimates of international immigrants from the ACS are not then converted to rates. With domestic migration, we can more comfortably make the assumption that there is a relationship between the number of migrants (our numerator) and another region (our denominator) that might be expected to remain relatively constant over time - for example the number of out-migrants relative to the region's population or the number of in-migrants relative to the U.S. population. In the case of international migration, it is harder to make an assumption that, for example, as the world population by age increases, the region's immigrants will increase at the same rate. In reality, a great number of factors not related to any particular

[7] To determine this proportion we applied a residual survival method using estimates of the college-enrolled and total populations by age in 2005 and 2010, based on enrollment levels by age indicated in the ACS 2005-2009 PUMS data.
[8] Out-migrants that are enrolled in college in regions outside of the study area, as captured in the ACS PUMS datasets.

region's current population will influence future immigration levels, including federal immigration policy change, college recruitment policies, and labor needs, to name just a few. Instead of trying to guess at which way these changes will affect immigration to each region, we assume that the levels experienced in recent history, in this case the 2007 to 2011 period, will be sustained, and in our Vintage 2015 model the number of immigrants by cohort remain constant over the time period.

There is no consensus on how best to deal with emigration in a gross-migration context. 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.

But, while we cannot directly estimate the number of emigrants in a five-year period using regional level ACS data, there are alternative methods that can be borrowed to at least approximate the a number for each region. The U.S. Census Bureau developed emigration rates for the foreign born population -- the population most prone to emigration -- for a demographic analysis of net international migration. The rates were developed using a residual method and data from Census 2000, the American Community Survey, and life tables from the National Center for Health Statistics[9]. They estimated emigration rates ranging from of 12.8 to 15.5 per 1,000 among the population of recently arrived foreign born (those entering the U.S. within 10 years prior to the survey) and rates of just 1.7 to 3.5 per 1,000 for the foreign born population with longer residency – (those arriving more than ten years prior to the survey).

To estimate emigration in our model, we first use ACS 2007-2011 information on the foreign born population by age and by decade of entry to create two estimates of the foreign born population for each state region: one recent-arrival group and one longer-residency group. Using a simplified survival method, we age these two populations forward every five years, decreasing them by letting the 85-and older population fall out (a rough proxy for mortality) and increasing them by the addition of new immigrants (using ACS 2007-2011 levels). After 10 years, new immigrants are moved into the longer-residency group. We apply the Census Bureau's middle-range rates for recently-arrived and longer-residency distinctly to each group in order to estimate the total number of emigrants by cohort in each time period.

It should be noted that in the Greater Boston, Central, and Lower Pioneer Valley regions, emigrating international students are already accounted for by the "revolving-door" approach of the college-fix method. In these three regions, we calculate international immigration and emigration only for the non-college population. College students in our model are withheld from the population at-risk for migration and aging. As such, they are not being counted as "immigrants" in the conventional sense, but instead are lumped in with all other college students, as a constant relative to the entire national population. In the Greater Boston region, college-enrolled immigrants ages 15-29 account for 30% of all international immigrants in the 2007-2011 ACS period, while in the Lower Pioneer Valley, they account for about 36%. These proportions can be thought of in our model as now

[9] Source: Population Division Working Paper No. 97: *Estimating Net International Migration for 2010 Demographic Analysis: An Overview of Methods and Results,* U.S. Census Bureau, February 2013.

removed from the foreign born population that would typically drive both immigration and emigration numbers, and so reduces the effect of any error in estimating emigration based on foreign born population estimates.

Finally, international immigrants who become part of the resident population are then subject to the same out-migration rates as the general population. If they move on to other parts of the U.S., they are captured as out-migrants in the next five-year period.

The final step of the migration model adds the estimated net number of domestic migrations (in-migrants minus out-migrants) and the estimated international migrants 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 last component in our regional cohort-component model 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 to2009). 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 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:

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

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 next 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- 4) and final (85+) cohorts are treated differently. The number of anticipated babies estimated in the previous step becomes the number of 0- 4 year olds in 2015. The number of persons in the 85+ cohort in 2015 is the number of surviving stayers in the 80- 84 age cohort (in 2010) added to the number of surviving stayers in the 85 and older cohort. As we made separate estimates 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 estimating population 'at-risk' of domestic in-migration. The U.S. Census Bureau regularly generates highly detailed national population forecasts.[10] We use the latest release of national forecasts (release date December 2014) which are based on information from the 2010 Decennial Census. Unfortunately, the Census Bureau no longer generates detailed state-level long-term projections; their last state-level projections were developed in 2005. So for estimating future in-migrants from neighboring Northeast states, we use the state-level age/sex projections developed by the University of Virginia's Weldon Cooper Center for Public Service[11] (release 2013).

Reconciliation to Current Population Estimates

As a final step in the regional model, we align our projections to the most current population estimates from the U.S. Census Bureau at the state and regional levels. We aggregate the vintage 2013 sub-county estimates[12] to the UMDI regions and then calculate the annual percent change in population from 2010 to 2013 for each region. This annual percent change is applied to the 2013 population to create a 2014 estimate for each region. The 2014 regional totals are then controlled to the Census Bureau's vintage 2014 state-level population estimate[13] to create updated regional totals to 2014. For each region, the resulting annual percent growth from 2010 to 2014 is calculated and then applied to the 2014 total to create a 2015 "target" population.

In the first five-year period of our projection series, 2010 to 2015, migration rates are adjusted across all age/sex cohorts by a fixed percentage so that the 2015 projection now matches this 2015 target. In regions where our unadjusted 2015 projection is less than the 2015 target, in-migration was adjusted upward and out-migration downward. In regions that were over-projected, in-migration was adjusted downward and out-migration upward. Adjustment factors varied by region from 0.00 to 0.13 (where adjustment = original rate x [1 + adjustment factor]). Because the adjustment is applied as a percentage of the original cohort rate, the effect is that high-migratory age groups are affected to a greater degree than the groups with less migration activity, in terms of resulting number of migrants. These final migration rates for the 2010 to 2015 period are essentially "synthesized" age/sex rates that capture the 2010 to 2014 population change trend while conforming to the to the age/sex distribution of migration found in the 2007-2011 ACS, the latest five-year set of age/sex migration data available at the PUMA level.

[10] Source: http://www.census.gov/population/projections/

[11] Source: *Population Projections by Age for the U.S. and States*. Updated August 9, 2013. Weldon Cooper Center for Public Service, University of Virginia. http://www.coopercenter.org/demographics/national-population-projections

[12] Source: Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013, U.S. Census Bureau, Population Division, May 2014.

[13] Source: Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013, U.S. Census Bureau, Population Division, December 2014.

Rates for subsequent projection periods – 2015 to 2020, 2020 to 2025, and so on – use an average of rates calculated from the 2005-2009 and 2007-2011 ACS datasets. The two sets are averaged in order to capture the longest recent time-span available in the ACS PUMS five-year datasets. This averaging also helps to reduce sample error for age/sex migration rates that occurs with sample survey data. While averaging these two overlapping periods effectively centers the migration rates on the 2007-2009 period, according to Census Bureau state-level component estimates[14], the centered average of these two overlapping periods is nearly identical to the average net migration estimated by Census for the most recent ten-year period, 2005 to 2014.

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 aged five 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 2035 using the previous projection as the new launch population. Projections for eighteen five-year age groups (0-4, 5-9 …80-84, and 85–and older) are reported for males and females. (Throughout this document, the term "age" refers to a five-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

[14] Source: ST-2000-7; CO-EST2010-ALLDATA; and NST-EST2013-ALLDATA, U.S. Census Bureau Population Division.
[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.

Data Sources

The launch populations by sex, age cohort, and MCD were obtained from U.S. Census 2010 data[16]. 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.

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[17]. 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.

Five-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 2035). 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 five-year period. The 85-and older cohort's survival rate was used as-is, since there was no older cohort to average.

[16] An exception is made in our model for the town of Lincoln, Massachusetts. For the Lincoln base we have instead created 2010 age/sex estimates using cohort-change ratios observed in the 1990-2000 period applied to the Census 2000 age/sex base. We do this because Lincoln was counted in Census 2010 with a significantly reduced population. This happened because, at the time of the Census count, a large number of the housing units at a military base had been demolished, with their replacement happening only later in 2011. This gave the town a Census 2010 base count that was out of trend with its population in the years right before and again shortly after, with population reduced by as much as 21%. While the 2010 Census may be considered as a relatively accurate point-in-time count, using it as a point of reference in a residual net migration model will create drastically altered migration rates for the town, and using it as the population base for future years will also produce unreasonably low projections.

[17] See footnote (above) on exception in the town of Lincoln.

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 to 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 five-year projection by applying the corresponding averaged five-year survival rates by age/sex.

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 25 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 ages five and older. 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 to 2009. In order to calculate five-year net migration by age, sex and MCD, natural increase (births minus deaths) by age/ sex for 2000 to 2005 is added to the 2000 population by age/ sex for each MCD. The results are then subtracted from the interpolated 2005 population by age/ sex for each MCD to estimate net migration by age/ sex and MCD for 2000 to 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 four males aged 70-74 and net migration shows four 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 projection 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 to 2005 and 2005 to 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[18]. We calculated regional rates using the same MCD-based vital statistics data from 2000 to 2009 as we used in calculating the MCD rates.

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.

[18] While MCDs with populations less than 10,000 are given the regional rate in this model, we make exception for "college bedroom" towns. Because fertility rates are generally lower among females enrolled in college compared to the general population of the same age group, applying regional fertility rates to small towns with high percentages of college-enrolled population resulted in inflated births. We developed criteria for identifying "college bedroom" towns and applied town-specific fertility rates to these instead of the regional rates. Criteria is: population under 10,000 in 2010; >20% of 18 and over female population is enrolled in college or graduate school according to 2008-2012 ACS; and use of regional fertility rate resulted in a ≥25% Increase in the 0-4 age group from 2010 to 2015. The three MCDs subject to the "college bedroom" exception include Wenham, Sunderland, and Williamstown.