ARIZONA POPULATION STATISTICS POLICIES

	POLICY NUMBER 045Z 05-08-1		
CHAPTER 045Z AZ Population Statistics	ARTICLE 05 Estimates Procedures		
SUBJECT 08 Population Projections Methodology	REVISION 1	EFFECTIVE DATE 03-31-06	

045Z 05-08-1
Index of Topics

ARIZONA POPULATION STATISTICS POLICIES

POLICY NUMBER		
045Z 05-08-1		
CHAPTER	ARTICLE	
045Z AZ Population Statistics	05 Estimates Procedures	
SUBJECT	REVISION	EFFECTIVE DATE
08 Population Projections Methodology	1	03-31-06

045Z 05-08-1

A. PURPOSE

To provide documentation which describes the population projections methodology

B. AUTHORITY

Governors Executive Order 95-2

C. POPULATION PROJECTIONS

1. Introduction

Population projections for Arizona and its counties were prepared using the State of Arizona Demographic Cohort-Component Projections Model. This model used age and sex specific fertility, mortality and migration rates to age the population forward, one year at a time, for a period of fifty years.

Projections covering the 50 year period were produced using a mixed approach. For the period 2006 through 2030, a bottom-up approach was used. Specifically, counties were calculated individually and the results of the 15 counties projections were then summed to obtain the state population for 2030. Next, a trend extrapolation of the state population, using prior census data and current state projections produced by the Census Bureau, was used to determine a target population for the year 2055. The long-range (2055) target populations for the counties were then determined on a growth-share basis of the long-range projected state population.

Each cohort in this model consists of all persons of the same age and sex. The components being projected are represented in the standard demographic equation, which describes how a population changes over time:

$$P_{x+n} = P_x + (B_{x, x+n} - D_{x, x+n}) + (IM_{x, x+n} - OM_{x, x+n})$$

Where:

P_{x+n} = the size of the population at the end (x+n) of the time period

P_x = the size of the population at the beginning (x) of the time period

$B_{x, x+n}$ = the number of births during the time period

$D_{x, x+n}$ = the number of deaths during the time period

$(B_{x, x+n}-D_{x, x+n})$ = natural increase between time x and time x+n (the time period of interest)

$IM_{x, x+n}$ = the number of in-migrants during the time period

$OM_{x, x+n}$ = the number of out-migrants during the time period

$(IM_{x, x+n}-OM_{x, x+n})$ = net migration during the time period

n = the length of the time period, in this case was equal to one year.

2. Inputs to the Model

The population counts from the 2000 Census, by age and sex, for each county, were the starting point for the projections process. These data, together with vital statistics obtained from the Arizona Department of Health Services, were used to develop rates for fertility and mortality.
In- and out-migration counts by county, together with the interim U.S. population projections, both of which were obtained from the Census Bureau, were used to calculate migration rates. The population estimates from the Arizona Department of Economic Security were used as a control in determining the 2005 population distribution.

Fertility and survival rates were calculated by region, i.e., for each of the six Councils of Government, while migration rates were determined by county.

a. Fertility:

Age specific fertility rates (ASFRs) were determined using data on births by single year of age of the mother, by county of residence, provided by the Arizona Department of Health Services, for the period from 1999 through 2001. An average of these three data points, by age, together with the population counts from the 2000 census, were used with the following formula:

$$ASFR = \frac{\text{Births to women of a given age}}{\text{Number of women of a given age}}$$

b. Mortality:

Deaths by single year of age and sex, by county of residence, for the years 1999 through 2001, were also provided by the Arizona Department of Health Services. An average of these three data points for each age by sex, together with the population counts from the 2000 census, were used to calculate a complete life table by single year of age. Age and sex specific life table period survival rates, also known as 'fraction of life', were determined using the following formula:

$$S_{x, x+n} = \frac{L_{x+n}}{L_x}$$

Where:

$S_{x, x+n}$ = probability of a member of the cohort surviving from time x to time x + n

L_{x+n} = number of persons alive at the end of the period x+n

L_x = number of persons alive at the beginning of time period x

n = the length of the time period, in this case was equal to one year.

c. Migration:

The Census Bureau compiled its migration data, for the period 1995 to 2000, for persons five years of age or older, from question 15 of the Census 2000 long form. The question consists of two parts: Part A asks the respondent to indicate if they lived in the same house or apartment five years ago. If the answer is no, Part B asks for their previous address.

The in- and out-migration data from the *1990* census were made available by single year of age by sex. However, citing confidentiality issues, the Census Bureau has not made available Census 2000 data with the same level of detail.

In- and out-migration data for the projections were determined from a special-tabulation prepared for the Federal-State Cooperative Program for Population Estimates (FSCPE). The file contains
data by 5-year age groups, for a total of 17 age groups by age by sex. The tabulation distinguishes between domestic and international in-migrants by county. Persons emigrating from the United States to other countries are not included as they were not resident in the U.S. at the time of the 2000 census. The international in-migrant counts were included in the computation of the migration rates without regard to the lack of any offsetting international out-migration data.

Since the Census Bureau's special tabulation of gross migration streams from the Census 2000 (STP-230) were reported in five year age groupings, the data were transformed into single year of age. To transform these data, we used an interpolation technique developed by Thomas Sprague over 100 years ago. The Sprague Multipliers utilize information on the distribution of population by age from the adjacent age groups in order to distribute the 5-year totals into single years. Discussion of this method may be found in G. Calot and J.-P. Sardon, "Methodology for the calculation of Eurostat's demographic indicators," European Commission, 2003; and Henry S. Shryock and Jacob S. Siegel, "Interpolation of Grouped Data," pp. 694-702, The Methods and Materials of Demography, U.S. Government Printing Office, 1973.

In the preparation of the migration rates, the number of migrants was compared to a base population. This base is the population considered to be 'at risk', i.e., the group of people who could potentially become migrants. It is preferable to use the population which existed at the beginning of the migration period, which in this case was 1995.

The population at risk of being counted in Census 2000 as in-migrants to the county for the period 1995-2000 is the U.S. population aged 5 years and older in 2000, minus persons residing in the county in 1995 and counted in Census 2000.

The base population at risk of being out-migrants for a county is the sum of persons reported in Census 2000 as having lived in the county in 1995 plus persons living outside the county who reported living in the county in 1995.

Age and sex specific in- and out-migration rates were prepared by dividing the number of migrants by their respective base populations and converting the results to annual rates. For ages less than 5 or greater than 85, the rate of the nearest computed rate was applied.

2. Projections Model

a. Control-to-Total:

Prior to calculating the population projections, a base population for 2005, consistent with the results of Census 2000 and the current population estimates, was determined. Fertility and mortality rates were assumed to remain constant during this period. Therefore, in order to determine a population distribution for the current estimates year, the migration rates were incrementally adjusted, using a plus-minus adjustment process, and the model rerun until the population calculated for 2005 matched the county's estimate for that year.

When necessary, fertility and mortality rates were incrementally adjusted so that the numbers of births and deaths occurring during the control period reflected historical values. Specifically, the resulting numbers of births and deaths were compared to records on vital statistics from the last 10 years, as well as preliminary 2005 data. If the historical data was consistent and the near term projected values were outside the average deviation of the last 10 years, then minor adjustments were made to fertility and/or mortality rates. Births, then infant mortality, and finally mortality for all other ages were incrementally adjusted based on a target range determined by the average deviation of the known values.

Due to the difference between the growth rates of most Arizona counties in relation to the growth rate forecasted for the U.S. population projections (see Determination of Migration Compensatory Factors), adjustments for vital statistics were based on a modified version of the model. This modification consisted of applying a growth factor, based on the difference between the county and U.S. population, for each year between the census and the current estimates. In this way, any adjustments made to vital statistics were not based on a reduction in the number of in-migrants due to the growth rate differential between the county and the U.S..

Once any adjustments to fertility and survival rates were completed, the age- and sex-specific in- and out-migration rates were iteratively adjusted until the population of the county on April 1, 2000, aged forward, matched that county's 2005 estimate total. This population provided the starting point for the 2006-55 projections.

b. Determination of Migration Compensatory Factors:

In the Cohort-Component Population Projections model, the in-migration population is based on the U.S. population projections provided by the Census Bureau, while out-migration is based on the county population.

The rates of growth of most Arizona counties exceed the projected increases in the U.S. population. When the migration rates are applied without regard to this relationship, the growth in out-migration is proportionately higher than that for in-migration. This results in a continual drop in net migration over time. That is, the difference in the rates of growth between the U.S. population projections and the county projections creates a disproportionate relationship between in- and out-migration numbers over time, resulting in an unwarranted decline in the net migration numbers.

In order to compensate for the differential growth rates described above, compensatory factors were calculated for each county. Following the 2000-05 control-to-total, then the original (initial 1995-2000) migration rates were compared to the controlled (iteratively adjusted) 2005 rates. The differences between the original and controlled rates were used to calculate the average annual change that occurred. The magnitude of the average annual change required to produce the 2005 population distribution determined the size of the required migration compensatory factors, i.e., factors which would cancel out the effects of the U.S.

proportional to the difference between the growth rates and is specific to each U.S.-county relationship. The faster a county is growing, the greater the adjustment required to compensate for the difference in growth rates.

For counties with growth rates higher than that of the U.S., an assumption is made that the relative differences in rates will diminish over time and gradually come into line with those of the U.S.. Any compensatory adjustments[1] to the migration rates were, therefore, phased out over the 50-year period in direct proportion to the reduction in the U.S. growth rate. That is, a relatively larger decrease in the U.S. projected growth rate between any two years is reflected in a relatively larger reduction in the migration rate compensatory factor for that same time period. In this way, the year-to-year fluctuations present in the U.S. population projections series were reflected in the county level projections. However, due to its high rate of growth, a reduction of compensatory adjustment factors back to baseline (those which existed at the beginning of the projections period) was not performed for Pinal county. Likewise, due to its currently negative rate of growth, the compensatory rates for Greenlee county were not reduced over time.

c. Projections Calculations:

Beginning with the 2005 population distribution, projections were calculated by applying the age-specific fertility rates, and the age- and sex-specific survival, in-, and out-migration rates, year by year, to the end of the mandated 50-year projections period.

Survival rates which were found to be low at the start of the projections period, were gradually increased over the projections period. However, survival rates above the 1999-2001 baseline were not adjusted downward. In a similar fashion, fertility rates which needed to be adjusted upward were decreased back to the 1999-2001 level by the end of the 50 year projections time frame.

Long-term county projections, i.e., those beyond 2030, were determined based upon analyses of historical trends and projected state population levels. The population for the state for the year 2055 was projected using a trend extrapolation based on historical census data and current state level population projections provided by the Census Bureau. Maximum values for long-term county level projections were then established by applying each county's share of state growth during the projections period to the total population growth expected for Arizona between 2030 and 2055. When necessary, yearly population distributions, consistent with the long-range 2055 target populations, were iteratively determined. In other words, if the target population for a county for 2055 exceeded the expected maximum value, the model was used to iteratively determine yearly population demographics consistent with the expected long-term share of state growth.

It should be noted that the U.S. population projections, which serve as the basis for determining the number of immigrants, only extend to the year 2050. The Governor's Executive Order 95-2, however, requires population projections for a period of 50 years. Therefore, the average rates of growth from the 2040 to 2050 projections, by age and sex, were used to approximate projections, by single year of age by sex, for the years 2051 through 2055.

[1] Note that these are reductions to the compensatory factors only. They are not reductions in the initial 1995-2000 migration rates or the adjusted 2000-2005 control-to-total rates.

Last updated March 31, 2006