POPULATION FORECASTING METHODS
A REPORT ON FORECASTING AND ESTIMATING METHODS

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS
URBAN PLANNING DIVISION

This report is a condensed version with modifications of a booklet prepared in 1952 by Van Beuren Stanbery, *Better Population Forecasting for Areas and Communities*. Revision prepared June 1964 by Frank V. Hermann

ABSTRACT

Planning transportation facilities for urban areas requires study, analysis, and forecasts of population, economic activity, and land use. These elements are the basic determinants of travel. This report deals with one of these elements, namely population forecasting. The report has been prepared to assist those having little or no background in demography to become acquainted with the general field and with the major population forecasting procedures in common use.

This report is not intended to serve as a textbook or an operational manual. Rather, it is a general introduction to the subject, a guide to more extensive works, and a source of information on data sources that have proven valuable in studying and forecasting population. The reader is cautioned that in reality the procedures are not as simple or clear cut as they may appear in this report. In actual practice, judgment plays a vital role in the preparation of any set of figures, and as much consideration must be given to the judgments used in a population analysis as to the method utilized.

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PREFACE

Planning transportation facilities for urban areas requires study, analysis, and forecasts of population, economic activity, and land use. These elements are the basic determinants of travel. This report deals with one of these elements, namely population forecasting. The report has been prepared to assist those having little or no background in demography to become acquainted with the general field and with the major population forecasting procedures in common use.

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Though population forecasting is treated in this report as an independent function, it must be recognized that population changes are to a great extent dependent on economic factors. Constant feed-back and comparison are essential here, as in most other phases of the planning process. The economic and population forecasts should be prepared so as to arrive at complementary results.

One of the first steps in any population study is to prepare a figure for the current population in the study area at the time of the forecast. In demographic terminology this is called "estimating," a term normally used to refer to calculations of current population. The terms "projection" or "forecast" normally refer to the anticipated population at some time in the future. Techniques for estimating current population are discussed in Appendix I.

A population forecast requires certain information on historic population counts, births, deaths, other rates which affect population change. Some of the most common sources of data are presented in Appendix II. This is not intended to be a complete listing of sources. Rather, the appendix provides the reader with a general idea of types of data available and where these data may be found.

As an aid to those who would like more information than is presented in this report, a bibliography has been compiled and is included as Appendix III. This bibliography, however,, is not a complete listing of the material available in the field. A more complete bibliography can be obtained in the publication by Hope T. Eldridge, The Materials of Demography , published by the International Union for the Scientific Study of Population and the Population Association of America in 1959.

Part I of this report is substantially the work of Van Beuren Stanbery, Better Population Forecasting for Areas and Communities." Part II also draws Heavily on Stanbery's report. This paper, currently out of print, was a guidebook prepared under the direction of the U. S. Department of Commerce in 1952**.** Mr. Stanbery's report has been revised to the extent necessary to bring the material up-to-date and to make the discussion more directly relevant to transportation planning studies. Thus, while the credit for the basic work goes to Mr. Stanbery, responsibility for any imperfections in the modifications is assumed by the Urban Planning Division (urban Development Branch) of the Bureau of Public Roads.

PART I: PROBLEMS OF POPULATION ANALYSIS

Population forecasting is essentially a matter of judgment. Judgment is required in selecting the kind of forecast to present, in determining the procedures for making it, and in appraising effects of the factors that induce population changes. Obviously, this should be an informed judgment, backed up by the most complete and thorough analysis of the particular problem that the forecaster is able to make.

The problem, of course, is much simpler for areas which have shown marked stability in the size of their populations for several decades, and for which no great change in the economic and social conditions of the locality seems likely. On the other hand 1 it may be extremely difficult and complex for areas which have had sharp fluctuations in the direction or rate of population change in the past, and which may continue to have them.

The crux of the solution lies in the thoroughness with which the probable effects of the factors influencing population growth, or decline, in the particular areas are evaluated and the skill with which the evaluations are translated into numerical figures.

Numerous aids to judgment in making population projections are pointed out in this report. Even the most thorough study will not assure that the forecast will come true. Well-founded projections are the best obtainable guides, but they are not infallible. Those who use population projections should always keep in mind the possibility that they may prove off the mark.

How Logically Founded Projections May Be Developed

The number of people residing in an area can be changed in only three ways: (1) By births, (2) by deaths, and (3) by movement in or out, the net result of which is called net migration, whether inward or outward.

The factors and conditions that cause the people to have children, to die, and to move from one place to another., are, of course., almost infinite in their variety. A comparative few, however, usually have greater influence than the others in changing the number of residents in an area. For example, establishment of a large new industry generally has greater and more direct effects on the size of a city's

population than improvement of its parks and playgrounds. Analysis of the causes, nature, and rates of past changes in the area's population, together with a careful appraisal of the probable effects of the more influential factors, can provide valuable clues to the size of the future population.

Rational population projections can be made by two operations:

12. Tabulating, plotting, and analyzing data showing the trends and rates of changes in the area population in the past.

2. Determining, as far as possible, the extent and nature of probable deviations from past trends likely to be caused by changes in factors affecting the volume of births, deaths, and net migration in the particular area.

Stated another way, the forecaster must try to answer the following questions for the period covered by his forecast:

- Will the population of the area increase or will it decrease?
- Is the increase, or decrease, expected to be in the same amount or at the same rate as in similar periods during the past, or will it probably be different?
- If so, why and by how much is it expected to be different?

The forecaster should give some idea about how large the population of the area or community will be on the forecast date, and why he expects it to be that size. He should support his Projections with sufficient data and analysis to show clearly the assumptions and methodology on which they are based so that the user can judge their validity for himself. If it is desired to provide a range rather than a single figure for the forecast, such a range can be provided by preparing alternative series of forecasts. For example, a high alternative series might be provided utilizing assumptions of high birth rates and/or in-migration while a low series might be based upon assumptions of low birth and/or in-migration rates.

Basic Assumptions Implicit in All Forecasts

Every population projection, except a pure guess, is based on some assumptions. These may be explicitly set forth in the projection, but, if not, they are implicit in the method that is used. By definition, a population projection assumes that the factors affecting births, deaths, and migration will interact in a manner that will produce the projected figure. In practice, the analysis should set forth the specific assumptions on which the forecasts for the particular area are based.

In addition to such special assumptions, several basic assumptions are implicit. It is usually assumed that during the period of the forecast:

The form of government and the Political, economic, and social organization and institutions of the United States will remain substantially unchanged.

- No all-out war, internal revolution, nationwide devastation, epidemic, or other disaster will occur.
- No large-scale epidemic, destruction by military action, fire, earthquake, or other disaster will occur in the area or within the geographical or economic region to which the area is closely related.

Any of these events might have completely unpredictable effects on the population. These basic assumptions, therefore, are either explicitly stated or are implied in nearly every population projection.

Knowledge of Population Data Essential

A variety of population figures are now reported differing according to the kind of population they represent. Therefore, the forecaster should have a good working knowledge of the population data reported by the Bureau of the Census, of birth and death statistics, and of the limitations and uses of these data.

No population census is 100 percent accurate in every respect. Obviously a few persons will be missed, while an even smaller number will be counted twice. The number of persons in the older-age group, 55 years and over, are often under-reported in some age brackets and over-reported in others. The number of births and deaths reported for an area is seldom complete.[1] Since these limitations in the data may affect the forecast, depending on the characteristics of the local area and the forecasting techniques to be used, they should be examined and understood.

The forecaster also should understand the principal factors and conditions affecting the number of births, deaths., and the direction and volume of net migration in an area. A brief discussion of these factors follows.

Principal Factors Affecting Births, Deaths, and Net Migration

Births

The number of births per thousand population during a year is called the "crude birth rate." It is obtained simply by dividing the number of births during the year by the total population and multiplying the result by 1,000. Such a figure does not take into account unique characteristics of an area. For example a frontier town where few women live would have a very low crude birth rate even though these women might be having a large number of children.

Amore meaningful figure would be the "fertility ratio." This is the number of children under age five per thousand women of child-bearing age. (Child-bearing age is usually defined as women aged 15 to 45.) Another term used in demography is the "fertility rate," which is the number of births in a given year per 1,000 women of child-bearing age. For more detailed analysis, an age-specific birth rate is sometimes used. This rate is composed of the number of births per 1,000 women of a specified age or age group.

Fertility rates are now widely used in making projections for areas in which natural increase or decrease (the excess or deficiency of births compared to deaths) is expected to be the predominant source of population change.

Fertility rates and age-specific birth rates seldom remain constant, but rise or decline from year to year depending on various factors and conditions. Chief among these are the rise or decline of economic activity and employment, and changes in the racial composition, religious affiliation of the population, and the attitudes of married couples toward having children. From 1910 to 1936, fertility rates in the United States showed a steady downward trend. World War II and the years that followed saw a

sharp reversal of this trend while the late 1950's and early 1960's have seen a leveling off and slight decline in fertility rates.

Fertility rates differ widely among areas and communities as well as for different ages within the child-bearing age range. The trends in these rates, however, usually follow and move toward the national average. Thus, in preparing local trend forecasts, it is advisable to study historic and projected national trends.

Deaths

The number of deaths in an area is determined chiefly by the size and age distribution of its population. The greater the proportion of elderly persons, the higher generally is the crude death rate, or number of deaths per thousand population. Approximately 60 percent of all deaths are of persons age 65 and over.[2] A large number of births also tends to cause a temporary rise in the average death rate because of the high mortality of infants in their first year.

In areas where natural increase predominates, it is often desirable to use age-specific mortality rates instead of crude death rates. Age-specific mortality rates are the number of deaths during the year per thousand persons in specific age groups. Changes in these rates are usually slow and gradual.

The long-term trend in age-specific mortality rates is downward because of the continual improvement in living conditions, and increasing control of disease and prolongation of life by the advancement of medical science. Future mortality rates will probably show some improvement, but it will be very slight and, in fact, many age-specific rates may remain constant. Other important factors affecting these rates are the racial composition of the population and the climatic and occupational characteristics of the locality. Some climates and some types of work are obviously more healthful than others.

Mortality rates differ among various areas of the nation, but the differences are generally smaller than for fertility rates.

Net Migration

Net migration is the difference between the number of people who move into an area and the number who move out during a specific period of time. The day-to-day and week-to-week movements can usually be ignored. What the forecaster needs to know is whether the net migration over a period of years has usually been inward or outward; the size of the net migration; the sex, age, racial, and occupational composition of those who have been adding to or subtracting from the area population; and the principal causes of their movement.

An approximate measure of net migration in past decades can be obtained by subtracting the crude natural increase (reported excess of births over deaths) in the area during the decade from the total numerical population change shown by the decennial census reports.

Approximate measures of the age, sex., and racial distribution of the net migration can also be obtained by comparing the changes by five-year age groups by sex, and by race, shown in the census reports. Rough approximations of interstate movements by decades also can be derived from the State-of-birth and State-of-residence data in the census volumes.

Causes of migration are many and varied. Chief among them are:

- The desire for better economic opportunities. Interstate migration is largely a movement from areas with relatively low planes of living to areas with higher income levels.
- The attraction of milder or more suitable climates in other areas.
- Desire for better living or housing conditions. This applies particularly to short distance migration within the same general locality.
- Movement for reasons of health, education., or retirement.
- Wives, young children, and close relatives usually follow the movement of their breadwinners, or family heads.

The direction and volume of net migration also vary widely from time to time. The levels and fluctuations of national economic activity have marked effects on internal population movements. People are more willing to take a chance on a new location when business is on the upgrade than when payrolls are shrinking and times are getting hard. Also it is easier to pull up stakes by selling property or liquidating other fixed assets when times are good.

The level of national economic activity also affects the direction of migration. When employment is high or rising, the movement is generally from rural areas and small towns to the medium-size and larger cities, because of the relatively larger dollar wages and economic opportunities in urban areas. But during periods of economic depression, the net movement in the past has usually been from the cities to the rural areas., generated largely by the hope of achieving a subsistence through living on the land. The extent to which old age pension payments, unemployment compensation insurance, and other governmental programs will affect such movements in the future is difficult to appraise, but they should tend to lessen back-to-the-land migration during periods of low economic activity. Newer generations, however, do not have ties to the farm and/or the skills and knowledge required to subsist in an agricultural environment. In addition social and economic ties developed in urban areas by these newer generations would inhibit any movement back to the farm in the future.

The relative income level and the expansion or decline of economic opportunities in an area obviously have an important influence on the direction and volume of its net migration.

Other factors are the size of the pool from which potential migrants might be drawn (i.e., the population of the nation outside the area), the size of the local population., and the rates of economic expansion and population growth in the area relative to those in other areas.

Employment Levels - The Dominant Influence on Area Population Growth

As indicated before, substantial changes in the size of the population of most areas are closely related to changes in the area's employment level. Principal exceptions are "dormitory" suburbs and educational communities, and those with large institutional populations, or other special features.

By enlarging the number of individuals to be provided with goods and services, natural increase in population of an area itself tends to expand economic opportunities and employment in that locality. But if employment opportunities in the area expand, or appear capable of expansion, at a rate faster than the natural increase in the population of employable age, people will move in from other areas. On the

other hand, if the population of working age increases more rapidly than employment opportunities, unemployment will rise and out-migration may ensue. Because of its effects on migration, the upward or downward trend of employment in an area or community has a greater influence on local population growth than the national level of employment has on the growth of the national population.

The national level of employment.. however, affects both the birth rate and the rate of economic development in most localities. Birth rates are generally higher throughout the Nation when national employment is high or rising, than when it is low or declining. In areas having potentialities for greater development., the expansion of agriculture, industry, and business is at a faster rate when national employment is high than when it is relatively low.

Population projections for areas and communities (with exceptions noted before) therefore involve assumptions concerning future levels of both national and local economic activity and employment. Such assumptions will be derived from intensive study of expected employment levels., which should be prepared as a part of the economic study phase of the transportation planning process.

Demographic Upheaval of the 1940s and 1950s and Its Future Effects

During the 1940s and 1950s, drastic and unexpected changes occurred in the population trends of the United States. These shifts were so radical and widespread that they virtually amounted to a demographic upheaval. Their effects on the future populations of areas and communities everywhere will be far reaching, and should be taken into account in making forecasts. These significant shifts were:

- A remarkable upsurge in the rate of population growth
- An extraordinary increase in migration from rural areas and small towns to metropolitan areas and large urban communities.

Upsurge in Rate of Population Growth

During the 1930s, most demographers became convinced that the population of the United States would reach its peak about 1960 and would then become stationary., or gradually decline. This conviction was based on a long decline in fertility rates and the restrictions placed on immigration from foreign countries in the 1920s. The increase in birth rates during and following the second world war soon made demographers aware that the national population would not decline or even remain stationary.

From 1950 to 1960 the population of the United States increased almost 28 million, the largest gain of any decade. More children were born than in any previous 10-year period and mortality rates declined. Together, these factors assure that the national population will continue to grow to the year 2000 at least, and probably for some time thereafter unless some unpredictable disaster should occur.

Not only was the downtrend in fertility and birth rates reversed, but the reversals were greatest where the declines had been relatively most severe, namely in urban areas and among families in the middle and upper income brackets.

Many influences contributed to this reversal. Among these were postponement of child-bearing during the depression of the 1930s, the war and war-hastened marriages, high levels of employment and

earnings, enhanced desires of married couples to have children., and the younger age at which people have been getting married.

This tremendous growth has injected a new and potent force into the economic and social life of the nation and its cities. Even though birth rates may decline from their current high levels., the millions of children born during the two decades are almost certain to create another upsurge of births in the 1960's and 1970's and probably a third wave in the 1980's and 1990's. Persons age 65 and over will be more numerous than previously estimated; however, they will constitute a smaller proportion of the whole population.

From 1850 to 1900, the population of the United States more than tripled from 23 million to 76 million. From 1900 to 1950 it doubled from 76 million to 151 million. If it were to increase only 50 percent during the second half of the century, it would exceed 225 million in 2000 A.D. By 1960 the actual population was almost 180 million and recent projections of population indicate a range between 233 million and 252 million by 1980.[3]

The full economic and social effects of the recent tidal wave of babies, of course, will not be felt until the children grow up. Then they will show up in many ways - in larger employment, production, and incomes; in greater demands for goods, services, and facilities of all kinds, including transportation facilities.

The population forecaster must appraise the short- and long-term effects on his particular area of the recent rise in fertility rates and birth rates. He must evaluate as far as he can (1) the probable levels of fertility rates (or birth rates by age of mother) during the next decade or two, and (2) the probable increase in number of women of 15 to 45 years., when the oncoming wave of girl babies reaches the child-bearing ages.

The forecaster should also recognize the continuing decline in age-specific mortality rates. While this decline will gradually level off, the number of survivors per thousand population in each age bracket should be greater in the future than in the past.

Increase in Population Migration to Urban Areas

Analysis of decennial census information indicates that more than 75 million Americans changed their home addresses between 1955 and 1960.[4] Of these, almost 28 million moved to another county and more than 14 million of these moved to another State.

This movement was predominantly from rural areas and small towns to larger urban places. According to the Bureau of the Census, the population increase within urban areas from 1950 to 1960 was larger than the national population increase during that period.[5] Nearly all large cities received a share of the migrants.

Continuing the trend of previous decades, most of the population growth in the metropolitan areas occurred outside the central cities. From 1950 to 1960, the population of the central cities as a whole increased 20 percent, while that of the outlying sections increased 81 percent or four times as fast.

Part of this increased migration can be attributed to the great expansion of employment in the heavily industrialized urban areas during World War II, and to the construction during that period of new manufacturing facilities and military establishments in certain localities. Another cause was the doubling

up of families during the depression of the 1930's and the lack of desirable housing during the war years. This brought after the war an enormous increase in residential construction and in movement of families to new locations. Still another cause was the attraction of millions of new jobs created in the larger urban areas by high levels of postwar business and incomes.

The increase of migration to urban areas is further compounded by movements within the urban areas. While the areas themselves were growing, certain sections within the areas such as the central cities were remaining almost constant or even declining. Thus the simple figures of net growth do not tell the full story of change in a study area.

Moreover, wage scales in similar occupations are now more nearly the same throughout the country than they were before the war and will probably continue to become more uniform in the future. With high level employment and more nearly equal wage scales throughout the Nation, migration will probably be influenced to a greater degree than in the past by climatic attractions and other factors.

Ranges in a Population Forecast

Population forecasts may be developed and presented as a single figure; as two figures, one high and one low, showing the expected range for the future population; or in three or more figures based on different assumptions.

Most of the forecasts that have been made for areas and communities in the United States have been single-figure projections. However, Census Bureau projections of the national population consist of four series, each based on a different set of assumptions.

The assumptions introduced into a forecasting technique will determine the magnitude of the forecast population. Thus, if assumptions which imply a low rate of growth are used, the forecast population will be smaller than if the assumptions imply a rapid rate of growth. The preparation of two forecasts, one using the high rate assumptions and one using the low rate assumptions, will give the user an indication of the likely range within which the future population will actually occur. On the other hand, the use of a single, most likely, set of assumptions will give a single figure forecast indicating the most likely size of future population.

Census Bureau Classifications of Population

Before World War II,, only one population figure was in general use in the United States, namely the total number of people residing in an area at a particular date. Because persons in the military services were then relatively few and widely scattered throughout the Nation, no distinction was made between the civilian and military population. They were lumped together in the Census figures.

The 1950 and 1960 decennial censuses of population enumerated each person as an inhabitant of his usual place of residence, which was generally construed to mean the place where he lives and sleeps most of the time. Visitors and transients in other areas when the Census was taken were allocated to their home communities.

Persons in the armed forces quartered on military installations were counted as residents of the States, counties,, and minor civil divisions in which their installations were located. Members of their families, however, were reported where they actually resided.

Several definitional changes have also occurred between recent censuses. In the 1950 and 1960 censuses, college students living away from home were considered residents of the communities in which they were residing while attending college. In the 1940 census they were allocated to their home areas. Crews of vessels in the American merchant marine were credited in 1940 to the home port from which the vessel operated., but in 1950 and 1960 were credited to the port where the vessel was berthed on April 1.

Persons confined to prisons, houses of correction, State hospitals, asylums, and other public or private institutions are reported as "institutional population" by the Census Bureau. The size of the institutional population usually remains about the same over long periods. Increases or decreases are brought about chiefly by the construction of new institutions or the abandonment of old ones,, rather than by the influences that normally induce changes in the size of the noninstitutional population.

The forecaster therefore should determine the size of the institutional population in the area he is studying. If it constitutes about 10 percent or more of the total figure, he should make separate studies of past growth and separate projections for the institutional and the noninstitutional populations.

It is important that the forecaster clearly define the kind of population his projections represent. If the population reported by the 1960 census is used as a starting figure, the projections presumably would represent the same kind of population unless they were otherwise defined and developed.

Because of large variations in the size of military forces quartered in several areas in the United States, it may be desirable to prepare projections for a more predictable type of population for the area. This might consist of resident civilians plus residents serving in the armed forces irrespective of their locations. The projections may be made by any of the methods discussed later in this report. Military personnel stationed in the area on the projected date therefore would be excluded, unless they had been residents at the time of their induction into the military service. Any projection of this group will involve an evaluation of the most likely future activities of the military establishment.

Thus, by preparing separate figures for civilian residents, military personnel residing in the area and residents serving in the armed forces, more meaningful studies and analyses can be made than if only one figure were presented.

PART II: CURRENT TECHNIQUES OF FORECASTING

Several general methods for making population projections for areas and communities are in common use. Under each of these general methods, a variety of procedures and techniques has been developed. Those most followed in practice will be briefly reviewed. The general methods are:

1. Graphical or mathematical projections of the curve of past population growth (trend based methods).
2. Projections based on relationships of population growth in an area to that in other areas (ratio methods).

3. Projections of net migration and of natural increase (component methods).

4. Forecasts based on specific estimates of future employment and other occasionally used methods.

It must be emphasized that in practice few studies will use one method in the manner described in this report. Often a particular area will have conditions which will best be met by adopting **a** unique method. Often, the background of the staff may lead them to change methods to achieve what they believe are better results. For example, the projections presented in the St. Paul, Minnesota, Community Plan Report No. 12 are based on empirical data from other studies. The Army engineers, faced with a need for forecasts to the year 2020 in the San Francisco Bay Area, adopted a ratio technique combined with considerable judgment and modifications.

Method I - Graphical or Mathematical Projection of the Curve of Past Population Growth (Trend Based Methods)

The trend based methods assume that population growth follows natural laws and, therefore, can be expressed in mathematical or graphical form. Basically, population is forecast by examining and projecting past trends into the future. Various types of expressions have been used such as linear, geometric, exponential, logarithmic, etc., to explain past historical growth and predict future growth. Usually, no analysis is made of factors that cause population changes, e.g., births, deaths, and migration.

Trend Based Projections by Graphic Techniques

Graphic projections are most commonly made using arithmetic, semilog, or probability paper. The data used in the plotting are historic data from decennial census reports and from available local or State census reports from intermediate years. The historic data are often plotted on all three types of graph paper, and the plot which comes closest to a straight line indicates the mathematical form to be used for the projection. In using the plotted information for projection purposes, the analyst assumes that the condition implied by the straight line will continue into the future.

(1) Constant arithmetic population increase

Historic data which plot as a straight line on arithmetic graph paper imply constant arithmetic change in population each year. This growth pattern implies that the population has changed by the same number of people each year. The data from Table 1 would appear as a straight line when plotted on arithmetic paper as shown in Figure 1. Since the base population each year has increased (or decreased) by a

Table 1. - Example of constant arithmetic population increase

Year	Population	Increase	Rate of change
1930	100,000		
1940	150,000	50,000	50.0%
1950	200,000	50,000	33.3%
1960	250,000	50,000	25.0%

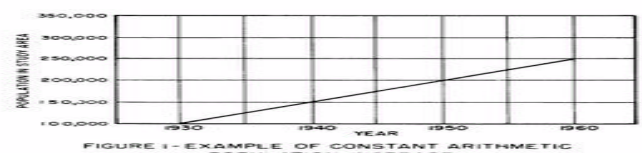


FIGURE 1 - EXAMPLE OF CONSTANT ARITHMETIC POPULATION INCREASE

constant amount, the rate of change is different each year.

(2) Constant rate of population increase

A different historic growth pattern for a city might show a constant rate of change. When the data shown in Table 2 are plotted on arithmetic graph paper, such a pattern of growth forms a curve as shown in Figure 2. When the same data are plotted on semilog paper (with population on the log scale and time on the arithmetic scale), a straight line plot results as shown in Figure 3. In this situation, the

Table 2. - Example of constant rate of population increase

Year	Population	Increase	Rate of change
1930	100,000		
		50,000	50.0%
1940	150,000		
		75,000	50.0%
1950	225,000		
		112,500	50.0%
1960	337,500		

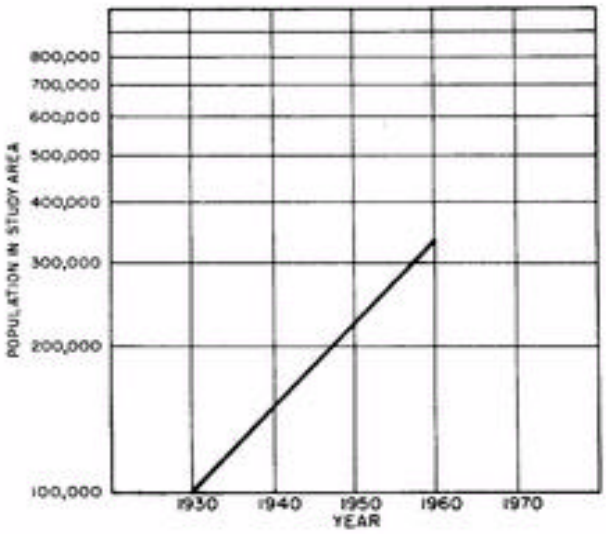


FIGURE 3-EXAMPLE OF CONSTANT GEOMETRIC POPULATION INCREASE ON SEMI-LOG GRAPH PAPER

numerical increase each year is greater than the year before, although the rate of increase is constant.

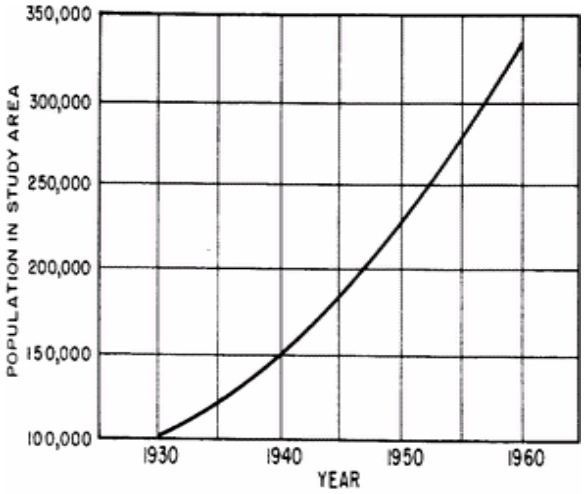


FIG. 2 - EXAMPLE OF CONSTANT GEOMETRIC POPULATION INCREASE ON ARITHMETIC GRAPH PAPER

(3) Variable rate of population change

Arithmetic plots for some cities have shown that at first the population increased at a low rate, then accelerated for a period of time, and later, as the city matures, the rate of growth decreased. When the data in Table 3 are plotted on arithmetic paper, such a condition results in the characteristic "S" shade curve shown in Figure 4. These same data may be plotted on probability paper resulting in a straight line as shown in Figure 5. This curve is known as the logistic curve.

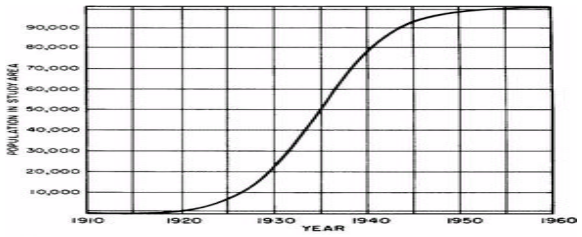
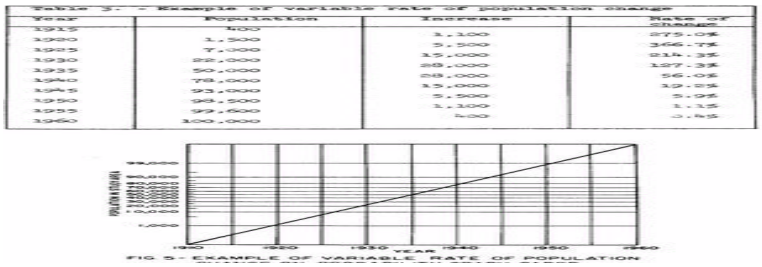


FIG. 4 - EXAMPLE OF VARIABLE RATE OF POPULATION CHANGE ON ARITHMETIC GRAPH PAPER



The logistic curve is based on a "law of growth in a limited area" propounded and mathematically developed by P. F. Verhulst in 1838. It is shaped like an elongated and flattened letter "S." The curve was rediscovered independently many years later by Messrs. Raymond Pearl and Lowell J. Reed from observation of the growth of fruit flies contained in glass jars and subjected to controlled conditions of food consumption.

It was found that in the early stages the increase in the number of fruit flies per unit of time accelerated to a maximum, after which it decreased at a continuously decelerating rate per unit of time, inverse to the previous growth. Some population analysts believe that what happens to the growth of fruit flies in a jar would apply to the human population of a completely self-contained area.

In fact, several population forecasts made a few decades ago indicated an upper limit to the population of the United States would be reached before 1990. The validity of this "law" for areas subject to net immigration that might accelerate for a time is questionable.

Trend Based Projections by Mathematical Techniques

The mathematical technique for projecting population also utilizes historic data and produces results similar to those obtained through the graphical techniques. In their simplest form, mathematical techniques are nothing more than the equations that will reproduce a straight or curved line. The basic theory for this is that any smooth line which can be plotted can be expressed (or at least approximated) by an equation.

A somewhat more advanced method is to derive the equation for the line which best fits the historic points and use this equation to estimate future population. Normally, the method of least squares would be used to obtain the equation of this line. Occasionally multivariate equations or equations using terms expressed to a power are utilized. Some of the factors included in these equations have been economic changes, land available, historic inter- and intra area population movements, etc. There is no standard group of variables employed in these equations, however, and in most cases the mathematical and graphic techniques have been used for very specific small area projections of only certain sectors of the population such as the number of home owners, or children in school.

Modified Projections

Forecasters often modify or alter projections arrived at by the previously described mathematical and graphic techniques according to their ideas about how the projected curve should look. In fact, given the same data of past growth, a dozen forecasters probably would come out with somewhat different graphic or mathematical projections. It is often difficult to determine by eye the graphic projection that would exactly fit the curve. Likewise, in computing the mathematical equation for projecting the curve, there might be differences in the number of points that would be considered or differences in the starting points.

In addition, forecasters often raise or lower their projections they have a hunch that the future population will be larger or smaller than the projected figure. Such subjective modifications are usually hazardous , and they are not recommended. Modifications should be made after a thorough study of influences end conditions affecting rate of population change in the area.

It is suggested, however, that projections obtained by other methods described later be plotted along with the curve of past growth. If the Projections thus plotted appear to differ sharply from the previous

curve, careful review of the analysis should be made to catch any error in the evaluations or computations.

Critique

The advantage of graphic or mathematical projections is that they are the easiest to make. They generally are better suited to areas which have had relatively constant changes per decade in the size of their populations and for which no marked changes from past trends appear likely, than for areas subject to rapid or erratic fluctuations in population. Obviously, they should be more dependable for short-term projections of 5 to 10 years, than for longer projections.

The weakness of such projections is that they are founded on the assumption that the factors and conditions which produced population growth or decline in the area in the past will continue unchanged and will have the same effects in the future, or that they are derived from an assumed curve of population growth. In view of the changes that have taken place during the past two decades in fertility, mortality, and migration trends, projections of this kind are becoming less reliable. Graphic and mathematical projections are useful, however, as rough checks on those obtained by other methods.

Method II - Projections Based on Relationships of Population Growth in an Area to Growth in Other Areas (Ratio Methods)

The factors and influences that accelerate or retard natural population increase are pervasive and tend to speed it up or slow it down concurrently throughout the Nation. Moreover, as mentioned before, economic and social conditions that cause birth rates to rise, or decline, also tend to accelerate or decelerate internal migration. Because of this, the rate of population growth in most areas and communities is related to some extent to the growth rate of the national population.

Population growth in an area or community is usually closely related to, or affected by., economic and population changes in the economic region or State in which it lies. Future population changes in those larger areas may have an important influence on growth or decline in the smaller area. Hence, past relationships between population growth in an area or community and that of its economic region or State are valuable guides for projection of the local population. If logically founded population projections for the Nation, State, or economic region are available, projections for the area or community can be derived directly therefrom. National projections are available in the Current Population Reports, Series P-25 published by the Bureau of the Census (see Appendix II, Data Sources).

Statistical Projections Based on Relative Rates of Past Growth

The population growth of a study area can be projected into the future by relating its growth to a larger area of which it is a part, such as the State, the region,, or the Nation. The basic procedure is to compute the ratio between the population of the study area and some larger area at the time of past censuses. This ratio may simply be between the study area and a larger area, or a series of interrelated ratios may be calculated between pairs of successively smaller geographical areas. Such a series, known as step-down ratios, might be between the study area and the State economic area, the State economic area and the whole State, the State and the region and, finally, the region and the Nation. The

availability of a reliable forecast for a larger area and comparable historic data for the subareas to be used should be examined before this method is selected.

The historic ratios developed must then be plotted in a time series and projected forward. Their projection is not a simple mechanical procedure, but involves taking into account all the factors discussed in part of this report. Local conditions must be examined and the probable factors which will influence the future ratios fully understood. Simply because a ratio has had a particular trend in the past is no assurance that it will continue to have that relationship in the future. For example, during the early decades of this century., coal mining towns in the Appalachian area grew at a faster rate than their State as a whole. However, during the past few decades, this trend has been reversed.[6]

Example of the Ratio Method

To illustrate the procedure used in the ratio method, a sample projection for the years 1970 and 1980 will be made of the population of a hypothetical study area by projecting the historic ratio with the State.

Table 4. - Example of historical ratio of study area to State 1930-60

A	B	C	D
Year	Census count total State population	Census count total study area population	Ratio of study area population to State population (column C / column B)
1930	1,000,000	110,000	0.110
1940	1,200,000	140,000	0.117
1950	1,500,000	178,500	0.119
1960	1,900,000	230,000	0.121

The first step is to list the historic population data for the study area and the State in order to derive the necessary historic rates. The type of information required, as shown in Table 4, may be obtained from census data.

In developing the ratios, care must be taken to see that the geographic boundaries of the area used in each census year are the same as for each of the other years. Thus, if a four-city area is the study area in 1960, the same geographic area of the four cities must be used in the time series.

The next step is to obtain State population forecasts for the years 1970 and 1980. These could be obtained by stepping down from the national forecasts prepared by the U.S. Bureau of the Census or some other agency. In this example, it will be assumed that a State agency has prepared population forecasts. The forecasted figures are 2,500,000 persons in 1970 and 3,200,000 in 1980.

In addition to obtaining the population forecast for the State, it is necessary to prepare ratios of the study area population to State population for the years 1970 and 1980. The preparation of these ratios is the most important part of this forecasting technique. All of the factors which influence population change as discussed in part I must be considered and analyzer as to their probable future effect on the study area's share of the future State population. In this example the study area share in the total State copulation has been increasing. Assuming that a study of births, deaths, migration, employment, and economic trends indicate a continuation of an increasing ratio, although at a declining rate, then the forecast ratios of 0.124 for 1970 and 0.126 in 1980 can be considered reasonable. With this

Table 5. - Example of population forecast by ratio methods

A Year	B' Forecast population for the State	D' Forecast ratio of study area population to State population	C' Forecast population in study area (column B' X column D')
1970	2,500,000	0.124	310,000
1980	3,200,000	0.126	403,200

information, the study area population can be forecast for 1970 and 1980 as shown in Table 5.

Critique

Purely statistical projections made by ratio methods should be used with caution. Former relationships between population growth in the area under consideration and that in other areas may suddenly change. Moreover, the economic and social forces that cause births and migration to increase, or decline, nationally exert differing effects at different times on particular areas. Some areas have shown fairly consistent trends between their population growth and that of their region, State, or the Nation. Others have shown divergent or erratic relationships to population changes in the larger areas. For these this method appears less valid than for areas exhibiting more consistent trends.

The ratio method, based upon a forecast for a large area, is subject to all the errors, incorrect assumptions, and inaccuracies inherent in that forecast.

Very often local forecasters are not aware of all the assumptions made in preparing the larger base area figures. Moreover, there is no assurance that the assumptions made would have the same effect on the study area as they would have on the larger base area. It is quite possible that the growth in the economy which is assumed in a national forecast would imply a change in technology. This change might force the basic economic activities in the study area to make radical reductions in employment or move to new areas. (Examples of such situations are the Appalachian coal mining companies and the New England textile mills.) Even on the State level., a forecast of continued population growth in a particular State does not necessarily imply an even distribution of growth within the State. It might also

mean a large growth in one or two urban areas with little or no growth (or even out-migration) in other urban areas within the State.

On the other hand, these procedures have several advantages over trend methods. The factors affecting population growth in the area or community may be more clearly visualized and appraised with a knowledge of its past relationships to growth in its economic region, State, and the Nation than if these relationships have not been studied. It may be easier to foresee and evaluate the effects of new conditions that may change past relationships than it would be to appraise the prospects for future growth in tile area irrespective of the rate of growth in other areas. Population projections for the Nation and for States have generally been closer to the mark than those for smaller areas or communities. By tying in their projection with those for the larger area, the range for error may be lessened.

Several recent transportation studies have used ratio techniques; among them Niagara Frontier, Billings, Montana, and Champaign-Urbana, Illinois. In the Puget Sound area, both the Regional Planning Council and the regional transportation study have used ratio techniques in preparing population forecasts.

Method III - Projections of Net Migration and Natural Increase (Component Methods)

Component analysis methods study separately several factors, such as births, deaths, and migration which affect the future size of population. The theory behind component analysis is that more accurate estimates can be made using the rates of change of the individual components of population than can be made using the rates of change for the population as a whole. For example, it is reasonable to assume that birth, death, and migration rates for 80-year old people are different than those for 20 year old people and that, based on historic experience, one can forecast the rates for such groups with reasonable accuracy. This discussion will concentrate on the two most common component methods: First, the natural increase and net migration methods, and then cohort survival and net migration methods. Because migration is common to both methods, and forecasts of net migration are usually made before those for the natural increase, migration projections will be discussed first.

Migration Projections

Logically founded projections of net migration can be developed from study of net migration in the area in the past and the conditions causing people to move into or out of it.

The direction and approximate volume and composition of net migration into or out of the area during recent decades are first determined. The influences that have induced the population movements., especially economic factors, are next investigated. The economic factors themselves are part of the economic study phase of the transportation planning process and the population forecaster should work closely with the economists in understanding these relationships. Analysis of the physical and economic resources and characteristics of the area, the trends and rate of its development, and other factors will usually reveal the principal causes. Factors affecting migration have been briefly reviewed in part I. Past relationships between net migration in an area and population growth in its economic region, State., and the Nation provide further guides for the projections.

Changes that occurred, or appear likely to occur, in the conditions and relationships affecting migration in the area are then considered. Finally, the probable effects of such changes on net migration during the forecast period are reviewed and appraised.

With these analyses and appraisals, it is usually possible to develop reasonable high and low projections for net migration. At least, they provide some indication whether net migration during the next decade may be expected to be about the same as, or larger or smaller than) that of the preceding decade.

Estimates of future net migration in substate areas also have been made by analyzing the trends of geographical distribution of net migration into the State in recent decades and projecting these trends.[7]

Natural Increase Projections

In the natural increase methods., the population is treated as a whole or as a few major groups and appropriate growth rates which reflect the net effects of births and deaths are applied to each group. For areas having substantial portions of nonwhite residents, historic trends should be analyzed and projections made separately. If natural increase is expected to be the principal source of growth, then this component of population change assumes greater importance and should be examined in greater depth. The natural increase rates to be used for projection are derived by study and analysis of the factors which influence births and deaths as discussed in part I of this report. The projected rates are then applied to the base period population to arrive at the population growth due to natural increase.

Migration and Natural Increase Methods

As an illustration of the natural increase and net migration method, another hypothetical city having the

Table 6. - Example of historic natural increase and net migration data

Year	Population	Net migration		Net natural increase	
		Ten year volume	Average annual rate of change	Ten year volume	Average annual rate of change
1930	230,000				
1940	270,000	18,000	0.0078	22,000	0.0096
1950	320,000	22,000	0.0081	28,000	0.0104
1960	400,000	27,000	0.0084	53,000	0.0166

The average annual migration and natural increase rates must then be forecast as shown in table 7. The rates have been developed by five-year periods but longer or shorter periods can be used depending on the need for projections in greater or lesser detail.

Table 7. - Example of projected annual migration and natural increase rates

Year	Projected annual migration rate	Projected annual natural increase rate
1960-1965	0.0087	0.0168
1965-1970	0.0089	0.0164
1970-1975	0.0090	0.0162
1975-1980	0.0092	0.0160

characteristics shown in Tables 6 and 7 and 8 will be used.

Applying these rates to the base year population in five-year increments, a projection would be developed as shown in table 8.

Table 8. - Example of population projection using natural increase and net migration methods

Year	Proj.pop.	Proj.ann. migration rates by 5-year periods	Proj. ann. migration for 5-year periods	Proj. ann. natural inc. rates by 5-year periods	Proj. natural increase for 5-year periods
1960	400,000*				
1965	451,000	0.0087	17,000	0.0168	34,000
1970	508,000	0.0089	20,000	0.0164	37,000
1975	572,000	0.0090	23,000	0.0162	41,000
1980	644,000	0.0092	26,000	0.0160	46,000

* The 1960 population would be the actual census count in the study area.

Cohort-Survival and Net Migration Methods

The other component method which will be discussed here is the cohort-survival and net migration method. A cohort in a population analysis is defined as a group of people with a common set of characteristics who were born during the same tire period. An example of a cohort would be all males born in January 1, 1915, through December 31, 1944, (this group would have been 15-44 year old male group in 1960), or all females, white born from January 1, 1940., through December 31. 1944.

Note that any specific age grouping (say 20-24 years of age) refers to any particular cohort at only one period in time. At the next period all the living members of the cohort will be in the next higher age group (in this case the group 25-29 years of age), but they will still be members of the same cohort (i.e., those born during the same time period).

There are no set of rules for defining the detailed breakdown of cohorts but a commonly used procedure in planning studies is to divide the population into five-year cohorts with two five-year intervals corresponding to one 10-year U. S. Census period. The five-year cohorts are then usually subdivided into male and female and where nonwhite population is of significant size, the age-sex groupings are further subdivided into white and nonwhite.

The future population is forecast by taking each of these age-sex groups and aging them through one of the forecast intervals. Assuming this period to be five years in length, this means that each cohort will move to the age group five years older. During this period some members of each cohort can be expected to die. Deaths are forecast by using annual death rates for each age-sex group multiplied by the forecast interval to obtain total forecast deaths for the interval. The survivors, who will become the new age group five years later, are forecast by subtracting anticipated deaths from the size of the cohort at the start of the forecast period.

The total net migration projected for the area to the forecast date is then distributed by sex and by age, and added to, or subtracted from, the figures for the surviving residents in the corresponding age groups. It should be noted that the sex and age characteristics of the migrant population are usually quite different from those of the resident populations of the areas from which they move or in which they settle. The sex and age distribution of net migrations into or out of the particular area or its State during recent decades, therefore, should be carefully analyzed and used as guides in estimating the sex and age distribution of the projected net migration.

Birth rates by age of mother during the forecast period are then projected or assumed. The expected number of births is then obtained by multiplying the assumed age-specific birth rates by the average number of women in each five-year age group within the child-bearing ages during the forecast period. This average figure is usually obtained by adding the number of women at the beginning and end of the forecast period in each five-year age group, and dividing by two. The survivors of those births on the forecast date are then computed by using death rates of young children. As the number of male births usually exceeds the number of female births in the ratio of about 105 or 106 to l00, this should be taken into account in precise calculations.[8]

The cohort-survival procedure does not directly measure natural increase itself. Instead, the population projection is obtained by-adding the survivors of the resident population., the expected net migration., and the survivors of babies born to residents and to newcomers during the period. If the net migration is outward, the estimate of births is reduced because of the smaller average number of women in the child-

bearing ages. Since most of the adult migrants are between ages 20-45 years,. when they move, net out-migration tends to reduce the crude birth rate also. Further refinements, such as allowances for births to in-migrant women who the during the period, are sometimes included in the calculations.

As an illustration of the cohort-survival technique, a population forecast will be made for one cohort in a hypothetical city. The cohort will be all those women born during the period January 1, 1935, through December 31, 1939. These are the women who were 20 through 24 years of age on January 1, 1960. It will be assumed that in the 1960 Census of Population., there were exactly 2,000 women in this age group.

The cohort-survival method requires as input the expected number of migrants in each age-sex group for each forecast period. This forecast is usually prepared by first forecasting the total migrants and then distributing them to the age-sex groups. The distribution into age-sex groups must recognize the different characteristics of migrants and residents. Often the historic ratios between the age-sex groups of migrants are used directly for this purpose.

To illustrate this method of distributing migrants into age-sex groups,, the anticipated number of women migrants for this cohort in 1965 and 1970 will be calculated. Historic ratios are calculated based on migration information obtained from the 1960 census which contains information on 1955 to 1960

Table 9. - Example of migration ratios derived from census data

Age-group on April 1, 1960	Female migrants	Male migrants	1955 - 1960 Ratio female migrants to all migrants
0.0- 4.9	182	189	0.052
5.0- 9.9	168	147	0.048
10.0-14.9	161	164	0.046
15.0-19.9	161	210	0.046
20.0-24.9	178	182	0.051
25.0-29.9	172	178	0.049
30.0-34.9	158	168	0.045
35.0-64.9	406	427	0.116
65.0 and over	91	158	0.026
	1,677	1,823	0.479

migration. Table 9 shows ratios derived from census data for the study area.

It will be assumed that for this example the forecast net migration into the study area is 4,000 for the period January 1, 1960, to January 1, 1965., and 5,000 for the period January, 1, 1965, to January 1, 1970. The migrants will be added in as a group at the beginning of each five-year time period.

The allocation of these migrants to age-sex groupings now becomes a simple process of using the historic ratios (or changing them if a study indicates that a change is to be expected) in conjunction with the total migration figure. In the following illustration it will be assumed that the ratios are satisfactory so they will be used unchanged. The allocations to the sample cohort of women will be:

Total net immigration 1960-1964		Ratio immigrants who are women age 25-29		Number of women migrants age 25-29 January 1, 1965
4,000	X	0.049	=	196
Total net immigration 1965-1969		**Ratio immigrants who are women age 30-34**		**Number of women migrants age 30-34 January 1, 1970**
5,000	X	0.045	=	225

The natural increase part of the cohort-survival method consists of estimating deaths occurring among members of each cohort during each iteration period and subtracting these deaths from the membership of each cohort. Death rates can be obtained from one of the sources described in the section on sources of data. -The death rate in the study area for women age 20 through 24 will be assumed to be 2.4 deaths per year per 1,000 women. Thus, in the case of this cohort the following calculations would be made:

No. of Members in cohort women age 20-24		Annual death rate per 1,000 women age 20-24		No. of years in interation period	Anticipated deaths per five-year interation period
		2.4			
2,000	X	1000	X	5	=24

These deaths are subtracted from the members in the cohort at the beginning of the iteration period to determine survivors at the end of the period. (2000 - 24 = 1976).

These survivors are now members of the 25 through 29 year age cohort in 1965. The full cohort in 1965 will consist of these survivors plus or minus migrants. In this example we have already calculated 196 women immigrants in this age group during this time period. Thus, the total membership of the cohort women born January 1, 1935, through December 31., 1939., is estimated to be: (1976 + 196 = 2172).

This total cohort is now in the 25-29 year age group in 1965, and may now be moved forward another five years by the same procedure. For example, assume that the projected death rate for women 25 through 29 years of age is 2.8 deaths per year per 1,000 women. The estimated deaths would then be calculated by multiplying the rates by the number of years in the iteration period.

2.8

(2172 X l000 x 5 = 30)

The forecast number of women immigrants in this cohort during this five-year period was calculated as 225. Thus, on January 1, 1970, the forecasted population of women age 30 through 34 is: (2172 - 30 + 225 = 2367).

The data on this cohort may be arranged as shown in table 10.

Table 10. - Example of tabulation of cohort-survival and net migration calculations

Age group	0.0-4.9	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	etc.
Annual death rate per 1,000 women					2.4	2.8		
% net migration in age group					5.1	4.9		
1960 census count					2,000			
1960-65 deaths					24			
1965 survivors					1,976			
1960-65 migration					196			
Sum, survivors and migrants					2,172			
1965 forecast						2,172		
1965-70 deaths						30		
1970 survivors						2,142		
1965-70 migration						225		
Sum, survivors, and migrants						2,367		
1970 forecast							2,367	

The data on this cohort may be arranged as shown in Table 10.

Note that the group illustrated is one cohort. That is, they were all born during the same time period and have common characteristics as they were previously defined. During each time period some of the original members are lost through deaths and new individuals migrate into the area and are added to the cohort. (The migration could be negative in which case the cohort would lose members.) The survivors and migrants are then moved to the next older age group. Note also that an identical table format would be prepared for males in the study area.

Births are handled as a separate set of calculations in cohort survival analysis. The local birth rates for each age group of women are obtained from vital statistics and these rates are then applied to the

number of women in each age group. Since most children are born to women in the 15-44 year age range, the rates are usually prepared and applied only to these groups.

As an illustration., it will be assumed that the birth rates in the study area are found to be 239.6 births per year per 1,000 women in the 20 through 24 year age range. Applying the proper rate to women in the 20-24 year age range, the following calculations are made:

Av. No. women age 20-24 alive during 5-year period		Ann. birth rate women age 20-24 (per 1,000 women)		No. of years in iteration period	No. of births to women age 20-24 during iteration period
2,000 1,976		239.6			
2	X	1,000	X	5	= 2,380

Similarly the number of births occurring in the study area to women who move into the area may be calculated by assuming that they live here one half of the time. (Such an assumption would assume an equal number of migrants would arrive each year during the five-year period.) Thus, the formerly assumed rate of 4,000 migrants from 1960-65 implies that 800 arrive each year. As noted earlier, 204 of the 4,000 migrants have been assumed to be in the 20-24 year age group. The following calculations are made:

No. of female migrants age 20-24 during 5-year period		Ann. birth rate women age 20-24 (per 1,000 women)		One-half No. years in iteration period	No. of births to migrant women age 20-24 during iteration period occurring in study area
		239.6			
204	X	1,000	X	2.5	=122

The estimated births to women in this age group are added to the births estimated for women in other age groups in the child-bearing range to determine the children born in the study area to be assigned to the 0-4 year age group in the next iterative period. Breakdowns by sex are obtained by studying past ratios of males to females among local births. To these children must be added children of migrants who were born elsewhere during this time period and brought into the study area by their parents (or who left with their parents if the local area is undergoing out-migration).

Critique

The component method is being relied on more and more for population projections. For most areas and cities, it should yield better forecasts than trend and ratio methods, particularly for projections not exceeding two decades.

Component methods take into account the size of the area's population at the beginning of the forecast period, and the effects of a population of that size on future births, deaths, and migration. Trend and

ratio methods do not provide as accurate measures of the effects of changes in the size of the population from decade to decade.

Moreover, this method requires the forecaster to appraise the effects of various influences on each of the three sources of population change instead of making a less discriminate evaluation of their effects on population growth as a whole. Certain influences, such as rapid economic development, may accelerate migration into an area but have relatively little effect on its birth and death rates. This method also measures the reaction of migration on natural increase instead of blanketing this quantitative effect in with a host of qualitative considerations.

The range of future birth and death rates usually can be determined with a smaller margin of error than that of future migration. Component methods are therefore especially useful for projections in which natural increase is expected to be the principal source of population growth. Hence, it is almost invariably used for projections of the national population.

If the population information is needed for a special purpose for example, anticipated school enrollment or licensed drivers - the cohort-survival method will provide this information without the need for additional calculations. In addition, the method is highly recommended for areas which have a population distribution which differs radically from that in the rest of the region (e.g., an area which has a large number of elderly residents).

Approximate projections of natural increase) assuming no migration in the area, can be made easily and quickly. These will give a good indication of minimum growth to the forecast date, unless there is a net out-movement, and are valuable checks on projections made by other methods.

It is also easy, once the initial data have been gathered, to prepare more than one forecast based upon different assumptions as to births, deaths, and migration. Such alternative series are especially of value in understanding the implications of some change which will affect one of these components (as for example, a road system which would encourage growth of economic activities which would attract heavy immigration).

Component methods have been used by several studies; among them the Penn-Jersey Transportation Study, the Portland, Oregon, Metropolitan Planning Commission, the Salt Lake Area Transportation Study, and the Dade County Planning Department. The Luzerne County, Pennsylvania, (Wikles - Barre - Hazleton area) Planning Commission used this method for the forecast and then used a ratio method as a check on the reasonableness of the projected figures.

Method IV - Forecasts Derived Directly from Specific Estimates of Employment and Other Occasionally Used Methods

The three methods already discussed; trend based, ratio, and component, are the most prevalent methods of forecasting population. Several other methods have also been used enough to warrant a brief discussion of them. Three of these methods will be discussed here; first, forecasts based on economic projections; second, comparative or analogy methods; and third, the holding capacity method. The last two methods are not considered satisfactory for large area forecasts and would best be avoided for transportation study purposes.

Population forecasts based on future labor force estimates

The ability of any area to grow in population depends to a great extent upon its ability to support this population with jobs. Thus, a forecast of the labor force[9] available from an economic study as a part of the urban transportation planning-process can form the basis for a population forecast. When so developed, this population forecast can be used to check the population forecast arrived at by demographic methods (i.e., using mathematical, graphical, or other type of projections of past relationships in which the effects of economic factors on population change are implied but not expressly stated or studied in detail).

The translation of a labor force forecast into a population forecast is accomplished by using the projected labor force-to-population ratio. (This is called the "labor force participation rate.")[10] Before undertaking to project it into the future a study should be made of past trends to gain an understanding of the factors that have influenced this rate in the past and which may affect it in the future; for example, the delayed entrance into the labor market of young people continuing their education and the increasing participation in the labor force of married women after their children are grown. Additionally, the early retirement of older workers may be an important element affecting this rate in a particular area, depending upon the characteristics of the population and the hiring practices of the firms in that area.

The population forecast is prepared by applying the projected labor force participation rate to the labor force forecast and making adjustments as necessary to account for the military and/or the institutionalized population. To illustrate, the following tabulation shows historical data on the total civilian population, the civilian labor force, and the labor force participation rates for an assumed study area.

Year	Total Civilian Population	Civilian Labor Force	Labor Force Participation Rate (Col. 3/col. 2)
1930	100,000	39,700	39.7%
1940	120,000	48,200	40.2%
1950	145,000	62,200	42.9%
1960	185,000	75,900	41.0%

Using the forecast of the total civilian labor force prepared by the economic study and applying the forecasted labor force participation rates (i.e., dividing the labor force by the rate and multiplying by 100), the civilian population can be computed as shown in the following tabulation.

Year	Forecast Civilian Labor Force	Forecast Labor Force Participation Rate	Labor Force Civilian Population
1965	31,600	40.8%	200,000
1970	87,100	40.5%	215,100
1975	94,500	40.2%	235,300
1980	102,000	40.0%	255,000

If the labor force figures are broken down by types Of jobs and characteristics of workers, it is possible to prepare more detailed estimates of population by age, sex, and race.

Critique

This method assumes that the volume of employment in an area on a future date can be forecast from consideration of certain economic factors alone, without taking into account the probable size of the future population. It implies that the volume of future employment can be forecast with greater accuracy without reference to the size of the future population than the size of the population can be forecast without having a specific forecast of the future employment level.

The relationship between economic expansion and population growth in an area, however, is somewhat like that of the chicken and the egg. Development of extractive or commodity producing industries, a new irrigation project or a large -new factory, normally will create new jobs. But people also move into an area for a variety of other reasons (e.g., health or retirement) and such in-migration itself tends to expand employment.

In most areas, the future employment level will not be determined solely by the rate of expansion or decline of the so-called "basic" industries. It will also be affected by the rate of population growth in the area, and by changes in transportation, trade, and service activities, and government employment,. Which may be unrelated to local production of tangible goods. Moreover, the rates of expansion in local agriculture, manufacturing, and construction themselves may be influenced by such changes. This is particularly true of areas receiving continuous immigration, such as those on the Pacific Coast.

Furthermore, the proportion of the population in the employable ages and the ratio of labor force to population may also differ over time from the assumed ratios. It would therefore seem unwise to rely solely on population forecasts made by this method.

On the other hand, the analyses and evaluations of prospects for increase or decline of economic activities provide valuable information which is useful in making projections of net migration and natural increase by component methods. They can especially aid the forecaster in determining net migration during the forecast period would likely be in the same direction. and in higher or lower amount, than in the preceding decade.

Comparative or analogy method (not recommended)

This method assumes that if two areas have similar characteristics such as geography, climate, economic potential, culture, natural resources, etc., their growth patterns will be similar. In practice the forecaster chooses a city which has these similar characteristics and is already further developed than his study area. He then projects the future growth of his study area as similar to the past growth of the developed area.

The simplest projection method is to choose a developed area with similar characteristics whose early population, growth curve is similar to the past growth curve of the study area: that is, the population growth curve for the developed area from 1850 to 1900 might be parallel to the growth curve for the study area from 1940 to 1960. An assumption is then made that the part of the curve being projected beyond 1960 for the study area will parallel the historic curve for the developed area following 1900. Such a situation is shown in Figure 6. Note that the population size for the two areas is not necessarily equal nor need the time scales (the X axis) be identical.

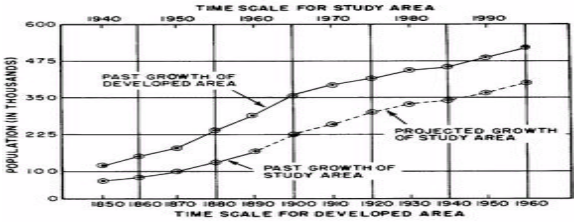


FIG. 6 - EXAMPLE OF A POPULATION FORECAST BY THE ANALOGY METHOD

A more complex method of making a comparative forecast is to study several developed areas, each of which has at least one or two similar characteristics in common with the study area. The differences and similarities between the study area and each of the developed areas are examined and an average population curve is developed from the several curves analyzed. This "cumulative" curve then becomes the population growth that is used in projecting the total population in the study area.

Critique

As a method of projecting population for a metropolitan area the comparative forecast analogy method has severe weaknesses. It is doubtful that there are two urban areas that are sufficiently alike to be able to say that the second will grow in a similar manner to the first. Moreover, even if one could assume that they were identical, it is still doubtful that two areas developing at different periods in history would follow the same patterns of growth.

The comparative or analogy method may still have same value in forecasting population for small areas. A good example would be in out-lying areas of a metropolitan community where urban development and population growth in a currently open area may be anticipated to follow that of a similar, but already developed area. When used in conjunction with such factors as zoning, holding capacity, accessibility, available utilities, etc., this procedure may give a reasonable indication of the small area patterns which might occur.

Holding capacity method (not recommended)

This procedure assumes that an upper population density limit can be established for an area, and therefore an upper limit to the number of people who live in that area can be established. The maximum. population capacity is derived through studies of zoning, land characteristics, available water, and other land use measures. The population is then -assumed to grow until it fills all or a certain percentage of this capacity.

Critique

Since the holding capacity of any metropolitan area is likely to be much larger than any realistic population size that will live in the area, the method requires the forecaster to assume some percentage of the capacity which will be filled. This in effect results in subjective decisions by the forecaster. Moreover, holding capacity is not a constant. Areas currently zoned for low density may be changed to density when the demand arises. For small area analysis within an urban area, the method may have more validity but it becomes less reliable When used for the total metropolitan study area.

An example of a study using this method is the Seattle, 98 Washington, City Planning Commission forecast by census tracts to 1985. It is important to note that this forecast is for a closed area, the city of Seattle, and not for the total area which would have to be included in the transportation study.

APPENDIX I: METHODS USED IN CURRENT POPULATION ESTIMATION

An important part of the population forecasting process is the estimation of actual population at the time the study is undertaken (the base year). If the study is undertaken at the same time as a census or within one or two years of such a census, most areas will find it satisfactory to use the census counts with only gross adjustments. Since the United States census is made only at 10-year intervals and few States make intermediate census enumerations, it is usually necessary to prepare or obtain current population estimates as the first stage in preparing a population forecast. These current estimates will become the base year -population which will be used in making the population forecast.

Many private and governmental agencies have needs for current population counts and prepare them for their own use. The first step should therefore be to determine whether such figures have already been prepared for all or part of the study area. Since transportation study area boundaries do not ordinarily correspond with the boundaries used by other agencies, it is usually necessary to make adjustments to get estimates for the study area. Often, use can be made of estimates for those areas pre-pared by other agencies, leaving to the transportation study the job of preparing only the remaining estimates.

If current population estimates are not available, the forecaster will have to prepare them. Several methods can be used including any of the forecasting methods previously discussed. If such procedures are used, the population is forecast forward from the last census year to the current year.

Other estimating procedures make use of "symptoms" of population change which are supposed to reflect changes in population. Symptoms are usually items which are readily counted or measured. Procedures using symptoms as indicators are normally better than forecasting methods since forecasting methods use historic population trends projected forward while the "symptomatic" methods attempt to determine the population by measuring the actual changes in the symptomatic factors.

An example of a symptom which is commonly used is elementary school enrollment figures. Assuming the size and other characteristics of families constant, changes in the number of children in elementary school would indicate changes in the total number of families and, therefore, changes in total population. Special adjustments are made to account for persons not having school age children (i.e., older persons, single people, etc.).

Considerable care must be exercised in the choice of symptoms to be used. At the time of the 1960 census several cities were surprised to find that their actual population had not increased as much as was indicated by the precensus estimates that they had prepared. Several reasons for these differences have been given, but one of the most common cause was the use of symptoms of changes in the standard of living of the community. For example, the ownership of automobiles and telephones usually increases as income increases. Thus, an overall increase in disposable income in an area might cause an increase in automobiles and telephones even if no additional people move into the area. Care must be taken to see that symptomatic data actually reflect population changes.

Any estimating method has certain inherent disadvantages and tends to more accurately estimate one segment of the population than other segments. It is usually desirable, therefore, to prepare local area estimates by utilizing more than one method and averaging the results. The exact methods to use and the desirability of weighing the estimates before averaging must be determined by studying local population characteristics.[11]

Estimates prepared by the U.S. Bureau of the Census

The U.S. Bureau of the Census prepares and distributes regularly current population estimates for the United States and less frequently for each State.[12] These estimates take into account immigration and emigration, natural increase, and for the State estimates, interstate migration. Natural increase is estimated by using birth and death data corrected for under reporting. Migration is estimated by comparing actual school enrollment with estimated school enrollment due to natural increase alone. These census estimates are useful as indicators of national and State changes and may be used directly in a ratio type of local estimate or as a control on the reliability of the local estimate.

Census Method I estimates net migration based on the difference between the percentage change in the school age population for the State and the corresponding change for the whole United States. This method has not performed well on tests, and is no longer used. Census Method II estimates net migration based on the difference between the actual population of elementary school age as reflected by school enrollment figures compared with the population of elementary school age which would exist if only natural increases occurred.[13]

Elementary School Enrollment Methods

There are many variations of the use of school data in estimating population. The following is an illustration of one of these methods. In this illustration the population on April 1, 1963, will be estimated using a procedure similar to Census Method II. The basic data are assumed available for the study area from the following sources; 1960 U.S. Census of Population and Housing, local area birth and death records and school records. Since these data would come from several sources, it is assumed that they have been corrected to represent the same geographic area as well as the same time period.

Total population, April 1, 1960, census count	100,000
Children, 7 through 14 years of age, April 1, 1960	20,000
School enrollment, grades 2 through 8, April 1, 1960	19,000
Net migration to study area, April 1, 1955, to April 1, 1960 (five years of age and over)	10,000
Net migration, children under five years of age April 1, 1955, to April 1, 1960 (obtained from State records)	2,000
Net number of children age 7 through 14 years who were migrants to the study area, April 1, 1955 to April 1, 1960	2,000
Number of children age 4 through 11, April 1, 1960 (these are the children who will be 7 through 14 on April 1, 1963)	21,000
Ratio, total population to children age 7 through 14 years of age	5.00

Ratio, children grades 2 through 3 to children 7 through 14 years of age, April 1, 1960	0.95
Ratio, net migration to study area April 1, 1955, to April 1, 1960, to children 7 through 14 years of age who were migrants to the study area, April 1, 1955, to April 1, 1960	6.00

The above figures and ratios are all for April 1, 1960.

The next step will be to list the necessary data for April 1, 1963:

Number of children grades 2 through 6, April 1, 1963	24,000
Number of births to study area residents, April 1, 1960, to April 1, 1963	7,000
Number of deaths of study area residents, April 1, 1960, to April 1, 1963	4,000
Number of deaths of study area residents who would have been 7 through 14 years of age on April 1, 1963, which occurred between April 1, 1960, to April 1, 1963	100

The first calculation would be the number of residents in the study area allowing for births and deaths but no migration.

Total population, April 1, 1960	100,000
Births to study area residents, April 1, 1960 to April 1, 1963	7,000
Subtotal	107,000
Deaths to study area residents, April 1, 1960 to April 1, 1963	4,000
Resident population, April 1, 1963	103,000

Next the number of children who would have been in grades 2 through 6 if no migration occurred will be determined. (This assumes that the ratio of children 7 through 14 years old to children in grades 2 through 8 does not change). First, survivors in the 7 through 14 year range as of April 1, 1963, are determined. These are the children who were 4 through 11 years old on April 1, 196), less those who died.

Children age 4 through 11, April 1, 1960	21,000
Deaths to these children occurring between April 1, 1960, and April 1, 1963	100
Survivors who are children 7 through 14 years of age, April 1, 1963	20,900

The number of these children in elementary grades will be estimated by applying 1960 ratio of children in these grades to children in this age group.

Survivors Who Are Children 7 through 14 Years of Age		Ratio, Children Grades 2 through 8 to Children 7 through 14 Years of Age		Estimated Resident Children in Grades 2 through 8 April 1, 1963
20,900	X	0.95	=	19,855

School enrollment showed that there were actually 24,000 children in these grades. Assuming no changes in enrollment procedures which would introduce inconsistencies in the data, the difference between those who would be in school if no migration occurred and the actual school enrollment would be the children of migrants who moved into the area.

Number of children, grades 2 through 8, April 1, 1963	24,000
Estimated resident children, grades 2 through 8, April 1, 1963	19,655
Estimated children of migrants, grades 2 through c3, April 1, 1963	4,145

Assuming that the ratio of children in grades 2 through 8 to children age 3 through 14 is valid for migrants as well as residents, an estimate of the number of children of migrants aged 7 through 14 on April 1, 1963, can be made. The procedure is to multiply the inverse of the ratio times the estimated children in grades 2 through S.

Estimated Children of Migrants Grades 2 through 8 April 1, 1963		Inverse of Ratio of Children in Grades 2 through 8 to those 7 through 14 Years of age		Estimated Children 7 through 14 Years of Age Who Moved to Study Area, April 1, 1960 to April 1, 1963
		1		
4,145	X	0.95	=	4,363

To get the estimated total number of migrants, the ratio of the number of people who moved to the study area, April 1, 1955, to April 1, 1960, to children aged 7 through 14 who moved to the study area in the same period will be used.

Estimated Children 7 through 14 Years of Age April 1, 1963 Who Moved to Study Area April 1, 1960 to April 1, 1963		Ratio, Net Migration to Study Area April 1, 1955, to Children April 1, 1960, to Children 7 through 14 Years of Age Who were Migrants to the Study Area, April 1, 1960		Estimated Migrants April 1, 1960 to April 1, 1963
4,363	X	6.00	=	26,178

Adding this to the net population derived from adjusting the 1960 resident population for births and deaths the total April 1, 1963, population is estimated.

Estimated resident population, April 1, 1963	103,000
Estimated migrants, April 1, 1960,. to April 1, 1963	26,178
Estimated population, study area, April 1, 1963	129,178

Obviously many simplifications have been made in the example just described. For instance, a more accurate estimate might have been-obtained by using ages 7½ to 14½ or 7 3/4 to 14 3/4 and making adjustments for differences in school enrollment in April and other months. Also, most analysts will not be fortunate enough to have all their data for the same time period and so will have to adjust it to the estimate and census dates.[14]

Composite method of estimating population

A more complex method of estimating current population is the composite method. As described by Donald Bogue[15] the current population estimate is prepared by making separate estimates for persons in different age groups using the "symptoms" that most accurately reflect the number of persons in each age group. The graph in Figure 7 illustrates how certain events are more common at certain ages than at others. The total estimate is then prepared by summing up the number of persons estimated in each group.

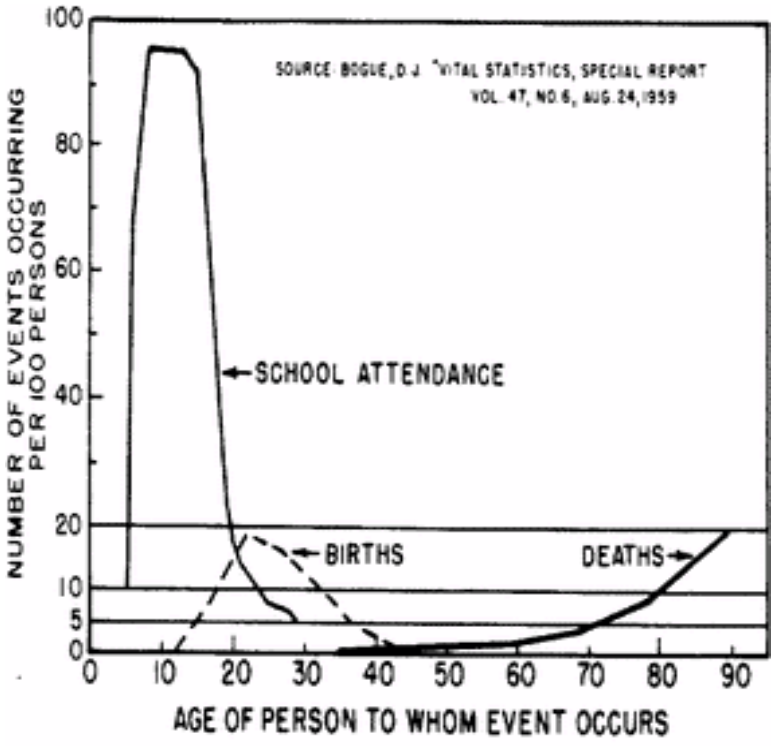


FIGURE 7-NUMBER OF EVENTS OCCURRING PER 100 PERSONS OF THE SPECIFIED AGE, UNITED STATES: 1950

The method may be briefly described in six steps:

3. Estimate the current population aged 45 years and over utilizing death rates and number of actual deaths recorded for residents of the study area.
4. Estimate the current number of females aged 15-44 years based upon birth rates and the number of births recorded for residents of the study area.
5. Estimate the current number of males aged 15-44 years based on historic ratios of males to females in this age range. (This estimate must also allow for males in the armed forces.)
6. Estimate the current population aged 5-14 years using current school enrollment figures and the ratio of children in this age range to children actually enrolled in school.
7. Estimate the current population under 5 years of age using the number of children in this age range per 1,000 women aged 20-34 and the estimated number of women in this age range.
8. Sum the components derived in steps 1-5 to obtain the total current estimate of population.

APPENDIX II: DATA SOURCES

Federal Government
- General notes

U.S. Bureau of the Census
- General notes
- Decennial Census of Population and Housing
  - General notes
  - U.S. Census of Population: 1960
  - U.S. Census of Housing: 1960
- Current Population Reports
  - Series P-20, Population Characteristics Series P-23, Special Reports on Methods and Concepts
  - Series P-25., Population Estimates
  - Series P-27, Farm Population
  - Series P-28, Special Censuses
  - Series P-60, Consumer Income
  - Series P-65, Consumer Buying Intentions
- Special Publications
  - Statistical abstract of the United States
  - County and City Data Book 1962
  - Historical Statistics of the United States, Colonial Times to 1957

U.S. Department of Health, Education, and Welfare
- General notes
- Office of Education
- Public Health Service
- Vital Statistics of the United States
- Monthly Vital Statistics Report

State Government
- General Notes
- State Department of Commerce State
- Department of Health
- State Department of Education
- State Bureau of Employment Security

Local Government
- General Notes
- Local Planning Office
- License and Inspection Office
- Tax Assessors Office
- Voter Registration Records

Private and Quasi-Public Sources
- General Notes
- Public Utilities
- Colleges, Universities, and Research Foundations
- Private Organizations

National Planning Association
City Directories

Federal Government: General Notes

A wealth of information useful for population studies (as well as many other phases of the transportation planning process) may be found in government statistical publications and reports. A fairly complete list of data available from the agencies of the Federal Government can be found in two Federal publications:

Statistical Services of the United States Government, Executive Office of the President, Bureau of the Budget, Revised edition, 1963.

Directory of Federal Statistics for Metropolitan Areas, An Information Report, The Advisory Commission on Intergovernmental Relations, October 1962.

Both of these publications are available from the U.S. Government Printing Office, Washington, D.C., 20402, for $1.00 each. They contain descriptions of agencies which collect data, definitions of important terms, the types of data collected and the tabulations available. The first publication is primarily a list of agencies and the types of data each collects. The second lists types of data available and which agencies can provide the data.

U.S. Bureau of the Census: General Notes

The Bureau of the Census in the Department of Commerce is the largest agency of the Federal Government for the collection, compilation and publication of general-purpose statistics. It is responsible for taking all the censuses authorized by law, including:

- Population - every 10 years (for years ending in "0").
- Housing - every 10 years (for years ending in "0").
- Agriculture - every 5 years (for years ending in "4" and "9").
- Business (retail, wholesale, and selected service trades) - every 5 years (for years ending in "3" and "8").
- Manufactures - every 5 years (for years ending in "3" and "8").
- Mineral industries - every 5 years (for years ending in "3" and "8").
- Transportation - every 5 years (for years ending in "3" and "8").
- Governments (state and local governmental units) - every 5 years (for years ending in "2" and "7").

The Bureau of the Census also collects information in sample surveys at more frequent intervals - monthly, quarterly, or annually - on many of the subjects covered in the decennial censuses, e.g., population, manufacturing activity and commodity production, retail and wholesale trade, State and local government finances, and housing characteristics and vacancies.

Decennial Census of Population and Housing

General Notes

The Decennial Census of Population and Housing collects and publishes detailed information on number of persons, age, sex, race characteristics, education, income, housing, labor force, etc., for small areas. There are large amounts of data that are never published by the Census, but which are available upon request. Information concerning these data, an estimate of costs, and the Procedures necessary for obtaining this information are found in tie following publications.

- U.S. Census of Population, 1960, Availability of Published and Unpublished Data (Cost $.50).
- U.S. Census of Housing, 1960, Availability of Published and unpublished Data (Cost $.25).

Both of these Publications may be obtained by writing to:
U.S. Bureau of the Census
Washington, D.C. 20233

U.S. Census of Population, 1960

Data on number of inhabitants and their characteristics are published in Volume I. This volume in turn is divided into four parts, each of which is further divided into 57 sections, one such section for each State, a United States summary and certain United States possessions. The four marts are:

- PC (l)-A Number of Inhabitants
- PC (l)-B General Population Characteristics
- PC (l)-C General Social and Economic Characteristics
- PC (l)-D Detailed Characteristics

U.S. Census of Housing, 1960

The data on housing are published in seven volumes of which volumes I and III are of special interest. Volume I State and Small Areas is subdivided into 55 reports, one for each State, a United States summary and certain United States possessions. The report contains data on the characteristics of housing units for the State with separate statistics for each standard metropolitan statistical area, urbanized area, place of 1000 inhabitants or more, county, and rural-farm and rural-nonfarm parts of the county.

Volume III, City Blocks, is subdivided into 421 separate reports, one for each city of 50,000 inhabitants or more and selected other cities. It contains information on housing characteristics and total population for each census block.

Current Population Reports

The Bureau of the Census publishes information on special censuses current estimates, population projections and special studies. The title "Current Population Reports" applies to each of the several series published, each series dealing with a specific subject.

9. Series P-20, Population Characteristics, is published occasionally and presents the results of special tabulations dealing with such factors as households, families, and mobility.
10. Series P-23, Social Reports on Methods and Concepts, is only published occasionally and not in any time sequence.

A recent publication of special interest in this series is P-23, No. 7, Components of Population Change, 1950 to 1960, For Counties, Standard Metropolitan Statistical Areas, State Economic Areas, and Economic ,subregions. This publication contains figures on migration for each of these areas from 1950 to 1960.

11. Series P-25, Population Estimates, is published monthly and occasionally special issues are published from time to time. These publications present current estimates of the U.S. population plus occasional projections of national population.

Issue No. 286, July 1964 contains projections to the year 1985 (with extensions to 2010) for the United States by age and sex. Four series of projections are provided and the methods are discussed in considerable detail.

12. Series P-25, Farm Population, is published annually and also has special publications published from time to time. These publications are produced in conjunction with the Department of Agriculture.
13. Series P-28, Special Censuses, is published occasionally and presents the results of special censuses conducted at the request and the expense of local areas.
14. Series P-60, Consumer Income, is published annually and occasionally and presents income data based on data collected in the Current Population Survey.
15. Series P-65, Consumer Buying Intentions, is published quarterly and presents data collected in the Current Population Survey.

Individual copies of these reports are available at a small cost. Annual subscriptions to the series P-20, P-23, P-25, P-27, and P-28 combined may be made for $4.50. Annual subscriptions to the Series P-60 and P-65 combined may be made for $1.25. Subscription orders may be sent to the Bureau of the Census, Washington, D.C., 20233.

Special Publications

Statistical Abstract of the United States

This book is published annually and contains s statistics from governmental and nongovernmental sources on the industrial, social, political, and economic organization of the United States. It may be

obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $3.50.

County and City Data Book, 1962

This publication presents data for each county, State, standard metropolitan statistical area, urbanized area, unincorporated urban place of 25,000 population or more, and for each city of 25,000 population or more. Copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $5.25 each.

Historical Statistics of the United States, Colonial Time to 1957

This volume contains more than 3,200 statistical time series, largely annual, extending back to the earliest year for which the data are available, with specific source notes, definitions of terms, description of development and reliability of the data, detailed subject index, and descriptive text. Copies of this publication may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $6.00 each.

U.S. Department of Health, Education, and Welfare: General Notes

This agency collects data on vital statistics (births and deaths) and information on school enrollment. Much of it is detailed on a State level although certain data are available for metropolitan areas and counties.

Office of Education

The data collected by this agency concern the condition and progress of American education and including such statistics as staff students, etc., of public and nonpublic elementary and secondary schools. Two publications, the Digest of Educational Statistics and Statistics of State School Systems contain information on national and State enrollment in public schools by grade. The second publication also contains similar data for nonpublic schools.

Public Health Service
(Including National Center for Health Statistics)

Statistics concerning the number of births, deaths, marriages, and divorces are prepared and published by the National Vital Statistics Division of the Public Health Service. In addition, this agency prepares life expectancy tables. The information published is for the nation as a whole. However, certain of the data are prepared for States.

Vital Statistics of the United States

This report is published annually in two or more volumes and contains counts on births, deaths, marriages, and divorces. These statistics are available on a national level and contain considerable detail.

Monthly Vital Statistics Report

Presents monthly and cumulative data on births, deaths, etc. Occasional special reports are also prepared on special subjects such as use of these statistics in preparing estimates.

State Government: General Notes

It is not possible in this report to list all of the sources or types of data available for each State. However, in this section several of the more general State sources of data will be mentioned. The reader should realize that the names of the public agencies from which data way be obtained will vary from State to State as will the type of data.

Furthermore, what may be a department in one State may only be a small office in another, or not even exist at all. Definitions will also vary between States. For example, the term "births" may mean all births in one State and only live births in another. Users of population data will have to investigate all sources for their own particular State and determine exactly what is available.

State Department of Commerce

Many States have a special department devoted to cooperating with and promoting commerce in the State. Such an agency may have current population estimates and/or forecasts for the State as a whole and/or local areas. It may also have information on economic activity within the State which would be of value in forecasting the growth potential, thus the migration trends, for the study area.

State Department of Health

Counts of actual births and deaths by age, sex, and race of person to whom the event occurred are usually available. This information is useful in calculating local area rates and preparing current population estimates. These data are normally corrected for areas of residence rather than places where the event occurred. For example, it is necessary to assign births and deaths to the place of residence. Otherwise, an area containing a large hospital would appear to have extremely high birth and death rates.

State Department of Education

16. School enrollment by grades. Annual, semi-annual, or monthly counts may be available. These are useful in preparing current population estimates (see Appendix I).

17. Special census of pre-school and school age children. This type of census is not always available for all areas and is often incomplete since adults are usually not enumerated. These data when available are useful in making short range forecasts and in preparing current population estimates.

State Bureau of Employment Security

The purpose of this State agency is to carry out the State unemployment insurance program. As a part of this program, this agency obtains employment information from all "covered" employees. If this employment information is made available for the study area, an analysis of the data would provide a great deal of insight as to the potential for future migration. For example, a sudden rise in construction activities may underlie a temporary increase in population which will disappear when the construction is completed. On the other hand, a recent rise in employment in manufacturing may indicate the introduction of stable activities which will indicate a more permanent, long range increase in population.

Local Government: General Notes

Local sources of data include both counties and cities or municipalities. In many cases the State organizations already mentioned will exist on a local level, and should be investigated. The same general comments apply to local governments as sources of data as to State governments. Since there are so many sources and so many ways to define the statistics collected, the worker in this field must investigate all possible sources and determine the precise definition of each bit of information collected.

In addition to local branches of State agencies or parallel local agencies, several other possible local sources should be investigated. These would include:

Local Planning Office

This office may have considerable information already available, including copies of State and Federal data sources (for example, a complete census library). In addition, it may have current estimates and/or population forecasts already prepared. Local Planning agencies often have historic data available which is of considerable value in studying and developing trends.
Plans of the agency ,nay affect the future size and distribution of population in the local area and so must be considered in preparing a population forecast.

License and Inspection Office

Assuming this is the local office handling occupancy and building code permits, this office may have an accurate record of the number of dwelling units and/or size. Occasionally, the number of occupants is included. This information, if available and up to date, may be used as an indicator of current population.

Tax Assessors Office

Depending on the types of local taxes collected and the procedure used in handling the records, this office may have information on number of individuals in the local area and changes in local employment characteristics..

Voter Registration Records

To a small degree, changes in the number of voters are used as symptomatic data in preparing current population estimates. In areas where long waiting periods or irregular voter registration procedures exist these records will be inadequate.

Private and Quasi - Public Sources: General Notes

Nongovernmental sources of data include public utilities, consultants, planning departments of various companies, etc. They may be operated for profit or as a nonprofit operation and the data may be a major part of the overall program or just a by-product necessary for the total project. Again, it would be impossible to list all possible sources, but some of the more valuable ones will be listed.

Public Utilities

Utilities find it necessary to plan for the future, and in many locations have prepared estimates and/or forecasts of their own which may be useful to the transportation study. Other data which may be available and of value can be classified as symptomatic data. Such "symptoms" as records on installations or removals of utility meters may be symptoms of changes in population. Utilities which require individual meters for every dwelling unit, as is often the requirement with electric companies, are the most useful. However, in those areas where one meter for a large apartment is permissible or in those areas where the number of meters is optional this symptomatic factor is less valuable.

College, Universities, and Research Foundations

There are many research projects being conducted at colleges, universities, and research foundations that involve the development of current population estimates or future forecasts.

Private Organizations

Many private organizations find it necessary to prepare population data for their use. These data may be confidential and not available or they may be provided upon request. Also valuable to forecasting purposes is information on company's plans for future expansion or relocation, and the effects this will have on employment. This is especially important in an area which is heavily dependent on one or a few companies or type of activity for its employment.

National Planning Association

The NPA is a private, nonprofit research organization founded to study the methods for the full utilization of the productive resources of the United States -to give the American people the highest possible material and cultural standards of living. Many publications of the NPA are useful planning tools. Of particular interest to demographers are their Regional Economic Projection Series publications; especially

Regional Projections-to 1976 (Population, Labor Force, Employment, and Income), Technical supplement No. 8, Feb. 1962.

This and other publications are available to subscribers. For further information write to the National Planning Association, 1606 New Hampshire Avenue, NW., Washington, D.C., 20009.

City Directories

Up to date city directories are valuable sources of population data, especially for small area counts. However, city directories are often only available for part of the study area; normally, the central areas and older suburbs.

APPENDIX III: ADDITIONAL READINGS

General Information

Chapin, F. Stuart, Jr., "Population Studies" Chapter 7 Urban Land Use Planning, New York, Harper & Brothers, 1957, pp. 152-190.

Dorn, Harold F., "Pitfalls in Population Forecasts and Projections," Journal of the American Statistical Association, Vol. 45, No. 251, September 1950, pp. 311-334.

Hagood, Margaret Jarman, & Siegel, Jacob S., Population Projections for Sales Forecasting, paper presented before the Business & Economics Statistics Section at the 111th Annual Meeting of the American Statistical Association, Boston, Massachusetts, Dec. 27, 1951.

Hajnal, John, "The Prospects for Population Forecasts," Journal of the American Statistical Association, Vol. 50, No. 270, June 1955, pp. 309-322.

Isard, Walter, and others, Methods of Regional Analysis: An Introduction to Regional Science, Technology Press of MIT and John Wiley & Sons, Inc.,

Jaffe, A. J., Handbook of Statistical Methods for Demographers, (preliminary edition 1951, third printing 1960), U.S. Government Printing Office, Washington, D.C., 20402. (cost $1.75)

Schnore, Leo F., "A Planner's Guide to the 1960 Census of Population, "Journal of the American Institute of Planners) Vol. 29, No. 1, February 1963, pp. 29-39.

Siegel, Jacob S., "Forecasting the Population of Small Areas," Land Economics, Vol. XXIX, No. 1, February 1953, pp. 72-88.

Siegel, Jacob, "Some Aspects of the Methodology of Population Forecasts for Geographic Subdivisions of Countries," Proceedings of the World Population Conference, 1954, United Nations, New York, 1955, pp. 113-133.

Siegel, Jacob S., Zitter, Meter, and Akers, Donald S., "Projections of the Population of the United States, by Age and Sex: 1964 to 1985, Current Population Reports, Population Estimates, Series p. 25, No. 286, July 1964.

Stanbery, Van Beuren, Better Population Forecasting for Areas and Communities, U.S. Department of Commerce, Washington, D.C., 1952, Domestic Commerce Series no. 32, (Out of print)

Taeuber, Conrad, & Hansen, Morris H., "A Preliminary Evaluation of the 1960 Census of Population," Demography, Vol. 1, No. 1, 1964.

U.S. Bureau of the Census, 1960 Census of Population, Vol. 1, Characteristics of the Population, Part I, United States Summary, pages XI to XCI.

Weiss, Shirely F., 'Basic Planning Studies, Population Studies," Local Planning Administration, International City Managers Association, Chicago, Illinois, third edition, 1959, pp. 76-83.

White, Helen R., "Empirical Study of the Accuracy of Selected Methods of Projecting State Population," Journal of the American Statistical Association, Vol. 49, No. 207, September 1954, pp. 480-499.

Zitter, Meyer, "Population Projections for Local Areas," Public Works June 1957.

Forecasting Methods
Ratio Methods

Hagood, Margaret J., and Siegel, Jacob S., "Projections of the Regional Distribution of the Population of the United States to 1975," Agricultural Economic Research, Vol. III, No. 2, April 1951, pp. 41-52.

Schmitt, Robert c ., "A Method of Projecting the Population of Census Tracts," Journal of the American Institute of Planners, Vol. 20, No. 2, Spring 1954, page 102.

Loomer, Harlin A., "Accuracy of the Ratio Method for Forecasting City Population: A Reply," Land Economics, Vol. 28, No. 2, May 1952, pp. 180-183.

Schmitt, Robert C. and Crossetti, Albert H., "Accuracy of the Ratio Method: Rejoinder," Land Economics, Vol. 28, No. 2, May 1952, pp. 183-184.

Stanbery, Van Beuren, Some New Techniques for Area Population Projections, San Francisco, California, September 25, 1959.

Sandgren, Ann S., and Walker, John R., Population Trends and Projections, Interim Report, Puget Sound Regional Transportation Study, September 14, 1959.

White, Helen R., Siegel, Jacob S., and Rosen, Beatrice M., "Short Cuts in Computing Ratio Projections of Population," Agricultural Economics Research, Vol. V, No. 1, January 1953, pp. 5-11.

Component Methods

Portland, Oregon, Metropolitan Planning Commission, Population Prospects (Projections of the metropolitan population to 1975 with age-group and geographic distributions) July 1960.

Tarver, James D., "A Component Method of Estimating and Projecting State and Subdivisional Population," Misc. Publications MP 54, Oklahoma State University Experiment Station, December 1959.

U.S. Census Bureau, Current Population Reports, Series P-25, No. 43

Estimating Methods

Bogus, Donald J., A Composite Method for Estimating Postcensal Population of Small Agree by Age, Sex, and Color, from "Vital Statistics-Special Reports, Selected Studies," Vol. 47, No. 6, August 24, 1959, U.S. Dept. of Health, Education, and Welfare, Public Health Service, pp. 167-185.

Bogue, Donald J., "A Technique for Making Extensive Population Estimates," Journal of the American Statistical Association, Vol. 45, No. 250, June 1950, pp. 1 9-1 3.

Brown, Hugh H., "A Technique for Estimating the Population of Counties," Journal of the American Statistical Association, Vol. 50, No. 270, June 1955, pp. 323-343.

Eldridge, Hope T., "Suggested Procedures for Estimating the Current Population of Counties," Population, Special Reports, U.S. Bureau of the Census, Series P-47, No. 4, April 30, 1947.

Maryland, University of, Bureau of Business and Economic Research, Studies in Business and Economics, Predicting Population changes in Small Areas Volume 14, No. 41 March 1961, College Park, Maryland.

U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 20, May 6, 1949, No. 133, March 16, 1956, and No. 165, Nov. 4, 1957.

U.S. Bureau of the Census, "Estimates of the Population of Selected Standard Metropolitan Statistical Areas-. July 1, 1962," Current Population Reports Population Estimates, Series P-25, 110. 282, April 14, 1964.

U.S. Department of Labor, Bureau of Employment Security, Handbook on Estimating Population of Labor, Washington, D.C., November 1959.

Zitter. Meyer and Shryock, Henry S., Jr., Accuracy of Methods of Preparing Postcensul Population Estimates for States 3, Local Areas, published in Demography, Vol. 1, 1964

ENDNOTES

1. The evaluation and adjustment of census figures and birth and death registrations are described in detail in the Handbook of Statistical Methods for Demographers (Preliminary Edition) by A. J. Jaffe, published by the Bureau of the Census in 1951. This handbook also describes procedures for measuring net migration, the use of life tables, and other statistical techniques helpful in making population projections. The third printing of this reference (published in 1960) is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $1.75.

   Since the Jaffe book was prepared for use with 1950 census data, some of the technical procedures are incorrect when applied to 1960 data. Some recent publications dealing with 1960 census data are:

   U.S. Bureau of the Census, 1960 Census of Population, Volume 1, Characteristics of the Population, Part 1, United States Summary, pages XXXIX and XL.

   Taeuber, Conrad, and Hansen, Morris H., "A Preliminary Evaluation of the 1960 Census of Population," Demography Volume 1, No. 1, 1964.

2. U.S. Department of Health, Education, and Welfare, Vital Statistics of the United States, 1962, volume II - Mortality, Part B, table 9-4, page 9-87. U.S. Government Printing Office, Washington, D.C., 20402.

3. U. S. Bureau of the Census. Current Population Reports, "Population Estimates" Series P-25, No. 279, February 4, 1964, table 2.

4. U.S. Bureau of the Census, U.S. Census of Population 1960, Detailed Characteristics, United States Summary, Final Report PC (1) - ID, U.S. Government Printing Office, Washington, D.C., 20402, 1963. Table 164, page 1-367.

5. U.S. Bureau of the Census, U.S. Census of Population, 1960, Number of Inhabitants, United States Summary,. Final Report PC (1) - IA, table 4, page 1-5, U.S. Government Printing Office, Washington, D.C., 20402, 1961.

6. For a discussion of a method of projecting ratios, see: U. S. Bureau of the Census, Current Population Reports, "Population Estimates," Series P -25, No. 110, February 20, 1955.

7. Considerable data on migration in local areas are available from the 1960 census of Population. A report of special interest is: U.S. Bureau of the Census, "Components of Population Change, 1950 to 1960,, for Counties, Standard Metropolitan Statistical Areas, State Economic Areas, and Economic Subregions," Current Population Reports, Series P-23,, No. 7., November 1962.

8. Many areas will find that a completely update forecast may be obtained by the simple use of birth rates for all women aged 15-44 and the number of women in this age group rather than perform the individual calculations for each five-year age group.

9. The U.S. Department of Labor defines the labor force as the noninstitutional population, 14 years of age and older, working or looking for work. Thus, those classified as employed plus those classified as unemployed constitute the labor, force. The total force includes the armed forces. The civilian labor force excludes the armed forces.

10. The labor force participation rate (or ratio) may be expressed in various ways. For example, the labor force figure may or may not include the military. The denominator of this ratio may also vary by including or excluding persons under 14 years of age. The national labor force participation rate relating the total labor force to total noninstitutionalized population varies around 41 percent (give or take 5 percent). But the rate for the nation that relates the total labor force to the population 14 years of age or older, varies around the 55 percent figure.

11. A report presenting several methods of preparing population estimates is: U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 282, April 14, 1964.

12. These estimates are available in the publication Current Population Reports, Population Estimates, Series P-25, which is published monthly and is available by subscription from the U.S. Bureau of the Census.

13. For a more detailed explanation of Census Methods see: U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 20, May 6, l949, No. 133, March 16, 1956, No. 1 5, Nov. 4, 1957.

14. For a description of a slightly different method of using school enrollment data to obtain current estimates see: Brown, Hugh H., "A Technique for Estimating the Population of Counties", Journal of the American Statistical Association, Vol. 50, No. 270, June 1955, PP- 323-343.

15. Bogue, Donald J. **"**A Composite Method for Estimating Postcensul Population of Small Areas by Age, Sex, and Color, Vital Statistics Special Reports, U.S. Dept. of Health, Education, and Welfare, Public Health Service, Vol. 47, No. 6, Aug. 24, 1959, PP. 167-185.