PDHonline Course G142 (1 PDH)

Population Projections

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2020

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Population Projections

Course Content

Data Sources

Some common sources of population information are:

- U.S. Census
- State, regional, county, and city planning agencies
- Municipal records
  - Births, deaths, other records
  - Building permits
  - Water billing records

The scope of the project may dictate the geographic area of interest. In other words, the proposed service area for a water treatment plant or other facility usually defines the boundary in which the population of interest is located. However, sometimes it may be valuable to consider a larger area, say the county or state in which a city is located, in order to:

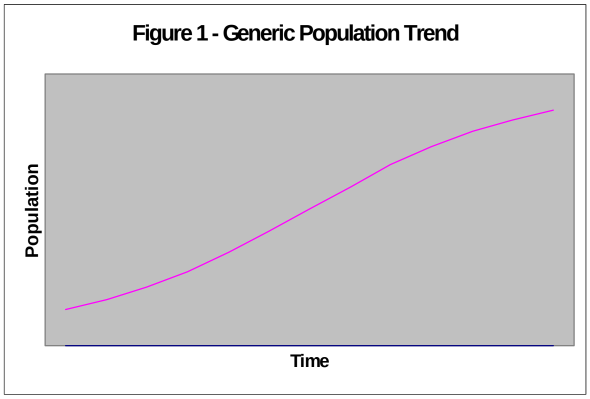
- Place the population trend in context.
- Consider potential anomalies.
- Account for uncertainties in the service area (e.g., for a privately operated landfill not restricted to accepting waste from a certain municipal area).

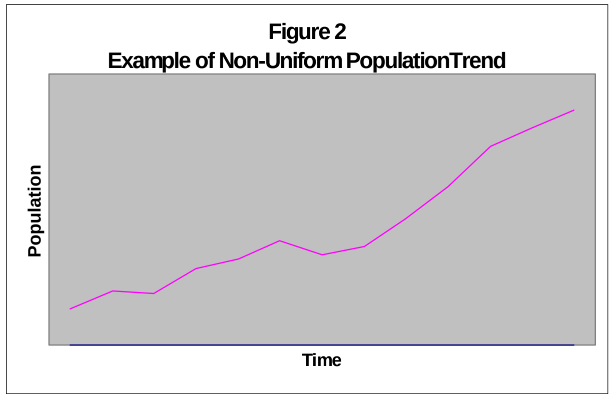
Projection Methods

Projections are an extrapolation of historical data (population versus time) into the future. The accuracy of population projections is generally considered directly proportional to the size of the existing population and the historical rate of growth, and inversely proportional to the length of the time projection. In other words:

More confidence in projection	Less confidence in projection
• Short time into the future	• Long time into the future
• Large population	• Small population
• Historically high growth	• Historically low growth

There are basically two types of projections, mathematical and graphical, although the two types are somewhat interchangeable because mathematical methods can be plotted and graphical data can be described mathematically. Both methods are generally based on an idealized model of exponential growth followed by linear growth and finally decreasing growth, as illustrated in Figure 1. Of course, actual population trends may be significantly less uniform, and may include periods of static or negative growth, as illustrated in Figure 2.





Mathematical techniques include:

- Linear growth
- Exponential growth
- Decreasing growth
- Correlation method
- Component method

Each of these techniques is explained below.

Linear growth

Steady growth can be represented as:

$$\Delta P / \Delta t = (P_b - P_o) / (t_b - t_o) = K_1$$

where:

ΔP = change in population
Δt = change in time
P_b = base population (start of projection)
P_o = initial population (in the applicable linear growth period)
t_b = base year (start of projection)
t_o = initial year (earliest year in the applicable linear growth period)
K_1 = growth rate = slope of line

A projection assuming linear growth can be calculated using the formula:

$P_f = P_b + K_1 t$

where:

P_f = future population
$t = t_f - t_b$ = # of years projected into the future
t_f = future year (end of projection)

Exponential growth

First-order growth can be represented as:

$\Delta P / \Delta t = K_2 P$, or $\ln (P_b / P_o) = K_2(t_b - t_o)$

where:

ΔP = change in population
Δt = change in time
K_2 = growth coefficient
P = population at a given year
P_b = base population (start of projection)
P_o = initial population (in the applicable exponential growth period)
t_b = base year (start of projection)
t_o = initial year (earliest year in the applicable exponential growth period)

A projection assuming exponential, or geometric, growth can be calculated using the formula:

$P_f = P_b e^{K_2 t}$

where:

P_f = future population
$K_2 = \ln (P_b / P_o) / (t_b - t_o)$
$t = t_f - t_b$ = # of years projected into the future
t_f = future year (end of projection)

Decreasing growth

Decelerating growth is assumed to asymptotically approach a saturation population, that is, the maximum population predicted for the geographic area of interest. The saturation population may be based on practical limitations such as the maximum number of dwellings under the zoning restrictions or other constraints.

Decreasing growth can be represented as:

$\Delta P / \Delta t = K_3(S - P)$

where:

ΔP = change in population
Δt = change in time
K_3 = growth coefficient
S = saturation population
P = population at a given year

As P approaches S, $\Delta P / \Delta t$ approaches zero, and a projection assuming decreasing growth can be calculated using the formula:

$P_f = S - (S - P_b)e^{-K_3 t}$

where:

P_f = future population
P_b = base population (start of projection)
$K_3 = -\ln [(S - P_b) / (S - P_o)] / (t_b - t_o)$
P_o = initial population (in the applicable decelerating growth period)
$t = t_f - t_b$ = # of years projected into the future
t_f = future year (end of projection)
t_b = base year (start of projection)
t_o = initial year (earliest year in the applicable decelerating growth period)

Correlation method

The correlation method uses a separate population projection for a similar community or region as a basis for determining a growth rate for the community or region of interest, assuming that the ratio of base populations is representative of the ratio of the projected populations. This method can be expressed mathematically as:

$P_{f2} / P_{f1} = P_{b2} / P_{b1} = K_4$

where:

P_{f2} = future population of community 2
P_{f1} = future population of community 1
P_{b2} = base population of community 2
P_{b1} = base population of community 1
K_4 = population ratio

Component method

This method, as suggested by its name, involves a summation of population growth components such as:

- Births
- Deaths
- Migration
- Employment opportunities
- Available housing
- Other data reflecting potential changes in the population

While this method may require significantly more effort than the previous methods, due to the amount of data needed, it may result in a more accurate projection if the data is accurate.

The component method can be represented by the following formula:

$$P_f = P_b + (F_1 + F_2 + \ldots F_n)$$

where:

P_f = future population
P_b = base population
F_1, F_2, F_n = population changes expected during the selected time period due to specific factors (births, deaths, etc.)

While the above techniques may utilize plots of data, they are based on mathematical approaches. A purely graphical technique that could be called the superposition method may also be used. It involves an approach described below.

Superposition method

As the name of this method suggests, the approach involves superimposing population trends. Population data from similar, but larger communities or regions can be plotted with offset times so that all lines or curves pass through the current population of the community of interest at the base time. Then a "best fit" line or curve can be drawn to represent a likely extrapolation of the population for the community of interest into the future.

Uncertainties

Any prediction of the future is likely to be inaccurate. To arrive at a defensible projection of future population, one should utilize the best available historical information in a technically appropriate manner. Even then, the designer should recognize the potential for error due to numerous unknowns, factors that cannot be predicted. This uncertainty should be explicitly reported with the results.

Additionally, it may be prudent to examine the sensitivity of the design to the lower and higher bounds on the range of population that could reasonably be expected. In many cases facilities that rely on population projections are designed in a modular fashion, so that unexpected population changes can be addressed by adding or deleting units as necessary in the future.