



Virginia Population Projections Methodology

This document describes in detail the steps involved in developing projections for the Commonwealth of Virginia and its 133 localities—95 counties and 38 independent cities—for 2020, 2030, and 2040. We use a combination of exponential growth, linear extrapolation, and Hamilton-Perry method to derive the projections. The state population total is from the national projections, also developed by the Weldon Cooper Center's Demographics Research Group. The remaining state population characteristics for Virginia are aggregate sums of projections for each of the 133 localities.

The results consist of projections for the following:

- Total population
- By age (18 age-groups at 5-year intervals: 0-4, 5-9, 10-14 ... 80-84, and 85+)
- By sex
- By race and ethnicity (Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic Other, Hispanics)

Data:

The following input data at the locality level are used,

- 2000 census total, by age, by race and ethnicity
- 2010 census total, by age, by sex, by race and ethnicity
- 2015 estimate by Weldon Cooper Center total

Projecting Total Population

The total population for each locality is calculated individually, and then raked according to the state control total.

Approach for 2020 total population:

- Calculating exponential population growth rate for each of the 133 localities, using data from 2010 and 2015.

$$LocalityPopulation_{2015} = LocalityPopulation_{2010} * e^{r*5.25}$$

which implies the rate is

$$r = \frac{1}{5.25} * \ln\left(\frac{LocalityPopulation_{2015}}{LocalityPopulation_{2010}}\right)$$

- Calculating the projected locality population for 2020 from exponential growth, using 2015 as the launch year,

$$LocalityPopulationExp_{2020} = LocalityPopulation_{2015} * e^{r*4.75}$$

- Setting the final locality level population projection for 2020, by redistributing the state control total,

$$LocalityPopulation_{2020} = \frac{LocalityPopulationExp_{2020}}{\sum_{Locality} LocalityPopulationExp_{2020}} * StatePopulation_{2020}$$

Approach for 2030 and 2040 total population:

- Calculating the annualized growth between 2000 and 2015, and applying it to the decade,

$$LocalityExpectedGrowth = (LocalityPopulation_{2015} - LocalityPopulation_{2000}) * \frac{10}{15}$$

- Calculating the projected locality population for 2030 from linear extrapolation,

$$LocalityPopulationLin_{2030} = LocalityPopulation_{2020} + LocalityExpectedGrowth$$

- Setting the final locality level population projection for 2030, by redistributing the state total,

$$LocalityPopulation_{2030} = \frac{LocalityPopulationLin_{2030}}{\sum_{Locality} LocalityPopulationLin_{2030}} * StatePopulation_{2030}$$

- Calculating the projected locality population for 2040 from linear extrapolation,

$$LocalityPopulationLin_{2040} = LocalityPopulation_{2030} + LocalityExpectedGrowth$$

- Setting the final locality level population projection for 2040, by redistributing the state total,

$$LocalityPopulation_{2040} = \frac{LocalityPopulationLin_{2040}}{\sum_{Locality} LocalityPopulationLin_{2040}} * StatePopulation_{2040}$$

Projecting Age and Sex Distribution

The age distribution for each locality is constructed using the Hamilton-Perry cohort-component method.

- Generating CPRs (child population ratio) and CCRs (cohort change ratio) for every age cohort within each locality, using data from 2000 and 2010.

For cohorts 0-4 and 5-9, CPRs capture the birth rates in the prior decades. We divide the child population by the appropriate population of child-bearing age to generate the CPRs.

$$CPR_{0-4}^{2000-2010} = \frac{LocalityPopulation_{0-4}^{2010}}{LocalityPopulation_{15-44}^{2010}} \quad \& \quad CPR_{5-9}^{2000-2010} = \frac{LocalityPopulation_{5-9}^{2010}}{LocalityPopulation_{20-49}^{2010}}$$

For cohorts 10-14, 80-84, 85+, CCRs measure the combined effects of deaths and migration. We use the ratio of population in an age-group (a) in one decade, to the population in age-group ($a-10$) in the previous decade, to calculate CCRs.

$$CCR_{Age Cohort}^{2000-2010} = \frac{LocalityPopulation_{Age Cohort}^{2010}}{LocalityPopulation_{Age Cohort-10}^{2000}}$$

- Calculating the locality population by age for 2020 from Hamilton-Perry age forwarding, using data from 2010 and locality specific CPRs and CCRs.

$$\begin{aligned} LocalityPopulation_{Age Cohort}^{HP2020} &= \frac{LocalityPopulation_{Age Cohort}^{2010}}{LocalityPopulation_{Age Cohort-10}^{2000}} * LocalityPopulation_{Age Cohort-10}^{2010} \\ &= CCR_{Age Cohort}^{2000-2010} * LocalityPopulation_{Age Cohort-10}^{2010} \end{aligned}$$

Now the total population of the locality for 2020 from Hamilton-Perry method can be calculated by summing across all age-cohorts,

$$LocalityPopulation_{HP2020} = \sum_{Age Cohorts} LocPopulation_{Age Cohort}^{HP2020}$$

- Calculating the locality's population for 2020 for each age-interval, by redistributing the total population for 2020 as per the age-distribution from Hamilton-Perry method.

$$LocalityPopulation_{Age Cohort}^{2020} = \frac{LocalityPopulation_{Age Cohort}^{HP2020}}{LocalityPopulation_{HP2020}} * LocalityPopulation_{2020}$$

To accommodate for the age-structure, each of the 65+ intervals are distributed according to their Hamilton-Perry shares but must add up to the Virginia aggregate for these older cohorts. The remaining age groups are re-distributed as per their shares in the residual of from the localities total population.

- Calculating the projected state population for 2020 by each age cohort, from summing the projected locality populations for 2020 by each age cohort.

$$VAPopulation_{Age Cohort}^{2020} = \sum_{Locality} LocalityPopulation_{Age Cohort}^{2020}$$

This yields the projected age distribution for Virginia's overall population in 2020.

- This process is repeated for 2030 and 2040 by applying the Hamilton Perry age forwarding to the locality population in the immediately preceding decade, and using this age distribution to redistribute the previously calculated locality total projections. The state projected population for Virginia by age for 2030 and 2040 is similarly calculated by summing over the projected age categories across all the localities.
- Projections by sex are determined by maintaining the population's age-specific sex-ratio as per the 2010 census. Since sex-ratios are historically stable, this ensures that localities with unique sex-

distribution (prisons, military barracks etc.) can retain their characteristics. The sex-ratio is applied to the projected population in each age cohort within each locality, for 2020, 2030 and 2040. The male and female population groups within each age cohort are then summed across all the localities, to get the population projections by sex for Virginia as a whole.

Projecting Race and Ethnicity

Based on the racial and ethnic categories of the Census and the data user's need, race and ethnicity projections were prepared in the following categories: Hispanics, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, and finally Non-Hispanic Other (which is a residual constructed by combining the people who identify as "Two or more races", "American Indian and Alaska Native", "Native Hawaiian and Other Pacific Islander", "Some Other Race Alone" in addition to being Not Hispanic or Latino).

The age-race-specific distribution for each locality's population is aggregated to a more stable regional level in order minimize random fluctuation and increase data robustness.

- Generating regional CPRs (child population ratio) and CCRs (cohort change ratio) for every age cohort by race/ethnicity, using data from 2000 and 2010.

For cohorts 0-4 and 5-9, CPRs capture the birth rates by region in the prior decades. We divide the child population by the appropriate population of child-bearing age to generate the CPRs.

$$RegionalCPR_{0-4}^{2000-2010} = \frac{RegionalPopulation_{0-4}^{2010}}{RegionalPopulation_{15-44}^{2010}} \quad \& \quad RegionalCPR_{5-9}^{2000-2010} = \frac{RegionalPopulation_{5-9}^{2010}}{RegionalPopulation_{20-49}^{2010}}$$

For cohorts 10-14, 80-84, 85+, regional CCRs measure the combined effects of deaths and migration. We use the ratio of population in an age-group (a) in one decade, to the population in age-group ($a-10$) in the previous decade, to calculate CCRs.

$$RegionalCCR_{Age\ Cohort}^{2000-2010} = \frac{RegionalPopulation_{Age\ Cohort}^{2010}}{RegionalPopulation_{Age\ Cohort-10}^{2000}}$$

- Locality population by age and race/ethnicity for 2020 can be calculated from Hamilton-Perry age forwarding, using the regional CPRs and CCRs. For each locality, within each age cohort. The age projections can then be distributed as per the Hamilton-Perry shares generated across the 5 race/ethnicity categories.
- Projected state population for 2020 by each race/ethnic group within an age cohort is obtained by from summing the race/ethnicity projections for each locality.
- The process is repeated for generating the 2030 and 2040 projections for the localities and the state.