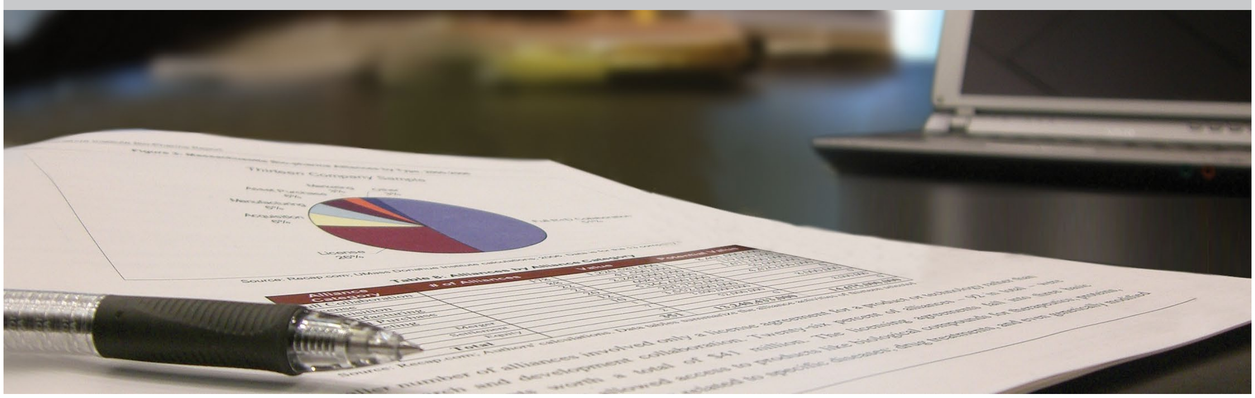
Long-Term Population Projections for Massachusetts Municipalities and Regional Planning Areas

Population Projections Methodology

December 15, 2022



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Socio-Economic Projections for Massachusetts Regional Transportation Plans

Population Projections Methodology

Prepared by the UMass Donahue Institute's
Economic & Public Policy Research Group
Population Estimates Program

Project Leader
Susan Strate, Senior Program Manager, Population Estimates Program

Unit Director
Mark Melnik, Director of Economic & Public Policy Research

Project Staff
Meghan Flanagan, Senior Research Analyst
Denis McAuliffe, Research Analyst
Lily Harris, Research Analyst
Ian Dinnie, Research Analyst
Chris Diaz, Research Analyst
Thomas Peake, Senior Research Analyst

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Acknowledgments

We wish to acknowledge the work of Dr. Henry Renski, Professor of Regional Planning at the University of Massachusetts in Amherst for his work in developing the methodology and methods report for the Long-term Population Projections for Massachusetts Regions and Municipalities published by the UMass Donahue Institute in 2013 and 2015. Much of the writing in the present report was taken or adapted from the previously published methodology statements for these two series.

Introduction

In 2017 and 2018, the Massachusetts Department of Transportation (MassDOT) led an effort to update population, household, and employment projections for Massachusetts and its metropolitan planning regions. Working closely with an advisory committee of regional and state agencies and other interested stakeholders, the University of Massachusetts Donahue Institute (UMDI) and the Metropolitan Area Planning Council (MAPC) contracted with MassDOT to develop, test, and refine a variety of methods and assumptions about the components of socio-economic changes occurring throughout Massachusetts. UMDI's work focused on population and employment trends and projections while MAPC's work focused on housing growth and changes to the labor force. The Central Transportation Planning Staff (CTPS) and the regional planning agencies (RPAs) provided input in all areas through regular meetings and consultations. As a result of these efforts, UMDI developed "Vintage 2018" (V2018) population projections by sex and five-year-age cohorts in ten-year increments to 2040 for each of the thirteen Metropolitan Planning Organization (MPO) regions in Massachusetts.

In 2021, MassDOT contracted again with UMDI and MAPC to produce an updated "Vintage 2022" (V2022) series of socioeconomic projections, with UMDI again developing population and employment projections. As with the previous vintage, UMDI worked in collaboration with a Projections Advisory Committee that included representatives from CTPS, MassDOT, and each of the Massachusetts RPAs. As with the previous vintage, the V2022 projections represent an average spring/fall condition and are consistent with Census residency rules, excluding seasonal-only residents and accounting for group quarters populations --such as students in college towns -- where they reside most of the time. In the V2022 series, UMDI extends the projection horizon to 2050 and adds a race and ethnicity component. UMDI also makes numerous updates to the data sources used and, with these, changes in the methodology for some components.

With this report, UMDI is publishing the "Vintage 2022" population projections for each Massachusetts Metropolitan Planning Organization (MPO), with support from MassDOT, as well as public-use city and town-level population projections, supported in part by the Massachusetts Secretary of the Commonwealth. This report details the methods, data sources, and assumptions used to develop the UMass Donahue Institute (UMDI) *Vintage 2022 Long-Term Population Projections for Massachusetts Municipalities and Regional Planning Areas*.

Limitations

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. The V2022 series employs 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 suggested by the demographic-accounting framework, the V2022 projections are based on demographic components of change to the exclusion of other factors, such as housing or transportation development initiatives, large-scale institutional changes, cultural shifts, and public policy revisions. To the extent that geographically-specific birth, death, and migration trends from the last ten years reflect the development that occurred in that place over the past ten years, the V2022 projections should serve as reasonable reflections of future development should development continue at the same relative pace in that geography. Should a region's economic development outlook change dramatically, relative to other places in the state or the U.S., then the migration component in the model may no longer reflect the migration that may be anticipated in future years. An important counterpoint to the very likely possibility of future changes in migration, however, is that the strongest predictor of future population in almost all places is the population residing there today.

Factors specific to the timing of this series may also greatly impact the accuracy of the V2022 projections. For one, the projections are based on trends unfolding during what may be described as an off-trend period. The COVID-19 pandemic drastically shifted short-term trends in births and deaths -- two of the main components used as direct inputs in the UMDI population projections method -- not only in Massachusetts but around the U.S. as a whole. Secondly, the pandemic altered typical migration and immigration patterns, with an already declining trend in immigration exacerbated by the global pandemic and with a shift in domestic migration out of urban and into more rural and seasonal areas. While population data from 2020 are incorporated into the launch populations in our projections models, it is still too early to tell whether 2020 residency choices will persist into future years as the "new normal" or whether they will revert to pre-pandemic tendencies, or, if something in-between, to what extent they will persist or rebound.

Another major consideration affecting our ability to produce accurate population projections in 2022 relates to the release schedule of detailed Census 2020 data. As of the date of this report, the only decennial Census data available for 2020 are the total combined male and female populations by race and ethnicity for two large age cohorts: under-18 and 18-plus years of age. While detailed count data by specific five-year and single-year age cohorts are usually available to researchers by this time in the Census cycle, due to both pandemic and methodological-related delays within the U.S. Census Bureau, the release of five-year age cohorts is now not anticipated until May of 2023.[1] The decennial Census counts published every 10 years by the U.S. Census Bureau are typically considered the "gold-standard" against which other estimates and rates may be evaluated or produced. In the V2022 estimates series, UMDI must instead rely on age distributions extrapolated from a Census 2010 base which, though reasonable, lack the precision of an actual recent count.

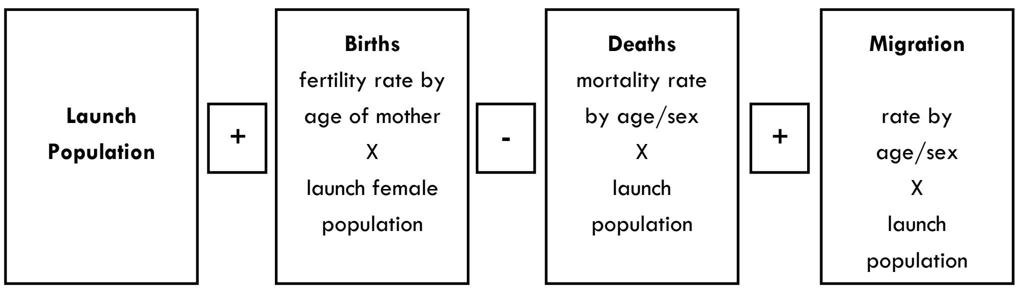
For all of these reasons, researchers should use caution when planning initiatives around the V2022 population projections, and be thoughtful about the data sources, methods, and assumptions that underpin the series. This methodology report represents UMDI's efforts to provide transparency and clarity on the inputs, methods, and assumptions used in the series so that potential users may be well informed on the components used to generate the final V2022 results.

[1] https://www.census.gov/programs-surveys/decennial-census/decade/2020/planning-management/release/about-2020-data-products.html

Method Overview

The UMDI Vintage 2022 (V2022) population 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. Figure 1 below displays the basic concept of a cohort-component model.

Figure 1. Cohort-Component Model Overview



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, and growth and decline and can differ greatly from one region to another based on their profiles. 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 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.

The V2022 projections methodology may also be described as a "*status-quo*" projections model; it assumes that recent trends in the demographic components of population change, such as fertility, mortality, and migration by age, will persist in future periods. While it is reasonable to expect that these rates will change in future years, predicting the directionality of these trends invites additional assumptions into the model and, with them, additional uncertainty. The recent COVID-19 pandemic is an example of how an unexpected event can reverse an apparently steady component trend, with mortality rates increasing after a long period of gradual decrease in most age groups. Likewise, fertility rates have been slowing over a long period, but economic or social influences could just as readily disrupt that trend, as happened with the unforeseen "baby boom" that kicked off in the late 1940s. Fluctuations in immigration and migration are even less predictable. For example, there was a steep drop off in net immigration to Massachusetts following the 2016 elections. This trend was further exacerbated by a global pandemic in 2020, but could be substantially reversed again, depending on future federal policy. For these reasons, the UMDI V2022 series may be defined strictly as "projections" and not as "scenarios" or "forecasts."

In the V2022 population projections series, UMDI uses a cohort-component model based on a combination of trends in fertility, mortality, and migration from 2010 through 2020 and decennial Census data from 2000, 2010, and 2020. The method produces population projections for three different geographic levels: municipalities, counties, and sub-state "migration" regions defined by the Census 2010 migration-PUMA (MIGPUMA) boundaries. These regional levels are controlled to one another using a "top-down" approach by which age/sex projections for smaller geographies are controlled "up" to the larger geography age/sex projections.

The "MIGPUMA" 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.[2] The county and municipal-level estimates both rely on residual net migration rates computed from vital statistics and decennial Census data. Municipal age/sex projections are controlled to the regional or county age/sex projections -- or both, depending on the region -- and are then summed up to Metropolitan Planning Organization (MPO) totals by aggregating all age/sex/town cohorts that fall within the MPO. As a last step, the MPO age/sex projections are distributed to race and ethnicity groups by use of a cohort-change-ratio model that incorporates decennial Census data from 2000, 2010, and 2020 and county-level age/sex/race/ethnicity estimates from the U.S. Census Bureau's Population Division.

In the *municipal-level* age/sex projections published by UMDI, the city and town total populations are calculated by summing the controlled age/sex estimates developed from the demographic cohort-component estimates described in this report. The municipal-level totals published by MassDOT are developed in a separate process by MAPC. For these, MAPC takes the MPO-level population projections developed by UMDI and redistributes them to cities and towns within the MPOs by use of an *UrbanSim* planning model that accounts for pipeline and planned development, among other factors.[3] For this reason, the population projections published as part of the MassDOT Socioeconomic Projections series differ from the projections published by UMDI at the municipal, but not MPO, geographic level. Appendix A to this report shows the geographic correspondence between municipalities and their respective UMDI model and MPO regions, and Figure 2 below displays the Regional Planning Agency (RPA) boundaries that comprise each MPO region, together with Massachusetts municipal boundaries.

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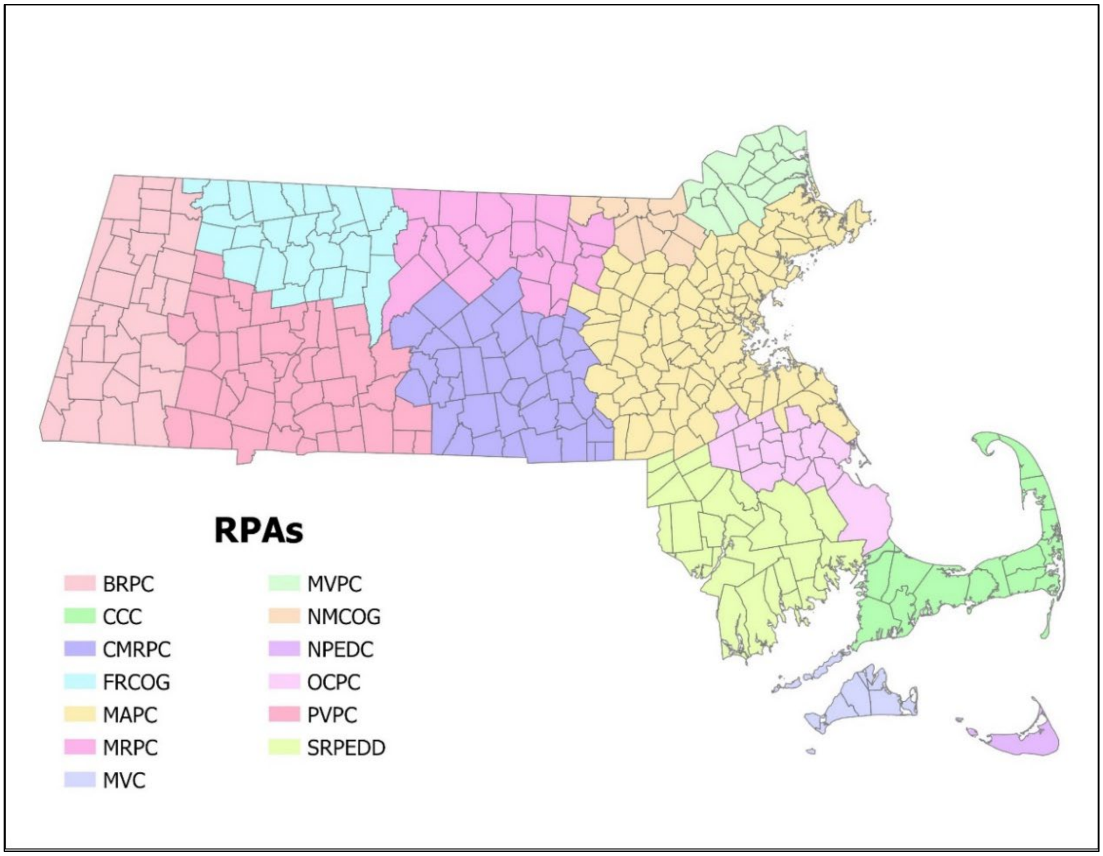
[2] PUMAs are the smallest geographic units used by the U.S. Census Bureau for reporting data taken from the detailed (micro) records of the American Community Survey (ACS) – our primary source of migration data. PUMA boundaries are defined so that they include no fewer the 100,000 persons, while Migration PUMAs (MIGPUMAs) must also incorporate the entirety of any county within their borders, leading to the aggregation of PUMAs into much larger MIGPUMAs in some areas of Massachusetts.

[3] Contact MAPC for more information on the application of the UrbanSim model on municipal population distributions.

Figure 2. Massachusetts Regional Planning Agency Areas and Municipal Boundaries



In the following sections, we discuss in more detail the methods, assumptions, and research considerations applied in the population projections produced for this report.

Technical Discussion of Methods and Assumptions

This section provides a technical description of the process used to develop 1) sub-state regional 2) county and 3) municipal-level population projections. While all levels of projections are prepared using a cohort-component method, the major methodological difference is in the way migration is modeled: the county and municipal-level estimates (also referred to as Minor Civil Divisions, or MCDs) rely on residual net migration rates computed from vital statistics and decennial Census data, while the sub-state regional projections use gross domestic migration rates based on the American Community Survey Public Use Microdata (ACS PUMS) for some state regions and residual net migration for other regions.

MCD-level age/sex projections are controlled to age/sex projections developed for fourteen 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 are then re-aggregated to MPO regions and, as a last step, assigned race and ethnicity distributions.

Note that, in the final population projections published by MassDOT, these MPO totals are then redistributed to their composite municipalities according to anticipated developments in each region through an *UrbanSim* planning model. [4] The MCD-level population projections published by UMDI, meanwhile, maintain the original town-level age/sex projections prepared by UMDI to create the MPO projections, and may be considered as strictly demographic projections, based on the age, sex, race, and ethnic profile of a region and recent rates of fertility, mortality, and migration specific to each cohort in the region.[5]

Defining Regions and Regional Controls

The UMDI V2022 model may be described as a "top-down" projections model, with smaller, or "lower-level" geographies controlling to larger or "higher" geographies. This method is often preferred in projections modeling because it allows the estimates to take advantage of data sources oftentimes only available at the higher level and smooths out irregularities in trends caused by the smaller number of observations in small geographies. For example, birth and death data are readily available by age of mother down to the municipal level in Massachusetts, while direct measures of migration are available only at the county-level or higher. ACS PUMS migration data is preferred in some areas because it provides a direct measure of migration broken out by age and sex and allows for the calculation of gross migration rates, however in some regions the dataset combines too many counties of disparate migration trends to be useful. For this reason, the UMDI V2022 Population Projection model employs different cohort-

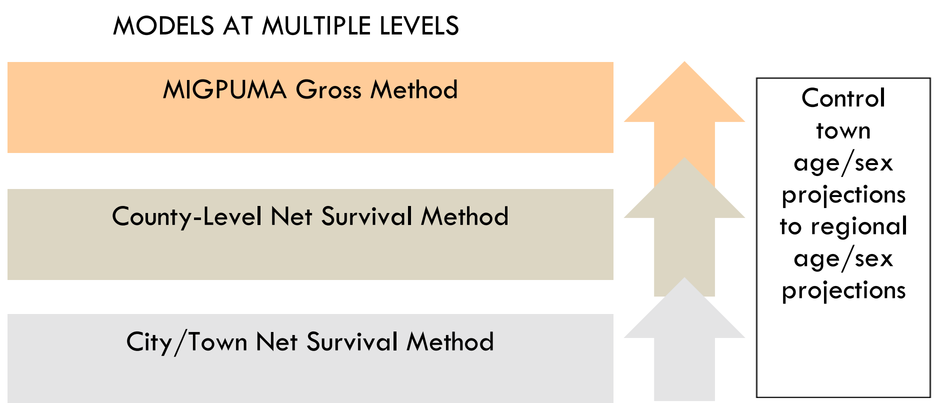
[4] Published by MassDOT at: https://www.mass.gov/lists/socio-economic-projections-for-2020-regional-transportation-plans

[5] Published by UMDI at: https://donahue.umass.edu/business-groups/economic-public-policy-research/massachusetts-population-estimates-program/population-projections

component methods for different geographies, choosing the ideal method at each geographic level based on that level's available migration data.

Figure 3 below describes the general geographic hierarchy used in the V2022 methodology and the migration method used at each level.

Figure 3. Model Control Hierarchy and Migration Method



American Community Survey MIGPUMA Regions

For the previous, V2018, projections series, UMDI was able to access data on gross migration by age, sex, and Public-Use Microdata Sample Area (PUMA) for 52 PUMAs in Massachusetts. This allowed for the aggregation of PUMAs into areas roughly corresponding to Massachusetts planning regions, with some geographic re-controlling to account for the imperfect overlap between MPO regions and PUMA boundaries. Starting with PUMS data released in 2012, the Census Bureau changed the geographic levels for which they release migration data from PUMAs to much larger "Migration PUMAS", or "MIGPUMAs". A key feature of the MIGPUMA development was that any time a PUMA crossed over a county boundary, the total extent of both counties represented in the PUMA had to be aggregated into the same MIGPUMA. The result of this was that instead having access to 52 Massachusetts PUMAs with gross migration data last decade, the most current ACS series includes gross migration data for only five large Massachusetts MIGPUMAs.

The five sub-state MIGPUMA regions for which 2012-2019 ACS PUMS migration data are available include:

- a Berkshire MIGPUMA, which aligns with Berkshire County
- a Western Mass. MIGPUMA, which encompasses Franklin, Hampshire, and Hampden Counties

- a Suffolk MIGPUMA, which aligns with Suffolk County
- a Cape and Islands MIGPUMA, which encompasses Barnstable, Dukes, and Nantucket Counties
- an Eastern Mass. MIGPUMA, which encompasses the remaining six Massachusetts counties, including Bristol, Essex, Middlesex, Norfolk, Plymouth, and Worcester Counties.

Figure 4 below displays the most current ACS PUMA boundaries in Massachusetts as compared to county boundaries; Figure 5 displays how these counties are aggregated to encompass all county-PUMA overlaps; and Figure 6 displays the resulting MIGPUMA geography.

Figure 4. Massachusetts PUMAs and County Boundaries for 2012-2019 ACS PUMS Data

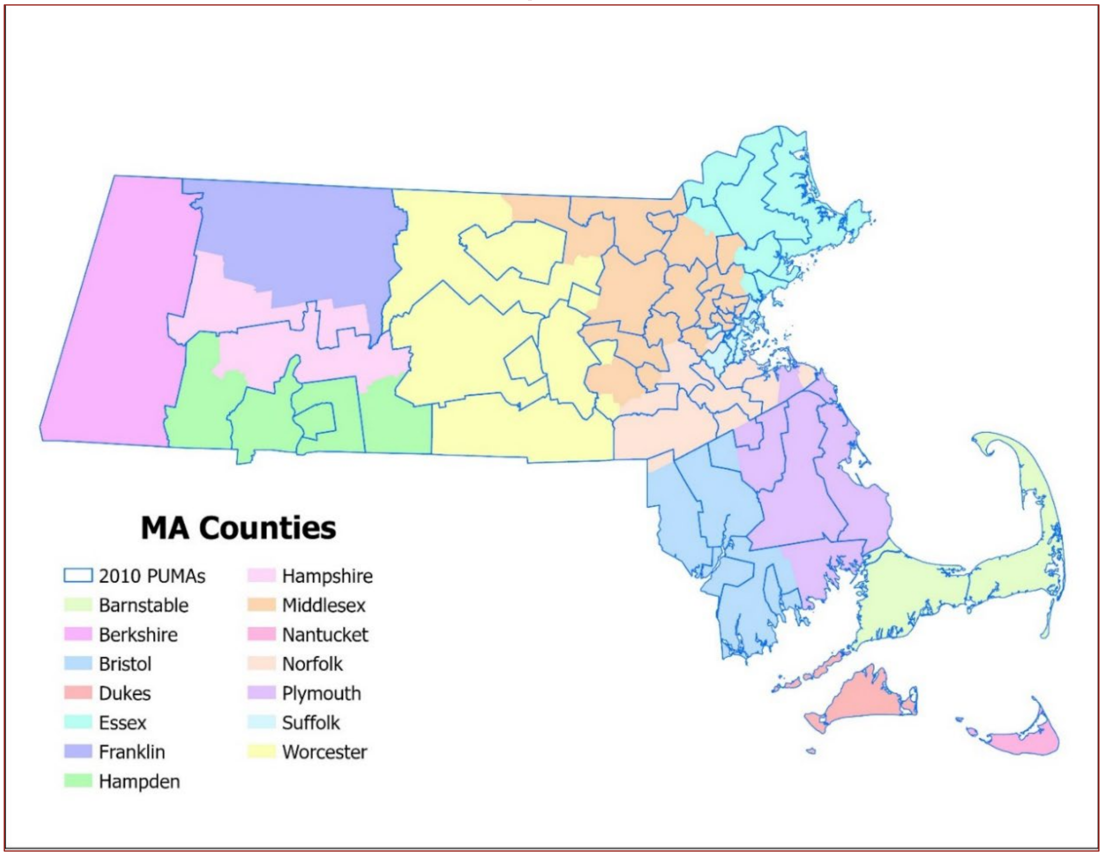


Figure 5. Massachusetts PUMAs Aggregated to County Boundaries for 2012-2019 ACS PUMS Data

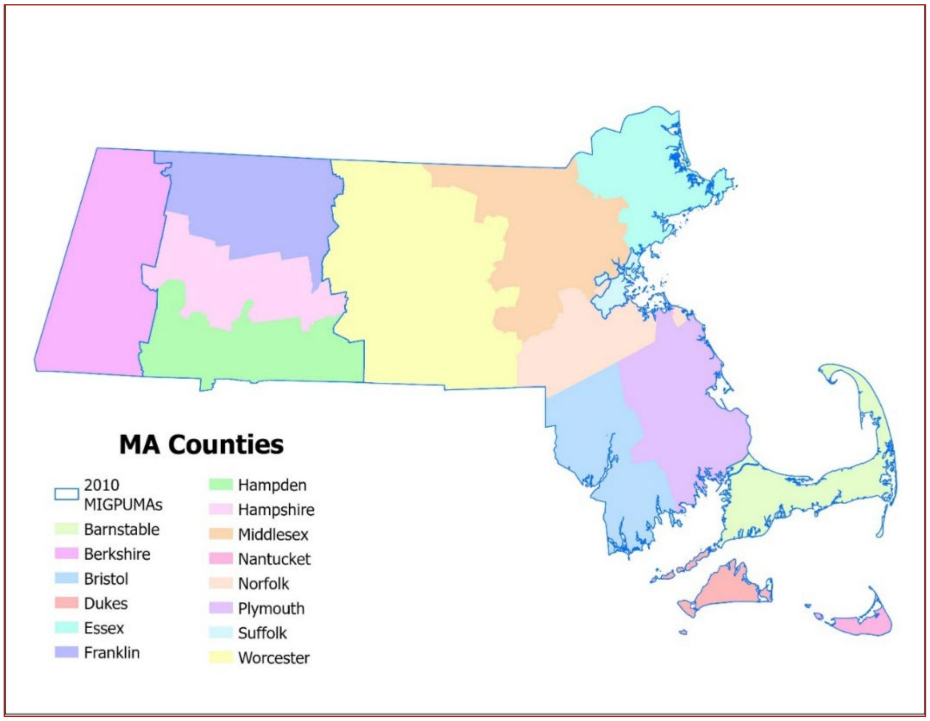
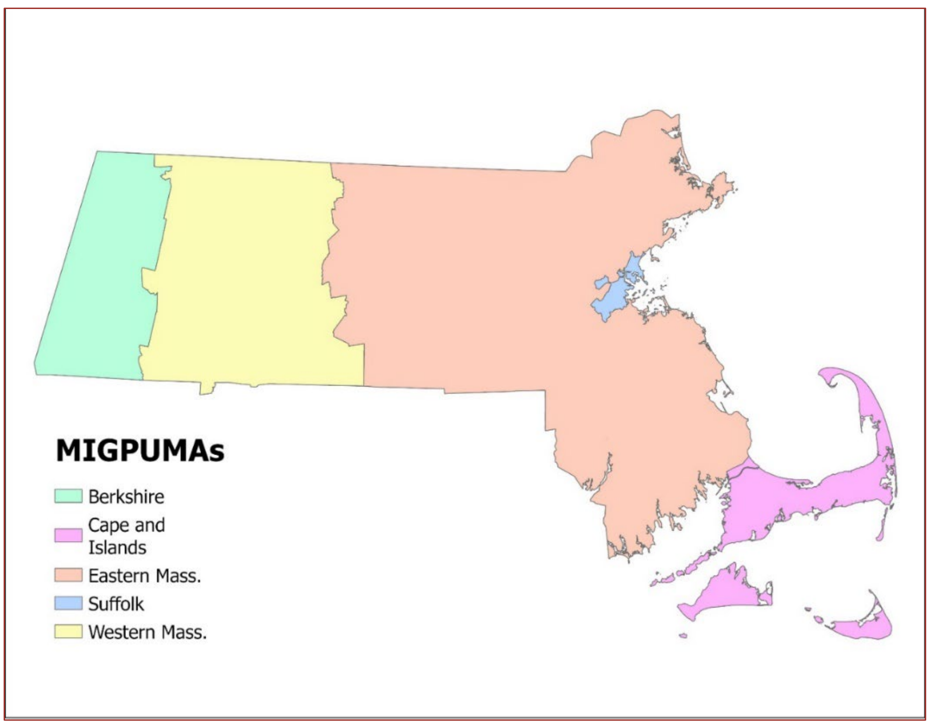


Figure 6. MIGPUMA Boundaries for 2012-2019 ACS PUMS Data



As seen in Figure 6 above, by aggregating counties and PUMAs in every instance of a border overlap, the resulting MIGPUMAs in some areas of the state are very large. While this is helpful in the sense that it provides a larger statistical sample for the migration question in the ACS survey, the downfall is that it diminishes the geographic precision of the migration trends it captures. For areas where counties and MIGPUMAs align, including Berkshire and Suffolk, the model can take advantage of the gross-migration component in the ACS PUMS data without difficulty. In areas where counties are combined into a single large MIGPUMA with similar migration-by-age patterns, as in the Eastern MIGPUMA, the model is run at both the county and MIGPUMA level, with county results controlling to the MIGPUMA results. This way, the model can leverage gross-migration data while still allowing for county-specific tendencies. For areas where counties are combined into a single large MIGPUMA but have significantly varying migration-by-age patterns, however, a projection is developed at the county level only, using a net-residual method to calculate migration rates.

Migration Methodology Variations, Overview

As a broad overview, the migration methods used in the V2022 estimates for each geographic control level are as follows:

The **MIGPUMA Gross-Migration model** calculates in and out-migration separately, using in-migrants and out-migrants by age and sex estimated in the American Community Survey (ACS) Public-Use-Microdata Sample (PUMS) file for each Migration PUMA (MIGPUMA) and for averaged years 2012 through 2019. MIGPUMA regions are Census statistical regions defined by the U.S. Census Bureau and aligning with county boundaries. In Massachusetts, there are five MIGPUMA regions including: Berkshire (Berkshire County), Pioneer Valley (combining Franklin, Hampden, and Hampshire counties), Cape and Islands (Barnstable, Dukes, and Nantucket Counties) and Eastern (combining all remaining Massachusetts Counties, from Worcester County and east, excluding Cape and Islands). The benefit of this method is that it is sensitive to the interplay between a region's population and the fluctuations of the greater U.S. population. For example, if a region typically attracts in-migrants of a certain age group from other states, as that "pool" of potential migrants changes over time, migration levels into the region will also change in response. Because MIGPUMA migration estimates are derived from a sample survey (ACS), this method tends to work better in large regions, where the sample size is adequate and margins of error are reduced.

The **MIGPUMA model with a College Fix** acknowledges that college-aged populations are notoriously difficult to capture in "direct" measures of migration, including IRS tax-filing statistics as well as the Census American Community Survey. This may be due in part to survey response rates, confusion over where to report "usual residence", as well as generally increased mobility in this age group. The U.S. Census Bureau applies a "college-fix" in their annual county-level population estimates, which "fixes" some portion of the college-aged population in place and time. Rather than aging forward, college students are treated like a "revolving-door" population, continuously refreshed in each new interval in the same age groups, while the rest of the population migrates and ages forward. The UMDI MIGPUMA College Fix model applies a similar approach, with college and non-college populations modeled separately. *College-enrolled populations* are replaced at each interval by a constant "enrolled" share of the U.S. cohort that is projected for each corresponding interval while the *non-college population* is subject to aging and migration, according to gross-migration rates calculated for the non-college population by age and sex. Finally, some share of the college-enrolled population is allowed to age forward and stay in the region, with this share determined by historic cohort-change ratios.

The **County Net-Migration model** is a widely used cohort-component model that estimates net migration by age and sex in a region by using a cohort-survival-residual calculation. In this method, the 2010 Census population by age, sex and county is used as the base. Actual births and deaths experienced in the region over the 10-year period from 2010 to 2019 are added and subtracted from the base population, and the resulting, "surviving" population is aged forward 10 years to calculate an expected, or "natural increase" population. The natural increase population is then compared to the "actual" population counted at the next Census – in this case the 2020 Census – and the difference between the actual population and the natural increase population is attributed to net migration. The number of net migrants by age and sex are then used to calculate a net-migration rate for the corresponding cohort, using the regional cohort population as its denominator, and this rate is then applied to the base populations projected for each subsequent interval.

The **County Net-Migration model controlled to MIGPUMA Gross-Migration model** is a combination of the County Net Migration and MIGPUMA Gross-Migration models described above. While the Berkshire, Pioneer Valley, Suffolk, and Cape and Islands MIGPUMAs in Massachusetts are modestly sized, ranging from about 125,000 to 800,000 population in each, the Eastern Massachusetts MIGPUMA is tremendously large in comparison, with a population of almost 5 million. While the Gross-Migration model based on PUMAs is valuable for establishing connections between migrants and the rest of the U.S., the local characteristics of one sub-region over another can be washed out by controlling MCD-level projections straight up to the MIGPUMA results. For each Massachusetts county in the Eastern MIGPUMA, including Bristol, Essex, Middlesex, Norfolk, Plymouth, and Worcester, UMDI produces County-Net-Migration projections as well as a single Eastern MIGPUMA Gross-migration projection. The age/sex/county cohort results are controlled to the Eastern MIGPUMA age/sex results at each interval. These "controlled" county-level projections are the used as the regional age/sex control totals for the MCDs in the Eastern Massachusetts region. This method effectively preserves the local migration characteristics of each county while still leveraging the benefits of the gross-migration model.

Migration Methodology by Region

UMDI produced and evaluated the above model variations for all counties before choosing which county to assign to which model. The primary determinant for choosing one model over another for any given region was the plausibility of the resulting future age profile progression compared to the actual age-over-time progression observed in previous Census counts from 2000 forward for the region. For example, if a region had tended to lose young people from Census to Census as they aged forward in time but showed a sudden reversal of that trend in the model, it indicated that the model version was less appropriate for the region. The most common example of this is seen when non-homogenous counties share a MIGPUMA. In the Cape and Islands region, for example, Nantucket County has a history of attracting large numbers of young families while Barnstable County does not, but instead attracts early retirees in large numbers. The individual characteristics of each of these counties are somewhat canceled out when both control to the same MIGPUMA model. In another example, both Franklin and Hampden Counties showed implausible boosts in the 15–19-year-old cohorts – compared to their past age profile progressions - when they were controlled to the same MIGPUMA region as Hampshire County, which maintains a perennial, large college-aged population in the region.

Two counties, Suffolk and Berkshire, correspond to MIGPUMAs that are their geographic and statistical equivalents. For these, using the MIGPUMA Gross migration model produced plausible future populations and age profiles. Other counties, including those in the Pioneer Valley and the Cape and Island MIGPUMAs were sharing PUMAs with other counties that had very dissimilar migration-by-age patterns. For these, the most plausible future population and age-profiles were observed in the County-Net-Migration model results. Finally, while the remaining Eastern Massachusetts counties showed differing migration by-age trends, the differences were based in the degree of migration rather than a divergent directionality of migrants, as was seen in the Cape and Islands and Pioneer Valley. For these, plausible results were seen in the County-Net model controlled to the MIGPUMA-Gross model.

Table 1 below displays net migration by age rates by county, using the net survival residual method, and the deviation of these county rates within their corresponding MIGPUMAs. It illustrates that migration rates by age are much more homogenous among Eastern MIGPUMA counties as compared to Cape & Islands and Pioneer Valley MIGPUMA counties. The average standard deviation of migration rates/age by county in the Cape and Island counties (0.051) was twice that of the Eastern MA counties (0.025), while the average standard deviation among Pioneer Valley Counties (0.077) was three times that of Eastern counties.

Table 1. Migration Rates by Age and County and Deviation in County Rates within MIGPMAs

Cape and Islands Net Migration Rate				
Age	Barnstable	Dukes	Nantucket	STD DEV P
1	0.051	-0.019	-0.015	0.032
2	0.036	0.039	-0.057	0.044
3	0.010	0.025	0.023	0.006
4	-0.020	-0.087	-0.073	0.029
5	-0.021	-0.025	0.159	0.086
6	-0.059	0.162	0.484	0.223
7	0.022	0.087	0.197	0.072
8	0.041	0.029	-0.047	0.039
9	0.001	-0.025	-0.003	0.011
10	0.049	0.015	0.054	0.017
11	0.052	0.003	-0.019	0.030
12	0.075	0.035	-0.016	0.037
13	0.100	0.032	-0.010	0.045
14	0.116	0.080	-0.002	0.049
15	0.043	0.014	-0.091	0.057
16	-0.008	0.012	-0.087	0.043
17	0.000	0.026	-0.088	0.049
18	-0.106	-0.099	-0.007	0.045
	avg ST DEV by age group:			0.051

Eastern MA Net Migration Rate							
Age	Bristol	Essex	Middlesex	Norfolk	Plymouth	Worcester	STD DEV P
1	-0.017	0.043	-0.007	0.052	0.079	0.032	0.033
2	0.046	0.035	0.006	0.060	0.066	0.043	0.019
3	0.031	0.031	0.017	0.034	0.037	0.019	0.007
4	0.030	0.049	0.134	0.026	-0.015	0.072	0.046
5	-0.007	-0.006	0.108	-0.015	-0.078	-0.035	0.056
6	-0.010	0.010	0.192	0.101	-0.034	-0.018	0.081
7	0.051	0.081	0.040	0.100	0.116	0.090	0.027
8	0.036	0.093	-0.010	0.084	0.141	0.046	0.048
9	0.006	0.024	-0.021	0.034	0.033	0.002	0.019
10	0.018	0.030	-0.001	0.011	0.040	0.021	0.013
11	0.014	0.014	-0.011	0.000	0.012	0.000	0.009
12	0.011	0.008	-0.016	-0.017	0.018	0.000	0.013
13	-0.004	-0.011	-0.033	-0.039	0.012	-0.015	0.017
14	-0.007	-0.013	-0.045	-0.042	0.003	-0.025	0.018
15	0.001	-0.016	-0.037	-0.037	0.009	-0.015	0.017
16	-0.008	0.003	-0.014	-0.002	0.023	0.008	0.012
17	0.032	0.038	0.011	0.040	0.042	0.049	0.012
18	-0.065	-0.057	-0.070	-0.059	-0.050	-0.054	0.007
							0.025

Pioneer Valley Net Migration Rate				
Age	Franklin	Hampden	Hampshire	STD DEV P
1	0.006	-0.003	0.040	0.019
2	0.008	0.010	0.061	0.025
3	0.005	0.012	0.040	0.015
4	-0.103	0.071	1.324	0.636
5	-0.077	-0.024	0.410	0.218
6	0.006	-0.063	-0.618	0.279
7	0.041	0.018	-0.056	0.041
8	0.070	0.011	0.025	0.025
9	0.009	-0.008	-0.023	0.013
10	0.007	0.002	-0.001	0.003
11	-0.031	-0.003	-0.010	0.012
12	0.022	0.001	-0.014	0.015
13	0.016	-0.007	-0.016	0.013
14	0.026	-0.027	-0.004	0.022
15	-0.018	-0.013	-0.004	0.006
16	-0.012	-0.004	0.005	0.007
17	0.007	0.032	0.030	0.011
18	-0.071	-0.079	-0.041	0.016
				0.077

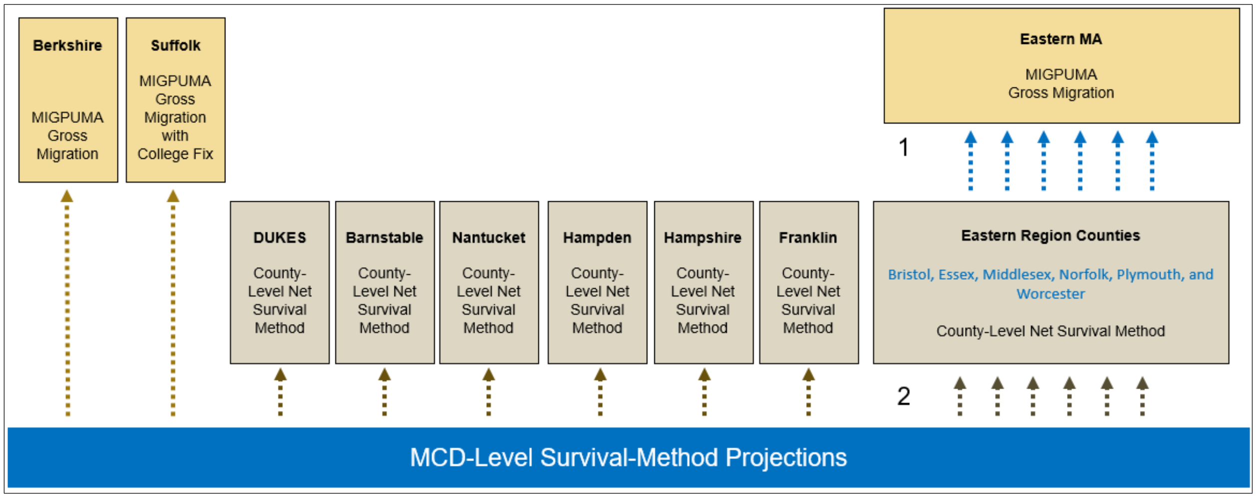
After analysis and testing of alternative control schemes for each geography, UMDI developed the following scheme for the regional control totals and migration method used in the model for each of the regions, also depicted in Figure 7 below:

- Berkshire County: *MIGPUMA Gross-Migration model*
- Suffolk County: *MIGPUMA Gross-Migration model with a College Fix*

- Pioneer Valley and Cape and Islands, including Hampshire, Hampden, and Franklin (PV) and Barnstable, Dukes, and Nantucket County (Cape and Islands): *County Net-Migration model*

- Remaining Eastern MA Counties (Bristol, Essex, Middlesex, Norfolk, Plymouth, and Worcester): *County Net-Migration model controlled to MIGPUMA Gross-Migration model*

Figure 7. Regional Cohort Controls by Region



The following sections of this report describe in more detail how population projections are modeled at the MIGPUMA, county, and municipal levels.

Regional and County-Level Methods and Assumptions

Summary

This section describes the process and data used to develop the regional population projections at both the MIGPUMA and county levels. A description of the methodology used for municipal-level projections follows in a subsequent section.

While the *Defining Regions and Regional Controls* section of this report describes the differences in how migration is modeled in each region or county, all regional models in the UMDI V2022 series share common features and basic assumptions. All regional models can be described as cohort-component models, meaning that for each cohort - in this case each 5-year age group by sex by geography – is subject to cohort-specific trends in the *demographic components of population change* – fertility, mortality, and migration. All regional models are also based on the "*status quo*" assumption that recent trends in births, deaths and migration by age, sex, and region will persist in future periods. All models start with a launch population by age/sex/region in 2020 with 5-year fertility, mortality, and migration rates applied to each cohort in 5-year intervals to 2050, and with each 5-year age/sex projection then serving as the new launch population for the subsequent interval. In addition to a 2020 age/sex/region launch population, the models require 2010 and 2015 base populations in order to calculate the migration, fertility, and mortality rates applied in the model. Sources and assumptions for all of these components are described in the following sections, which include sections on the launch and base populations, survival, and fertility methods common to all region types, followed by a break-out of migration methodologies by regional type.

Determining the launch population and cohort classes

Launch Populations

The first step in the cohort-component model is to classify the composition of resident population into discrete cohorts by age and sex. Following standard practice, in the 2022 vintage series, we used five-year-age cohorts (e.g., 0-4 years old, 5-9… 80-84, and 85-and older) and developed separate profiles for males and females. While normally these profiles would be based on information provided in the 100% Count (SF 1) file of the Decennial Census of Population, at the time of the V2022 series production, this data was not yet available from the U.S. Census Bureau. Instead, the age/sex cohorts used to calculate both the starting (or "launch" population) as well as the populations used in rates calculations (or "endpoint" populations) are both estimates.

For the 2020 launch population by age and sex, we use the *UMDI 2020 Interim Population Estimates by Age, Sex, and Municipality* developed for the Massachusetts Department of Transportation and consistent with the 2020 age/sex/race estimates that UMDI produced for the Massachusetts Department of Public Health.[6] The *UMDI Interim Estimates* apply estimated age/sex distributions to the U.S. Census Bureau's Census 2020 PL-94.171 redistricting population counts of under-18 and 18-plus populations in each Massachusetts *Minor Civil Division* (MCD), which is the Census geographic equivalent of municipality in Massachusetts geography.

To estimate the age/sex distributions, UMDI starts with a modified *Hamilton-Perry* or *cohort-change-ratio* (CCR) model using 2000 and 2010 decennial Census data by age, sex, and MCD. The CCR method accounts for the aging of each individual cohort from one census to the next and creates a ratio between a specific cohort population (by age, sex, and geography) age $_a$ in year $_y$ to its corresponding cohort ten years younger, aged $_{a-10}$, and ten year earlier, in year $_{y-10}$. As a modification to the standard Hamilton-Perry model, before we integrate the resulting ratios into our model, we cap them at "1" for cohort groups including fewer than 25 people and "2" for groups under 100 people. A ratio of "1" in this context would mean that the starting population cohort ages forward ten years without adding or subtracting any population due to deaths or migration. A ratio capped at "2" means that the cohort cannot more than double as it ages up into the next age bracket. For child cohorts under the age of ten, a ratio is calculated between the child population and the same-year female population, taking the 0-4-year-old cohorts as a share of the female population aged 20-44 and the 5-9-year-old cohorts as a share of the female population aged 30-49. For each age/sex/MCD cohort, the resulting cohort-specific ratio is then applied to the corresponding base population (the Census 2010 population in this case) to estimate the population

[6] UMDI 2020 Interim Population Estimates by Age, Sex, and Municipality, UMass Donahue Institute Population Estimates Program, October 18, 2021.

ten years later (2020 in this case). The estimated population for each single year in the time series is then interpolated between 2010 and the 2020 projection for each cohort.

In the *UMDI Interim 2020 Estimates*, the resulting population estimates by age/sex/MCD in 2019 are next controlled to the U.S. Census Bureau's V2019 county-level population estimates by age and sex.[7] This control measure leverages the post-2010 updates that the Census Bureau makes to each county's population based on actual county-level births and deaths; estimated domestic migration and immigration; and reported changes in the group quarters populations since 2010. The resulting age/sex estimates are then controlled again to the Census Bureau's Census 2020 population counts of under-18 and 18-plus by MCD, as reported in the official Census 2020 PL-94.171 redistricting data. By this method, the age/sex estimates in the UMDI Interim estimates will sum to the Census 2020 PL-94 totals for each city and town. Population estimates for years 2011 through 2019, which are used to develop historic fertility rates in our model, are developed by interpolating populations for each single year in the time series between the Census 2010 populations and the 2020 estimates.[8]

While the *level* of combined net migration[9], births, and deaths for each city and town is updated to reflect the Census 2020 count totals – or the change from 2010 to 2020 – the methodology used for the *UMDI Interim 2020 Estimates* assumes that:

- the *distribution* of combined net migration and deaths by age and sex in each city and town *relative to its county* is the same as was experienced between 2000 and 2010,
- the *distribution* of births, deaths, and net migration by five-year age and sex within each county is aligned with Census Bureau estimates by age, sex, and county through 2019,
- the 2010-2019 county-level population changes by age and sex accurately predict the 2020 age/sex proportions when extraploted to 2020, and
- the Census V2019 county level estimates and 2020 PL-94 counts are accurate.

Base Populations for Rates and Ratios

In addition to a launch population, population projection models also require population data to be used in rate or ratio calculations which, in this context, we are calling the base or "endpoint" populations. For the 2010 endpoint population, we take the population counts by age and sex from the decennial Census 2010 Summary File 1 (SF1) file. For the 2020 age/sex endpoint populations, we use the same methodology used to develop the estimated 2020 *launch* population except that instead of controlling the 2019

[7] CC-EST2019-AGESEX-[ST-FIPS]: Annual County and Puerto Rico Municipio Resident Population Estimates by Selected Age Groups and Sex: April 1, 2010 to July 1, 2019, Source: U.S. Census Bureau, Population Division. Release Date: June 2020.

[8] For additional details on UMDI's modified cohort-change ratio method, see the Methodology section of: *Small Area Population Estimates for 2011 through 2020*, UMass Donahue Institute. October 2016.

[9] "Net migration" in this summary refers to combined Net Domestic Migration and Immigration.

age/sex estimates to the Census 2020 PL-94 count totals, we instead extrapolate the 2010-2019 age/sex time series out to 2020. This variation is applied in order to overcome the instability of the 2020 count observed in many areas of Massachusetts relative to their V2019 and V2021 estimates.[10] While we accept that pandemic-related disruptions in place of residence does affect the starting population in the projections series, we observed that using this off-trend 2020 population point to create a rate -- which is then applied for the next thirty years -- produces unreasonable projections, either inflating or decreasing the expected future populations to levels out of alignment with recent historic trends.

Population estimates for the year 2015, which are used to develop some of the five-year rates used in the model, are developed using this same methodology. For these, we first interpolate age/sex/MCD cohort values from the 2010 Census counts and the 2020 CCR projections, and then control these results to the 2015 age/sex/county values in the Census V2019 county-level population estimates.[11]

Suffolk Region Launch and Base Populations

The Suffolk County study-region is treated slightly differently in the launch and endpoint estimations method. The U.S. Census Bureau's Vintage 2019 age/sex estimates for Suffolk County show a large increase in the age 25-29 cohort since 2010.[12] This could represent real population change, or it could be a by-product of U.S. Census Bureau estimation techniques. Because the post-census estimates are not actual counts and rely on IRS data to estimate migration rates, it is hard to determine. Suffolk County is home to large numbers of college and graduate students – notoriously difficult to capture in the IRS measures - who might have been aged forward in place in the Census Bureau estimates when they should have been out-migrated and replaced with new students instead. The concept of treating college students as a "revolving door" population is called the "college fix", and it is a method applied by the Census Bureau's annual population estimates for many other "college counties." Because Suffolk County is over the population-size threshold for the Bureau's college fix, this method was not applied by the Bureau in our study year.[13] For this reason, UMDI determined, in agreement with the region's MPO, to apply an alternative control method to the Suffolk age cohorts.

To estimate the Suffolk County base cohorts, UMDI starts with the Census 2010 counts of population by age and sex in Suffolk County municipalities, subtracts actual deaths, adds actual births, and applies averaged 2000-2010 net-residual migration rates to each age/sex/MCD cohort to develop a 2015

[10] As published in the Subcounty Resident Population Estimates: April 1, 2010 to July 1, 2020 (SUB-EST2020) and Subcounty Resident Population Estimates: April 1, 2020 to July 1, 2021 (SUB-EST2021). U.S. Census Bureau, Population Division. Release dates: May 2021 and May 2022.

[11] CC-EST2019-AGESEX-[ST-FIPS]: Annual County and Puerto Rico Municipio Resident Population Estimates by Selected Age Groups and Sex: April 1, 2010 to July 1, 2019, Source: U.S. Census Bureau, Population Division. Release Date: June 2020

[12] In the U.S. Census Bureau's V2019 County Characteristics file (CC-EST2019-AGESEX-25) Suffolk County shows the highest increase in population of the 25-to-29-year-old cohort out all counties in the state from July 1, 2010 to July 1, 2019, at 19.6% and with a gain of 16,651 people.

[13] The college fix WAS applied to Hampshire County in the U.S. Census Bureau's V2019 estimates series, another Massachusetts county with a large percent of population enrolled in college in the county.

age/sex estimate. The age/sex estimates are then controlled to the Census Bureau's total 2015 population estimate for Suffolk County. The 2015 age/sex estimates are then used as the launch populations against which the 2000-2010 fertility, mortality, and migration rates by age, sex, and MCD are again applied, resulting in projected 2020 population by age, sex, and MCD. These 2020 projections serve as the endpoint or base populations used to develop the MCD-level migration rates. Consistent with other regions, the projected 2020 age/sex/MCD populations are then controlled to the Census 2020 PL-94 total counts for each MCD to create the 2020 launch populations, against which 2010-to-2020 mortality, fertility, and migration rates are applied going forward. This method assumes that the by-age distribution of migrants in the 2010-to-2020 period is the same that was reflected in the 2000-to-2010 period through the decennial counts, but still allows for updated population totals in both 2015 and 2020.

Deaths and Survival Rates

The first component of change in our regional model 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. For the UMDI V2022 series, the Massachusetts Department of Public Health provided a detailed dataset that included all known deaths in the Commonwealth that occurred between 2010 to the end of calendar year 2019. 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. In the regional model, 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 ten years (2010 to 2019) divided by the base population in 2015 and then raised to the fifth power, or:

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

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. Finally, we estimate the number of eventual survivors in each cohort by 2025 by multiplying the operational survival rate against the cohort 2020 launch population and repeat this process for each successive period. In the model, survival rates are calculated separately for each age group, sex, and county or region.

Migration

Migration is the most dynamic component of change, the most difficult to estimate, and 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.

MIGPUMA Gross-Migration model

The migration approach used in the viable MIGPUMA regions (including Berkshire, Suffolk, and Eastern Massachusetts) are based on a somewhat 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 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) in censuses prior to 2010. 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, however, be tabulated from the ACS PUMS – which is 5% random sample of individual records drawn from the ACS surveys[14]. In our model, we develop migration rates using averaged data from the 2012 to 2019 ACS PUMS, the most recent years available for post-2010 PUMA geographies. [15]

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[16]. Sample sizes can be particularly small

[14] 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 Berkshire region, male and female migrants under the age of 15 are assigned the male/female average number of migrants before a rate is calculated 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.

[15] Due to operational issues with survey responses related to the COVID-19 in the year 2020, the U.S. Census Bureau published ACS data for 2020 on an "experimental" basis only. For more information, see: https://www.census.gov/programs-surveys/acs/data/experimental-data.html

[16] 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 currently. 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

when distributed by age and sex cohorts for different types of migrants, especially in small regions. For this reason, the Berkshire Region results may be treated with more skepticism in our projections results and are subject to greater cross-examination by alternative methods[17]. The Berkshire Region population averaged just 127,648 per year over the 8-year sample period, compared to an average population of 779,927 in Suffolk and 4,942,310 in the Eastern Massachusetts MIGPUMA.

To develop out-migration rates for each cohort, we take the 2012-2019 average of the cohort population *living outside of the MIGPUMA region* and reporting residence one-year-ago *within the MIGPUMA region* divided by the average 2012-2019 MIGPUMA region population. Because current residents of the study region (i) are those who are 'at risk' of moving out, the appropriate cohort (j) migration rate is:

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

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 average single-year rate 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.[18] The operational rate for each cohort is then multiplied against the number of eventual survivors in 2020 to estimate the number of likely out-migrants from the surviving population, and the process is repeated for each successive interval.

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.

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

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

[18] 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 a person can only die once. 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.

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:

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

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

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.

To establish the Northeast and U.S. potential in-migrant populations used in the multi-region gross migration model, UMDI uses a combination of age/sex population projections from the University of Virginia Weldon Cooper Center and the U.S. Census Bureau. The New England regional projections for New York, Connecticut, Rhode Island, New Hampshire are taken from the Weldon Cooper Center's Vintage 2018 population projections, developed for all 50 U.S. States and released in ten-year increments from 2020 through 2040. [19] UMDI modifies Weldon-Cooper's 2020 projection by controlling the age/sex results for each state to their actual 2020 population counts released in the Census 2020 PL-94 dataset. To project past 2040, UMDI developed 2050 projections for these four states by applying a CCR method to the Weldon-Cooper 2030 and 2040 projections by age and sex, developing 2030-to-2040 change ratios for each cohort and applying these to the corresponding 2040 launch population. Child-to-Women ratios were based on 5-year-age groups from 20-24 through 35-39.[20] For the "rest-of-the-nation" population, UMDI subtracted the aggregate New England states from the U.S. Census Bureau's V2017 middle-series ("Main Series") U.S. population projections to 2050 by age and sex.[21] Lastly, populations for years ending in "5" are interpolated from each ten-year projection.

MIGPUMA Model College Fix

Tracking the migration of college students is often problematic for researchers, as neither the ACS nor conventional tax-return migration data – the two "direct measures" of migration - capture their movement

19 University of Virginia Weldon Cooper Center, Demographics Research Group. (2018). National Population Projections. Retrieved from https://demographics.coopercenter.org/national-population-projections

20 91% of U.S. fertility is accounted for in these age groups according to National Center of Health Care Statistics fertility data for 2018.

21 Projected Population by Single Year of Age, Sex, Race, and Hispanic Origin for the United States: 2016 to 2060 File: 2017 National Population Projections Source: U.S. Census Bureau, Population Division Release date: September 2018.

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[22]. 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.

While measuring the movement of college students is less prone to error when using *indirect* methods of calculating migration, as in the net-residual survival approach used in the county-level regions, the Suffolk MIGPUMA region in our model relies upon a *direct* measure of migration (ACS survey data in the PUMS dataset) and also includes a high share of population enrolled in college, and thus merits a college fix in its migration rates.[23]

The UMDI college fix method, like the Census Bureau's, removes the college-enrolled portion of the 15-19, 20-24, and 25-29 age cohorts from aging and migration calculations and then adds it back into its original cohort five years later. We use 2012-2019 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 to the base-year cohort populations 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 U.S. cohort total population in the next projected time interval 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 of the method applied to the 2020-to-2025 period (Figure 8).

Figure 8. College Fix Method Example

2020		2025
non college pop 10-14	*age 5 years and add net migrants 2020-2025→*	non-college pop 15-19
college pop 15-19	*not aged; apply % enrolled to 2025 U.S. population 15-19→*	college pop 15-19
non college pop 15-19	*age 5 years and add net migrants 2020-2025→*	non-college pop 20-24

22 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.

23 32.4% of the cohorts aged 15-29 in the Suffolk County region are enrolled in college or graduate school according to ACS PUMS data for 2012-2019, averaged.

college pop 20-24	*not aged; apply % enrolled to 2025 U.S. population 20-24→*	college pop 20-24
non college pop 20-24	*age 5 years and add net migrants 2020-2025→*	non college pop 25-29
college pop 25-29	*not aged; apply % enrolled to 2025 U.S. population 25-29→*	college pop 25-29
non college pop 25-29	*age 5 years and add net migrants 2020-2025→*	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 make two additional adjustments to our model. First, we allow portions of the college-enrolled cohorts aged 15-19, 20-24, and 25-29 to age forward into the non-college population. This accounts for the college-enrolled population that ages in place into the non-college population (i.e., those that come for college and stay after graduating or un-enrolling). The share of "aging stayers" is determined in our model by calculating the historic change ratios between the non-college cohort in a particular age group to the summed college and non-college cohort populations five years younger and five years earlier.[24] Five-year ratios are calculated for the three historic time periods – 2000 to 2005; 2005 to 2010; and 2010 to 2015 – which are then averaged together and applied to future college-aged cohorts in the region to determine the age-in-place populations. Finally, we account for some portion of the region's non-college population joining the college population elsewhere upon migrating out of the region (i.e., those who leave their homes in Massachusetts to attend college elsewhere in the U.S.) by accounting for the college-enrolled out-migrants captured in the 2012-2019 PUMS data[25].

MIGPUMA Immigration

While the ACS PUMS data provides information on gross *domestic* migration – allowing us to calculate in- and out-migrants distinctly, it cannot be used in the same way for international migration. While it captures the characteristics of recent immigrants -- defined in the survey as having a place of residence outside of the U.S. one year ago – it cannot capture *emigration* in the same way, as people who have moved out of the U.S. are no longer part of the U.S. Census survey frame. For this reason, in our regional model we instead estimate international migration as a single, net component.

Net international migration in our regional model is based on the average annual number of net international migrants estimated for each region in the U.S. Census Bureau's annual county-level population

24 The historic shares of college and non-college populations are determined by applying the 2012-2019 average share of population enrolled in college to each historic age/sex cohort in the 15-29 age cohorts. This method assumes that the regional college enrollment rates of by age and sex in the populations 2000 through 2015 are the same as in the 2012-2019 averages.

25 Out-migrants that are enrolled in college in regions outside of the study area with residence one year ago in the study region, as captured in the 2012-2019 ACS PUMS datasets.

estimates series over the years 2010-2019.[26] Because the annual county-level components-of-change estimates released by the Bureau do not break the components into age/sex cohorts, we take the age/sex shares of *immigrants* reported in the averaged 2012-2019 ACS PUMS data, and apply these to the net international migrant totals for each corresponding region. This method assumes that emigrants in each region – persons leaving the U.S. for other countries – have the same age distribution as immigrants coming into each region.

Another major assumption in this method is that the number of annual net international migrants for each region will persist for the entire forecast horizon and, unlike domestic migration in our model, the estimates of net international migrants are not converted to rates. With domestic migration, we can more comfortably assume 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 assume 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 region's current population will influence future immigration levels, including federal immigration policy change, college recruitment policies, and political disruptions in other parts of the world -- to name just a few. Instead of trying to guess at which way these changes will affect immigration in each region, we assume that the levels experienced in recent history, in this case the 2010-2019 period, will be sustained over the full projection period.

Surviving Stayers

The final step of the MIGPUMA regional 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 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.

County-Level Net Migration Model

As described in the *Defining Regions and Regional Controls* section of this report, some state regions are modeled using ACS PUMS data at the MIGPUMA-level (Suffolk and Berkshire), some are modeled at the county level (Cape and Island and Pioneer Valley Counties), and others are modeled at the county-level before controlling to the MIGPUMA region results (Eastern and Central Massachusetts counties in the Eastern MIGPUMA). While the model for MIGPUMAs incorporates gross-migration data from the ACS PUMS, there exists no direct source of gross migration by age at the county level or below. In the county-level model, migration by age, sex, and county is instead estimated using a residual net migration method that relies on vital statistics and decennial Census data.

26 Annual Resident Population Estimates, Estimated Components of Resident Population Change, and Rates of the Components of Resident Population Change for States and Counties: April 1, 2010 to July 1, 2020 (CO-EST2020-ALLDATA). U.S. Census Bureau Population Division. Release date: May 2021.

Residual Net Migration from Vital Statistics

The residual net migration method is used in the county model 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 county to the county's survived population by age/sex 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.

Determination of Net-Migration Rates

Vital statistics are used to infer total net migration totals for 2010 to 2020 in five-year increments, with migrants then converted to five-year rates and averaged together. To calculate five-year net migration by age, sex, and county, natural increase (births minus deaths) by age/sex for 2010 to 2015 is added to the 2010 population by age/sex for each county. The results are then subtracted from the interpolated 2015 population by age/sex for each county to estimate net migration by age/sex and county from 2010 to 2015. This number of net migrants is then divided by the 2010 base population to calculate a five-year-migration rate for each cohort. This same process is used to calculate migration between 2015 and 2020, dividing the number of calculated, residual migrants over the 2015-2020 period by the 2015 base pop to create a 2015-2020 net migration rate. The two five-year net migration estimates are then averaged together and applied to the corresponding base populations by age and sex to project five-year net migration. The five-year net migration rates are held constant throughout the projection period. The sources for these calculations include MCD-level vital statistics by age and sex aggregated to each county, Census 2010 Summary File data for the 2010 base populations by age and sex, and UMDI estimated 2015 and 2020 populations by age and sex, which are developed using the methods described in the *Base Populations for Rates and Ratios* section of this report.

Because the residual-net-migration method accounts for all migrants over a select period – including domestic in- and out-migrants, net international migrants, and college and non-college population combined -- all of these are modeled in a single net migration rate and without applying a college-fix.

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 county 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 in those regions where control to a MIGPUMA region are reasonable. We also assume that age, sex, and county are the key factors by which migration rates vary. Other non-demographic factors, such as macroeconomic factors or local policy changes, are not explicitly included in this model. To the extent that recent, historic trends in development and economic activity are captured in the regional migration that occurred between 2010 and 2020, these factors are indirectly accounted for. Finally, this model assumes that the rates of net migration by age, sex, and region that occurred between 2010 and 2020 will persist in future years.

Aging the population and generating projections for later years

The last step in generating our first set of five-year forecasts (for year 2025) 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 survived births estimated in the previous step becomes the number of 0-4-year-olds in 2025. The number of persons in the 85+ cohort in 2020 is the number of surviving stayers in the 80-84 age cohort (in 2020) added to the number of surviving stayers in the 85 and older cohort. This process is repeated for all future year projections; the 2025 projection becomes the launch population for estimating the 2030 population, which in turn is used to launch the 2035 population and so-forth.

Births and Fertility

The last component, in both our regional and county-level cohort-component models, involves estimating fertility rates using past data on the number of live births by age and residence of the mother. Births by mothers' age and city or town of residence for years 2010 through 2019 and age cohorts 10-14 through 40-44 are provided by the Massachusetts Department of Public Health and are aggregated for each maternal cohort by county or region. Next, an average annual number of births for each maternal cohort is calculated and multiplied by five to determine the average number of births per five-year period for each age/region cohort. The five-year average births over the 2010-2019 period are then divided by the corresponding 2015 female population by age and region to transform average births into five-year fertility rates. In the model, rates are operationalized by averaging the rate of the current age cohort and the rate of the next older cohort, to account for female cohorts aging up into the next group over the five-year period. Each fertility rate is further allocated into male and female shares of births using a multiplier of 0.512 for male births and 0.488 for female births. Finally, the estimated fertility rates are multiplied against the number of "surviving stayers" female population (after migration and survival rates are applied) in each of the child-bearing age cohorts. This provides an estimate of the number of infants that are anticipated within the next five years, and this number is summed across all maternal age cohorts.

Municipal-Level Methods and Assumptions

MCD-Level Model Overview

Municipal, or "MCD-level" population projections serve as stand-alone output products in the UMDI *V2022 Long-Term Population Projections for Massachusetts Municipalities* series and are also key building blocks in the V2022 MPO-level population projections produced for MassDOT. As described in the regional-level methods section of this report, separate projections are produced for 351 Massachusetts MCDs and for sub-state regions made up of counties or MIGPUMAs. 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. While both the regional and MCD-level projections are prepared using a cohort-component method, the MCD estimates, like the county-level projections, rely on residual net-migration rates computed from vital statistics and decennial Census data, while the MIGPUMA regional projections use gross-domestic-migration rates based on the American Community Survey Public Use Microdata (ACS PUMS).

The cohort-component method is used to account for the effects of mortality, migration, and fertility on population change. 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 2020, with projections made in five-year intervals from 2025 to 2050 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.

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 Table 2 below.

Table 2. Projection Method by Component

Component	Projection
Mortality	Survived population by age/sex
Migration	Net migration by age/sex
Fertility	Births by sex and mother's age
Launch	UMDI's V2019 population estimates controlled to the U.S. Census Bureau's PL94 by age (Under 18 and 18+), sex, and MCD for 2020; five-year projection thereafter

Data Sources

Data sources used in the MCD-Level population projections include *UMDI 2020 Interim Population Estimates by Age, Sex, and Municipality* for launch populations, Census 2010 SF1 data and UMDI estimates for base populations, and births and deaths by place of residence from 2010-2019 provided by the Massachusetts Department of Public Health.

MCD Projections Launch Population

The initial launch population for the 2020 projection is the 2020 PL94 Census population, distributed by age/sex according to the *UMDI 2020 Interim Population Estimates by Age, Sex, and Municipality* for each MCD. [27] Each projection thereafter uses the previous projection as the launch population (i.e., the 2025 projection uses the 2020 projection as the launch population).

MCD Projections Base Population

Where it was necessary to have a 2020 population for the calculation of model rates, a different 2020 population was used. Here, UMDI used a linear extrapolation of the UMDI V2019 population estimates without control to the 2020 PL-94 2020 counts. There are several reasons for this choice. First, due to the disruptive nature of the COVID-19 pandemic during the time when the Census count was taking place, we believe that the rates of change in population in the future will be more like patterns seen pre-pandemic

[27] See the *Determining the launch population and cohort classes* section of this report for additional explanation of the development of launch and rate populations for 2020.

(2010-2019) than what was seen during the height of the pandemic in 2020 while the census was taking place. Second, in the U.S. Census Bureau's *Post-Enumeration Survey* results, there is some evidence that the Massachusetts population was over-counted in 2020.[28] Using a slightly inflated data-point from 2020 to calculate rates could affect future populations by inaccurately increasing migration rates or decreasing fertility rates. Finally, where a "midpoint" 2015 population was needed for a rate calculation, the UMDI V2019 estimates were used, again without control to the Census 2020 PL-94 data.

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 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 calculates five-year survival rates by age, sex, and MCD using deaths by age, sex and MCD from 2010 to 2019 (January 1, 2010 through December 31, 2019) from the Massachusetts Department of Public Health. The formula used to develop each age/sex municipal rate for places with populations over 10,000 is the same as that used at the county and regional levels. We estimate the five-year survival rate for each cohort in study region as one minus the average number of deaths over the past ten years divided by the base population in 2015 and then raised to the fifth power. These survival rates by age, sex and MCD are assumed to be constant for the duration of the projections at the MCD level. Survival rates for each age cohort up to 80-84 are 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.

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 2010 Census, we used regional survival rates by age and sex instead of MCD-specific rates to smooth the results. [29]

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.

[28] https://www.census.gov/library/stories/2022/05/2020-census-undercount-overcount-rates-by-state.html

[29] Regions are defined as Berkshires, Cape & Islands (Barnstable, Dukes, and Nantucket counties), Eastern MA (Essex, Worcester, Plymouth, Norfolk, and Middlesex counties), Pioneer Valley (Franklin, Hampden, Hampshire counties), and Suffolk County.

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 30 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 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 2010 Census population below 2,000, a linear migration assumption (described in the section below) is used to smooth migration.

Determination of Net Migration Rates

Vital statistics are used to infer net migration totals for 2010 to 2019. To calculate five-year net migration by age, sex and MCD, natural increase (births minus deaths) by age/sex for 2010 to 2014 is added to the 2010 population by age/sex for each MCD. The results are then subtracted from the 2015 population by age/sex for each MCD to estimate net migration by age/sex and MCD for 2010 to 2014. A similar process calculates migration between 2015 and 2019.

For MCDs with 2010 population equal to or greater than 2,000, 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 2010 population under 2,000, 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 also 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. Finally, we assume that net migration by age and sex experienced in each MCD in the 2010-to-2020-period (using estimated 2020 values) will persist for the next 30 years.

MCD Projections: 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 distribution of total births to male and female births 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 using seven maternal age groups (10-14 through 40-44). For each cohort, the sum of births over the period 2010-2019 divided by two gives average births over a five-year period.

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, in this case, the 2015 values from the UMDI V2019 population estimates. 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 2010 Census, we used regional[30] fertility rates by age and sex instead of MCD-specific rates to smooth the results[31].

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[30] Regions are defined as Berkshires, Cape & Islands (Barnstable, Dukes, and Nantucket counties), Eastern MA (Essex, Worcester, Plymouth, Norfolk, and Middlesex counties), Pioneer Valley (Franklin, Hampden, Hampshire counties), and Suffolk County.

[31] 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 for an earlier (V2015) population projections series, and we apply town-specific fertility rates to these instead of the regional rates normally applied for very small towns. The criteria used to identify "college bedroom" towns included: 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 the use of

Key Assumptions

We assume age, sex and MCD to be adequate indicators of fertility rates for MCDs. 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.

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 age/sex population 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.

Race and Ethnicity

The UMDI V2022 Population Projections series includes population projections by age, sex, race, and ethnicity for each of the MPO regions. The methodology for these involves developing future race by ethnicity shares for each MPO age/sex cohort by using a cohort-change-ratio model, and then applying these shares to the age/sex/MPO projections developed by the methodologies described earlier in this report. This section describes the methodology used to develop the UMDI V2022 population projections by race and ethnicity, as well as the limitations and assumptions associated with these projections.

Defining Race and Ethnicity Categories

As a first step in producing population projections by age, sex, race, and ethnicity, UMDI first identifies the aggregate categories of race-by-ethnicity cohorts to be used in the projections. While the U.S. Census Bureau reports up to 126 race/ethnicity combinations from the decennial count in the full PL-94 dataset, UMDI limits the projections to seven broad categories in order to 1) reduce error associated with using very small cohorts and 2) align the projections with other datasets commonly published to describe race and ethnicity.[32] While the race groups represented in the UMDI V2022 projections are not representative of all of the race groupings possible using Census count data, these groups are consistent with the categories used by the U.S. Census Bureau's Population Division in their U.S. Population Projections series and in their annual county-level population estimates by race and ethnicity, with one exception; the UMDI categories combine all races with Hispanic origin into a single "Hispanic of Any Race" while the Census Bureau's county-level estimates report each of the 6 race groups by both Hispanic and Non-Hispanic. The

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.

[32] The U.S. Census Bureau's full PL-94 dataset includes five minimum distinct race categories including White, Black or African American, American Indian or Alaska Native, Asian, and Native Hawaiian or Other Pacific Islander, plus a "some other race" response category, and a "two-or-more" category that yields that yields 57 possible combinations, for a total of 63 race-alone or in-combination categories, each further classed by Hispanic or non-Hispanic ethnicity.

combined Hispanic-of-Any-Race cohort represents 12.6% of the total Massachusetts population in the 2020 Census.

Table 3 below displays the race/ethnicity aggregations used in the Census Bureau's *2020 PL-94 Table P1*, the U.S. Census Population Estimates released annually by the U.S. Census Bureau's Population Division for each U.S. county, the U.S. Census Bureau's Population Projections series, and the categories selected for the UMDI V2022 series, along with each grouping's percentage share of the total Massachusetts population in 2020, rounded to the nearest 0.1%.

Table 3. Race and Ethnicity Aggregations in Common-Use Datasets and Massachusetts Percent of Population by Race and Ethnicity in 2020

Percent of Total MA Pop. 2020	Census 2020 PL 94 Table P1		Census Annual Estimates	Census U.S. Population Projections	UMDI V2022 Projections
67.7%	Non-Hispanic	White Alone	White Alone	White alone	White alone
6.5%	Non-Hispanic	Black or African American Alone	Black or African American Alone	Black or African American Alone	Black or African American Alone
0.1%	Non-Hispanic	American Indian and Alaska Native Alone	American Indian and Alaska Native Alone	American Indian and Alaska Native Alone	American Indian and Alaska Native Alone
7.2%	Non-Hispanic	Asian Alone	Asian Alone	Asian Alone	Asian Alone
0.0%	Non-Hispanic	Native Hawaiian and Other Pacific Islander Alone	Native Hawaiian and Other Pacific Islander Alone	Native Hawaiian and Other Pacific Islander Alone	Native Hawaiian and Other Pacific Islander Alone
1.3%	Non-Hispanic	*Some other Race Alone*	-	-	-
4.7%	Non-Hispanic	Two or More Races	Two or More Races	Two or More Races	Two or More Races
12.6%	Hispanic	Hispanic of any race	*Each x Hispanic or Non-Hispanic*	Hispanic of any race	Hispanic of any race

Race and Ethnicity Projections Model

This section describes the data sources and steps used to develop the V2022 race projections.

Data Sources

To develop a cohort-change-ratio model for each MPO, cohort populations must be established for both 2000 and 2010 for each MPO. These are developed by establishing MCD-level cohorts for both time periods that are then summed to their corresponding MPOs.

The source for the 2000 and 2010 MCD-level cohorts is the Census Summary File 1 data with "some other race" populations reassigned to one of the six race categories treated in this model. As shown in Table 3 above, decennial Census data is first released with a "some other race" category, however this category may be considered a "response category" as versus an OMB classification. To align Census responses with OMB categories, the Census Bureau develops a "Census Modified Race Summary File" after each decennial census to re-distribute Census race responses to the OMB categories that are used in the Bureau's post-censal population estimates. The summary file redistributes the races by each age/sex/race cohort distinctly for each U.S. county. UMDI uses this same *Census Modified Race Summary File* to distribute "some other race" to the defined race categories at the municipal level.

The source for 2020 age/sex/race/MCD populations follows the same cohort-change-ratio or "modified Hamilton-Perry" method that was used to develop the 2020 launch and base "endpoint" populations for the age/sex estimates except that a race/ethnicity component is added to each age/sex cohort used in the formula.[33] Essentially, 2000-to-2010 change ratios by age, sex, race, ethnicity, and MCD are calculated for each cohort reported in the Census 2000 and 2010 Summary File 1 datasets (after race-redistribution) and these ratios are then applied back to the 2010 age/sex/race/ethnicity base populations to project 2020 cohort populations by age, sex, race, and ethnicity. The resulting projections are then controlled to the Census Bureau's V2019 county-level estimates by age, sex, race, and ethnicity and are then either 1) controlled again to the PL-94 population counts to determine the 2020 *launch* populations or 2) extrapolated one year further to 2020 to determine the 2020 *"endpoint"* population that are used to calculate the updated, 2010-to-2020 change ratios that will be applied to all subsequent decades in the model.

To reiterate the difference between the two distinct 2020 populations used in this model; the *launch* population used as the starting population for 2020 forward is controlled to the PL-94 population by race and ethnicity counted in the 2020 Census while the *endpoint* or *base* population used to develop the 2010-to-2020 change ratio is not, but, rather, is an extrapolation of the 2010-to-2019 trend.

The rationale for using a different population for the launch as versus for the rate or ratio is described elsewhere in this report and is essentially an effort to overcome inconsistencies caused by the COVID-19 pandemic in the specific 2020 count year as compared to the longer-term trends that unfolded over the course of the decade. In the case of race assignment, there are additional factors that suggest that a race distribution based on the 2010 Census will serve as a more reasonable endpoint for calculating the rates of change. Between decennial Census counts, there always exist variations in how individuals self-identify and self-report race from one decade to the next. Between the 2010 and 2020 Censuses, there are additional variations in how race was recorded in the actual Census survey and, as a result, how specific responses were recoded into race categories by the U.S. Census Bureau. One major change was that the 2020 Census questionnaire allowed additional space for write-in responses below race categories, which then had to be recoded to one of the six official Census categories. As an example of how this worked in the 2020 count, a person who checked "White" as race and then wrote in "Cuban" would have been recoded as "White" and "some other race" -- since "Cuban" is not a race by OMB standards, but a

[33] See the *Determining the launch population and cohort classes* section of this report for a more detailed explanation of the cohort-change-ratio method.

nationality. This respondent would then be counted in the "Two-or-more" race category[34]. As a result, where the Census PL-94 data for 2020 shows a dramatic increase in the "Two-or-more" race category, it is unclear how much of this increase is due to an actual change in the population and how much is due to the change in the Census questionnaire. For the applied purpose of developing ten-year-change rates, we have more confidence in the Census Bureau's V2019 county-level estimates series, which builds off of the Census 2010 count base, maintaining the same race-assignment standards, and updating population with actual birth, death, and IRS migration records -- many of which are linked to other sources of race reporting within the Bureau's internal processing protocols.

Application of Cohort-Change Ratio Method

Once the MCD-level cohorts have been established for 1) the 2010 base population, 2) the 2020 base population, and 3) the 2020 launch population, these cohorts are aggregated to MPO-level age/sex/race cohorts[35]. A 2010-to-2020 (base) cohort change ratio is developed for each cohort and then applied to its corresponding 2020 launch population to develop a projection to 2030.[36] Next, each age/sex/race cohort's share of the projected age/sex/race/MPO total cohort is calculated, and this share is finally applied to the age/sex/MPO projection already developed through the cohort-component models described earlier in this report. The resulting "controlled" 2030 race projections are then used as the new launch populations to project again to 2040, using the same 2010-2020 change ratios, and the steps are repeated to project to 2050.

Race Projections Limitations and Assumptions

While all population projections are limited by both the quality and accuracy of data inputs and the assumptions used in the model, projections by race and ethnicity, by age and sex, are likely to be more inaccurate and unstable over time. In addition to the great variability in migration by age over time that affects all cohort projections, populations by race are also subject to several unpredictable variations including:

- changes in an individuals' racial self-identification over time;
- changes due to refugee or asylum resettlements in specific communities;
- changes in national immigration policy;

[34] See: Census.gov/ Random Samplings: *Improvements to the 2020 Census Race and Hispanic Origin Question Designs, Data Processing, and Coding Procedure*. U.S. Census Bureau, August 03, 2021. Accessed on November 16, 2022 at: https://www.census.gov/newsroom/blogs/random-samplings/2021/08/improvements-to-2020-census-race-hispanic-origin-question-designs.html

[35] Age/sex/race/ethnicity cohorts are sometimes described as "age/sex/race" or "race" cohorts in this report for expediency.

[36] The mechanisms of a cohort-change ratio model are described in more detail in both the *Data Sources* and the *Determining the launch population and cohort classes* sections of this report.

- shifts in fertility and mortality by race as populations assimilate; and
- changes to the Census questionnaire in 2020 compared to 2010.

In addition to these external variations, the projections methodology itself also encompasses several assumptions. Some of these key assumptions include the following:

- This method assumes that the *Census Modified Race Summary File* at County level developed for 2010 represents an accurate redistribution of "some other race" reported in the Census in both 2010 and 2020; and that
- the re-distribution of "some other race"-by-age and sex in municipalities is the same as in their parent counties, as estimated in the *Census Modified Race Summary File;*
- the cohort-change ratios by age/sex/race and region – which capture migration, death, and fertility from one Census to the next – experienced from 2010 to 2020 will persist in future years;
- the cohort-change-ratios experienced from 2000-2010 by MCDs *relative to their counties* have persisted through 2020;
- the Census V2019 age/sex/race/county estimates are an accurate reflection of 2019 populations;
- the 2010-to-2019 trends in population change by age/sex/race/county reflected in the Census V2019 estimates accurately predicted the change from 2019 to 2020;
- the 2010 and 2020 Census accurately counted populations by race and age; and
- children generated by the CCR method are the same race as their mothers (some may actually be two or more).

For these reasons, together with the limitations of the age/sex projections, researchers are cautioned to treat the race projections as modeled projections only, and not as certain predictors of future populations.

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.

Appendix A: Crosswalk of Municipalities by County and MPO Region

MCD	County	MPO Code	MPO
Abington	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Acton	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Acushnet	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Adams	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Agawam	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Alford	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Amesbury	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Amherst	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Andover	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Aquinnah	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Arlington	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Ashburnham	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Ashby	Middlesex	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Ashfield	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Ashland	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Athol	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Attleboro	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Auburn	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Avon	Norfolk	OCPC	OLD COLONY PLANNING COUNCIL
Ayer	Middlesex	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Barnstable	Barnstable	CCC	CAPE COD COMMISSION
Barre	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Becket	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Bedford	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Belchertown	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Bellingham	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Belmont	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Berkley	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Berlin	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Bernardston	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Beverly	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Billerica	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS

Blackstone	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Blandford	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Bolton	Worcester	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Boston	Suffolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Bourne	Barnstable	CCC	CAPE COD COMMISSION
Boxborough	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Boxford	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Boylston	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Braintree	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Brewster	Barnstable	CCC	CAPE COD COMMISSION
Bridgewater	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Brimfield	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Brockton	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Brookfield	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Brookline	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Buckland	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Burlington	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Cambridge	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Canton	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Carlisle	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Carver	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Charlemont	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Charlton	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Chatham	Barnstable	CCC	CAPE COD COMMISSION
Chelmsford	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Chelsea	Suffolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Cheshire	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Chester	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Chesterfield	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Chicopee	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Chilmark	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Clarksburg	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Clinton	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Cohasset	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Colrain	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Concord	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Conway	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Cummington	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Dalton	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION

Danvers	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Dartmouth	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Dedham	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Deerfield	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Dennis	Barnstable	CCC	CAPE COD COMMISSION
Dighton	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Douglas	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Dover	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Dracut	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Dudley	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Dunstable	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Duxbury	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
East Bridgewater	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
East Brookfield	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
East Longmeadow	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Eastham	Barnstable	CCC	CAPE COD COMMISSION
Easthampton	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Easton	Bristol	OCPC	OLD COLONY PLANNING COUNCIL
Edgartown	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Egremont	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Erving	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Essex	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Everett	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Fairhaven	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Fall River	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Falmouth	Barnstable	CCC	CAPE COD COMMISSION
Fitchburg	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Florida	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Foxborough	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Framingham	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Franklin	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Freetown	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Gardner	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Georgetown	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Gill	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Gloucester	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Goshen	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Gosnold	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Grafton	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION

Granby	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Granville	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Great Barrington	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Greenfield	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Groton	Middlesex	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Groveland	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Hadley	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Halifax	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Hamilton	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Hampden	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Hancock	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Hanover	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Hanson	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Hardwick	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Harvard	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Harwich	Barnstable	CCC	CAPE COD COMMISSION
Hatfield	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Haverhill	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Hawley	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Heath	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Hingham	Plymouth	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Hinsdale	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Holbrook	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Holden	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Holland	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Holliston	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Holyoke	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Hopedale	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Hopkinton	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Hubbardston	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Hudson	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Hull	Plymouth	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Huntington	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Ipswich	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Kingston	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Lakeville	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Lancaster	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Lanesborough	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Lawrence	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION

Lee	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Leicester	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Lenox	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Leominster	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Leverett	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Lexington	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Leyden	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Lincoln	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Littleton	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Longmeadow	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Lowell	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Ludlow	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Lunenburg	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Lynn	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Lynnfield	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Malden	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Manchester	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Mansfield	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Marblehead	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Marion	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Marlborough	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Marshfield	Plymouth	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Mashpee	Barnstable	CCC	CAPE COD COMMISSION
Mattapoisett	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Maynard	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Medfield	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Medford	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Medway	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Melrose	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Mendon	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Merrimac	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Methuen	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Middleborough	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Middlefield	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Middleton	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Milford	Worcester	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Millbury	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Millis	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Millville	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION

Milton	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Monroe	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Monson	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Montague	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Monterey	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Montgomery	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Mount Washington	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Nahant	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Nantucket	Nantucket	NPEDC	NANTUCKET PLANNING & ECONOMIC DEVELOPMENT COMMISSION
Natick	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Needham	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
New Ashford	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
New Bedford	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
New Braintree	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
New Marlborough	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
New Salem	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Newbury	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Newburyport	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Newton	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Norfolk	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
North Adams	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
North Andover	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
North Attleborough	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
North Brookfield	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
North Reading	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Northampton	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Northborough	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Northbridge	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Northfield	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Norton	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Norwell	Plymouth	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Norwood	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Oak Bluffs	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Oakham	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Orange	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Orleans	Barnstable	CCC	CAPE COD COMMISSION
Otis	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Oxford	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Palmer	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION

Paxton	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Peabody	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Pelham	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Pembroke	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Pepperell	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Peru	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Petersham	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Phillipston	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Pittsfield	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Plainfield	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Plainville	Norfolk	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Plymouth	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Plympton	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Princeton	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Provincetown	Barnstable	CCC	CAPE COD COMMISSION
Quincy	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Randolph	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Raynham	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Reading	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Rehoboth	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Revere	Suffolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Richmond	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Rochester	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Rockland	Plymouth	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Rockport	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Rowe	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Rowley	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Royalston	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Russell	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Rutland	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Salem	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Salisbury	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
Sandisfield	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Sandwich	Barnstable	CCC	CAPE COD COMMISSION
Saugus	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Savoy	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Scituate	Plymouth	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Seekonk	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Sharon	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL

Sheffield	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Shelburne	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Sherborn	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Shirley	Middlesex	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Shrewsbury	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Shutesbury	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Somerset	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Somerville	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
South Hadley	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Southampton	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Southborough	Worcester	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Southbridge	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Southwick	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Spencer	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Springfield	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Sterling	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Stockbridge	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Stoneham	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Stoughton	Norfolk	OCPC	OLD COLONY PLANNING COUNCIL
Stow	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Sturbridge	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Sudbury	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Sunderland	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Sutton	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Swampscott	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Swansea	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Taunton	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Templeton	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Tewksbury	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Tisbury	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Tolland	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Topsfield	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Townsend	Middlesex	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Truro	Barnstable	CCC	CAPE COD COMMISSION
Tyngsborough	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Tyringham	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Upton	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Uxbridge	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Wakefield	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL

Wales	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Walpole	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Waltham	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Ware	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Wareham	Plymouth	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Warren	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Warwick	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Washington	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Watertown	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Wayland	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Webster	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Wellesley	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Wellfleet	Barnstable	CCC	CAPE COD COMMISSION
Wendell	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Wenham	Essex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
West Boylston	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
West Bridgewater	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
West Brookfield	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
West Newbury	Essex	MVPC	MERRIMACK VALLEY PLANNING COMMISSION
West Springfield	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
West Stockbridge	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
West Tisbury	Dukes	MVC	MARTHA'S VINEYARD COMMISSION
Westborough	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Westfield	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Westford	Middlesex	NMCOG	NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS
Westhampton	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Westminster	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Weston	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Westport	Bristol	SRPEDD	SOUTHEAST REGIONAL PLANNING & ECONOMIC DEVELOPMENT DISTRICT
Westwood	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Weymouth	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Whately	Franklin	FRCOG	FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS
Whitman	Plymouth	OCPC	OLD COLONY PLANNING COUNCIL
Wilbraham	Hampden	PVPC	PIONEER VALLEY PLANNING COMMISSION
Williamsburg	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Williamstown	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Wilmington	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Winchendon	Worcester	MRPC	MONTACHUSETT REGIONAL PLANNING COMMISSION
Winchester	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL

Windsor	Berkshire	BRPC	BERKSHIRE REGIONAL PLANNING COMMISSION
Winthrop	Suffolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Woburn	Middlesex	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Worcester	Worcester	CMRPC	CENTRAL MASSACHUSETTS REGIONAL PLANNING COMMISSION
Worthington	Hampshire	PVPC	PIONEER VALLEY PLANNING COMMISSION
Wrentham	Norfolk	MAPC	METROPOLITAN AREA PLANNING COUNCIL
Yarmouth	Barnstable	CCC	CAPE COD COMMISSION