POPULATION PROJECTIONS FOR MARYLAND AND ITS JURISDICTIONS:

A GUIDE TO THE METHODS USED

1. Introduction

This document provides an overview of population projection methods, their underlying assumptions, and their suitability for different planning and policy contexts. The goal is to enhance understanding of how population projections are developed and used, especially in the context of state and local planning in Maryland.

It explains the concept of population projections and how they differ from related terms like estimates and forecasts. It introduces various projection methodologies, including deterministic and probabilistic projection methods, and evaluates their strengths, limitations, and applicability to different policy settings. In addition, it describes the specific methodologies used by the Maryland Department of Planning's State Data and Analysis Center (SDAC) staff to produce population projections for the state, its jurisdictions, and municipalities.

This resource is intended for planners, policymakers, researchers, and community stakeholders who rely on population projections to inform decision-making. It also provides a useful guide to anyone interested in learning about projection methodologies and how they are used in anticipating future population change.

2. Understanding Population Projections

Definition and distinction from forecasts and estimates

Population projections, estimates, and forecasts each give us different types of information about population characteristics. Population projections are computations of changes in population size at a given date based on some assumptions about future trends in the rates of fertility, mortality and migration. Population projections do not try to predict future population but show what the population would be if a set of assumptions holds true. Estimates, on the other hand, show the size and characteristics of a population at a present or past period. Forecasts are a special type of projection where the assumptions are chosen because they are believed to be the most likely to occur. In other words, forecasts aim to predict what population is expected in the future. While all forecasts are projections, not all projections are forecasts: projections can be made for both past and future dates, but forecasts are always about the future.

Common uses in policy, planning, and research

Projections have several uses in planning, policy, and research. One of the uses involves preparing for future demands of social infrastructure in areas such as education, healthcare, transportation, public safety, housing, and recreation. For instance, state and local agencies in Maryland, such as the Department of Education and county school districts, rely on projections of school-age children to plan for future school enrollment. In areas like Charles County with a growing population, projections guide decisions about building new schools or upgrading and expanding existing facilities. Similarly, projections of the population help inform statewide and local planning for the care of elderly people, including expanding healthcare facilities, increasing home-based services, and strengthening social support programs. In addition, fast-growing counties use projections to plan for future recreational needs, such as developing new multi-use trails, sports complexes, and public waterfront access to serve residents as communities grow in population.

Projections can be used as a marketing tool to invest in certain locations. In Howard County with a growing population and highly educated workforce, projections can help to promote development in key business hubs such as Columbia Gateway and Maple Lawn, which draw tech companies, life sciences firms, and professional services. In Southern Maryland counties like Charles and Calvert, projections showing steady increases in commuter populations and new residents can support efforts to attract grocery stores, healthcare centers, and shopping malls that meet the needs of both long-time residents and new families. Similarly, in Baltimore City, projections can support efforts to revitalize neighborhoods and encourage small business investment in areas targeted for redevelopment.

Projections can serve as early warnings, helping communities prepare for future changes. For instance, if projections show potential future population loss in places like Baltimore City, planners can develop strategies to stabilize housing markets, support current residents, and prevent economic decline. If projections show more young families moving to areas like Howard or Frederick County, public health departments can start preparing by expanding maternity care services for mothers and newborns, adding more pediatric care, and making sure children have access to vaccinations.

3. Overview of Projection Methodologies

3.1 Deterministic Models

Deterministic projection methods are used to estimate future population based on fixed assumptions. These methods deal with uncertainty in a subjective way by exploring a few possible scenarios, but they do not include a statistical measure of uncertainty or random variations[1]. They assume vital rates (e.g., birth rates, death rates, or migration rates) will follow a certain path and then calculate what the population will be if those assumptions hold true. Common deterministic methods include the cohort-component method and trend-based methods.

Cohort-component method

Cohort-component method is a projection technique that calculates total, household, or group quarters population by age, race, and sex groups based on separate allowances for the components of population change i.e., fertility, mortality and migration. This method has an advantage in understanding the ways population change by making explicit assumptions on fertility, mortality, and migration. It is widely used, thus allowing for comparability among different sets of projections produced across states in the United States.

Trend-based methods

Trend-based methods use observed patterns or trends from past population changes to estimate future population changes. Using these methods does not require separate data by individual component of population change. Instead, these methods rely on historical values and overall trends observed over time. Trend-based methods may be categorized into mathematical extrapolation models, share-based projection methods, and moving average method.

Mathematical extrapolation

Mathematical extrapolation is one of the commonly used techniques within trend-based projection methods. This approach involves the use of mathematical equations or fitting curves to estimate future population given the population data from one or more past censuses. There are several examples of mathematical extrapolation models including:

- Arithmetic growth model – a method which assumes that there is a constant amount of increase to the population each period.

  The formular is expressed as: $P_t = P_0 + (r \times t)$

  where P_t is population at time t, P_0 is the starting population, r is the growth rate, and t is the period

[1] Uncertainty is the level of accuracy that might be expected for population projections or the extent to which current population projections might conform to future patterns of changes in fertility, mortality and migration. It recognizes that we cannot fully know the future. One common way to assess uncertainty is by using different scenarios. Scenarios are alternative population projections developed by using different assumptions about future trends in fertility, mortality, or migration.

- Geometric growth model – a method that multiplies the population by a constant growth rate each period.

$$P_t = P_0 \times (1 + r)^t$$

where P_t is population at time t, P_0 is the starting population, r is the growth rate, and t is the period
- Exponential growth model – a method which assumes continuous compounding of growth over time.

$$P_t = P_0 \times e^{rt}$$

where P_t is population at time t, P_0 is the starting population, e is the mathematical constant ≈ 2.71828, r is the growth rate, and t is the period
- Linear regression – a method that fits straight line to historical population data, assuming the trend patterns will continue.

$$P_t = a + (b \times t)$$

where P_t is population at time t, 'a' is the starting population, 'b' is the slope or average annual change in population, and t is the period
- Polynomial regression – a method that fits a curved trend to historical population data.

$$P_t = a + b_1 \times t + b_2 \times t^2 + b_3 \times t^3 + \cdots + b_n \times t^n$$

where P_t is population at time t, 'a' is the starting population, b_1 to b_n are coefficients from fitted data, t is the period, and n is the degree of the polynomial.

Share-based projection methods

These methods assume that the share (or proportion) of a population in a smaller area (e.g., a county or municipality) relative to a larger region (e.g., a state) will remain constant or change gradually over time.. They use ratios or proportions rather than fitted mathematical equations. Types of share-based projections methods include:

- Constant ratio – assumes that an area's share (e.g., a municipality's share) of a larger region's population will remain the same over time.

- Share-of-growth – distributes projected growth to smaller areas (e.g., counties or municipalities) based on their share of total growth of a larger region observed in a recent historical period.

- Shift-share method – distributes projected growth in a local area by decomposing it into components that reflect statewide or national growth (the "share" effect) and local deviations from those broader trends (the "shift" effect). This allows analysts to distinguish between changes driven by general trends and those resulting from area-specific factors.

Moving average

The Moving average is a trend-smoothing projection technique. It calculates the average of past values (e.g., population counts or growth rates) over a fixed number of years (e.g., 5-year or 10-year averages) to smooth out short-term fluctuations and project future values. It is often used for projections based on local historical trends, without considering how the area compares to broader regional or state patterns.

3.2 Probabilistic Models

Probabilistic methods estimate future population by taking uncertainty into account through statistical methods like standard error and confidence interval. Instead of giving just one number (or outcome) per scenario in the case of deterministic methods, probabilistic methods show a range of possible outcomes. For example, they might say there is a high chance the population in 2050 will be between 10 and 11 million people. Probabilistic population forecasting methods are divided into three broad approaches, namely expert-based methods, statistical/ time-series methods, and ex-post/ historical error analysis.

Expert-based methods

Expert-based methods involve two broad steps. First, a panel of experts – such as demographers, economists, and public health officials – is selected for their specialized knowledge and experience to provide subjective probability distributions for key projection inputs (e.g., birth and death rates)[2]. In the second step, these inputs are combined and used in simulations to generate a range of possible future scenarios, capturing the uncertainty and variability in projections[3].

Time-series methods

Time series methods rely on historical time series data – like birth or death rates over time – to estimate a statistical time series model. This model is then utilized in simulations to produce a range of possible future scenarios, reflecting the uncertainty and variability in projections.

Unlike expert-based methods which are grounded in expert judgement, time series methods combine both data-driven (objective) and expert-informed (subjective) approaches, relying

[2] A probability distribution refers to a range of possible values that a population variable (such as total population, births, or migration) might take in the future, along with the probability or likelihood assigned to each of those values. It helps express the uncertainty in projections by showing not just what might happen, but how likely each outcome is.

[3] Simulation means using computer models to explore how the population might change in the future. It works by repeating the same steps many times while allowing for different assumptions or random changes each time.

more heavily on the objective side. In other words, they mainly use actual historical data to build statistical models. While expert judgment might still play a role in selecting models or interpreting results, the process is mostly guided by what the data shows.

Ex-post/ historical error analysis

Ex-post analysis assumes that current projections may have similar types and patterns of errors as those observed in historical projections. In ex-post analysis, the errors found in past projections are analyzed and used to estimate uncertainty in current projections. These past errors help create uncertainty intervals around a new projection that was produced using another method.

3.3 Comparative Summary of Methods, their Strengths, Limitations and Suitability for Different Policy Contexts

In summary, deterministic methods generally use fixed assumptions, address uncertainty by exploring a few scenarios, and generate one outcome per scenario. On the other hand, probabilistic methods use statistical models and historical data to simulate a wide range of likely future outcomes, address uncertainty statistically with a range of outcomes and confidence levels and generate a full distribution of possible outcomes.

Deterministic methods are relatively easy to implement, although they are often critiqued as not incorporating statistical or probabilistic validity. Nevertheless, in practice, deterministic methods, especially the cohort-component method – which give one outcome per scenario – often give results similar to what we would get from probabilistic models, as long as the population analyzed is large (typically over 100,000 people). This is because, with large populations, the random variation (or “noise”) that probabilistic models try to capture becomes relatively small, so the straightforward deterministic approach still gives a good approximation.

Probabilistic methods have several strengths, including statistical rigor in accounting for uncertainty and offering a clearer picture of possible variation and risk. They are also well-suited for distant time horizons. However, these methods can be more complex to implement. In addition, projection users sometimes expect agencies to provide alternative scenarios, so they can choose the one that conforms to their own assumptions. Unfortunately, probabilistic methods are unconditional, meaning they do not easily allow adjustments to reflect different assumptions about future changes in demographic rates.

Projection methods generally differ with respect to their assumptions, data requirements and level of complexity. The choice of a suitable projection method also depends on the policy context, such as data availability, geographical scale, length of time, and the need to address uncertainty. Long-term strategic planning is best supported by more comprehensive projection techniques, such as the cohort-component method or probabilistic models, which rely on detailed demographic data and explicitly incorporate the main components of population change (fertility, mortality, and migration).

In situations where detailed data is limited, especially for short-to-medium term projections, trend-based methods like moving averages, linear regression, or share-based approaches (e.g., constant ratio or share-of-growth) can provide immediate projections for planning purposes. For smaller areas such as municipalities or districts with limited or unreliable data, share-based methods and expert-based approaches may be more appropriate. These rely on proportions or expert knowledge rather than detailed component data, making them feasible for local-level planning.

Additionally, public communication may influence method selection. In this case, simpler models that produce a single outcome per scenario (such as basic deterministic or trend-based methods) are often preferred, as they are more straightforward and easier for non-technical audiences to understand.

4. Methodology Used by Maryland Department of Planning

4.1 *Mandate or legal basis*

The Maryland Department of Planning is mandated by state law to prepare and revise population projections for the state and its 24 jurisdictions (Maryland Code, State Finance and Procurement, Section 5-306). This responsibility is carried out by the Maryland Department of Planning's State Data and Analysis Center (SDAC).

4.2 Model Framework

SDAC uses the cohort-component model to calculate population projections for the state and its jurisdictions at five-year intervals by age, sex, and race. The cohort-component method is rooted in the demographic balancing equation (a basic formula used to calculate how a population changes over time by incorporating births, deaths, and migration).

For example, a balancing equation for a five-year interval is expressed by the formula:

$$P_{t+5} = P_t + B_{t,t+5} - D_{t,t+5} + M_{t,t+5}$$

Where:

P_{t+5} is the population at the end of five years,

P_t is the starting population,

$B_{t,t+5}$ is the count of births during the five-year period,

$D_{t,t+5}$ is the number of deaths during the five-year period, and

$M_{t,t+5}$ is the number of in-migrants minus out-migrants during the five-year period

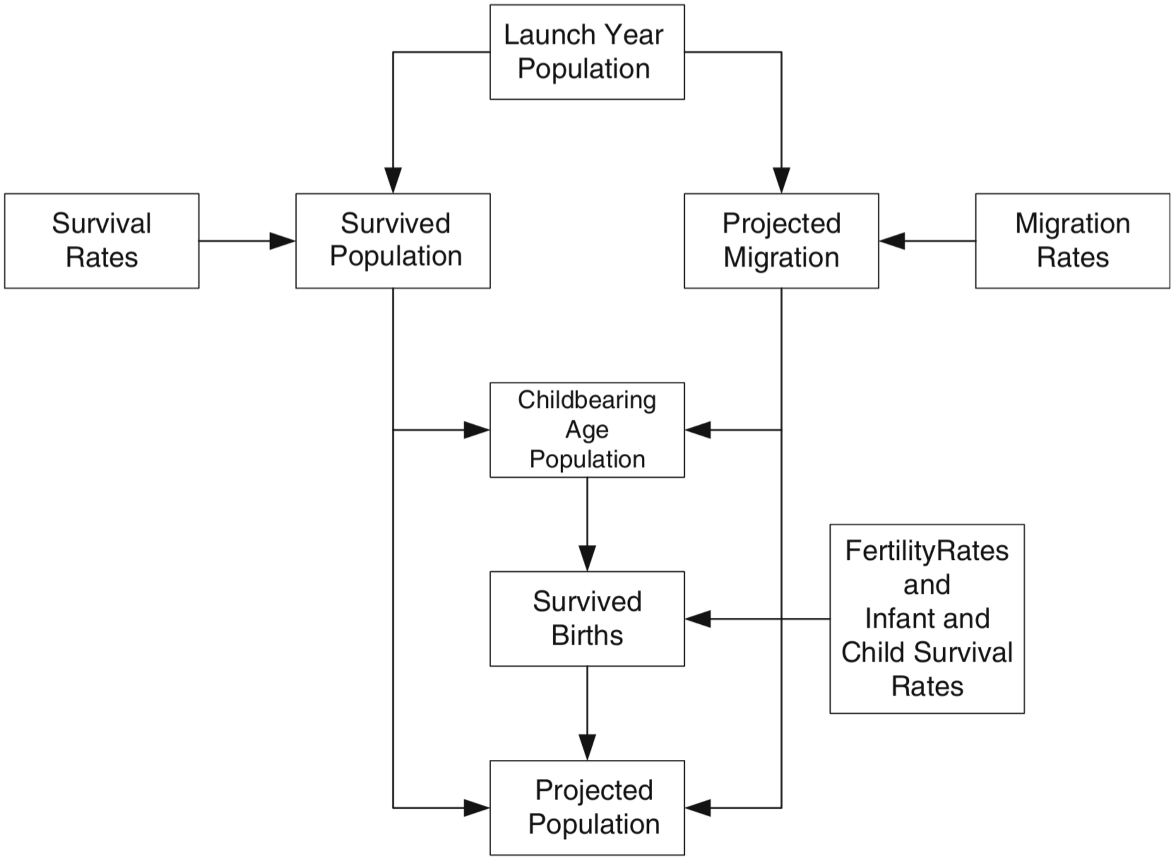
Consistent with the demographic balancing equation, the cohort-component method accounts for the components of population change (i.e. fertility, mortality and migration) as well as the population composition by age, sex, and race. To illustrate, figure 1 below outlines the steps the SDAC follows in implementing the cohort-component method.

The initial population is divided into age-, race-, and sex-specific cohorts. SDAC classifies race and ethnicity into four groups (Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Other, and Hispanic) and age into 18 distinct categories (five-year age groups from 0-4 to 80-84, and 85 and above) for male and female populations. Next, SDAC applies cohort-specific survival rates to the starting population, which generates the number of persons moving forward to the next age-, race-, and sex-specific group.

For each population subgroup, the number of children age 0–4 years depends not only on survival, but also on how many babies are born. To project the size of the youngest age group, SDAC applies age-, race-, and sex-specific fertility rates to the female population of childbearing ages. SDAC then incorporates migration data by applying migration rates to the survived population of each cohort.

SDAC uses Microsoft Excel to organize the data that goes into the model followed by a Fortran-based computer model that generates population projections – including total, household, and group quarters – for each jurisdiction, disaggregated by age, sex, and race.

SDAC uses a bottom-up approach to project Maryland's total population. Projections by age, sex, and race are first developed using the cohort-component method and aggregated to produce totals for each of the 24 jurisdictions. These jurisdictional totals are then summed to generate the statewide population projection. The current set of projections produced by SDAC spans a 35-year period from 2020 to 2055.



Source: Smith, S. K., Tayman, J., & Swanson, D. A. (2013). A practitioner's guide to state and local population projections.

Fig. 1. Overview of the cohort-component method

Data inputs

- Total and Group Quarters Population. Population counts by age, race, and sex for each jurisdiction, including both total and group quarters populations.
- Household Population. This is defined as the total population minus the group quarters population under age 65.
- Fertility Rates. Estimated and projected fertility rates by age, race, and sex are developed for each jurisdiction in five-year intervals, beginning with the base year and extending through the projection period.
- Survival Rates. Estimated and projected survival rates by age, race, and sex are prepared for each jurisdiction at five-year intervals from the base year through the projection period.
- Migration Rate. Migration rates by age, race, and sex are estimated for each jurisdiction in five-year intervals starting from the base year through the projection period.

- Group Quarters (GQ) Population. Data are sourced from the Decennial Census. The GQ population includes individuals living under care, custody, or supervision in facilities operated or owned by an organization[4]. These include:
    - Correctional facilities (e.g., prisons, detention centers, halfway houses)
    - Care institutions (e.g., nursing homes, hospices, residential schools for individuals with disabilities)
    - Student housing
    - Military quarters
    - Other non-institutional group settings (e.g., homeless shelters, group homes, residential treatment centers)

Data Sources and Model Assumptions:

Fertility

To calculate fertility rates, we use two main data sources:

1. The Maryland Department of Health for data on live births by jurisdiction, categorized by the mother's age, sex of the child, and race.
2. The Census Bureau's Decennial Census and the annual Population Estimates for data on female household populations

We calculate age-specific fertility rates separately for male and female births. The age-specific fertility rate for each five-year age group (from 15–19 to 40–44) is computed as the number of live births to women in that cohort divided by the total number of women in the same age group.

Researchers at the U.S. Census Bureau have speculated that over the next 100 years, fertility rates would converge for all racial-ethnic groups[5]. Below is a chart illustrating the convergence of age-specific fertility rate patterns for all women in the years 2020, 2040, 2060, 2080 and 2100. Consistent with this assumption, we have updated our projections to reflect a smaller gap (about 35 percent) between the fertility rates of Non-Hispanic White and minority racial-ethnic groups over the projection period.

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[4] Group Quarters (GQ) populations are not projected separately for each jurisdiction. Instead, a proportion of the statewide GQ projection is distributed across jurisdictions. This proportion is based on a jurisdiction's 2020 share of the state GQ population for each age, sex, and race cohort.

[5] For more details on the assumption of linear convergence, see pages 4 and 5 of the Census Bureau's methodology and assumption at https://www.census.gov/data/tables/2023/demo/popproj/2023-summary-tables.html

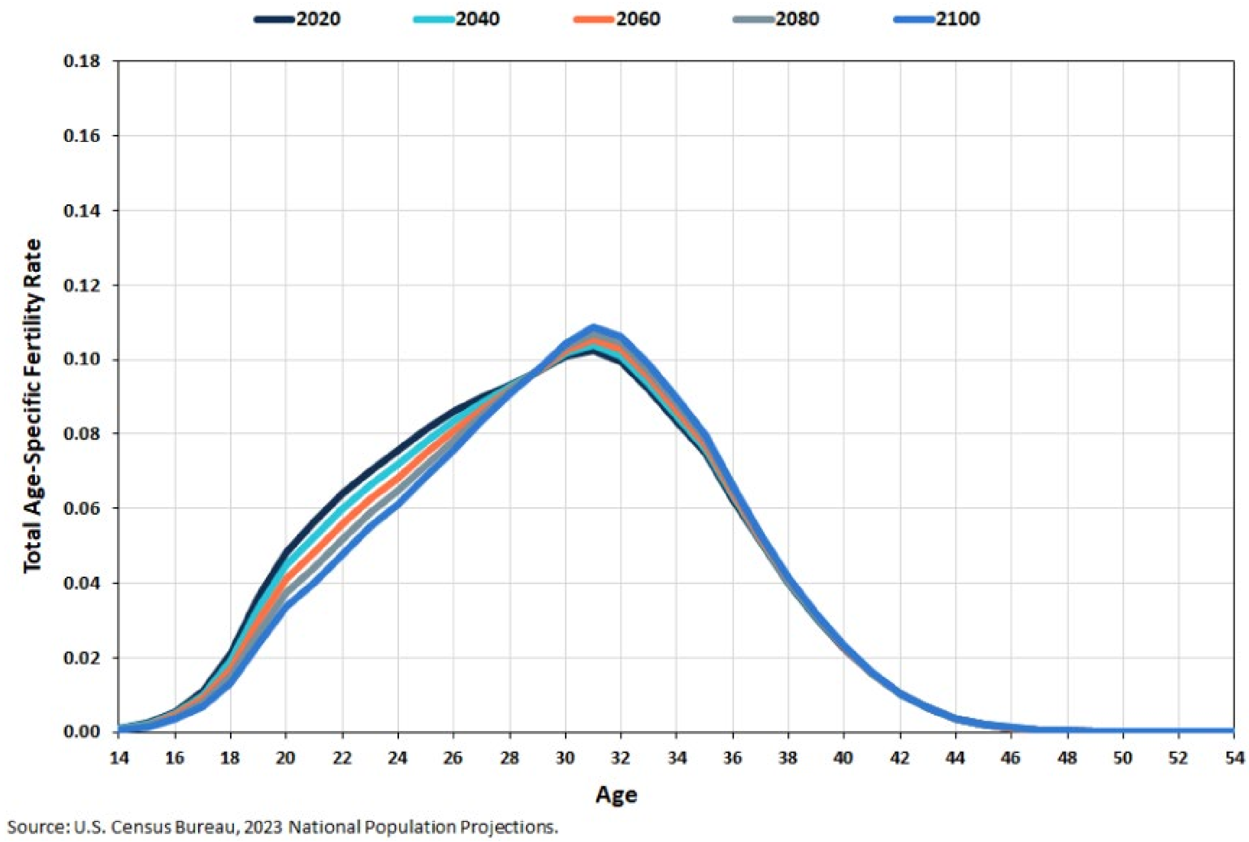

Figure 2. Total Age-Specific Fertility Rates: 2020 to 2100

Survival rates

To calculate survival rates, we used:

1. Death records from the Maryland Department of Health
2. Population data (both household and group quarters) from the Decennial Census and Population Estimates (PEP) from the U.S. Census Bureau.

We estimate survival rates by age, race and sex for each jurisdiction. The survival rates are based on two censuses, considering the effects of deaths, net migration, and possible census enumeration errors. For our purposes, we express survival rates as the probability that a group of people in a specific age cohort will live from one period to the next.

In jurisdictions where the distribution of the non-white population does not meet a minimum threshold, the statewide survival rates for that cohort are substituted for the jurisdiction derived survival rates.

Migration

We use a residual method to calculate migration rates for each jurisdiction by age-sex-race cohorts at five-year intervals over the projection period.

Migration rates are derived by first surviving the population from year one to year five, accounting only for births and deaths and excluding people in group quarters under age 65. This produces a closed household population—one in which no migration has occurred. The closed population is then subtracted from the actual Census count in year five (also excluding people in group quarters under age 65). The difference represents net migration over the five-year period and is disaggregated by age, sex, and race. Net migration rates are then calculated for each age-sex-race cohort by dividing the net migration by the closed population for that cohort.

5. References

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