Chapter Three

Population Distribution and Composition

THERE IS IMMENSE VARIATION in the distribution and composition of societies, whether measured by age, ethnicity, race, or where people live, with the composition of a population playing a major role in guiding decisions about the provision of government and other services. Not surprisingly, population geographers are frequently called upon to describe the related concepts of population distribution and composition. Population distribution refers to the geographic pattern of the location of a population, including its density and where it lives, whereas population composition refers to the characteristics of the population in a given area.[1] This chapter explores the related topics of population distribution and composition. Its "Focus" section looks at the changing face of the population of the United States, while the "Methods, Measures, and Tools" section introduces the concept of life tables, a mathematical way of describing the shape and structure of a population.

POPULATION DISTRIBUTION

At a global and even national scale, populations are distributed unevenly. Large parts of the globe, including the North and South poles and deserts, are sparsely populated, providing few options for their inhabitants in terms of livelihood and survival and harsh living conditions. Other areas, including agriculturally productive areas, are densely populated. Even in the United States, large parts of the interior plains are comparatively sparsely populated, with the population overwhelmingly located along the western and eastern seaboards and Gulf Coast.

Geographers have a number of tools at their disposal to describe the observed distribution of a population. The most common representation of a population is the population size for a given geographic area (such as the state of Illinois), or the proportion of a population living in an area (the proportion of the US population that lives in the state of Illinois). Importantly, we need to clearly identify the population and area that we are trying to describe (see chapter 2). Most commonly, the population will be contained within some political unit, such as a census tract, neighborhood, city, state, or nation, so that reliable and meaningful statistics are available and referenced to a particular point in time. We may also be interested in defining a particular subpopulation, such as the number of African Americans or immigrants in a particular geographic area. While important enough on its own, the simple count tells us little about its geographic distribution or its composition. For greater information, we turn to other measures.

Population Density

A common measure of population distribution is *population density*, an expression of the degree to which a population is clustered within a given area j, expressed as

$$D_j = P_j / A_j$$

where P_j is the population (count) in area j and A_j is the geographic area of interest, usually defined as miles or kilometers squared. Clearly, this measure is a rough guide to how dense a population is. If we were to calculate the population density for Canada, for instance, we would arrive at a density of 3.3 people per square kilometer, giving it one of the lowest population densities in the world. However, the density of Canada's population varies dramatically, with the majority of Canada's population living within approximately two hundred kilometers from the US border, while parts of Canada's largest city—Toronto—have population densities in excess of 1,000 per square kilometer.[2] As such, density is an incomplete measure of population distribution, and reflects a number of physical factors, such as the availability of resources and suitability of climate, as well as human factors, such as social and economic resources. Nevertheless, density is commonly used to compare population distribution across countries or regions. Applying this measure at the global scale reveals striking contrasts in the population density of the world's countries. Relative to Canada, the density of the United States is over ten times higher (32 people per square kilometer) (see Figure 3.1), China's population density is 139, and Hong Kong has a population density of 6,403 per square kilometer.[3]

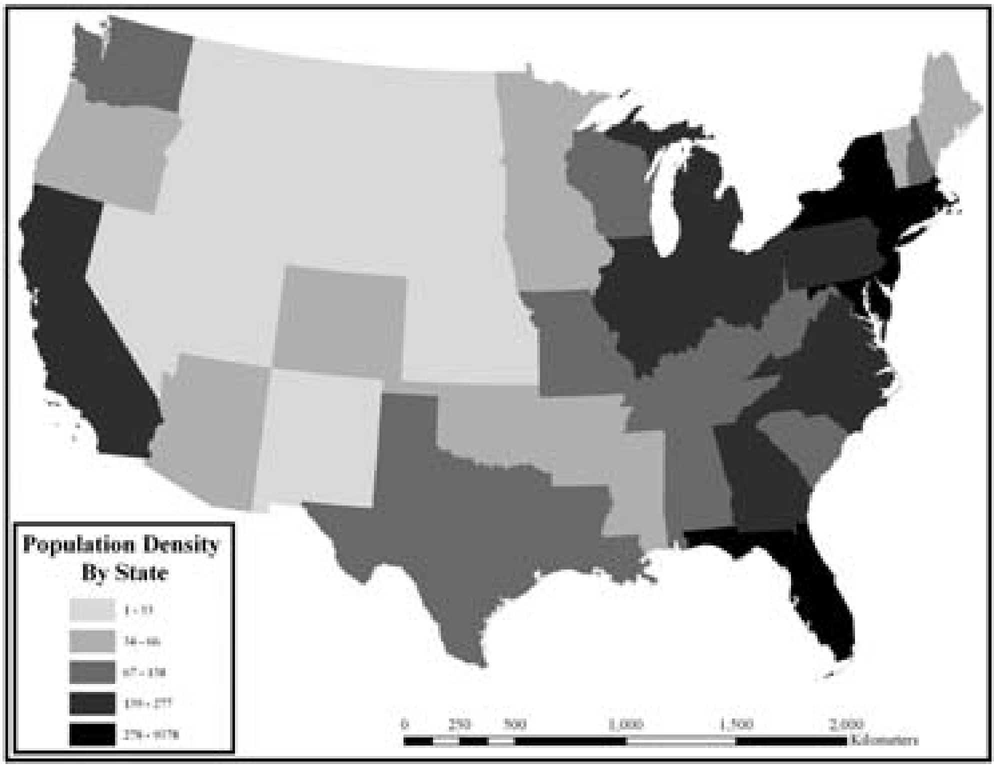

Figure 3.1 United States Population Density by State, 2000.
Readers can also see population density at the county scale at www.census.gov/population/www/censusdata/2000maps.html.
Source: Data derived from the US Census Bureau.

Maps

In addition to measures of population density, maps are frequently used to represent the distribution of a population, including dot and choropleth maps (figure 3.2). Dot maps, for instance, may be used to represent the distribution of a population. Typically, one dot is equated with the location of one person or a group of people across space. Choropleth maps, like figure 3.1, may also be used, with regions such as states or counties shaded relative to their population density (or other population attribute). In both cases, choices of scale, symbols, and other design issues, as well as the actual placement of dots, are important considerations when constructing the map.[4]

POPULATION COMPOSITION

In addition to the distribution of a population, population geographers are interested in its composition or characteristics. For instance, the composition

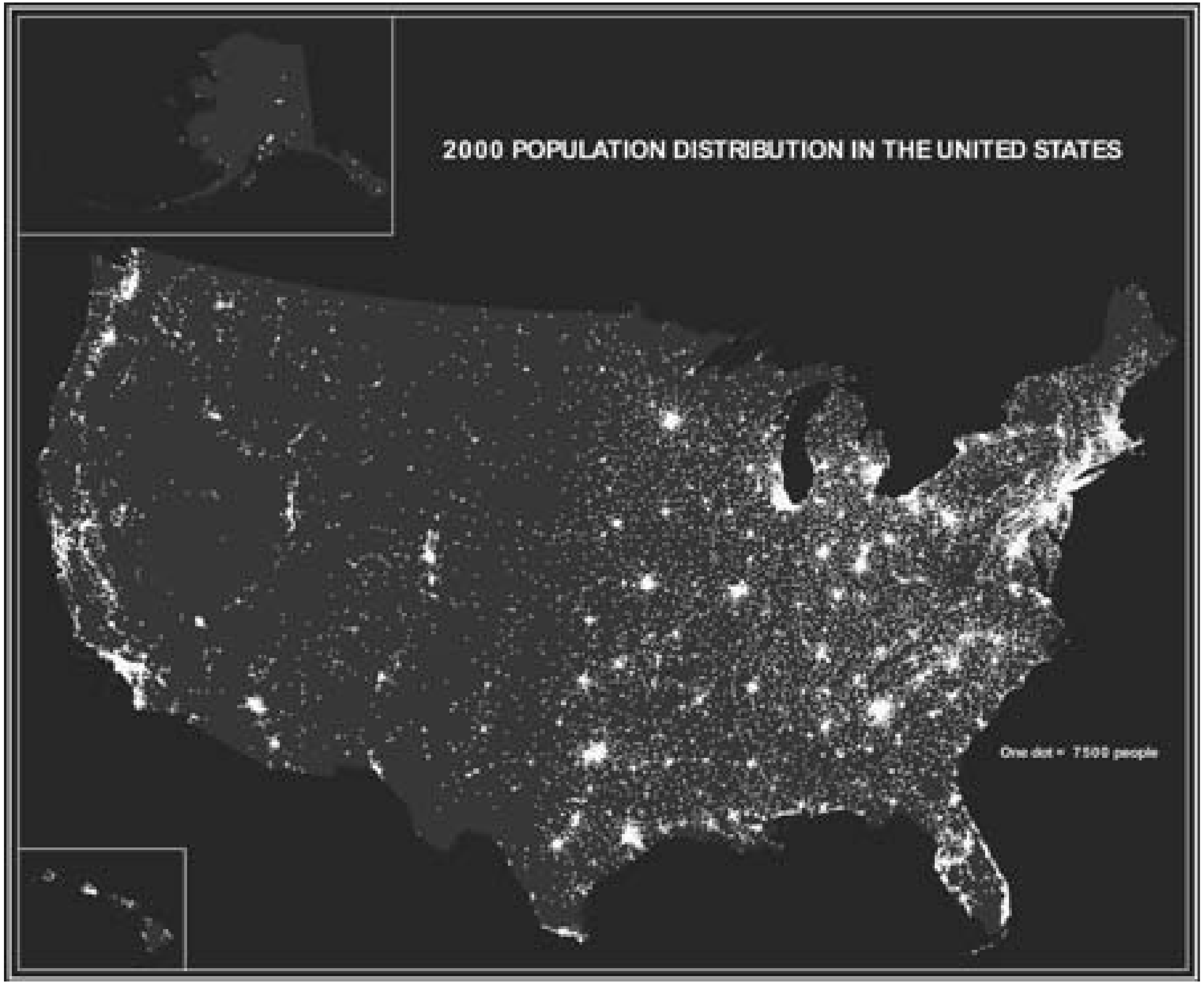

Figure 3.2. 2000 Population Distribution in the United States.

Source: US Census Bureau.

of the population in a given city will be different from that of its surrounding rural area. Likewise, the composition of a suburban population will likely differ from that of the inner city, or differ from suburb to suburb. For this reason, the composition of a population is intrinsically linked to its distribution, a feature that is dependent on geography.

Population Pyramids

Population pyramids provide the analyst with a way of describing the sex and age composition of a population. Expressed graphically, the age of the population is placed on the vertical axis and the share (or number) of the population along the horizontal axis, with males typically shown on the left and females on the right. Typically (although not exclusively), five-year age groups are used in their construction, with an open-ended age group (i.e., eighty-plus) for the oldest segment of the population.

Construction and observation of the pyramid reveals a number of features of a population. First, age pyramids are generally wider on the bottom than on the top, an outcome of increasing mortality with increasing age and a characteristic of above-replacement fertility. Second, the base of the pyramid is typically wider for males than it is for females, reflecting the sex ratio at birth (see below). Conversely, the upper portion of the pyramid favors females, reflecting differences in mortality and life expectancy between males and females, with females having greater life expectancies. Third, observation of population pyramids over a period of time can reveal changing population composition. For instance, observation of the population pyramid for the United States in 2005 reveals an age structure that is nearly pyramidal: increasing age is associated with a decreasing share of the population (figure 3.3a). The projected pyramid for 2025 suggests a more rectangular age structure (figure 3.3b), reflecting the aging of the baby boomers, increased life expectancy, and declining fertility levels. Together, these mean smaller numbers amongst the youngest age groups and an increasing proportion of elderly.

The shape of population pyramids may also reflect the impact of war or disease. In some parts of sub-Saharan Africa, HIV/AIDS has dramatically altered population pyramids due to declines in life expectancy and an increase in death rates. Consequently, the traditional population pyramid, with a wide base of young and tapering with increasing age, is being restructured and is better characterized as a population "chimney" in countries that have high HIV prevalence rates (figure 3.4). As AIDS "hollows out" the young adult population, it generates a base that is less broad with fewer young children. With fewer women reaching and surpassing their childbearing years and with women having fewer children, the most dramatic changes occur when young adults who were

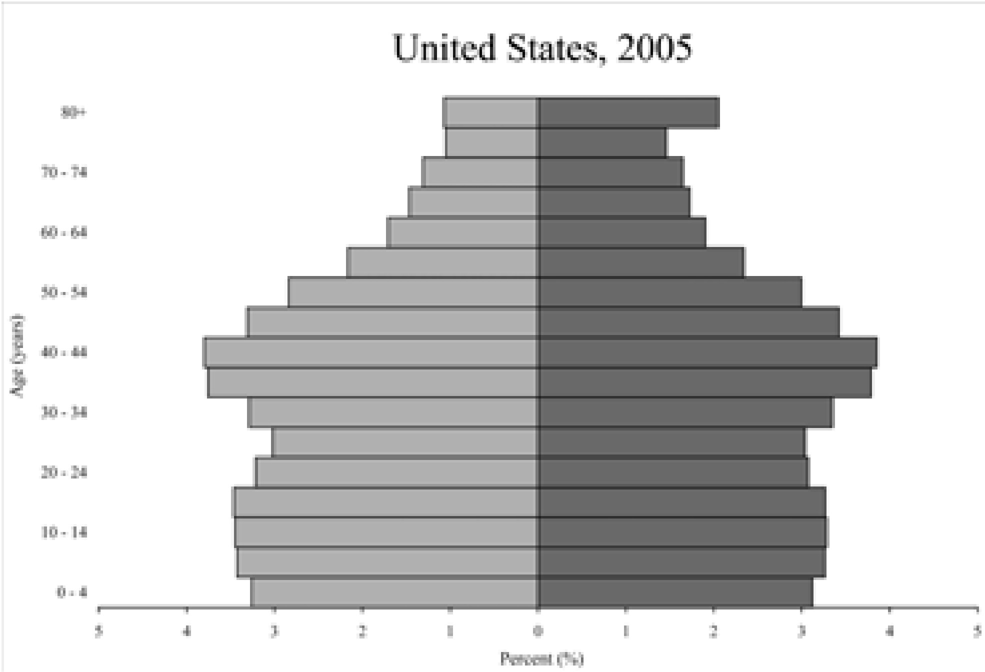

Figure 3.3a United States Age Pyramid, 2005.

Source: Data derived from US Census Bureau.

infected in their adolescence die, substantially shrinking the adult population, particularly the population in their twenties and thirties.

Sex Ratios

The *sex ratio* of a population is defined as the number of males per 100 females. Values greater than 100 imply more males than females, with the opposite true for values less than 100. Typically, sex ratios at the national scale are somewhat less than 100. However, this obscures variations by age. At birth, males usually outnumber females, with a sex ratio of approximately 105 (105 boys for every 100 girls). This advantage is quickly lost with increasing age, as males have shorter life expectancies such that the sex ratio swings in favor of females in the older age groups and results in national sex ratios being less than 100. Based on the 2000 US census, the sex ratio for the young aged zero through fourteen was 104, and for those sixty-five and over was just 70.

Beyond natural biological effects that influence the sex ratio across age groups, five other effects may alter the sex ratio across space or over time. First, and occurring at smaller geographic scales, migration may have an important impact, particularly if males are more prone to migration than females. The net

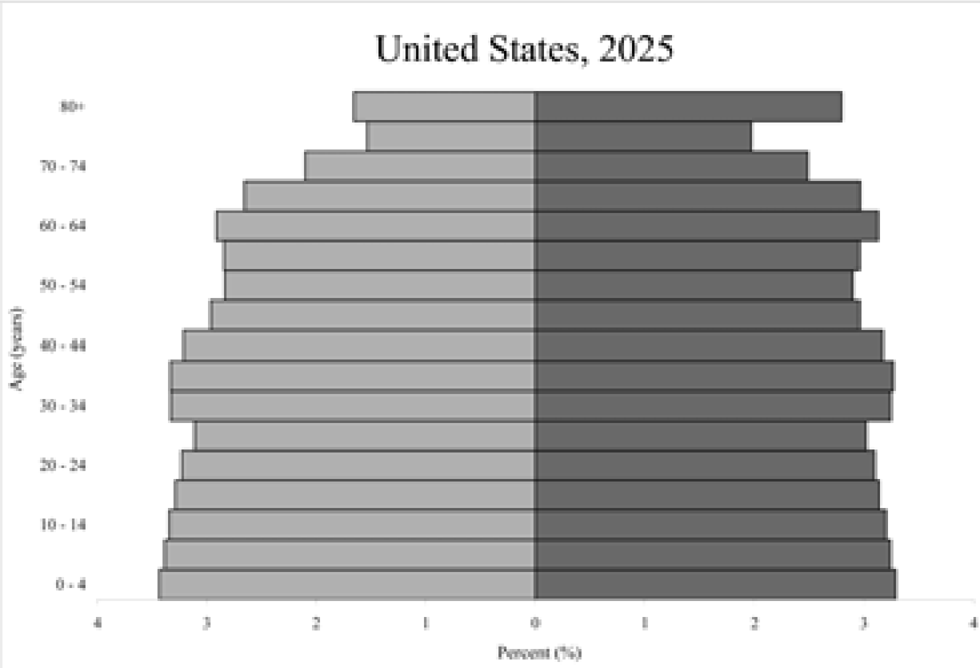

Figure 3.3b United States Age Pyramid, 2025.
Source: Data derived from US Census Bureau.

effect may be to lower the adult sex ratio in sending regions (i.e., places men are migrating out of, leaving women behind) and to increase the ratio in the destination places. Resource and "boom" towns have often been associated with high sex ratios. Additionally, historic immigration patterns have also favored males, with men first establishing themselves in the host country before bringing a spouse and family over. Second, environmental effects may have an effect on sex ratios at birth. Although still poorly understood and debatable, exposure to environmental contaminants, including endocrine disruptors, which are found in a variety of chemicals; PCBs; and dioxins, may alter the live-birth sex ratio, or the ratio of boys to girls that survive childbirth.[5] Third, there may be genetic/biological reasons for variations in the sex ratio at birth. There is, for example, a greater possibility of male conception at the beginning and the end of the ovulation cycle (where the probability of spontaneous abortion is greatest).[6] Sex ratios have also been linked to mother's age, with older women more likely to have girls. As women delay marriage and childbearing, more females may be born.[7] Fourth, in societies that value male children but small family sizes, women may opt for ultrasounds to determine the sex of their children, practice infanticide if the child is female, or underreport female births. Reports of this practice are common from China, where the official one-

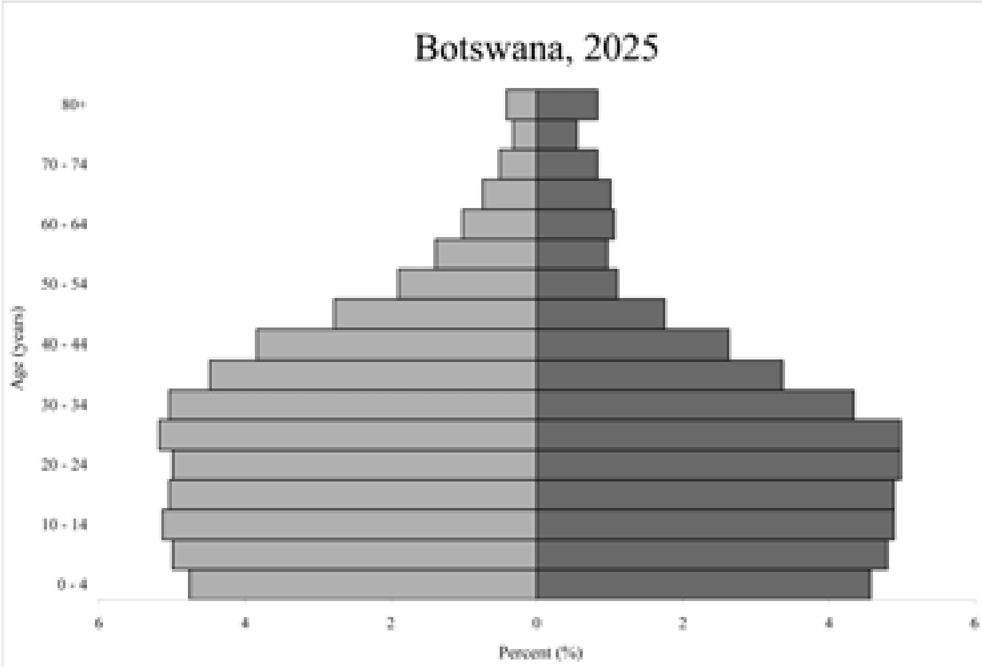

Figure 3.4 Projected Population Structure with AIDS, Botswana 2025: The AIDS "Chimney."

Source: US Census Bureau, IDB, 2008.

child policy restricts family sizes. In places, the sex ratio approaches 120, while the live-birth sex ratio is approximately 135.[8] It is interesting to note that the preference for male children among some Asian cultures has been transplanted to the United States, with the sex ratio increasing to 1.17 (rather than the usual 1.05) if the first child was a girl in families of Chinese, Korean, and Indian descent. If the first two children were boys, the ratio increased to approximately 1.5, indicating a much greater preference for boys.[9] Finally, sex ratios appear to vary by latitude, independent of cultural or economic factors.[10] Ratios in latitudes close to the equator were more equitable—50.7 percent boys in Africa—and were the highest in Europe and Asian countries (51.4 percent boys). Of all of these factors, however, identifying the contribution of any one single variable is extremely difficult.

Population (Median) Age

Population geographers and others are frequently asked to describe the age of a population. Is it young or old, and how best to describe this? As a measure of the average age of a population, *median age* (meaning half the population is younger and half is older) is commonly used. In 2000, the median age of the

US population was 35.3 years, the highest it had ever been. Between 1990 and 2000, the median age had increased by two-and-a-half years, reflecting the aging of baby boomers born between 1946 and 1964. By 2005, median age had continued to increase, reaching 36.4 years, and it is expected to continue to increase over the coming years, reaching 38 years by 2025.[11] California has one of the country's youngest populations, with a median age of 34.4 years. New York state, on the other hand, is relatively old, with a median age of 37.5 years. Many of the northeastern states have relatively older populations, with Maine having the oldest population (41.2 years). These older ages are reflective of the out-migration of younger age groups, while states in the South and West have generally younger populations given the in-migration of the young. Interestingly, Florida has a relatively old population (39.5 years), reflecting its role as a retirement destination.

Dependency Ratios

In addition to the median age of a population, we can identify the proportion that is young or old within a population, such as the proportion of a population that is dependent (typically aged fifteen years or less), the labor force–aged population (fifteen to sixty-four years), and the older population (aged sixty-five-plus). More specifically, *dependency ratios* capture the age distribution of the population relative to the labor force–aged population. Generally, the "dependent population," either aged zero to fifteen or sixty-five and over, are contrasted with individuals aged fifteen to sixty-four and who can "support" either young or old dependents. When there are more working-age adults relative to children and the old, the labor force age group has a lower dependency burden: fewer people to support with the same income and assets. Parents, for example, provide most of the financial support for their children, including housing, clothing, and education. At the same time, taxes paid by workers pay for programs and support health and social-welfare programs and education, with the young and old relatively dependent on these.

Three dependency ratios are commonly used. The first, the *young dependency ratio* (YDR), refers to the relative size of young dependents to the labor force population, defined as follows.

$$YDR = (P_{0-14} / P_{15-64})^{*}100$$

Likewise, the *old dependency ratio* (ODR) is defined as follows.

$$ODR = (P_{65+} / P_{15-64})^{*}100$$

The *total dependency ratio* (TDR) is defined as follows.

$$TDR = ((P_{0-14} + P_{65+}) / P_{15-64})^{*}100$$

In all of these examples, $P_{x\text{-}y}$ refers to the population aged x–y (i.e., zero through fourteen).

We can use the United States to illustrate this measure (see table 3.1). Between 1996 and 2025, the young dependency ratio is expected to stay relatively constant (approximately 0.30). Reflecting the slow aging of the US population and the aging of baby boomers into retirement, the old dependency ratio is expected to increase from 0.19 in 1996 to 0.29 by 2025. This means that while there were approximately four workers for each older person in 1996, this will drop to three workers by 2025, with potential implications for taxation and welfare support.

Despite their widespread use and intuitive meaning, the use of dependency ratios can be problematic, particularly when linked to policy. In part, the measure would be more reflective of economic reality if the young dependent age group was defined as zero through nineteen and the labor force as those aged twenty to sixty-four, given the reality that relatively few fifteen- to nineteen-year-olds are working full time in most developed countries. The definition for the old dependency ratio also implies, for example, that all people over age sixty-five are in some sense dependent on the population of working age, given the use of payroll taxes to support health and social-welfare programs. For this reason, changes in the old dependency ratio are assumed to have a greater effect on government spending and the economy. However, "dependency" does not suddenly change with age. In fact, there is a growing tendency for many youth to remain financially dependent on their parents for a longer period of time than was seen even in the 1980s.[12] It is not uncommon, for example, to find children in their twenties still living with parents and either active in the labor force or still in school. Similarly, many of those over sixty-five remain active in the labor force and make important economic contributions. Concurrently, there are individuals in the labor force age group that have withdrawn

Table 3.1. Dependency Ratios, United States, 1990–2025

Year	*Young dependency ratio*	*Old dependency ratio*	*Total dependency ratio*
1990	0.33	0.19	0.52
1996	0.33	0.19	0.53
2000	0.32	0.19	0.51
2005	0.31	0.19	0.49
2010	0.30	0.19	0.49
2015	0.31	0.22	0.53
2020	0.32	0.26	0.57
2025	0.32	0.29	0.61

Source: Based on data derived from the US Census Bureau.

from the labor force for reasons including health. For this reason, we must interpret dependency ratios with caution.[13]

CONCLUSION

The distribution and composition of a population often lies at the heart of describing a population, reflecting such things as its age and gender structure both visually and numerically with knowledge of its age structure and sex structure acting as building blocks in terms of understanding the population and the provision of services. Governments will, for instance, gauge the provision of services based on the age of the population, so that areas with a larger proportion of older adults will receive the necessary level of services. The rise of GIS and related spatial analysis techniques has also provided new venues for looking at the distribution of a population. Indeed, the popularity of GIS and new analytical tools has meant that more people understand why "geography matters" when it comes to population issues.[14]

Multiple processes, including fertility choices, migration, and mortality, can affect population structure and composition. Declines in mortality, for instance, increase the proportion of older adults and also shift the gender balance in favor of females. Fertility tends to have significant changes on a population's composition, with decreasing fertility associated with population aging. Migration will also redistribute a population and its characteristics, with the potential for significant short-term impacts, as it tends to be age- and sex-selective, typically selecting younger adults while favoring one gender over another in some situations. Thus, analysts need to be aware of the potential effects of these processes on a population, particularly if longer-run trends are desired. However, we save the discussion of these impacts for elsewhere in this book.

FOCUS: THE CHANGING FACE OF THE US POPULATION[1]

Over its history, the size, composition, and distribution of the US population has changed significantly. Historically, the distribution of the country's population followed western expansion and the annexation of new territory such as the Louisiana Purchase in 1803, the Mexican Cession in 1848, and the Texas Annexation in 1845. Exploration, land, resources, and new frontiers attracted new immigrants as well as Americans to settling in these new territories and slowly shifted the distribution of the population westward, a process which continues to this day. The westward drift of the US population has been captured through the use of population centroids,[2] which represent the geographic center of the population. Starting on the east coast in the late 1700s, it has slowly but consistently drifted west and south over time. By 1890, it was located in southeast Indiana, and moved west of the Mississippi by 1990 and into Phelps County, Missouri by 2000. The distribution of the US population can also be captured through population density. Historically, population density was just 1.8 persons per square kilometer in 1790, and 8.3 per square kilometer by 1900.[3] By 2000, the country's population density had increased to 31 people per square kilometer.[4] Washington, D.C., is the most densely populated area, with 3,621 per square kilometer. Wyoming is the least dense state in the continental United States, with just 1.96 persons per square kilometer.

The nation's changing population composition can be measured by shifts in its age profile, reflected in such measures as median age, population pyramids, and dependency ratios. Again based on the 2000 census, the median US age was 35.3 years,[5] up from 32.9 years in 1990. The jump in the median age largely reflects the aging of the baby boom cohort, although the aging of this cohort has not yet influenced the dependency ratios, with both the young and old dependency ratios relatively consistent between 1990 and 2000 (0.33 and 0.19 for the young and old, respectively). That is, for example, there are about five people in the labor force supporting each older adult. However, this is a significant departure from what it was in 1900, when the old dependency ratio was 0.07 (reflecting shorter life spans and higher fertility), while the young dependency ratio has consistently drifted downward as fertility has decreased.[6] As the baby boom cohort ages further into retirement, however, the old dependency ratio will start to increase. By 2030, the last of the baby boomers will have turned sixty-five, and nearly 20 percent of Americans will be over sixty-five, compared with just 13 percent today.[7]

Not surprisingly, the distribution of the nation's older population varies across the country.[8] Florida had the largest proportion (16.8 percent) of older (sixty-five and older) people in 2000 (median age equals 39.5 years), reflecting its attractiveness to retirees. States in the Great Plains and some northeastern states such as Rhode Island, Pennsylvania, and West Virginia also have comparatively large proportions of older people. In contrast, many of the western and southeastern states have relatively smaller proportions of the old. States with some of the youngest populations include Utah, Colorado, and Texas.

The changing ethnic and racial composition of the country perhaps reveals the most fundamental and far-reaching changes occurring in the nation. Originally shaped by historical immigration flows from western Europe and the slave trade, the composition of the United States was long defined by its white and black roots. This began to change in the 1960s with the liberalization of the country's immigration policies, which increased immigration flows from Asia and other "nontraditional" origin areas. The number of new entrants has also increased, totaling over one million new arrivals per year early in the new century. Over the 1990s, legal and illegal immigration flows from Latin America, and particularly Mexico, altered the country's ethnic composition, making ethnic and racial minorities the majority population (compared to non-Hispanic whites) in both California and Texas.

Based on the 2000 census, 11.1 percent of the country's population is foreign-born. Although this is less than historical standards (15 percent in 1910), the proportion of foreign-born could surpass the historical high by 2025, and may reach as high as 20 percent by 2050. The largest proportion (51.7 percent) is from Latin America, and

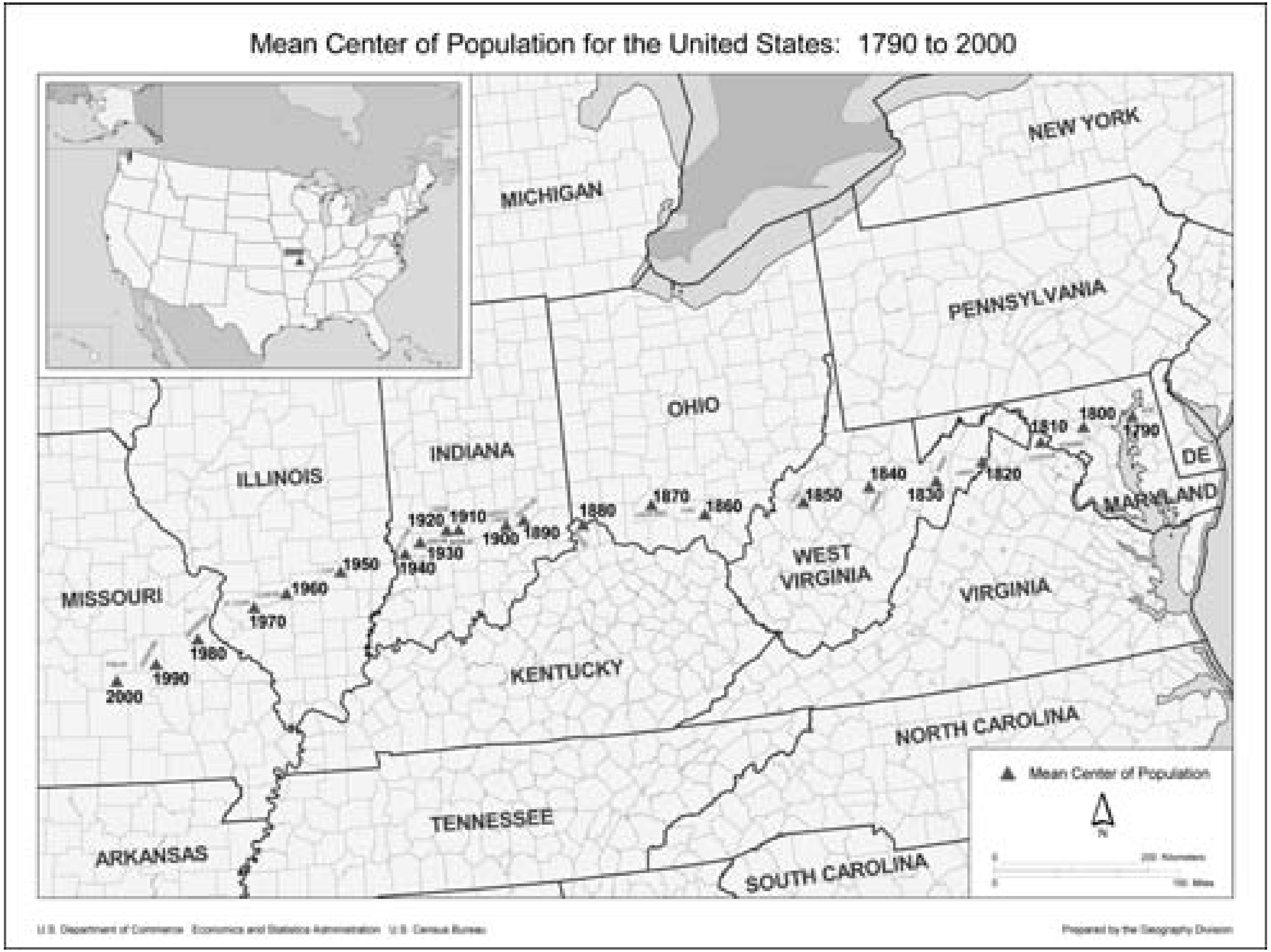

Figure 3F.1 Mean Center of Population for the United States: 1790 to 2000.

Source: US Census Bureau.

particularly Mexico. Asians represent 26.4 percent of the foreign-born, with major origin countries including China, India, and Pakistan. Europeans represent just 15.8 percent of all foreign-born in the country.[9] In comparison, Europeans represented 74.5 percent of all foreign-born in 1960.[10] The country's ethnic composition has also been altered far beyond the usual immigrant magnets of cities like New York or Los Angeles. Reflecting a changing distribution within the United States, recent arrivals have filtered across the country, so much so that suburban and rural America is dealing with immigration issues seemingly overnight.[11]

So significant is the impact of the foreign-born on the composition of the American population that the Census Bureau predicts that ethnic and racial minority groups will represent the majority of the population by the early 2040s. By that time, Americans identifying themselves as Hispanic, black, Asian, American Indian, Native Hawaiian, and Pacific Islander will outnumber non-Hispanic whites.[12] By 2050, non-Hispanic whites will represent just 46 percent of the population, down from 66 percent in 2008. The main reasons for this, as noted elsewhere, are the significantly higher levels of fertility amongst these minority groups and the number of immigrants entering the United States. Individuals are also changing how they identify themselves, with more identifying themselves as multiracial. In short, the future US population will appear much more diverse than it currently does.

Finally, there are significant compositional differences between native-born Americans and the foreign-born. For instance, 79 percent of the foreign-born were aged eighteen to sixty-four in 2000, compared to 60 percent of natives. Similarly, only 10 percent of the foreign-born were eighteen years old or less, compared to 28 percent amongst the native-born. This gives the population pyramid of the foreign-born a shape similar to a football, with a small proportion in the younger and older age groups, and the majority in the labor force ages. In large part, this reflects immigration policy, with most immigrants arriving as younger adults. However, if we consider the US population in terms of ethnicity or race, as opposed to immigrant and native-born, the picture changes again. Given that fertility rates tend to be higher amongst minority groups than non-Hispanic whites, these differences are shaping the future ethnic and racial makeup of the United States. For instance, between 1990 and 2000, the population under eighteen had the largest gain since the 1950s, with minorities accounting for most of this growth.

METHODS, MEASURES, AND TOOLS: LIFE TABLES

Demographers often rely on life tables as a way of summarizing mortality and life expectancy within a population. Essentially, information contained in the tables represents the probability of surviving from one age to another and the life expectancy for a person aged *x*. Table 3MMT.1 illustrates a basic life table for the United States (both sexes, 2006),[1] which can be interpreted as a summary of the mortality experiences of a cohort of individuals born at time t. The initial size of the cohort, l_o, known as the *radix*, is often set to one hundred thousand. Two assumptions are key to the life table. First, rates of age-specific mortality will not change over the lifetime of members of the cohort. Second, as the cohort ages, individuals will die according to the specified death rates. The individual columns in the table are defined as follows.

- $_hM_x$ the observed age-specific mortality for individuals age x to $x + h$
- $_hq_z$ the probability that an individual aged x will die before reaching age $x + h$
- l_x the number of individuals in the cohort surviving to age x
- $_hd_x$ the number of individuals in the cohort dying between ages x and $x + h$
- $_hL_x$ the number of person-years lived by the l_x individuals between ages x and $x + h$
- T_x the cumulative number of person-years lived by the cohort beyond age x
- e_x the life expectancy (in years) for the person surviving to age x

Each hypothetical cohort is subjected to an age-specific mortality rate ($_hM_x$), beginning from birth. For each age group, the value of q is derived from M, and then d is derived.

We start with the derivation of the age-specific death rates as follows.

$$_hM_x = {_hD_x} / {_hP_x}$$

The numerator, $_hD_x$, is the observed age-specific deaths. The denominator, $_hP_x$, is the observed age-specific population, which is typically defined as the midyear population. These mortality rates can be used to define the probability of dying, $_hq_z$, which is defined as follows.

$$_hq_x = \frac{h\,{_hM_x}\,{_hP_x}}{_hP_x + (h/2)\,{_hM_x}\,{_hP_x}}$$

This essentially indicates that the probability of not surviving to the next age group $x + h$ is related to the number of deaths in that cohort relative to those alive at age x, assuming, of course, that deaths are distributed equally across the time period. Using data from table 3MMT.1, the probability that an American aged forty does not survive to age forty-five is 0.01129.

Within each cohort, a given number of individuals ($_hd_x$) die, so that the given number of individuals reaching a particular age x is reduced as the cohorts age. The number of deaths can be determined as

$$_hd_x = l_x\,{_hq_x}$$

or the number of individuals reaching age x (l_x) multiplied by the probability of dying before age $x + h$. This also means that the number of individuals surviving until the beginning of the next age group ($x + h$) is equal to the following formula.

$$l_{x+h} = l_x - {_hd_x}$$

Returning to our example based on table 3MMT.1, the number of deaths ($_hd_x$) occurring in the forty to forty-five cohort is 1,090. Since 96,611 members survive to age forty, the number surviving to age forty-five is 96,611 − 1,090 = 95,521.

The number of person-years lived by the cohort over h years is defined as follows.

$$L = \frac{h(l_x + l_{x+h})}{2}$$

That is, L_x is a function of the number of persons alive at the midpoint of the age group $(l_x + l_{x+h})/2$ and the number of years in the

Table 3MMT.1. Life Table: United States of America, 2006, Both Sexes

Age	${}_hM_x$	${}_hq_z$	l_x	${}_hd_x$	${}_hL_x$	T_x	e_x
< 1	0.00662	0.00658	100,000	658	99,408	7,800,885	78.0
1–4	0.00028	0.00112	99,342	111	397,101	7,701,477	77.5
5–9	0.00014	0.00070	99,231	59	495,981	7,304,3777	73.6
10–14	0.00017	0.00087	99,162	86	495,593	6,808,396	68.7
15–19	0.00063	0.00314	99,075	311	494,598	6,312,803	63.7
20–24	0.00094	0.00468	98,764	463	492,664	5,818,205	59.9
25–29	0.00094	0.00470	98,301	462	490,353	5,325,541	54.2
30–34	0.00108	0.00537	97,840	526	487,884	4,835,188	49.4
35–39	0.00145	0.00722	97,314	703	484,813	4,347,305	44.7
40–44	0.00227	0.01129	96,611	1,090	480,329	3,862,492	40.0
45–49	0.00344	0.01705	95,521	1,629	473,531	3,382,163	35.4
50–54	0.00509	0.02513	93,892	2,359	463,561	2,908,631	31.0
55–59	0.00719	0.03531	91,532	3,232	449,582	2,445,071	26.7
60–64	0.01116	0.05427	88,301	4,792	429,523	1,995,488	22.6
65–69	0.01670	0.08014	83,509	6,692	400,813	1,565,965	18.8
70–74	0.02611	0.12257	76,816	9,415	360,543	1,165,152	15.2
75–79	0.04088	0.18546	67,401	12,500	305,754	804,609	11.9
80–84	0.06624	0.28414	54,901	15,599	235,506	498,855	9.1
85–89	0.10640	0.42024	39,301	16,516	155,217	263,350	6.7
90–94	0.16970	0.56226	22,786	12,811	75,493	108,132	4.7
95–99	0.27059	0.69487	9,974	6,931	25,613	32,639	3.3
100+	0.43319	1.00000	3,343	3,043	7,026	7,026	2.3

Source: WHO Statistical Information System (WHOSIS), www.who.int/whosis/database/life_tables/life_tables.cfm (accessed 11 June 2008).

cohort, h, assuming that deaths are distributed equally over the age group. For the forty to forty-five cohort example, the number of person-years lived is 5 x (96,611 − 95,521)/2 = 480,330.

Next, the cumulative number of person-years lived by the cohort beyond age x (T_x) is found by adding ${}_hL_x$ from x to the last group,

$${}_hT_x = \sum_{i-x}^{z} {}_hL_i$$

where z is the oldest cohort in the life table. The number of person-years remaining to be lived beyond age forty-five for the example cohort is 3,382,163.

Finally, the remaining life expectancy for those individuals currently aged x (e_x), is calculated by dividing the number of person-years lived beyond age x by the number of persons reaching age x.

$$e_x = \frac{{}_hT_x}{l_x}$$

Therefore, the expectation of years to live for an American reaching age 45 is 35.4 years (3,382,163 / 95,521), equal to an expected age of 80.4.

There are three exceptions to the above noted calculations. First, deaths for infants are more likely to occur in the first half of the year than in the second. Consequently, children less than one year old are typically tabulated separately. One method to estimate this is defined as follows.

$$L_0 = \frac{l_0 + l_1}{2}$$

Following this, and since the age group zero to one has already been estimated, $h = 4$ should be used (rather than $h = 5$, assuming the age interval is equal to five years) for the calculation of L for the age group one to four.

Second, the last age group is open-ended. In this case, q is allowed to equal 1.0, since everyone reaching this age group must die in it.

$$_{\otimes}d_z = l_z$$

Finally, the number of person-years lived by individuals in the oldest age group also needs to be adjusted. In this case, demographers assume that the age-specific mortality rates in this oldest age cohort are equal to those observed in some theoretical "stationary" population (m_z), which is an unchanging population arrived at by adding l_o births to the population each year. Given that $M_z = m_z$, we can derive as follows.

$$L_z = \frac{d_z}{M_z}$$

USE Of LIFE TABLES

Far from being a set of abstract calculations, life tables are commonly used within the insurance industry to set insurance premiums and are typically further disaggregated by age (i.e., single-year age groups) and gender, given survival differences between males and females (with females typically surviving longer). They can also be used to determine survival ratios. For example, the proportion of forty- to forty-five-year-old Americans who reach their forty-fifth birthday is defined as follows.

$$\frac{5l_{45}}{L_{40}} = \frac{5(95{,}531)}{480{,}329} = 0.9943$$