# II-3

## Modeling the Demographic Characteristics of the Paso del Norte Region

*James Peach*


## Abstract

Demographic change in the border region, an overview of which is provided in this chapter, is affected profoundly by national demographic and economic trends in the United States and Mexico. The population growth rates of the two nations were far different in the 19th century than the 20th century, and even during the 20th century population growth rates in the two nations have been highly variable from decade to decade. Projections of the two nations' populations over the next 50 years illustrate clearly that demographic trends are closely related. Within both nations there has been a century-long tendency for the population of the border states to increase as a proportion of the total population.

Projection accuracy is not necessarily the most important aspect of the Border Plus Twenty Years (B+20) model. The model emphasizes relationships among sectors and feedback effects so that policymakers can examine different long-run scenarios and policy options. Nevertheless, the benchmark population projections from the B+20 model are well within the range of other published projections. The projections at the national level for both Mexico and the

United States closely approximate the medium projections of the United Nations. Similar comparisons are made for both El Paso, Tex., and Ciudad Juárez, Chih.

# Modelado de las Características Demográficas de la Región Paso del Norte

*James Peach*

## Resumen

El cambio demográfico en la región fronteriza, como se discute de manera general en este capítulo, es afectado profundamente por las tendencias demográficas y económicas nacionales en México y los Estados Unidos. Los índices de crecimiento de la población de las dos naciones eran más diferentes en el siglo 19 que en el siglo 20, y aún durante el siglo 20 los índices de crecimiento de la población en las dos naciones han variado de década a década. Las proyecciones de las poblaciones de las dos naciones para los próximos 50 años ilustran claramente que las tendencias demográficas están muy relacionadas. Dentro de ambas naciones ha habido durante un siglo una tendencia en los estados fronterizos de incremento de su población como proporción total de la población.

La exactitud de la proyección no es necesariamente el aspecto más importante del modelo Frontera Más 20 Años (F+20). El modelo enfatiza relaciones entre sectores y efectos de retroalimentación para que los responsables de elaborar políticas puedan examinar diferentes escenarios de larga duración y opciones de política. No obstante, las proyecciones de referencia de la población del modelo F+20 están bien dentro del rango de otras proyecciones publicadas. Las proyecciones a nivel nacional para ambos, México y los Estados

Unidos se aproximan a las proyecciones medianas de los Estados Unidos. Comparaciones similares se han llevado a cabo para ambos El Paso y Ciudad Juárez.

## Demographic Background: The National and State Context

Demographic change in the border region is affected profoundly by national demographic and economic trends in the United States and Mexico. The population growth rates of the two nations were far different in the 19th century than the 20th century. Mexico's population increased from 5.7 million in 1800 to 13.6 million in 1900—or by roughly 2.4 times—while the U.S. population increased from 5.3 million in 1800 to 75.9 million in 1900—or about 14 times. The U.S. population then increased to approximately 281.4 million in 2000. During the same time period, Mexico's population increased from 13.6 million to nearly 100 million. In terms of absolute numbers, the increase in the U.S. population was more than double the increase in Mexico. In relative terms, Mexico's population increased at about twice the rate of the U.S. population[1].

Even during the 20th century, population growth rates in the two nations have been highly variable from decade to decade (Figure 1). In the United States, the highest population growth rates are associated with the pre-Depression era and baby-boom years following World War II. In Mexico, population growth rates increased in each decade from the 1920s to the 1970s, following the tragic loss of population during the Mexican Revolution from 1911 to 1920. By the mid-1970s, Mexico's birth rate began to fall dramatically; this fact is reflected in lower population growth rates in Mexico during the 1980s and 1990s compared to earlier decades.

Projections of the two nations' populations over the next 50 years illustrate clearly that demographic trends are closely related. United Nations population projections indicate a range of 293 million to 419 million for the United States in the year 2050. Differences in the projections for the two nations depend mainly upon differing migration assumptions. That is, the low figure for Mexico and the high figure for the United States are both based on significant migration from Mexico to the United States. In many respects, the demographic characteristics of the two populations complement each other and provide numerous possibilities for mutual cooperation. The U.S. labor force is aging rapidly and (without substantial immigration) will almost certainly grow slowly. Mexico's population, with a lower median age (22.0 in Mexico versus 35.3 in the United States), will add nearly 1 million relatively young workers per year to its labor force. As a result, Mexico faces a serious job-creation challenge over the next two or three decades. While demographic interaction between the two nations will be influenced powerfully by national economic conditions and immigration policies, it is difficult to imagine that the demographic futures of the two nations are not inherently intermingled.

Within both nations there has been a century-long tendency for the population of the border states to increase as a proportion of the total population. In the United States, the four border states (California, Arizona, New Mexico, and Texas) accounted for only one out of 18 U.S. residents in 1900. By 2000, more than one in five (21.9%) U.S. residents lived in a border state and the combined population of the border states had reached 61.6 million. In Mexico, the pattern is similar. In 1900 only one Mexican in 10 lived in a border state (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas), while by 2000 that figure had reached one in six. Given these trends, it should not be surprising that in most decades of the 20th century the populations of the border states were growing more rapidly than the populations of their respective nations. Another important feature of border state population growth rates is that they have been highly variable from state to state and decade to decade. There is little reason to suggest that these trends will end in the next decade or two.

## Demographic Background: El Paso and Ciudad Juárez

The El Paso, Tex.-Ciudad Juárez, Chih., metropolitan area is the second largest urban region on the U.S.-Mexican border—surpassed in population size only by the San Diego, Calif.-Tijuana, B.C., urban area. The region ranked second in population size in 1940, the starting point for this analysis, and ranked second along the border, according to the 2000 censuses of Mexico and the United States. This brief demographic history of the region begins in 1940 because it was during this decade that that the rapid growth of the border began. Prior to 1940, the border region as a whole was sparsely populated.

In 1940, the El Paso population was two-and-a-half times as large as Ciudad Juárez, which had a population of 55,024 (Table 1). Between 1940 and 1950 the region's population grew to 326,000, an increase of 76.9%. This growth rate was more than five times the growth rate of the U.S. population and more than double the population growth rate of Mexico. However, this growth rate was not unique along the border.

## Table 1. Population Growth in the El Paso-Ciudad Juárez Region: 1940–2000

| Year | El Paso | Percent Change | Ciudad Juárez | Percent Change | Total | Percent Change |
|---|---|---|---|---|---|---|
| 1940 | 131,067 | n/a | 55,024 | n/a | 186,091 | n/a |
| 1950 | 197,968 | 48.8 | 131,308 | 138.6 | 329,276 | 76.9 |
| 1960 | 314,070 | 61.1 | 276,995 | 111.0 | 591,065 | 79.5 |
| 1970 | 359,291 | 14.4 | 424,135 | 53.1 | 783,426 | 32.5 |
| 1980 | 479,899 | 33.6 | 567,365 | 33.8 | 1,047,264 | 33.7 |
| 1990 | 591,610 | 23.3 | 798,499 | 40.7 | 1,390,109 | 32.7 |
| 2000 | 679,622 | 14.9 | 1,218,817 | 52.6 | 1,898,439 | 36.6 |

Source: Author

The region's growth rate peaked during the 1950s (79.5%). By 1960, the population of Ciudad Juárez was rapidly approaching the size of El Paso, although El Paso remained the larger of the two cities until the 1970 censuses. The 1960-to-1970 population growth rate for the two cities was less than half the growth rate of the previous decade, while El Paso's growth rate was only about one-fourth of the previous decade. By 1980, the population of the two cities reached 1 million for the first time. El Paso's growth rate during the 1970s was more than double that of the previous decade, while the growth rate of Ciudad Juárez declined substantially.

By 1990, the population of Ciudad Juárez was more than 200,000 larger than El Paso. Growth rates for both cities remained substantially higher than the corresponding national figures. During the 1990s, El Paso's population growth rate declined to 14.98%, not much higher than the U.S. population's growth rate of 13.15%. During the same decade, however, the Ciudad Juárez population growth rate increased substantially to 52.6%. By 2000, the population of the region was slightly more than 10 times its 1940 figure.

In general, population growth rates for both cities over the last 60 years have been high relative to their respective nations, but also highly variable. This pattern of high but highly variable growth rates is found in other border twin cities as well. In the context of building a simulation model of the border region over the next two decades, it is important to remember the historical pattern of variation in growth rates. In short, there is no *a priori* reason to expect constant growth rates during the coming decades.

Historically, both cities have had a relatively young population. As recently as 1970 the median age in Ciudad Juárez was 16.8 years and 46.1% of the population was under the age of 15. The median age in El Paso was 22.7 years, compared to the U.S. figure of 28.0 years. As in both nations, the populations of the two cities have been aging. By the census of 2000, the median age in Ciudad Juárez (23.0 years) was slightly higher than the corresponding figure for Mexico as a whole (22.0 years). The El Paso population, with a median age of 30.0 years in 2000, has not been aging as rapidly as the United States as a whole, which had a median age of 35.3 years in 2000. Nevertheless, both El Paso and Ciudad Juárez will have considerable demographic momentum over the next decade or two.[2]

The rapid growth of the border population has been attributed to many factors. These include the Mexican Revolution (1910–1920), U.S. prohibition (1919–1932), the beginning (in 1942) and end (1964) of the Bracero Program, the maquiladora program (starting in 1965), U.S.-Mexican wage differentials, the North American Free Trade Agreement (NAFTA), Mexico's various economic crises, and other factors. In all likelihood these and other issues have contributed to border region population growth, but some skepticism of these allegations is appropriate. Some of these phenomena occurred after, not before, the highest regional population growth rates. Further, the absence of these events is rarely suggested as a reason for a slowdown in border population growth rates. Finally, all of these factors operate only through migration and ignore the importance of fertility and mortality.

## Methods of Population Projection

There are five basic types of population projection methods and literally hundreds of variations of these techniques. The five basic categories include:

- Purely subjective
- Naïve models
- Econometric models
- Cohort-component models
- Hybrid models

Purely subjective population projections consist of statements such as: “I think the population of Ciudad Juárez will be 7 million in the year 2025” or “Everyone knows that the population of Ciudad Juárez will be 7 million in the year 2025.” The purely subjective projection method, while suffering from a number of defects, is commonly used. Unfortunately, the results of such procedures are often quoted and sometimes become widely accepted as more scientific than subjective. The author of this chapter once participated, reluctantly, in a focus group organized to project the population of very small geographic areas in a city for transportation planning purposes. The essential idea of the project was to bring together a number of local experts to produce a consensus population forecast. When totaled, the projection for the city far exceeded the potential growth of the city as a whole.

The term “naïve model” is not as pejorative a reference as it may sound. There are many varieties of naïve models, but generally, such models start with a currently known value, such as the total population from the most recent census, and apply a recent growth rate, also based on census data, to the base value in order to calculate projected values.[3]

Naïve models have a number of advantages over purely subjective and more sophisticated methods. For example, naïve models are based on very few assumptions and these assumptions are usually stated explicitly or are obvious to the user. Naïve models are also inexpensive computationally and anyone can recalculate the projections using alternative assumptions with little more than a handheld calculator. Finally, naïve models often produce projections of population totals similar to those from more sophisticated methods. Indeed, many analysts who use more sophisticated projection methods check their results by comparing their own projections with naïve model comparisons. Nevertheless, naïve models suffer from some serious defects because they do not generally incorporate information on basic demographic processes (births, deaths, and migration) or information on economic and social trends that might directly affect demographic processes.

Econometric methods of population projection are based on the assumption that future population changes in a region are in part (or mainly) determined by the future behavior of key economic variables. Typical variables in this type of analysis are employment, unemployment, value added in manufacturing, and per capita income. Generally, such methods assume that migration is particularly sensitive to levels and changes of economic variables. For example, a common assumption is that people move toward areas of high per capita income and low unemployment and move away from areas of low per capita income and high unemployment. Economic migration models are based on the economist's usual assumption that potential migrants make rational economic decisions. Growing amounts of literature support a link between economic conditions and migration decisions.

Critics of econometric approaches to population projection point to the fact that economic variables are not the sole determinants of migration decisions. That is, people move for a variety of reasons including family ties, attractiveness of alternative locations, or major life-cycle events. Another common criticism of the use of econometric methods for population projection is that it is often more difficult to predict the future of the economic variable (e.g., unemployment) than to predict the size of a population itself.

The cohort-component method is based on the fundamental demographic equation:

$$P_t = P_{t-1} + B_{t-1'\mathrm{t}} - D_{t-1'\mathrm{t}} + I_{t-1'\mathrm{t}} - O_{t-1'\mathrm{t}}$$

where,
$P_t$ = Population in time period *t*
$P_{t-1}$ = Population in time period *t*-1
$B_{t-1't}$ = Births from time period *t*-1 to time period *t*
$D_{t-1't}$ = Deaths from time period *t*-1 to time period *t*
$I_{t-1't}$ = In-migration from period *t*-1 to time period *t*
$O_{t-1't}$ = Out-migration from period *t*-1 to time period *t*

The components in the cohort-component method refer to births, deaths, and migration. The term cohort refers to a group of people with a common characteristic such as age or sex. In the cohort component method, each component of demographic change (births, deaths, and migration) is projected separately for specific cohorts. For example, projections of births, deaths, and migration are often calculated for five-year age and sex groups (cohorts). The projection of total population is then a simple process of adding up the projections for the various cohorts.

The cohort-component procedure has a number of advantages over other methods and is the procedure generally preferred by demographers. This procedure, for example, is based directly on the three basic demographic processes (fertility, mortality, and migration). The cohort-component procedure generates projections of the cohorts as well as the total population. The cohort-component procedure can be combined with other methods. For example, projections of migration based on an econometric model can easily be combined with demographically based projections of births and deaths (hybrid models).

Compared to naïve models and some econometric models, the cohort-component procedure requires more data and is sometimes more computationally intensive, but modern computing technology has virtually eliminated data and computational intensity as a valid criticism of the cohort-component technique. A more serious criticism at the regional and local levels is that the detailed data on fertility and mortality rates that the cohort-component method requires are sometimes not available, requiring researchers to use national or state trends for these critical variables.

No matter which technique is used, there are a number of useful cautions about population projections[4]. First, the probability of producing population projections that are identical in all respects to actual future values is essentially zero. Second, the difficulty of projecting population usually increases as the size of the geographic area and the size of the population base increase. Third, the uncertainty associated with population projections increases as the length of the time horizon of the projection increases. Fourth, the baseline data on which population projections depend are never without error. Finally, human behavior is extraordinarily complex and highly irregular. All three components of demographic change are subject to a great deal of variation over time.

## The B+20 Population Model

The population sub-sector is a critical component of the Border Plus Twenty Years Project (B+20) modeling system. While all the sub-sectors are interrelated in some fashion, it is literally the case that if the border region population were stable or declining, there would be little interest in border region environmental or quality of life issues. As a result, the population sector was one of the first to be discussed by the core modeling group and among the first to be implemented in the El Paso-Ciudad Juárez prototype model.

After much discussion, the modeling team concluded that the population sector modeling effort should be based on the following criteria:

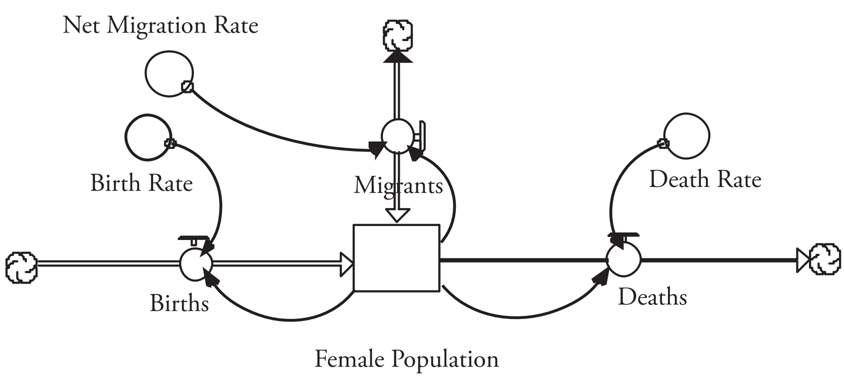
- An expectation that the resulting model was capable of producing realistic benchmark projections of population in a binational metropolitan area
- The structure and parameters of the models should be easily understood by potential users who would not necessarily have a background in demographic analysis

- The basic structure of the model, as implemented in the El Paso-Ciudad Juárez prototype, should be easily adapted to other border twin cities
- The model should reflect the three basic demographic processes of fertility, mortality, and migration in a binational context
- The migration component of the model should be linked in some fashion to economic conditions—such as wage differentials—in the cities under consideration

Consistent with these criteria, the population sub-sector consists of single-year-of-age cohort component models. For each twin city, such as El Paso-Ciudad Juárez, there are four population sub-models. The first two models project population by age and sex for Mexico and the United States at the national levels. The same national models are used for each twin city. Two additional population models project population by age and sex for each twin city. In each of the four cases, the model can also produce population totals or sub-totals of particular age-sex groups.

An easy way to understand the population models is a guided tour of the following diagram (Figure 1), which depicts a general demographic process and not the specifics of the Paso del Norte population models. Details of these models are discussed later.

Figure 1. A General Demographic Process




Source: Author

While this diagram may appear complex, it is really very simple. The square box in the middle of the diagram represents the female population of an area. This box indicates a stock. The arrows going into and out of the box (stock) represent flows. How does the stock change? Fluctuations in the number of people—in this case, females—arise from three sources: fertility, mortality, and migration. In this case, fertility is represented by a flow (circle with a valve) into the population stock. The number of births added to the stock depends on the current population—notice the arrow from the population stock to the flow of births and birth rates—also connected to the flow of births by an arrow.

The other two demographic processes work in a similar, but not identical, way. Notice, for example, that the flow of deaths is in the opposite direction from the flow of births. Deaths depend on the current size of the population and death rates. Migration—look at the top of the population stock—differs from the flow of births and deaths because it is a bidirectional flow. An important feature of the model is that users can quickly and easily adjust the baseline birth, death, and migration rates.

The diagram describes the essential features of the population models in the Paso del Norte model, but some important details have been ignored. First, the single box representing population in the diagram above is misleading. The Paso del Norte population models contain many such population boxes. For example, the national population box for Mexico contains 100 boxes for the female population and another 100 boxes for the male population. Further, the circles representing birth, death, and migration rates are also age and sex specific. That is, there are birth, death, and migration rates for each single year of age by sex. In short, there are approximately 2,400 values of baseline parameters for the four population models.

The base year population data for all four models are from the U.S. and Mexican national population censuses conducted in 2000 (U.S. Bureau of the Census 2002; INEGI 2001a, 2001b). For the United States, age-specific birth and death rates were obtained from the National Center for Health Statistics (2002a, 2002b). U.S. migration rates were obtained from the U.S. Bureau of the Census's population projection documents (U.S. Bureau of the Census 1996, 2000). The migration rates were adjusted to reflect the 2000 census population numbers.

For Mexico, the age-specific birth rates were derived from census data. The Mexican census provides age-specific birth rates for five-year cohorts. The five-year cohort rates were interpolated and smoothed to obtain single-year rates. Mexican death and migration rates were obtained from the Consejo Nacional de Población.

Projection accuracy is not necessarily the most important aspect of the B+20 model. The model emphasizes relationships among sectors and feedback effects so that policymakers can examine different long-run scenarios and policy options. Nevertheless, the benchmark population projections from the B+20 model are well within the range of other published projections. As can be seen in Table 2, the projections at the national level for both Mexico and the United States closely approximate the medium projections of the United Nations. Table 3 contains similar comparisons for both El Paso and Ciudad Juárez. Again, the B+20 model projections are reasonably close to the medium variant of the other projections.

## Table 2. National Population Projection Comparisons for 2020

| Country | UN Low | UN Medium | UN High | B+20 Model |
|---|---|---|---|---|
| Mexico | 117,228 | 125,176 | 133,137 | 122,089 |
| United States | 332,033 | 344,270 | 356,530 | 344,618 |

Note: B+20 model projections are baseline projections from the Paso del Norte model run of 13 February 2004.
Source: United Nations 2003

Table 3. El Paso and Ciudad Juárez Population Projections for 2020

| City | PW Low | PW Medium | PW High | B+20 Model |
|---|---|---|---|---|
| El Paso | 733,525 | 766,388 | 808,250 | 801,073 |
| Ciudad Juárez | 1,644,206 | 2,019,855 | 2,348,576 | 1,901,120 |

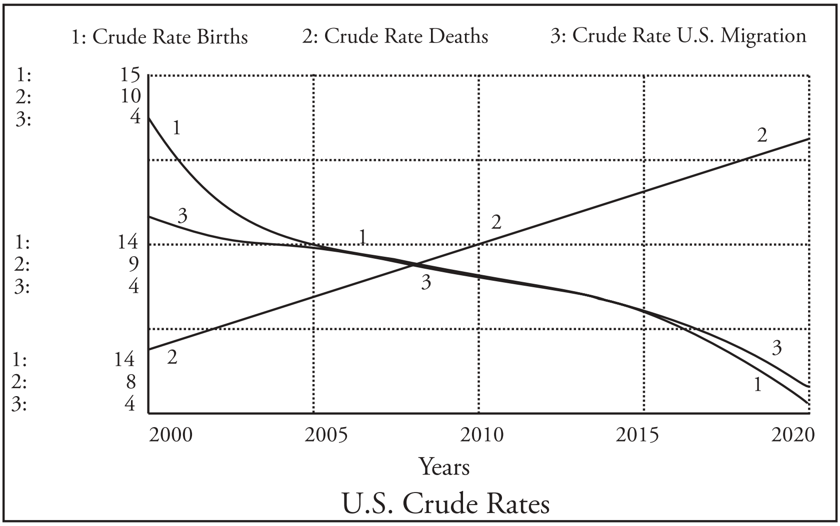
Note: Peach-Williams (PW) (Low, Medium, and High) projections were produced by James Peach and James Williams of New Mexico State University. The PW projections will be released in a forthcoming SCERP document.
Source: Author

The demographic models also demonstrate the importance of analyzing changing age-sex distributions. Consider, for example, the crude birth, death, and migration rates displayed in Figure 2. The crude birth and death rates decline over the 20-year projection period while the crude death rate increases. What accounts for these non-linear changes in crude rates? The answer is a changing age-sex distribution. Recall that a crude rate expresses the number of births, deaths, or migrants per 1,000 people. Even if age-specific rates, such as the probability of dying at a particular age, remain constant, the crude rates will change if the population is aging. In other words, the upward trend in the crude death rate occurs because the population is getting older and not because people of a given age are dying more frequently. Capturing the age-sex dynamics is important because many other critical variables in the model (including labor force participation) are also age-dependent.

## Links to Other Sectors

Direct and indirect links between the population sector and nearly all other sectors of the B+20 model are apparent in the overall flow diagram. In many cases the links are bi-directional, reflecting the fact that population change affects other sectors (for example, the growth of total population is an important determinant of both residential and industrial water use), as well as the fact that other sectors affect the growth of the region's population (for example,

Figure 2. U.S. Crude Rates




Source: Author

economic expansion in one city may affect population growth in the other city). It is not possible or desirable to discuss all the links, but some of the more important are described below.

At the national level, population by age and sex is the basis for labor force calculations in the economic sector. In turn, economic conditions in the two nations directly affect the flow of migrants from Mexico to the United States. Because national economic conditions affect economic conditions in border cities, the national level population data also affect local economic conditions.

At the city level, the economic and population sectors are linked in several ways. As in the national models, city population size and its age-sex distribution are used to derive the size of a city's labor force and potential employment. Because total output in the economic sector is a function of the size of the labor force and size of the capital stock, population growth or decline has a direct impact on each city's total output. Because total population is also a critical input into total employment, the population sector is also directly linked to output per worker in each city. In turn, the relative output per worker in each city is linked directly to migration flows from one city to another.

In addition, population is a critical input into the water, land use, air quality, and quality of life sectors. The relationships between these sectors are often subtle and indirect. For example, an increasing population will increase water consumption, possibly resulting in a water supply gap in one or both cities. A water supply gap may result in a decrease in regional economic activity, which may subsequently reduce migration flows to the area. In brief, the population sectors of the model affect, and are affected by, all other sectors of the model.

## Endnotes

[1] Mexico's population was 7.35 times as large in 2000 as it was in 1900. The U.S. population was 3.77 times as large in 2000 as it was in 1900.

[2] Demographic momentum—the tendency of a population to grow due to its age-sex distribution even in the face of declining fertility rates—suggests that Mexico's population will continue to grow substantially during the first decade or two of this century.

[3] A common variation of the naïve model is the so-called ratio method, in which a local area population projection is constructed from an existing projection of a larger area. For example, projections for a city that currently contains about 5% of its state population could be derived from a state-level projection by assuming that this ratio will remain relatively constant.

[4] See the discussion in: Peach and Williams. 1987. *Projections of the Population of New Mexico Counties by Age and Sex: 1980–2020.* Las Cruces, N.M.: New Mexico State University.

[5] A crude rate expresses the number of births (deaths or migration) per 1,000 people. Crude rates should not be confused with age-specific birth rates or total fertility rates.

## References

Instituto Nacional de Estadística, Geografía e Informática. 2001a. *XII Censo Nacional de Poblacíon y Vivienda, Tabulados Basicos de los Estados Unidos Mexicanos. Tomo I.* Aguascalientes: INEGI.

Instituto Nacional de Estadística, Geografía e Informática. 2001b. *XII Censo Nacional de Poblacíon y Vivienda, Tabulados Basicos de Chihuahua. Tomo I.* Aguascalientes: INEGI.

National Center for Health Statistics. 2002a. "Births: Final Data for 2000." *National Vital Statistics Report* 50(5). Cited 21 November 2002. http://www.cdc.gov/nchs/releases/02news/womenbirths.htm.

National Center for Health Statistics. 2002b. "Deaths: Final Data for 2000." *National Vital Statistics Report* 50(15). Cited 21 November 2002. http://www.cdc.gov/nchs/data/nvsr/nvsr50/nvsr50_15.pdf.

United Nations Population Division. 2003. "World Population Prospects: The 2002 Revision, Population Database." Cited 13 February 2003. http://esa.un.org/unpp.

U.S. Bureau of the Census. 1996. *Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1995 to 2050. Current Population Reports, Series P25-1130.* Washington, D.C.: U.S. Government Printing Office.

U.S. Bureau of the Census. 2000. "Methodology and Assumptions for the Population Projections of the United States: 1999–2000." Cited 13 January 2000. http://www.census.gov/population/www/projections/natproj.html.

U.S. Bureau of the Census. 2002. "U.S. Census of Population and Housing, Summary File 1." Cited 21 November 2002. http://factfinder.census.gov/servlet/DatasetMainPageServlet?_ds_name=DEC_2000_SF1_U&_program=DEC&_lang=en.