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Methodological Differences in Census Programs

This white paper reviews the three following census programs: Decennial Census, Population Estimates Program's (PEP) Annual Estimates of the Resident Population, and the American Community Survey (ACS). The paper examines the differences between the programs and how their methodologies affect Boston population estimates.

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Methodological Differences in Census Programs

The United States Census Bureau's mission is to be the leading source of quality data about the nation's people and economy. It conducts over 130 surveys and population counts including the decennial census, Population Estimates Program's (PEP) Annual Estimates of the Resident Population, and the American Community Survey (ACS). These programs are similar in that they provide population counts/estimates, but each program uses a different methodology to generate its population total. This report describes key components of these methodologies to help explain how each program can produce different population totals for the same year.

Figure 1 shows these three census programs' population estimates for Boston since 1990. The decennial census provides population counts for 1990, 2000, and 2010. The PEP provides yearly estimates from its 1999, 2009, and 2018 Vintages, while the ACS provides estimates from 2006 to 2017. The 2005 ACS estimate does not contain Boston's group quarters population. Starting in 2006, the ACS estimate contains Boston's total population.

The methodologies of the three census programs are related. The previous decennial census provides the starting point for the intercensal ACS and PEP estimates. During the decade after the decennial census, survey and administrative data are used to estimate changes to Boston's population from the previous census count. The PEP and ACS share data, and their methodologies produce their population estimates based on these administrative and survey data.

These programs are independent of the next decennial census. After completing the 2020 Census, this process will start again with the PEP and ACS using the 2020 Census as the starting point for their intercensal population estimates, and the Census Bureau will start preparing for the 2030 Census.

Boston's Population Estimates 1990 to 2018
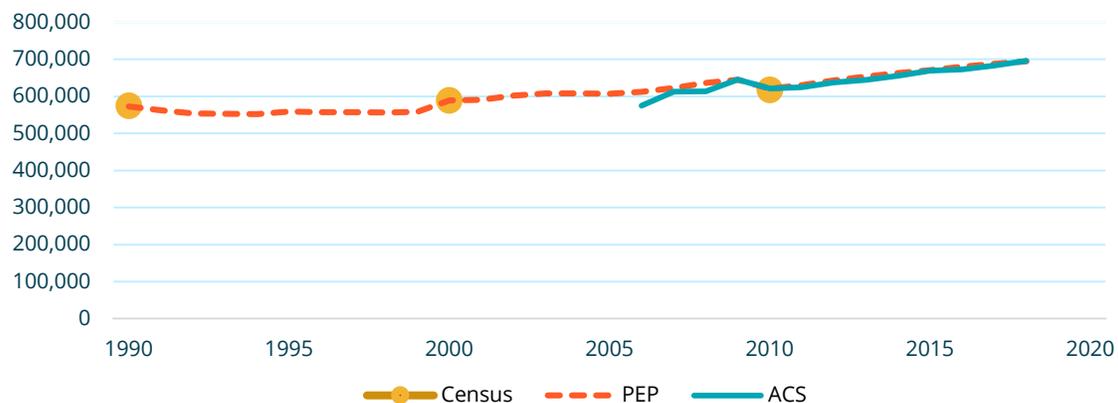
Sources: 1990, 2000 & 2010 Decennial Census, Vintage 1999, 2009 & 2018, Annual Estimates of the Resident Population, and 2006-2018 American Community Survey, BPDA Research Division Analysis

## Decennial Census: Population as of April 1, 2020

The decennial census is the Census Bureau's most comprehensive effort to count the population, but after its release provides the least current population total. The Census Bureau has a constitutional mandate (Article I, Section 2) to count the U.S. population for apportionment of taxes and representation in the House of Representatives. The census methodology attempts to count residents in the United States on April 1st of every year ending in 0. People are counted based on their usual place of residence. Usual place of residence is defined as the place where a person lives and sleeps most of the time.

Nearly 60% of Boston's census tracts are located in Census Bureau designated hard-to-count areas. A hard-to-count area is defined as having 73% or less of households in an area return a mailed census questionnaire. The 2010 Census mailed questionnaire return rate was 74% nationally, but only 71% for Suffolk County. Map 1 shows this response rate for Boston's census tracts. Excluding tracts that have little or no population, the response rate ranges from 54.1% in tract 1001 in Dorchester to 85.6% in tract 1203.01 in Jamaica Plain.

Hard-to-count populations include people who are highly mobile, racial and ethnic minorities, non-English speakers, low-income, undocumented immigrants, or distrustful of the government. This hard-to-count designation is associated with areas containing two large components of Boston's population: foreign citizens and college students.

MAP 1

2010 Census Mailed Questionnaire Response Rate by Census Tracts

Mail Return Rate
- 54.0% - 64.9%
- 65% - 69.1%
- 69.2% - 73%
- 73.1% - 77.6%
- 77.7% - 85.6%
- Little or No Population
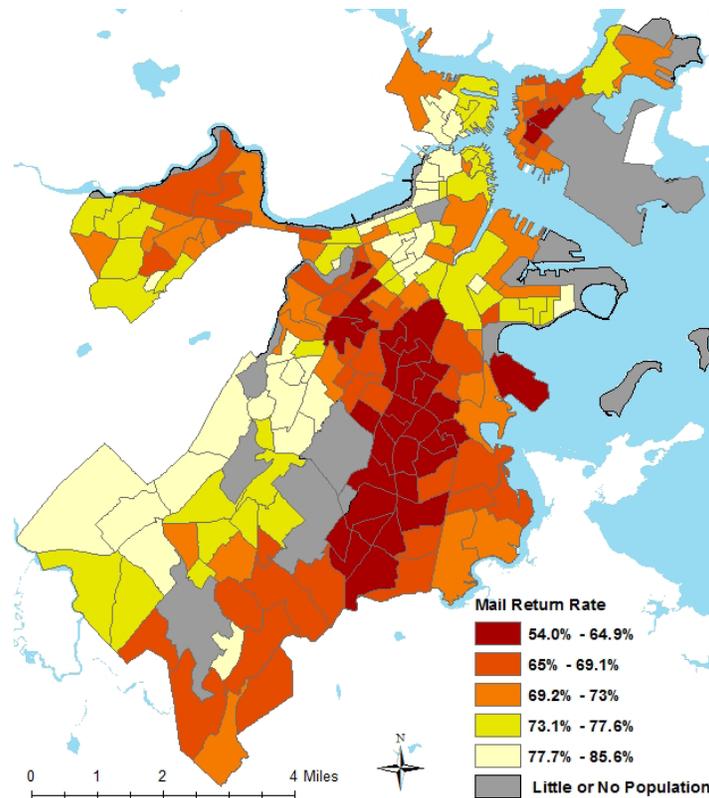
Sources: Census Bureau's Planning Database, 2010 Mail Return Rates, BPDA Research Division Analysis

People visiting the United States, such as those on a vacation or business trip, are not counted in the census because they do not fit the residency definition. All residents of the United States, including those who are foreign born, should complete a census questionnaire. However, the foreign born have several characteristics that may influence their compliance with returning a census questionnaire. One or a combination of the hard-to-count characteristics (such as lack of English proficiency) could prevent foreign-born residents from being correctly enumerated by the decennial census methodology.

College students are another hard-to-count population because they are mobile and may not reside in Boston for the entire year. The census methodology requires college students to be counted at the on- or off-campus residence where they live and sleep most of the time on April 1st. This date occurs when colleges are in session. Some college students could choose not to respond to the census questionnaire in Boston and not be correctly enumerated by the decennial census methodology.

The Census Bureau's Non-Response Follow-Up (NRFU) operation has the task of completing a questionnaire for all nonresponding households. The NRFU schedules up to six in-person visits to these nonresponding households. If these attempts are unsuccessful, administrative records or proxies are used to determine if the address is a valid housing unit and if so, its occupancy status and household size. The United States Postal Service (USPS), the Internal Revenue Service (IRS), and the Centers for Medicare and Medicaid Services are examples of institutions whose administrative records are used in this process. Examples of proxies include immediate neighbors, landlords/real estate agents, and utility workers. When administrative and proxy data cannot be found, the Census Bureau imputes the household status and size of a housing unit. The Census Bureau imputed a household status and size for less than 0.5% of housing units in the 2010 Census.

The NRFU also identifies the characteristics of the household count from administrative or proxy data for households that failed to complete a census questionnaire. Complete individual characteristics (age, race/Hispanic origin, sex, tenure, relationship) for household members are more difficult to obtain from administrative or proxy data. After the NRFU operation was completed for the 2010 Census, at least 90% of each characteristic was reported. The missing characteristics of household members were imputed from addresses with a similar household size in the same census tract.

Because the decennial census contains imputed information, the Census Bureau conducts a post-census test to check the count's accuracy. This approach involves a case-by-case matching of persons in the Census Coverage Measurement (CCM), a post-census survey, with persons in the census to determine who was missed or counted in error.

Even though the 2010 census had a national net over count of 0.01%, 36,000[1] people, the CCM estimated that Boston had an undercount of 7,200[2] persons and 5,600[3] housing units. This undercount was within the CCM's acceptable statistical range, and thus the Census Bureau has statistical confidence in Boston's population of 617,594 and housing units of 272,481 in 2010.

The national components of this post-census evaluation demonstrate how the over- and under-counts help explain Boston's 2010 Census population count. The Census Bureau estimated the United States had a net undercount of:
- 2.06% for the black alone-or-in-combination population.
- 1.54% for the Hispanic population.
- 0.08% for Asian alone-or-in-combination population.
- 1.09% for renters

All populations above but the Asian alone-or-in-combination had statistically significant results.

The Census Bureau estimated the United States had a net over count of:
- 0.83% for the Non-Hispanic White population.
- 0.57% for homeowners

Both of these had statistically significant results. Even with a possible population and housing undercount for Boston, the decennial census provides the most accurate population information because of the resources employed to count the population in each housing unit in the country. However, this information was representative for only one day, April 1, 2010. The Population Estimates Program and American Community Survey methodologies described below used this population count in their methodologies to estimate the population after 2010.

Population Estimates Program: Annual Estimates of the Resident Population

The Census Bureau's Population Estimates Program (PEP) produces Annual Estimates of the Resident Population as of July 1st for the nation, states, counties, and cities and towns (county subdivisions). The PEP annually utilizes birth, death, and migration data to produce these time-series estimates of the population. Each year an estimate for the most recent July 1st population is generated, and all estimates of previous years back to the decennial census are updated. Prior estimates remain available and are cataloged by vintage. Additionally, housing unit estimates are produced for the nation, states, and counties, but not for cities or towns.

The PEP methodology uses natural change and net migration data in producing its population estimates. Natural change represents the difference between births and deaths. Net migration represents the difference between persons entering and leaving a region. These two components explain the population change over time.

The PEP methodology uses a variety of administrative and survey data sources:

- The National Center for Health Statistics provides both birth and death data.
- Domestic migration for the population 0-17 and 18-64 uses Internal Revenue Service (IRS) and Social Security Administration (SSA) data.
- Medicare enrollment data are used for the population 65 and older.
- International immigration is divided between native- and foreign-born migrations. The ACS provides both of these estimates of immigration.

- Foreign-born emigration estimation uses a residual method from a combination of two years of Mexican-, Canadian-, European-, Asian-, and other-born populations.
  - Asian migration is measured over 5-year intervals; Canadian, European, and other born are measured over 10-year intervals;
  - Mexican migration is measured over both 10-year and more than 10-year intervals.
- Puerto Rican migration estimates use both ACS and the Puerto Rican Community Survey (PRCS) data.

All other native-born emigration is estimated from migration records from over 80 countries.

- The Defense Department provides data on net movement of the armed forces.

The PEP first estimates the number of housing units in which people reside using a "top-down approach" for the national total. All subsequent estimates for regions of the country sum to this national housing total. The PEP housing unit estimates are produced by accounting for new residential permits and any new mobile homes, minus housing unit loss since the 2010 Census housing count. A national average for housing completions is applied to new building permits to account for new housing units. A regional housing loss rate is applied to the existing housing units based on the housing stock's age to account for any demolitions. The PEP uses the same method for state and county estimates, but each of these areas is controlled so that they sum to the state and national total. The PEP provides no housing estimates for a county subdivision like Boston.

Following this "top-down approach" methodology, the PEP next generates a national then state, and county population estimates by age, sex, race and ethnicity. Starting with the 2010 population, births are added, deaths are subtracted, and net domestic and net international migration are added to produce the national household population.

The PEP estimates the group quarters population through self-reported changes in the population by institutional and non-institutional facilities to the Federal-State Cooperative for Population Estimates (FSCPE), at the University of Massachusetts' Donahue Institute. These data are from sources like the medicare.gov website, the MA Department of Correction, and student housing from each college or university in the state. Changes to the household and group quarters populations inform each year's national population estimate. The same methodology is used for state and county estimates. The state estimates are controlled to sum to the national estimate, and the county estimates within a state are controlled to its state's population.

A different methodology other than the "top-down approach" produces Boston's population estimate. As described above, Suffolk County's housing unit total is produced. As a county subdivision, Boston's Inspectional Services Department (ISD) reports new building permits to the Massachusetts FSCPE. The PEP applies a national housing completion rate to Boston's building permits. Any new mobile home delivered to Boston accounts for changes in mobile homes. A regional housing loss estimate is applied to the existing housing stock by age. These changes and those reported by Chelsea, Revere, and Winthrop contribute to Suffolk County's housing estimate.

With Boston's share of Suffolk County's housing units estimated, the PEP multiplies Boston's estimated housing units by the 2010 Census occupancy rate and persons per household to produce the uncontrolled household population for Boston. The PEP next applies a "raking factor" to Boston's uncontrolled estimates, along with those for Chelsea, Revere, and Winthrop to ensure that they sum to the previously released Suffolk County population estimate.

As previously mentioned, the PEP relies on institutions to submit group quarters data. The PEP starts with the 2010 decennial group quarters population for Boston. It receives annual group quarters updates from data submitted by the Donahue Institute. This updated group quarters population is added to the household population to produce each year's Annual Estimates of the Resident Population for Boston.

The PEP updates the prior year's population estimates based on updated administrative data. Table 1 shows each vintage estimate from 2011 to 2018 to show changes to the PEP estimates over time. The PEP estimates can be used to identify the actual year-to-year population change reported in the most recent set of estimates, as well as cross-vintage changes that reflect updates to past estimates. Because the most recent vintage contains the most accurate population estimates for each year, it contains the actual population change where the cross-vintage estimate contains older data that are not as accurate as the most recent vintage estimates.

TABLE 1

2011 to 2018 Vintages of Boston's Population Estimates

Vintage	Year									Change	
	2010	2011	2012	2013	2014	2015	2016	2017	2018	*Actual*	*Cross Vintage*
2011	617,147	625,087									
2012	620,223	628,335	636,479							1.3%	1.8%
2013	620,451	629,064	637,845	645,966						1.3%	1.5%
2014	620,598	630,645	640,839	649,917	655,884					0.9%	1.5%
2015	620,623	630,286	642,031	651,710	660,278	667,137				1.0%	1.7%
2016	620,701	630,195	641,911	651,090	659,180	665,984	673,184			1.1%	0.9%
2017	620,702	630,072	641,955	652,039	661,103	669,255	678,430	685,094		1.0%	1.8%
2018	621,074	630,480	643,003	653,103	663,017	670,791	680,470	688,276	694,583	0.9%	1.4%

Source: 2011-2018 PEP Vintages of the Annual Estimates of the Population, BPDA Research Division Analysis

For example, the population change from 2017 to 2018 is the difference between 694,583 and 688,276, not the cross vintage difference from 2017, 685,094. The degree of this cross-vintage change due to updated population estimates in the vintages is highlighted by the updates to the 2011 population in each vintage.

In Vintage 2011, Boston's population estimate is 625,087. By Vintage 2018, the 2011 estimate increased by 5,393 to 630,480. This is a 0.86% increase in Boston's population due to updated administrative data that more accurately estimates the population.

The Census Bureau considers the most recent 2018 PEP estimates the most accurate after the decennial census. The PEP provides no estimate of error but instead provides yearly updates of its estimates. This lack of reported error should not be interpreted as the absence of error in the PEP methodology. These PEP population estimates provide the best information available about Boston's population growth since the 2010 census. These updates to the 2011 population show that these estimates have some degree of error when released, and they can be revised. By not using sample data, no statistical error can be estimated. As the 2020 Census approaches, it is not known how close next year's 2019 PEP estimate will be to the number eventually reported in the 2020 Census. From the previous decades in Figure 1, the 1999 population estimate was lower than the 2000 census count, and the 2009 population estimate was higher than the 2010 census count. The resources used for the 2020 Census will provide the most accurate data on the U.S. population. Not until the release of the 2020 Census will the magnitude of the error in the PEP's Annual Estimates of the Resident Population be known.

American Community Survey (ACS)

The ACS was designed to replace the decennial census' long-form data (SF3 and SF4 in the 2000 Census). The ACS has three primary purposes:

1. Understand the characteristics of the population for local planning needs,
2. Make comparisons across areas
3. Assess change over time.

A complete ACS was first released in 2006.[4] The ACS reports both 1- and 5-year estimates. Any 5-year ACS will be more precise (a smaller margin of error) but less current than any 1-year ACS.

The ACS uses a survey methodology that is different from the decennial census and the PEP methodologies to obtain its estimates. The decennial census counts the population on April 1st of a decennial year. The PEP uses administrative and survey data to estimate the population of July 1st every year. The ACS, as its name implies, is a population survey over a specific time period.

A major difference in the decennial and ACS methodologies is the residency definition. The census residency definition is the place where a person lives and sleeps most of the time. The ACS residency definition requires a person to live in a surveyed household for at least two months prior to the interview. Everyone living in a group quarters on the day of the ACS interview is eligible to be surveyed. Depending on the time of year, these residency definitions play a role in surveying Boston's college student and other young adult populations. College students may leave Boston after the academic year ends. In addition, Boston's college student population is not evenly distributed among its neighborhoods. The housing stock in some neighborhoods attracts more mobile young adults. As a result of these patterns, the ACS methodology may influence neighborhood population estimates compared to those generated by the decennial census.

The ACS sampling methodology randomly selects addresses from the Census Bureau's Master Address File (MAF). Any person selected for an ACS interview lives in a household or group quarters randomly selected from this MAF. Each year, the ACS randomly surveys 2.5 percent of households in the United States. Persons can be interviewed through a mailed survey, telephone interview, or in-person visit. An ACS interview takes approximately one hour to complete. The ACS is collected on most days of the year, and the results are evenly distributed over a 12-month period. Any 1-year ACS is representative of Boston's population over that year and is not linked to any specific day as are the decennial census and PEP.

The randomly selected ACS data have two important statistical properties. The sample data can be generalized to the population by a weighting technique. The ACS first assigns household weights from each household's probability of being selected. It then develops person weights from each individual's probability of being in a sampled household or in a group quarters. Also, the ACS estimates have statistical properties that can produce a margin of error (MOE). This MOE is a measure of the possible variation of an estimate around the population estimate. The 2018 ACS population estimate for Boston is 695,926 with a MOE of +/-3,776. This means that the ACS is 90% confident the true number of people in Boston during 2018 is somewhere 3,776 greater or less than 695,926.

Boston's ACS household weights are derived from several factors, including survey non-response and interview method (mail, telephone, or in-person). Boston's weighted housing unit total conforms to the PEP's housing unit estimate for Suffolk County. Boston's weighted ACS population estimate is linked to its weighted housing unit total.

Boston ACS person weights are derived from surveyed people residing in Boston's housing units and group quarters. The household and group quarters population are independently estimated. The group quarters component of the total estimate is a combination of persons residing in institutional and non-institutional facilities. The household population is estimated by controlling for a combination of household characteristics. These include people who are married or in two-person relationships; those who are householders but not in one of these relationships; and the remainder of the population. These sample data are controlled for by age, sex, race/Hispanic origin to conform to the population estimates for the county, state, and nation.

The 5-year ACS weighting is similar to the 1-year ACS but adds information from 5 years from the PEP's latest vintage to refine its estimates and MOEs. These administrative records are linked to actual ACS records. These 5-year ACS weights are then calibrated so that weighted administrative record totals match the age and sex populations over the latest PEP vintage. The reason that the 5-year ACS is not an average of the five previous ACSs is that the PEP revises Boston's annual population estimates. The 5-year ACS factors in these revised 1-year PEP population estimates, but the 1-year ACS is already released and is never revised.

Conclusion

Different Census Bureau programs provide discrete population estimates for Boston in any given year in which they are conducted. The reason that these population estimates differ is that the programs have different methodologies that produce population estimates for different points or periods of time in reference. Understanding how these methodologies are implemented helps to better identify how the census programs population estimates for Boston differ.

Citations

1   U.S. Census Bureau. Census Coverage Measurement Estimation Report: Net Coverage for the Household Population in the United States.

2   U. S. Census Bureau. 2010 Census Coverage Measurement Person Results for Boston city, MA. https://www.census.gov/coverage_measurement/pdfs/massachusetts/plc2507000.pdf

3   U. S. Census Bureau. 2010 Census Coverage Measurement Housing Unit Results for Boston city, MA https://www.census.gov/coverage_measurement/pdfs/massachusetts/huplc2507000.pdf

4   The 2005 ACS was released for areas of the nation with a population greater than 65,000, but it did not contain group quarters population in its estimates.