

**ESTIMATING THE FOREIGN-BORN:
AN EVALUATION OF METHODS AND DATA
2 December 2008**

**Working Paper 09-04
Blakely Center For Sustainable Suburban Development
University of California Riverside
<http://cssd.ucr.edu/Papers/Index.html>**

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I. Introduction

As Gary Gerstle (2008) has observed, the history of the United States is deeply intertwined with immigration and for most of its history the country has been remarkably open to immigrants. In fact, it is this immigration that is largely the history of the racial and ethnic composition of the United States and its majority- minority relations. Territorial expansion, the incorporation of the people living within these acquired territories, and the “great migration” of African-Americans out of the south, round out the story of the nation’s racial and ethnic composition and majority-minority relations (Flanagan, 2002).

With the exception of the 1860s and the 1890s, the number of international migrants to the United States increased in each decade from the 1820s to the 1901-1910 decade (Schmidley, 2001). The Decennial Census data show that the foreign-born population increased rapidly from 2.2 million in 1850, the first year in which place-of-birth data were collected, to 13.5 million in 1910 (Schmidley, 2001).

The number of new foreign born arrivals declined between 1911 and the 1920s, due first to World War I and then to the restrictive immigration legislation enacted in 1921 and 1924 in which a national origin quota system was established. This system severely limited immigration and favored countries in the Western Hemisphere and Northern or Western Europe (Schmidley, 2001). Because of decreased migration to the United States, the proportion of foreign-born in the total population, which had fluctuated in the 13 percent to 15 percent range from 1860 to 1920, dropped from 14.7 percent in 1910 to 11.6 percent in 1930. By 1950, the U.S. foreign-born population dropped to 10.3 million in 1950 or 6.9 percent of the total population. By 1970 it was down to about 9.8 million,

which at about 4.8 percent of the total population, represented a record low in the 20th century (Hansen and Bachu, 1995).

Given the often tumultuous nature of racial and ethnic relations in the United States, it comes as no surprise that Americans have also feared immigrants and responses – both physical and legal – have been aimed at specific groups who were viewed as threatening (Gerstle, 2008). A landmark response came in the form of the national origins quota system, which was enacted in the 1920s and reaffirmed in the Immigration and Nationality Act of 1952. However, attitudes shifted by the 1960s and the national origins quota was eliminated by the 1965 Amendments to the Immigration and Nationality Act of 1952 (Schmidley, 2001). This legislation and subsequent legislation, including the Immigration Reform and Control Act of 1986, which permitted some illegal aliens to obtain lawful permanent residence, and the Immigration Act of 1990, which increased the annual cap on immigration, have contributed to increased international migration (Schmidley, 2001).

Since 1970, the numbers of foreign-born have increased, reaching 31.1 million, or 11.1 percent of the US population, by 2000 (Malone, Beluja, Costanzo, and Davis, 2003). By 2003, the US Census Bureau estimated the foreign-born population at 33.5 million (Larsen, 2004), or approximately 11.5 percent of the total U. S. population.

While there are uncertainties in the counts and estimates of the foreign-born population, they appear to be less than those for estimates of the foreign-born who are not “authorized” to reside in the United States. Walsh (2007), for example, reports seeing estimates ranging from 7 million to 20 million. However, when in examining estimates that provide descriptions of the methods and data underlying them, the range of numbers

is reduced considerably. Passel, Van Hook, and Bean (2004), estimate that there were 8.3 million unauthorized people residing in the US in 2000. Passel (2005) estimates that there were 10.3 million in 2004. Hofer, Rytina, and Campbell (2007) estimate that there were 11.6 as of January 2006, while Fortuny, Capps, and Passel (2007), for example, estimate that in 2007 there were between 11 and 12 million. If the current number is between 11 and 12 million, it would represent about one-third of the foreign-born population in the US.

Just as the uncertainty increases in moving from estimates of the foreign-born population to estimates of the unauthorized population, so does the level of contentiousness. Gerstle (2008), for example, points out that the historical record shows that war or near-war conditions often are associated with less-than enthusiastic “responses” to immigrants. Given the current situation of the United States with troops in Iraq and Afghanistan, it again should come as no surprise that historical tensions have once again arisen between those who “were already here” and those who “have recently arrived.”

One example of the contentiousness can be found in a recent paper by Walsh (2007: 220), who refers to a 2005 report done by Jeff Passel as “...largely advo-babble (immigrant advocate babble) under the guise of research and statistical analysis...” Others view this same report as valid research (see, e.g., National Research Council, 2006b; Orrenius and Zavodny, 2006; State of Minnesota, 2005). I point out the contentiousness surrounding this issue because it affects not only the estimates and other determinations of the foreign-born in the United States, especially when status (i.e., authorized and unauthorized) is considered, but also the task of evaluating the methods

used to determine the numbers of foreign-born (Walashek and Swanson, 2006) The present “climate” noted, the present paper is aimed at identifying, describing, and evaluating methods that have, are, or could be used to estimate the US foreign-born population.

The substantive remainder of the paper is organized into nine sections. The following section provides a general background to issues associated with measuring the foreign-born and immigration. It is not meant to be inclusive, but suggestive. The third section deals with population estimation as a whole and includes topics related to direct and indirect measures, formal demography, censuses, and samples. The fourth section deals with estimating the foreign-born using residual methods, which are based on the Decennial Census, the Current Population Survey, and, more recently, the American Community Survey. The fifth section deals with estimating the foreign born using administrative records while the sixth section covers method for estimating the foreign born using specialized survey methods. The seventh section covers methods that do not fit neatly into the preceding categories and the eighth section provides an evaluation of the methods used to estimate the foreign-born. The ninth section provides suggestions in regard to data, methods, and administrative arrangements that could be used to generate regular estimates of the foreign-born by status

References are at the end of this report, which is a companion piece to an annotated bibliography and glossary. The bibliography is organized into seven sections that match sections II through VIII in this report. The glossary is focused on population estimation. By necessity it covers demographic terms that are not exclusively found in either field. Finally, endnotes are found on the last two pages of the report.

II. The Foreign-Born and Immigration: Some Background¹

Historical Overview

As indicated in the preceding section, attempts to count the foreign-born population in the United States have a long history. They appear to have started with the 1820 and 1830 decennial censuses, in which enumerators were asked to take note of individuals who were aliens (see, e.g., Malone, Beluja, Costanzo, and Davis, 2003). However, no specific questions on citizenship status were asked until the 1890 census. These questions remained with some variations except in 1960. Questions concerning an individual's place of birth have appeared in the decennial censuses since 1850.

From 1870 to 1970, parental nativity (place of birth of the individual's father and mother) was also asked. Census 2000 asked, "Where was this person born?" asking for the name of the state for those born within the United States or the country name for those born elsewhere. In many decennial censuses, an additional question asked the year in which a person born outside the United States (whether native or foreign born) came to live in the United States. However, as noted by Grieco (2003) because there is no "long form" planned for the 2010 census, these questions are now found within the American Community Survey (ACS). Unfortunately, as is discussed later, the ACS uses a different definition of residency than does the decennial census, one that is essentially that for a De facto population rather than the De jure definition used in the Decennial Census, the CPS, SIPP, and the Census Bureau's estimates and projections programs (see, e.g., National

Research Council, 2007: 31; National Research Council, 2006a). This is a point to which I return in the several times in this report.

Currently, the ACS (2008 Questionnaire) asks three questions in regard to the foreign born. These questions are similar to those just described for the decennial censuses. For example, there is an ACS question that asks if one was born in the United States or out of the United States. A second ACS question asks if one is a citizen and a third, which is directed at all except citizens born in the United States, asks the year in which these non-US-born citizens came to the United States.

Definitions of Foreign-Born and Immigrants by “Status”

The U. S. Census Bureau defines the foreign-born as people who are not U.S. citizens at birth (Deardorff and Blumerman, 2001). This population consists of legal immigrants, temporary migrants, and unauthorized migrants as shown in the following equation (Deardorff and Blumerman, 2001):

$$FB = [L - (M + E) + T + R]$$

where

FB = Foreign-born population

L = Legal Immigrants

M = Mortality to legal immigrants

E = Emigration of legal immigrants

T = Temporary (legal) migrants

R = Residual foreign-born (unauthorized and quasi-legal migrants)

The preceding equation is a useful way to look at the foreign-born as a whole as well as by status. Among other reasons, it serves as an illustration of the ‘residual’ method for estimating the unauthorized and quasi-legal migrants, a topic that is covered later.

Although the definitions by Deardorff and Blumerman (2001) are useful, there is no single set of conventions used to describe the “status” categories that immigrants fall into (see, e.g., Edmonston and Michalowski, 2004; Passel, Van Hook, and Bean, 2004). One of the major sources of confusion in terms of defining immigration status categories involves foreign-born residents with applications pending. Some of these pending applications have different objectives and potential immigration status outcomes. In other cases, an immigration status may be determined in order to develop estimates of immigrants by status category. As three simple examples of the former, immigrants may petition to become lawful permanent residents, receive changes in temporary or non-immigrant status, or to obtain extensions of non-immigrant status. In terms of the latter, valid reasons exist for interpreting the immigration status of the resident foreign-born population in multiple ways. As two simple examples, an agency may need to render a legal classification for enforcement, budget, or program purposes, while a policymaker may want an estimate of how many foreign-born residents may be affected by proposed legislation. These simple examples point toward the fact that there is neither a single data set nor a single method that can be used to estimate numbers of foreign-born residents with pending applications by immigration status.

There also are two additional situations that may in fact be combined in some situations. First, some of them have “employment authorization documents;” and second,

some of them are not legally entitled to be in the United States. In combination, then, some of the foreign-born with employment authorization documents may not be legally entitled to be in the United States.

Further complicating these definitions is the issue of the residence rule used, De jure or De facto. If data from the Decennial Census, CPS, and SIPP are used to generate estimates of the foreign-born by status, then the result is the De jure foreign-born population (by status); if the ACS is used, the result is, in essence, the De facto foreign-born population (by status). As is discussed later, it is not clear what results when DHS data and some other types of administrative data are used. The situation with special surveys aimed at directly counting the foreign-born (by status) also has some ambiguity: a given survey could be aimed at either the De jure or De facto population.

These situations and statuses interact, thereby contributing to the lack of standard definitions and conventions on how to define the foreign-born with pending applications. Are they legal? Are they unauthorized? The Department of Homeland Security (DHS), for example, uses the term “unauthorized” to describe foreign-born persons residing illegally in the United States, but includes some “unauthorized immigrants” who have pending applications.

Given the lack of consensus, Judson (2006) constructed a table that attempts to bring some order to this situation. It is reproduced here as Table 1 and forms a useful point of departure for this report in terms of discussing the various categories into which the foreign-born whose place of residence is in the United States as of July 1st (the official estimate date) or April 1st (the official census day) might be classified.

Table 1: Legal Status Terms Developed by Judson (2006)

Term		Legal and procedural definition
(Authorized) Legal Immigrant		
	Naturalized	Has obtained U.S. citizenship.
	Lawful Permanent Resident (LPR)	Has applied for LPR status, and has been formally admitted.
(Authorized) Legal Temporary (“Legal Non-immigrant”)		Lawful temporary application has been accepted; AND Terms of admission have not been violated; AND Neither naturalized nor LPR status has been granted, even if application exists.
Refugee/Asylee		Has applied for refugee or asylee status and been granted same; OR Present in the U.S., citizen of Temporary Protected Status-recognized country; AND Has not converted status to Legal Temporary, Lawful Permanent, or Naturalized.
Residual, Unauthorized* or Other		All other: Application in process but not yet granted; OR Entered without inspection; OR Violated terms of residence. Application in process but not yet granted
	Within residual:	
	Quasi-legal	Has applied for Lawful Permanent Resident, Legal Temporary status, Refugee, Asylee, or Temporary Protected Status; AND Status not yet granted.

With the exception of the methods based solely on the ACS, most of the different ways that the authors covered in this section have defined the foreign-born population (by status) are based on the De jure concept of a population, which is the definition used to enumerate the population in the decennial census of the United States. However, this is not always explicit, which is not surprising because the major sources of population data in the United States also are based on this approach (See, e.g., National Research

Council, 2006a). However, there may be a significant proportion of the unauthorized population that would not be considered as ‘residents’ according to the census enumeration procedures used by the US Census Bureau. Consequently, instead of being enumerated as part of the De jure population, those who do not meet the ‘residence rules’ requirements would not be enumerated because they be considered as part of the De facto population. In later sections, the effect of these implied definitions on estimates is discussed, especially in terms of estimates generated by the residual method and its variations. Unless otherwise specified, I generally use the term “unauthorized” in this report to described those who would be enumerated in a census as a resident of a given location, but, in fact, entered the United States without inspection, or have an application in process that has not yet been granted, or have violated terms of ‘legal residence’ in the United States.

Current Sources of Data on Immigrants

Edmonston and Michalowski (2004) observe that official records of immigration to the United States have been kept by a Federal agency since 1820, but official records of emigration have been kept only since 1908. The Department of State, the Department of Labor, and other Departments compiled the statistics before this work was shifted from the Department of Labor to the Justice Department in 1944, where it is now located (Edmonston and Michalowski, 2004).

The data on migration of the Immigration and Naturalization Service do not fit any simple classification scheme and, in fact, because of the complexity and variety of the

data, more than one classification scheme is required to present them (see, e.g., Camarota and Capizzano, 2004). Edmonston and Michalowski (2004) identify two principal collection systems and a few subsidiary and supplementary ones. The first is confined to aliens and is based on visa forms surrendered by aliens at ports of entry and visas issued to aliens adjusting their status in the country to permanent residence. This system covers only a small part of the movement across the United States borders.

The second principal collection system is more inclusive than the first and, in general, covers all persons arriving at and departing from U.S. ports of entry. From a demographic point of view, however, these data have serious limitations not shared by the first classification, including lack of the more detailed information collected. This system covers three subsidiary groups: passengers arriving or departing principally by sea or air, land border crossers, and crewmen. The types of statistics compiled and their precise definitions vary from one period to another. The description given below (Edmonston and Michalowski, 2004) applies to the current situation.

“In general, "admission statistics" covers four classes: (1) aliens admitted to the United States as "immigrant aliens admitted," (2) aliens departing from the United States as "emigrant aliens departed," (3) aliens admitted as "non-immigrant aliens admitted," and (4) aliens departing as "non-emigrant aliens departed." Immigrant aliens are nonresident aliens admitted to the United States for permanent residence (or with the declared intention of residing here permanently) or persons residing in the United States as non-immigrants, refugees, or "parolees" who acquired permanent residence through adjustment of their status.

Emigrant aliens are resident aliens departing from the United States for a permanent residence abroad (or with the declared intention of residing permanently abroad). Statistics on emigrant aliens were discontinued as of July 1, 1957, when persons departing were no longer inspected.

The first two classes, which are considered as the basic classes of alien migrants, are supplemented by two additional classes of alien admissions or departures -- non-immigrant aliens admitted and non-emigrant aliens departed. In general, non-immigrant aliens are non-resident aliens admitted to the United States for a temporary

period or resident aliens returning to an established residence in the United States after a temporary stay abroad (i.e., an absence of more than 12 months). On the basis of recent experience, numerically the most important group of non-immigrant aliens is the group "temporary visitors for pleasure." Other numerically important groups are "returning residents," "temporary visitors for business," "transit aliens," "temporary workers and industrial trainees," and "students." Also included among non-immigrant aliens are "foreign government officials," "exchange aliens," and members of international organizations.

"Non-emigrant aliens departed" are nonresident aliens departing after a temporary stay in the United States or resident aliens departing for a temporary stay abroad (i.e., for more than 12 months). Data on non-emigrant aliens were tabulated up to July 1, 1956; such figures are not available since that date. The classes of arrival and the classes of departure do not correspond to each other completely because the intended length of stay as declared does not always correspond to the actual length of stay. Thus, persons who are admitted as non-immigrant aliens for a temporary stay but remain longer than a year are classified as emigrant aliens on departure, and aliens who are admitted for permanent residence but decide to depart within a year are classified as non-emigrant aliens on departure.

The second collection system provides "arrival" and "departure" statistics and may be viewed as having three distinct components. The first component covers principally arrivals and departures by sea and air; the second covers "border crossers," i.e., persons who cross frequently to or from Canada or Mexico; and the third covers crewmen. The statistics are classified by citizenship. The first component may also be designated as "passenger" statistics: the count is derived from lists of names on passenger manifests prepared by the airlines and steamship companies.

The second component, "border crossers," represents principally a count, made by immigration inspectors at established points of entry, of persons entering the United States over its land borders with Canada and Mexico. It is a count of crossings; hence, the same persons may be counted more than once. As mentioned above, in addition to the two basic classes of international migrants (immigrants or "new permanent arrivals" and emigrants departing or "permanent resident departures"), some statistical information is secured for several other groups of persons who cross the borders of the United States. Some account should be taken of these other groups in any assessment of the impact of immigration on the population, particularly on the De facto population: Particular attention should be given to:

1. Non-immigrants. Most non-immigrants are tourists whose visits range from a few days to a few months. A large number of other non-immigrants are business people who stay typically for less than a few weeks. Non-immigrants, however, also include several groups who usually stay in the United States for several months or more. Among them are government officials, students, and temporary workers as well as their spouses and children. In recent years, about

one million non-immigrants enter the United States annually for longer periods of residence.

2. Aliens paroled into the United States. From time to time, special legislation allows political refugees to enter and remain in the United States outside the requirements of the Immigration Act. Refugees from Hungary after the revolution in 1956, refugees from the Communist regime in Cuba in the 1960's, and El Salvadorians in the 1990's were granted asylum by special legislation.
3. Arrivals from and departures to the outlying areas of the United States. In the basic tabulations on admissions, the United States and its outlying areas are treated as a unit. Data on movement between the United States and Puerto Rico are currently available, however, in the form of passenger statistics compiled by Puerto Rican authorities.
4. U.S. military personnel. Direct data are not available but their number may be estimated from data on the number of U.S. military personnel overseas given in census reports and reports of the U.S. Department of Defense.
5. Illegal entrants and unrecorded departures.
6. Aliens deported from the United States or departing voluntarily under deportation proceedings. During 1997, 1,537,000 deportable aliens were located. Almost all deportees had entered the United States without inspection and were removed under conditions of voluntary departure.

Except daily commuting, all of the movement across a country's borders, however temporary, should be considered demographically significant in relation to a De facto count of the population. The groups of migrants who would be considered consistent with a De jure count of the population would be much more restricted. In the case of the United States, these include members of the armed forces who are transferred into and out of the United States; all "immigrant aliens admitted" and "emigrant aliens departed;" certain classes of "non-immigrant aliens admitted" and "non-emigrant aliens departed" (such as students, resident aliens arriving and departing, some temporary visitors for business, and temporary workers and industrial trainees); "refugees" and "parolees" who enter under special legislation and may later have their status adjusted to that of permanent residence; and citizens who change their usual residence (movement to or from outlying areas and foreign countries). The discontinuance of data collection for certain of these categories (emigrant and non-emigrant aliens departed) and the volatility of the figures for passenger movement (citizens arrived and departed, aliens departed) present a challenge in estimation of additions through immigration to the De jure population."

Edmonston and Michalowski (2004) note that the quality of data on international migration based on frontier control operations is generally much poorer than that of census counts or birth and death statistics. Such data tend to suffer from serious problems of completeness and international comparability. They go on to note that there

are several reasons for the poor quality of the data. First, there are many forms of international movement, and they are not easy to define or classify. Second, classification based on duration of stay or purpose of migration depends on statements of intentions, and the actual movements may not correspond to these statements of intentions. Next, the mere counting of persons on the move is extremely difficult, especially when a country has a very long boundary that is poorly patrolled. It is certain that many international migrants enter or leave a country unrecorded under these conditions. Controls over departures are usually less strict than over arrivals so that statistics of emigration are more difficult to collect and less accurate than statistics of immigration. Given these shortcomings, it is not surprising that the United Nations considers that, where available, population register data are the most satisfactory for the measurement of international migration and advises that (Edmonston and Michalowski, 2004).

As can be deduced partially from the preceding discussion on immigration and emigration, there are neither federal administrative records nor federal survey data sources that directly provide information on the foreign-born in the United States who lack documents demonstrating that they are legally in the U.S., whether as members of the De jure population or as part of the De facto population. However, there are three federal agencies that currently collect information on the foreign-born: (1) the Census Bureau; (2) the Department of Homeland Security; and (3) The National Center for Health Statistics. The Census Bureau collects this information via two major vehicles: (1) the decennial census; and (2) the American Community Survey (ACS). Other vehicles include the Survey of Income and Program Participation (SIPP) and the Current

Population Survey (CPS), in its annual (March) social and economic supplement. The decennial census, SIPP, and the CPS are aimed at the De jure population, while the ACS is aimed at the De facto population.

The Department of Homeland Security's Office of Immigration Statistics (OIS) collects information on the foreign-born via several administrative records systems. One is the Non-Immigrant Information System (NIIS). Another is comprised of records maintained by the U. S. Citizenship and Immigration Services (IUSCIS). It is not clear if the NIIS is aimed at the De jure population, the De facto population, or a combination of both. The IUSCIS appears to be aimed at the De jure population. Both OIS and USCIS were part of the former Immigration and Naturalization Service (INS).

The National Center for Health Statistics collects place-of-birth information that is found on death certificates. However, death certificates collect neither information on citizenship nor on status for the foreign-born. Certificates do show, however, place of occurrence for each death and place of residence of each decedent. Thus, the death certificates could be used in conjunction with methods aimed at estimating either the De jure or De facto population. Birth certificates have similar information.

Similar to the federal government, no state governments collect information that directly provides information on the foreign-born who lack documents of legal residence. However, there are data collections, none of which is either routine or broadly-based, that have been done by individual researchers (see, e.g., Droitcour and Larson, 2002; Heer, 1979; Heer and Passel, 1987; Golden, 2008; Marcelli and Heer. 1998; North and Houston, 1976).

Coupled with the lack of data on the foreign-born, particularly in terms of legal status, is an intense interest on the part of policy makers and others on the foreign-born, particularly their legal status. Not surprisingly, there is a demand for data on the part of those who are intensely interested and with the lack of data from census, survey, and administrative activities, estimation methods have been used to fill the information gap.

III. General Methods of Population Estimation²

The most complete and reliable source of information on a population is taken from a census. In the United States (and in Canada), the census is based on the concept of a De jure population while in Mexico it is based on the concept of a De facto population (Thorvaldsen, 2006). However, a complete enumeration of a population is costly and not all populations have been subject to a census. Even in countries such as the United States, where census counts have mandated since 1790, their high costs only allow them to be done once every ten years. This means that data can become outdated and that a substitute is needed – a set of population estimates. The development of methods of population estimation roughly corresponds to the development of censuses and vital statistics registries. For example, in the late 17th century, John Graunt estimated the population of London and then of the whole of England and Wales using what today we would call a censal-ratio method (Devlin 2008: 93-94). Not long afterward, in the 18th century, the French mathematician, Laplace, also used a censal-ratio method in combination with recorded births and a population sample to estimate the population of France (Stigler, 1986: 163-164). However, methodological development really only took

off in the late 1930s and early 1940s, fueled in large part by the need for low-cost and timely information generated by the great depression of the 1930s and World War II (Bryan, 2004; Eldridge, 1947; Hauser and Tepping, 1944; Shryock, 1938; Shryock and Lawrence, 1949). In the United States, the Census Bureau played a major role in this effort, but it was not alone. During the early 1940s, the Washington State Census Board, for example, developed a comprehensive program of annual population determinations based on estimation methods that are still used today (Swanson and Pol, 2005; Swanson and Pol, 2008). Around this same time, demographers also began developing estimation methods for what were then called “underdeveloped countries,” (Brass et al. 1968, Chandrasekaran and Deming, 1949; Popoff and Judson, 2004; United Nations, 1969) and the use of sample surveys as a substitute for complete census counts took hold (Bryan, 2004).

Today, population estimates are ubiquitous. They are done around the world by a host of governmental and non-governmental entities, as well as individual consultants (Bryan, 2004; Siegel, 2002; Swanson and Pol, 2008). The widespread availability of data, methods, and technology has made it possible for many people not only to develop estimates, but to do so more quickly and less expensively than has ever been done before. This trend is not likely to abate, but it carries with it a cost in that estimates may both be made and used with little or no understanding of the issues involved, what constitutes good estimates, and how to identify them.

What is a Population Estimate?

A population estimate is the determination of the size or the characteristics of a population at a current or past date in the absence of census data for the same date. In the United States, they usually are made on a De jure basis, which makes sense because it is the De jure population that is desired in the United States and such an estimate generally makes use of historical census data. However, there is a need for De facto estimates on occasion and researchers have developed these estimates (Swanson and Pol, 2005; Swanson and Pol, 2008). Also, as noted earlier, the ACS represents a major break with this history in that it effectively is targeted at the De facto, rather than the De jure population (National Research Council, 2006a). While the American Community Survey effectively counts a De facto population, it is important to note that the raw numbers are then controlled to a De jure population (National Research Council, 2007; Swanson and Hough, 2007).

The term “population estimate” is frequently used in the public domain to refer to the determination of the size or the characteristics of a population at a future date. However, most demographers prefer to use the term projection when talking about the possible size and characteristics of a population in the future. In developing a portrait of a given population in the future, it is not uncommon for a series of projections to be made that incorporate a range of plausible assumptions (e.g., expected trends in fertility, mortality, and migration). However, when one of these projections is selected as representing the most likely future, it then becomes the forecast for the population in question.

As opposed to a projection or a forecast, then, a population estimate is concerned with either the present or the past, but not the future (Smith, Tayman, and Swanson, 2001: 3-4). An estimate can be prepared for a nation or a sub-national area such as a state, county, city, town, or census tract. An estimate also can be prepared for groups of sub-national areas, groups of nations, or even the world as a whole. The principal demographic characteristics for which an estimate is made include age and gender. However, in multiracial and multi-ethnic countries such as the United States and Canada, an estimate might be done not only by age and gender, but also by race and ethnicity. An estimate also can be made of social and economic sub-groups of the population, households, and families.

Types of Estimation Methods

Demographers and statisticians have developed a population estimation toolkit that contains a range of methods designed to meet different information needs at varying levels of accuracy and cost. For the most part they are based on the concept of a De jure population although there are exceptions (Swanson and Pol, 2005). The methods can be roughly placed into three categories: (1) analytical and statistical models that use data symptomatic of population and its changes; (2) mathematical models that use historical census data; and (3) sample surveys. Methods falling into the first category have generally been developed by and for applied demographers, most of whom work for national, state, and local governments. Methods falling into the second category have generally developed by and for academic demographers, most of whom work at

universities and research institutes. The methods falling into the third category have generally been developed by and for statisticians and survey research scientists, but they also are widely used by demographers. Not surprisingly, there also are techniques that combine methods from two or even all three categories.

It also is useful to classify population estimates along a temporal dimension: (1) intercensal estimates, which refer to a date between two census counts and usually take the results of both counts into consideration; (2) postcensal estimates, which refer to a date subsequent to the latest census count and usually into account one or more previous census counts; and (3) pre-censal estimates, which refer to a date prior to a census count, but usually take into account one or more subsequent census counts. This temporal classification is useful because different methods are typically employed in the development of intercensal, postcensal, and pre-censal estimates (Bryan 2004).

There are other schema for classifying estimation methods. John Long (1993), for example, categorizes them generally into two types: (1) “flow” methods; and (2) “stock” methods. Flow methods are also known as component methods, because they require estimation of each component of population change since the last census. Stock methods relate changes in population size since the last census to changes in other measured variables: the number of housing units, automobile registrations, total number of deaths (and births), and tax returns. Long also notes that stock and flow methods may be used in combination.

Accuracy and Utility

Without question, an estimate should be accurate, but accuracy is not the only criterion by which an estimate should be judged. Following the argument presented by Swanson and Tayman (1995), I suggest that attention be focused on the broader concept of utility. As alluded to earlier, there are many methods that in principle can be used to estimate a population, and improvements are a regular feature of these methods. Further, there is a wide range of decision-making situations in which population estimates are used. It follows, therefore, that no method should be universally judged to be superior to others and, by the same token, neither should any method be judged universally inferior to all others. I suggest instead, that relative to a given use, utility is gained by selecting a method that provides a sufficient amount of information for the purpose(s) at hand, while keeping cost and time to a minimum. In the case of an estimate, the sufficiency of the information provided is judged on the ability of using it to make good decisions. So, if an estimate is produced at minimal cost but provides timely information sufficient to make good decisions, then it has high utility. If an estimate does not meet these conditions then it has low utility. An important underlying component of sufficiency is “transparency.” That is, the ability of a decision-maker to understand how an estimate was done so that he or she can determine if the assumptions, methods, and data are reasonable.

Estimating the Foreign-Born

In addition to the schema described in general for population estimation, methods for estimating the foreign-born can be classified along other lines. Judson (2006) in evaluating four methods of estimating the foreign-born, for example, classifies them into three groups. The first he calls a “stock estimate using a residual component” (Passel, Van Hook, and Bean, 2004; Cassidy, 2004a; Cassidy, 2004b). He labels the second group “flow-based stock estimates (Judson, 2006) and the third, “an imputation modeling method” (Judson, 2006).

In this report, a variation of Judson’s classification scheme is used, one which has four primary categories. The first is comprised of “residual methods,” which are based on Census Bureau products such as the Decennial Census, the Current Population Survey, and, more recently, the American Community Survey. There is some ambiguity here in that the Decennial Census and the Current Population Survey are both based on the concept of a De jure population, while the ACS is effectively based on the concept of the De facto population (National Research Council, 2006a). The second is made up of “administrative records methods,” which are based on records collected and maintained by, for example, the Department of Homeland Security. It is not clear if these data are based on a De jure or De facto concept. The third is “specialized survey methods,” which, as the name suggests, are designed to obtain status information on the foreign-born. These methods can be targeted at either a De jure or De facto population (or both simultaneously).

The fourth and final category consists of method not otherwise described and includes, for example, the “sex-ratio” method (Bean, King, and Passel, 1983). Since this method uses vital statistics data from the United States in conjunction with census data from the United States and Mexico, it inherently represents a combination of the De jure and De facto concepts. Both the “Death Registration” and the “Birth Registration” methods described by GAO (1993) are essentially based on the De jure concept, although either one could be a mixture of both if deaths and births by place of occurrence are used in conjunction with the vital rates method (Bogue, 1950) instead of deaths and births by place of residence.

As was noted by Long (1993) in regard to stock and flow methods, the methods in the classification system used here can be combined. Thus, these four primary categories are sub-divided into stock and flow methods, or combinations of stock and flow methods, as appropriate. Finally, it is useful to note here that any system for classifying methods of population estimation (or methods of population projection, for that matter) is inconsistent in that none is mutually exclusive and exhaustive.

IV. Estimating the Foreign-Born using Residual Methods³

The use of the a residual estimate for estimating the foreign-born is primarily, but not exclusively, aimed at estimating those who lack legal documents (see, e.g., Deardorff and Blumerman, 2001; Passel, Van Hook, and Bean, 2004; Van Hook and Bean ,1998) There are several variations of the ‘residual’ method for this purpose. Many of them are members of the “stock method” in that they attempt to estimate the number without

legal documents as the difference between the non-citizen population enumerated in a census or a survey (i.e., the Current Population Survey or the American Community Survey) and the legally resident alien population, where enumerated unauthorized resident migrants = enumerated non-citizens - legally resident aliens. Others are “flow-based” residual methods.

In general, the residual methods can be done by national origin, period of entry, age, sex, and depending on the level of detail available in estimates of the legal population, by state and metropolitan area.

“Stock-based” Residual Methods

GAO (1993: 21) provides a general form of the stock-based residual method as follows:

$$I = F - L.$$

Where

I = estimated illegal alien population

F = the counted foreign-born population

L = an independent estimate of the total legally resident foreign-born population

GAO(1993: 21) notes that “L” was constructed on the basis of the latest available (1980) data obtained from the Alien Registration Program, to which were added estimated legal immigration from permanent INS files and to which were subtracted the estimated emigration of foreign-born persons.

The Passel, Van Hook, and Bean Residual Method of 2004

In this “stock-based” residual method, Passel, Van Hook, and Bean (2004) attempted to match micro-data from the Decennial long form and the ACS (e.g., a person’s place of birth, year of entry, age, sex, education, occupation, and spousal characteristics) to the requirements for the legal statuses: naturalized citizens, non-immigrants, and refugees/asylees. Each of the foreign-born observations in the micro-dataset is attempted to be assigned to one of these three statuses. All cases that do not match the criteria of one of the legal statuses are considered to be in the residual category, which includes both the unauthorized (e.g. entries without inspection and visa over-stayers) and the quasi-legal. The estimate of the residual category of the foreign born is then calculated as either: (1) the total weighted number of people in the residual category; or (2) the total foreign born population subtracting the weighted estimates of naturalized citizens, lawful permanent residents, and legal non-immigrants.

Because this method uses survey data, all of the limitations of survey data apply (e.g., measurement error, non-response error, coverage error, and sample error). In addition, this method not only assumes that the assignment algorithm accurately measures legal status, but it also assigns respondents with the same characteristics into the same legal status. This means that the components are constructed from imputations of legal status rather than from known legal status. This means that some cases with characteristics that appear to match the criteria of a legal category may not actually have

that legal status, while others who, by their surveyed characteristics, appear not to match a legal category may still have that legal status.

In spite of these limitations, the method due to Passel, Van Hook, and Bean (2004) has several strengths. First, it is flexible and can be adapted to changes in definitions of legal status. Second, the algorithms can be reproduced under alternate assumptions regarding the matching between the micro-data information and visa or LPR criteria. Third, this method can potentially be used with data sets that have information similar to that found in the 2000 Decennial Long form and the ACS. If used with the former (or the CPS), it targets the De jure foreign-born population (by status); if used with the ACS, it targets the De facto foreign-born population (by status); if used with a combination of Decennial Census, ACS, and SIPP on the one hand and the ACS, on the other, the result is a mixture of De jure and De facto populations.

The Residual Method Described by Cassidy in 2004

Another variation of the “stock-based” residual method is found in work by Rachel Cassidy (2004a, 2004b). It combines an algorithm for assigning legal temporary migrant status with an algorithm for identifying the probabilities that a migrant has come to the U.S. under voluntary or humanitarian conditions. The method produces estimates of the foreign-born population across four distinct legal status categories: (1) Legal Permanent Resident (LPR); (2) Legal Temporary; (3) Quasi-Legal; and (4) Unauthorized. This method starts with the total foreign-born population for a given vintage period of a survey (e.g., Census 2000 long form) and first removes from this pool the naturalized

foreign-born. An algorithm then extracts people from the remaining pool who are likely to be LPR's. This extraction includes people who entered the United States more than 10 years prior to the vintage year of the survey, received some form of public assistance, and had children who entered the U.S. prior to them, or whose spouse or householder is a U.S. citizen. The remaining foreign born are subjected to the temporary migrant algorithm, which (put simply) assigns foreign-born people to various legal non-immigrant categories according to various demographic conditions that they meet and performs consistency checks to ensure that spouses and children of assigned legal non-immigrants are also classified as legal non-immigrants. This algorithm operates on 100% assignment based on met criteria. Those people who pass through the temporary migrant algorithm but are not assigned a category represent the residual, which is assumed to contain refugees, asylees, quasi-legal migrants, and unauthorized migrants.

When the four major groups have been formed, the total foreign-born population is then subjected a "humanitarian status" algorithm. At this stage, each case is assigned the probability of being an involuntary migrant (refugee, asylee, or quasi-legal) on the basis of their country of birth and year of U.S. entry. These probabilities are derived from USCIS administrative records of annual LPR, refugee, and asylee flows. After this process, the probability assigned to each case is multiplied by the person-weight (original or re-weighted) to create a new grouping weight.

When aggregated according to the grouping weight, estimates of humanitarian and voluntary migrants for each migrant status group are generated. Naturalized citizens and legal non-immigrants are not subject to further processing and are left as is. Among the likely LPR's, which represent most of the cases that are assigned to LPR status, the

aggregated estimate of voluntary migrants who entered the U.S. between 10 and 20 years before the survey year that do not meet any other condition are assumed to be unauthorized migrants. Finally, among the residual group, the aggregated estimate of involuntary migrants are assumed to be quasi-legal, refugees, or asylees, whereas the aggregated estimate of voluntary migrants are assumed to be unauthorized migrants.

This method shares a number of assumptions, advantages and disadvantages with the method due to Passel, Van Hook, and Bean (2004) and is aimed at targeting the De jure foreign-born population (by status).

Other “Stock-Based” Residual Methods

Passel (2007) discusses methods of measuring unauthorized migration to the United States. This is a “stock-based” method, which involves comparing an analytic estimate of the legal foreign-born population with a survey-based measure of the total foreign-born population. The difference between the two population figures is a measure of the unauthorized migrant population in the survey; it can then be corrected for omissions to provide a measure of the total unauthorized population. The report includes a detailed description of the residual methods and the underlying data and assumptions as it has been applied to recent data from the Current Population Survey (CPS) and decennial censuses. Because this method uses decennial census and CPS data, it is aimed at the De jure foreign-born population (by status).

Passel’s (2006) estimate of unauthorized workers is derived by using a variant of a basic “residual” method. That is, the unauthorized population consists of persons and

groups not included in the authorized population. To reach that number, the first step is to develop an estimate for the legal, foreign-born population. That estimate is based on admissions into the country provided by the Department of Homeland Security (DHS) and its predecessor, the Immigration and Naturalization Service (INS), as well on the number of refugees admitted and the number of asylum applications granted.

Using data from the March 2004 Current Population Survey, Passel (2005) applies the residual method and finds that the unauthorized residents reached an estimated 10.3 million in March 2004 with unauthorized Mexicans numbering 5.9 million or 57 percent of the total. Again, this is aimed at estimating the De jure foreign-born population (by status).

Passel and Woodrow (1984) estimate the number of unauthorized aliens counted in the 1980 census for each state and the District of Columbia using aggregated data derived by a residual technique. This is obviously based on a De jure concept.

Passel and Woodrow (1987) develop estimates of the number of unauthorized aliens included in the April 1983 Current Population Survey (CPS). Their estimates are derived by subtracting an estimate of the legally resident foreign born population from the survey estimate of all foreign born residents. The methodology is similar to that used by Warren and Passel (1987) with the 1980 census and, like it, is aimed at estimating the De jure foreign-born population (by status).

Passel, Van Hook, and Bean (2004) use data from Census 2000 and myriad other sources, to develop direct estimates of the unauthorized foreign-born population of the United States and six states in the year 2000. The estimates are presented by age, sex, and period of entry for broad country of origin groups and for 29 individual countries of

origin. The authors believe that the estimates are the first using Census 2000 data incorporating improved methods for identifying and adjusting directly on the basis of micro-data for the presence of legal non-immigrants (or legal temporary migrants²) among the enumerated foreign-born in census data. It is aimed at producing estimates of the De jure foreign-born population (by status).

Van Hook, Zhang, Bean, and Passel (2006) introduced a new method for estimating foreign-born emigration that takes advantage of the sample design of the Current Population Survey (CPS): repeated interviews of persons in the same housing units over a period of 16 months. Individuals appearing in a first March Supplement to the CPS but not the next include those who died in the intervening year, those who moved within the country, and those who emigrated. They use statistical methods to estimate the proportion of emigrants among those not present in the follow-up interview. They argue that their method produces emigration estimates that are comparable to those from residual methods in the case of longer-term residents (immigrants who arrived more than 10 years ago), but yields higher--and what appear to be more accurate--estimates for recent arrivals. Although somewhat constrained by sample size, they also generate estimates by age, sex, region of birth, and duration of residence in the United States. Because this method is based on the CPS, it is aimed at estimating the De jure foreign-born population (by status).

Warren and Passel (1987) and Passel and Woodrow (1984) use a variation of the residual method to estimate the number of unauthorized aliens counted in the 1980 census for the United States and each state, respectively. The method involves comparison of census figures for aliens counted with estimates of legally-resident aliens

developed principally with data from the Immigration and Naturalization Service (INS). For this study, estimates by age, sex, and period of entry were produced for persons born in Mexico and living in Los Angeles County. On the one hand, this is based on the De jure concept because one set of number is based on the De jure concept; on the other hand, it is not clear if the INS data are based on the De jure concept, the De facto concept, or a combination of both.

Passel and Woodrow (1987) applied a residual method to data from the April 1983 CPS to estimate of the number of unauthorized foreign-born for the U.S. as a whole. In this case, they subtracted an estimate of the legally resident foreign-born population from the CPS estimate of all foreign born residents. The methodology is similar to that used by Warren and Passel (1987) with the 1980 census. Also presented are similar estimates for the November 1979 CPS, that is, re-estimates following the work of Warren (1982). Estimates are presented by period of entry for Mexico and other groups of countries. Comparison of the April 1983 estimate with the census-based estimate and the November 1979 survey-based estimate provide an indication of growth in the unauthorized alien population for 1980-83. For this recent period, the implied annual growth in the unauthorized alien population is in the range of 100,000 to 300,000—a range lower than has usually been offered in speculative assessments. The resulting estimate is aimed at the De jure foreign-born population (by status).

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Yet another variation of the “Stock-based” residual approach described by Judson (2006) is a ‘stock’ method described by Judson (2006). It can be labeled as the “SIPP Imputation” method. According to Judson (2006), it develops a legal status imputation model from the Survey of Income and Program Participation (SIPP) and applies this model to ACS data, thereby diverging substantially from the preceding three methods. Because it uses both SIPP and ACS data it uses both De jure and De facto population concepts.

Judson (2006) describes this method for using SIPP data as a tool for developing a statistical imputation model as follows:

1. Recode the SIPP questions into categories that can be used to predict legal status
2. Determine comparability between SIPP and ACS variables and concepts
3. Develop a multinomial logistic regression model that uses SIPP data to predict a person’s immigration status

4. Using the estimated parameters from SIPP, apply the model to ACS respondents
5. Tabulate ACS respondents by applying predicted probabilities to the ACS person weight thereby creating a vector of probability weights

Judson (2006) observes that the model that links the two data sets requires equivalent (or approximately equivalent) variables as right hand side predictors. This imputation method is not new; it has been used in place of statistical matching or other hot deck procedures in other contexts (e.g., imputing health insurance status, or imputing tax statuses). As Judson (2006) notes, there are several assumptions underlying this method:

1. The SIPP data can be recoded in a way that is a reasonable representation of the respondent's current migration status;
2. The imputation model will have sufficiently high goodness-of-fit properties to make it feasible to impute individual legal statuses; and
3. The parameters estimated on the SIPP will be successful when applied to ACS.

Judson (2006) also notes that the multinomial logit model in this method allows the use of more refined characteristics to derive estimates, whereby using a probabilistic approach allows for the creation of probabilistic weights and aggregate estimates by category, and a range of probabilities may be specified for each individual observation, allowing for the extension of micro-simulation. This method allows for multiple estimates, including for sub-groups by age, race, sex, and educational attainment, and is relatively easy to implement. Judson (2006) argues, however, that the main limitation of this method involves the timing and availability of data as follows.

“SIPP estimates are static estimates for spanning January to April 2004. ACS estimates are being derived for multiple years. Policy and behavioral changes

that affect immigration patterns may not be captured in the model's vector of probabilities. Another important limitation is that different sample designs are used for data collection. The SIPP sample is a panel where all households are interviewed in a four-month collection window. The ACS sample is collected on a rolling basis using a 12-month reference period corresponding roughly to a calendar year. That along with the fact that we are predicting probabilities based on monthly data while predicting probabilities using annual data is another potential concern. Finally, with a sample size of less than 50,000 households, SIPP's sample is comparatively small relative to other nationally based surveys (e.g., CPS-ASEC and ACS). The foreign-born portion of the SIPP sample is only 9,825 (un-weighted) cases (625 of which are children under the age of 15). These cases form the basis for the imputation model."

"Flow-based" Variations of the Residual Method

As a concrete example of the "Flow-based" residual method for estimating the unauthorized and quasi-legal migrants, it is useful here to recall the equation due to Deardorff and Blumerman (2001) that was presented earlier:

$$FB = [L - [M + E] + T + R]$$

where

FB = Foreign-born population

L = Legal Immigrants

M = Mortality to legal immigrants

E = Emigration of legal immigrants

T = Temporary (legal) migrants

R = Residual foreign-born (unauthorized and quasi-legal migrants)

According to Van Hook and Bean (1998), this method was not employed with data collected prior to 1980 because the 1980 census was the first decennial census in which a

sizable enumerated migrant population could be detected through demographic analysis. Van Hook and Bean (1998) identify three variations of this “residual” method.

Bean et al. (1998) note that while stock and flow estimates of the unauthorized migrant population tended to be unreliable prior to 1980 due in part to lack of methodologies for correcting for biases in the available data sources and otherwise to the fact that these methods tended to be inconsistent in their assumptions and methodologies, that changes that took place in the methods since 1980 and note that these changes have narrowed considerably the range of plausible estimates.

These ‘flow-based’ residual methods include work by Ahmed and Robinson (1994), who attempt to develop estimates of emigration of the foreign-born population at the national level based on the numbers of foreign-born persons enumerated in the 1980 and 1990 censuses. The methodology employed is a residual technique in which the counted population is subtracted from the expected population to obtain the amount of emigration and emigration rates. It is aimed at estimating the De jure foreign-born population (by status).

Bhaskur, Rastogi, and Kennedy-Puthoff (2008) employ a residual method to produce contemporary emigration estimates and rates using Census 2000, the 2005 and 2006 American Community Survey (ACS), and National Center for Health Statistics life tables, the latter of which are based on De jure populations. Because this method uses data representing both De jure and De facto population concepts, its results represent a mixture of the two.

Bean, Corona, Tuiran, and Woodrow-Lafield (1998) note that as of 1980, stock and flow estimates of the unauthorized migrant population tended to be unreliable due in

part to lack of methodologies for correcting for biases in the available data sources and that early analytic estimates tended to be inconsistent in their assumptions, methodologies, and consequently, in the populations they describe. They describe changes that took place in the methods since 1980 and note that these changes have narrowed considerably the range of plausible estimates.

Costanzo, Davis, Irazi, Goodkind, and Ramirez (2001) evaluate the U.S. Census Bureau's estimates of the "residual" foreign-born population (including both unauthorized and quasi-legal migrants) in 1990 and 2000, in part, by developing a residual-based set of estimates that were calculated in conjunction with estimates of other components of international migration: legal permanent migration and legal temporary migration. The authors note that this residual foreign-born population is not an estimate of the number of unauthorized migrants, but rather, includes people who are here legally but are not yet included in the official estimates of legal migrants and refugees as well as people in "quasi-legal" status who are awaiting action on their legal migration requests. Because the estimate was derived from a residual methodology, any limitations in the methods or in the measurement of other migration components are reflected in the residual number. In addition, their assumptions include a great deal of uncertainty, especially for small migration components. Therefore, the residual may be quite different from the actual number of unauthorized migrants. According to their calculations, the estimated residual foreign-born population was 3,765,906 in 1990 and 8,705,419 in 2000. The residual foreign born were less likely to be male (48.4 percent) in 1990 than in 2000 (54.2 percent). These authors compare De jure estimates produced by the U.S. Census Bureau

with numbers produced by the authors that appear to have a mixture of De jure and De facto populations.

Gibbs, Harper, Rubin, and Shin (2003) examine assumptions about emigration of the native population used by the Census Bureau. From the 1970s through the 1980s, the Census Bureau estimated annual emigration of the native population at a constant level of 27,000. For the 1990-2000 inter-censal decade, the Census Bureau estimated annual emigration of the native population at a constant level of 48,000. The evaluation attempted - unsuccessfully - to replicate the approach taken to arrive at the 48,000 figure. Working with published data from population censuses and statistical reports of other countries, the authors were able to calculate a rough estimate of the net effect of the native emigrant flow on the 2000 national resident population estimate. They compared the available data for dates as close to 1990 and 2000 as possible for 16 countries for which data were available. These 16 countries represented 58 percent of the American population abroad as measured by 2000 State Department data. They then applied 1990 U.S. survival rates to survive the populations of the 11 countries for which age distribution data were available. The authors note that the limitations on the available data make the estimate of the native emigrant population questionable, but that their research indicates that the magnitude of this population is small and likely to fluctuate over time. Their work is based on a De jure concept, but some of the countries to which U.S. survival rates were applied use the De facto concept in their census enumerations.

Goldberg (1974) uses data on the number of legally admitted aliens and counts of the entire population to estimate the number of illegal aliens. His calculations involve the subtraction of the expected number of people (those who reside legally in the United

States) from the actual number of people (those who have been found to be in the United States). Thus, it is basically aimed at the De jure foreign-born population (by status).

Hill (1985) assesses methods to estimate the flows and stock of migrants, and focuses on residual techniques. Hill (1987) presents two methods for estimating migration flows from census data and illustrates them by applications to recent U.S. data. The first method is a simplification of existing intercensal projection methods, and will be affected by changes in census coverage. The second method incorporates independent information on the age pattern of intercensal migration and estimates consistent adjustment factors for census coverage and the scale of the migration schedule. Interpretation of the results of the two methods is discussed. Both of these methods are aimed at estimating the De jure foreign-born population (by status).

Hoefer, Rytina, and Campbell (2005, 2006, and 2007) estimate the number of unauthorized immigrants residing in the United States as of January in a given year by period of entry, region and country of origin, and state of residence. Their estimates were obtained using a “residual” methodology, whereby estimates of the legally resident foreign-born population as of January 1st were subtracted from the total foreign-born population at the same point in time. Estimates of the legally resident foreign-born were based primarily on administrative data of the Department of Homeland Security (DHS), while estimates of the total foreign-born population were obtained from the American Community Survey (ACS) of the U.S. Census Bureau. The starting point for the estimates was 1980, as persons who entered the United States earlier were assumed to be legally resident. Revised estimates of the unauthorized immigrant population living in the United States in 2000 are also presented in this report. These revised estimates are also

based on the “residual method” and do not include as legally resident those persons who had applied for but not yet been granted asylum or legal permanent resident (LPR) status as well as Temporary Protected Status (TPS) applicants and beneficiaries. These estimates are based on the De jure concept of population, but in using the ACS, a De jure population is introduced.

Another variation of the residual approach is described by Judson (2006). He labeled it as a “Flow-based, Stock” method because it follows a similar type of demographic accounting procedure to that used for producing national, state and county population estimates for the total resident population. For population estimates, the components of population change are births, deaths, net domestic migration, net international migration and net military movement to and from overseas. However, for estimating foreign-born population by legal status, the appropriate components of population change are more complicated. The equation for each type of legal status category *i* has the following flow equation between time *t1* and time *t2*:

$$POP_i_{t2} = POP_i_{t1} + NAI_{t1}^{i2} + AI_{t1}^{i2} - AOI_{t1}^{i2} - AEI_{t1}^{i2} - EI_{t1}^{i2} - DI_{t1}^{i2}$$

where:

POP_i_{t2} = Foreign-born population of legal status *i* at time *t2*

POP_i_{t1} = Foreign-born population of legal status *i* at time *t1*

NAI_{t1}^{i2} = New arrival foreign-born population of legal status *i* between time *t1* and time *t2*

AI_{t1}^{i2} = Adjustment of foreign-born population into legal status *i* between time *t1* and time *t2*

AOI_{t1}^{i2} = Adjustment of foreign-born population out of legal status *i* between time *t1* and time *t2*

AEI_{t1}^{i2} = Foreign-born population of legal status *i* expelled between time *t1* and time *t2*

EI_{t1}^{i2} = Foreign-born population of legal status *i* emigrated between time *t1* and time *t2*

DI_{t1}^{i2} = Foreign-born population of legal status *i* who died between time *t1* and time *t2*

In addition, the sum of each legal status category i at time t must equal the total estimate of the foreign-born population at time t , as shown below.

$$POP_t^{FB} = POP_t^{Nat} + POP_t^{LPR} + POP_t^{LT} + POP_t^{RA} + POP_t^{QL} + POP_t^{Oth}$$

where:

FB = Total foreign-born population

Nat = Naturalized foreign-born population

LPR = Legal Permanent Resident foreign born population

LT = Legal Temporary foreign-born population

RA = Refugee/Asylee foreign born population

QL = Quasi-legal foreign-born population

Oth = Other foreign-born population

Conceptually, the preceding equation fully represents the appropriate flows of the foreign-born population from one category to another, as well as movement from “outside the system” and exits to “outside the system.” Judson (2006) notes, however, that in practice the data sources required to construct a stock estimate based on appropriately accounting for movement between legal status categories have not been available and that a major assumption underlying this approach is that the components of population change are closely approximated by measuring change in selected administrative or survey data sources. Lacking firm numbers on legal temporary flow (in and out), too much inflow is generated by this method and insufficient outflow, which can easily lead to judgments about what is too much or too little.

In order to apply the model, Judson (2006) states that Census Bureau demographers estimate each component of population change and legal status category separately. In addition, this method makes the (crucial) assumption that the administrative and survey data that are used to construct demographic flows are

comparable; that is, that the time reference, time frame for data production, and concepts can be appropriately compared to one another.

Judson (2006) observes that the “slippages” between data sources is a significant limitation of this method for two reasons. First, he notes that transaction-based data that have not been converted to a person-based estimate. Second, he argues that it is not clear if the major assumptions underlying the method are reasonable. This method is aimed at targeting the De jure foreign-born population by status because it uses census data.

Woodrow (1990) discusses the estimation of emigration and unauthorized immigration rates for the United States and uses a residual methodology that compares census or survey data on the resident foreign-born population with an independently derived estimate of the legally resident foreign-born population. The difference is the estimated unauthorized population which may be compared for alternative dates to derive measures of change. Her method is aimed at the De jure population.

Robinson, Ahmed, Das Gupta, and Woodrow (1993) describe “Demographic Analysis,” which is a residual “components of population change” method used as an analytic tool for census coverage measurement. This technique can be used to shed some light, indirect, but illuminating, on the numbers of unauthorized foreign-born around the time of a decennial census. This technique is based on a De jure concept.

Woodrow-Lafield (1995) notes that national surveys monitored growth in the foreign-born population for the 1980s, especially net unauthorized migration's continuing role, but the 1990 census portrayed an even larger foreign-born population than these surveys. She suggests that under-coverage in 1990 could have been higher than initially presented and observes that assumptions intended to maintain a high net undercount of

the unauthorized population performed poorly when census counts of foreign-born residents became known. She argues that any point estimate for net unauthorized migration, calculated as a residual, is likely to be biased by assumptions and data gaps for components of calculating net legal immigration, especially in the direction of underestimation. Despite the importance of unauthorized migration measurement for census evaluation and policy purposes, the author believes that differences among various unauthorized estimates are more likely to stem from discrepancies in universe, reference dates, or individual judgment, rather than analytic refinement. She concludes that better measurement of the foreign born population or its census coverage would aid in setting upper limits on net unauthorized migration. Implied in her analysis, is the fact that she is largely viewing the foreign-born population on a De jure basis

V. Estimating the Foreign-Born using Administrative Records

Espenshade and Acevedo (1995) examine macro-structural conditions that affect time trends in aggregate probabilities of unauthorized alien apprehension along the Mexico-U.S. border. It shows that the number of migrants attempting to cross the border illegally in a given period and the level of effort expended by the INS to apprehend unauthorized migrants are principal determinants of apprehension probabilities. These findings differ from those by Donato, Durand, and Massey (1992) who argued that individual, household, and community factors are not significant predictors of apprehension probabilities and conclude that escaping INS detection at the border is essentially a random process unrelated to personal traits or to enforcement provisions of the 1986

Immigration Reform and Control Act. Espenshade and Acevedo (1995) conclude that it is worth modeling the effects of individuals' characteristics on apprehension probabilities by including as predictors an estimate of the flow of unauthorized migrants and measures of INS border enforcement effort. The estimates produced by Espenshade and Acevedo are based on data that are De facto in nature while the work of Donato, Duran and Massey, appear to be more inclined toward a De jure perspective, although not exclusively so.

Fernandez (1995) uses the cohort survival method in conjunction with State Department U.S. citizen registration-data to estimate the annual rate of U.S. born emigration. The author claims that the estimates generated, by age, sex, and race are not unreasonable, reaching 48,000 U.S. native born emigrants annually. This appears to be based on a De jure concept.

Grieco (2004) uses a “stock” method based primarily on data from the Department of Homeland Security’s Non-immigrant Information System (NIIS). Stock estimates for the total non-immigrant population by category of admission and country of citizenship were generated using this administrative flow data and a “person year” methodology. The results of this analysis suggest that, on a typical day in 2004, there were an estimated 3.8 million non-immigrants in the United States, including 2.3 million tourists, business travelers, and other short-term visitors, 704,000 temporary workers, 640,000 students and exchange visitors, and 68,000 diplomats and other representatives. This method appears to produce a combination of De jure and De facto estimates of the foreign-born population (by status).

Lancaster and Scheuren (1978) speculate on the number of illegal aliens residing in the United States using data from the 1973 CPS-IRS-SSA Exact Match Study, which was conducted by the Census Bureau and the Social Security Administration, assisted by the Internal Revenue Service. Direct estimates are presented only for the age group 18 to 44 years old as of April 1973; however, there are some discussions of ways, using other sources, that one can extend these figures to all age groups and project them forward in time. The estimates produced by Lancaster and Scheuren appear to be largely targeted at a De jure population, but they may include elements of a De facto population

Rytina, (2007) presents estimates of the legal permanent resident (LPR) population living in the United States on January 1, 2006. The LPR population includes persons granted lawful permanent residence, e.g. “green card” recipients, but not those who had become U.S. citizens. The estimates are shown for the total LPR population and the LPR population eligible to apply to naturalize by country of birth, state of residence, and the year LPR status was obtained. Data for the estimates were obtained primarily from administrative records of U.S. Citizenship and Immigration Services (USCIS) of the Department of Homeland Security (DHS). The methodology used for the 2006 estimates is similar to that used in previous DHS estimates (see, e.g., Rytina, 2006; Rytina, 2005; Rytina, 2004). Minor changes in assumptions, made to be consistent with DHS estimates of the unauthorized population, had little effect on the estimates. Rytina’s estimate appears to be largely aimed at the De facto population.

U. S. GAO (2004) identified major government sources of data that could be used to estimate illegal alien school children. If used, these data could produce estimates of either the De jure or De facto foreign-born population, or both.

Woodrow-Lafield (1998) focuses on estimating net authorized immigration from all countries and from Mexico and presents 30 alternative series on the basis of varying assumptions as to emigration levels, agricultural legalization beneficiaries as resident, and other nonspecific authorized or ambiguous immigration. Net authorized immigration for 1960-1996 may have resulted in 16.1 to 19.4 million residents of foreign-born. She argues that measurement is an essential step for quantifying net unauthorized or unauthorized immigration requiring further exercise of expert judgment. Her work appears to be largely aimed at estimating the De jure population of foreign-born.

In my investigation of the literature, I did not find any researchers who proposed using either the Social Security Death Master File (SSA DMF) or the National Center for Health Statistics' Death Index File (NCHS DIF) as administrative records that potentially could be used via "record matching" processes (see, e.g., Ericksen and Kadane, 1986; Hogan, 1993; Judson, 2004; Krotki, 1977; Madrian and Lefgren, 1999; Wolter, 1986; Statistics Finland, 2004) to identify foreign-born decedents who were not authorized to be in the United States. If the deaths (by age and sex) of the unauthorized foreign-born population can be estimated from this process, then it may be possible that they could be used in conjunction with data derived from life tables that describe the mortality regime(s) for the unauthorized foreign-born population(s) to estimate the numbers of the unauthorized foreign-born using a variation of the "vital statistics" method for estimating Population (Bogue, 1950). As an example of how this might work, suppose deaths for a given period have been matched between the SSA DMF and the NCHS NIF and that the un-matched cases represent a reasonable estimate of deaths to the unauthorized foreign-born

population (by age and sex). If we have a life table that provides a good representation of this population, we can apply the method of Greville (see, e.g., Kintner, 2004) for estimating “ ${}_nL_x$ ” to get an estimate of the unauthorized foreign-born population aged x to $x+n$ at a given point in time as follows:

$${}_nP_x = [({}_nd_x)/({}_nD_x/{}_nL_x)]$$

where

${}_nP_x$ = the (estimated) unauthorized foreign-born population aged x to $x+n$

${}_nd_x$ = estimated deaths of unauthorized foreign-born aged x to $x + n$

(from the SSA DMF/NCHS NIF matching process)

${}_nD_x$ = Deaths in the Life Table to the population reaching age x (l_x) before reaching age l_{x+n}

${}_nL_x$ = Life Table Population aged x to $x+n$

These aged-based estimates of the unauthorized foreign-born population could be done by sex and geographic area and compared to estimates generated from other methods. A variation on this proposed method is to use the “Vital Rates” Method (Bogue, 1950) to estimate this same population. This would be accomplished as follows:

$${}_nP_x = {}_nd_x/{}_nm_x$$

where

${}_nP_x$ = the (estimated) unauthorized foreign-born population aged x to $x+n$

${}_nd_x$ = estimated deaths of unauthorized foreign-born aged x to $x + n$

(from the SSA DMF/NCHS NIF matching process)

${}_n m_x$ = the death rate for those aged x to $x+n$ in a population believed to represent the mortality to which the unauthorized foreign-born population is subject.

It is, of course, a research question as to the efficacy of either of the two variations of this proposed method, given that the SSA DMF and NCHS NIF files can be obtained for this purpose and processed in a cost-effective manner and that record linkage error is low. To assess each of these three conditions, a small pilot study could be implemented. If the record matching process yields a good estimate of deaths to the unauthorized population at a given point in time by age (and sex), then successive sets of the estimates can be used to generate estimates (and projections) using the principles underlying the method for estimating unauthorized immigration due to Edmonston and Michalowski (2004) that was just described. If these conditions were met then these two variations could be used for De jure or De facto estimates, depending on the use of “place of residence” or “place of occurrence” death records.

VI. Estimating the Foreign-Born using Specialized Survey Methods⁴

Although Grieco (2003), among others, has called for a large-scale post-census survey on the foreign-born (presumably by the US Census Bureau), neither has such survey been undertaken nor is one planned. Moreover, few surveys have been undertaken to specifically isolate the illegal immigrant population. Most information on illegal immigrants in the workforce has been generated from Census Bureau data, using, for example, the residual method, as has been discussed. David Heer (1990) describes one of the early uses of a survey-based method to estimate the size of the unauthorized foreign-born, in this case, Los Angeles County, California. The method that he describes uses a combination of 1980 census data and the results of a survey conducted in Los Angeles County in 1980 and 1981. A sample was selected from babies born in Los Angeles County who had a mother or father of Mexican origin. The survey included questions about the legal status of the baby's parents and certain other relatives. The resulting estimates of unauthorized Mexican immigrants are for males aged 18 to 44 years and females aged 18 to 39 years. Heer and Passel (1987) compared the estimates obtained from this survey to estimates they derived from estimates of the unauthorized foreign-born obtained from the 1980 census using a residual method (Warren and Passel, 1987; Passel and Woodrow, 1984). Specifically, Heer and Passel (1987) derived estimates by age, sex, and period of entry for persons born in Mexico and living in Los Angeles County.

Heer (1987) followed up with a survey jointly conducted in the fall of 1994 by the University of Southern California and El Colegio de la Frontera Norte (COLEF), an academic institution located in Tijuana, Mexico. From this survey, he obtained estimates of the legal status of the children of unauthorized Mexican immigrants in Los Angeles County, California. Using data from this same survey in conjunction with the March 1994 and 1995 Current Population Surveys, Marcelli and Heer (1998) estimated the number of unauthorized Mexican immigrants residing in Los Angeles County, and compared their use of seven welfare programs with that of other non-U.S. citizens and U.S. citizens.

In 1991, DaVanzo, Hawes-Dawson, Valdez, Vernez, Andrews, Levitan, Peterson, and Schoeni (1994) conducted a pilot study, the “Los Angeles Community Survey of Salvadorans and Filipinos.” The survey was able to obtain information from eleven-year-old census data to target high-concentration sample areas; it successfully recruited and trained bilingual staff; it enlisted respondents' cooperation at acceptable rates; and it elicited responses to sensitive questions, including immigration status, that are critical for developing and assessing policy. The authors concluded that costs for a similar survey conducted in selected sites across the country, though substantial, would be low compared with the potential costs that immigration may impose, or even with the costs of programs intended to address immigration issues.

Regional studies using survey data are found outside of California. Flores (1984), for example, obtained social and demographic data from a sample of parents of unauthorized children in Texas while analyzing the international ramifications of a legal case.

As another example of a specialized survey not restricted to California, Doug Massey (1987) describes an “ethnosurvey” research approach designed to overcome the limitations of federal immigration statistics and to illuminate the social processes underlying aggregate patterns of migration. Massey (1999) evaluates the validity of the ethnosurvey as a method of demographic data collection by analyzing the representativeness of the Mexican Migration Project (MMP) as a source of information on Mexico-U.S. migration. He finds that the ethnosurvey is an accurate and reliable method of data collection and the MMP as a good source of reasonably representative data on authorized and unauthorized migration to the United States, even though it over-represents migrants in the western states and mid-sized communities.

Paradies and Barnes (2005) provide a description of a variant of dual-record population estimation (see, e. g. Krotki, 1977), which relies on the availability of specific additional information to relax the assumption of perfect frame specification. This variant is applied to two remote Indigenous communities in the Northern Territory of Australia, using locally available data sources. Further theoretical exploration of this method is presented along with possible applications in estimating area-enumerated populations and census coverage.

Droitcour, Caspar, Ezzati, Hubbard, Parsley, and Visscher (1991) describe a an innovative survey-based method that extends “randomized response,” which uses two questions, one sensitive and one not to get at sensitive information. They call it the “item count method,” in which respondents are given lists of behaviors in which the sensitive behavior is imbedded among a list of non-sensitive behaviors. Respondents indicate the number of the behaviors that apply to them rather than answering questions on the actual

behaviors. Random parts of the sample receive lists with and without the sensitive behavior. Like Randomized response, the item count method allows the researcher to use statistical methods to estimate the total number of people who engaged in the sensitive behavior; However, neither randomized response nor the item count method allow one to determine if a particular person engaged in the sensitive behavior. Because of this feature, both randomized response and the item count method preclude disclosure to the general public and sponsor as well as to the interviewer and other persons who may be nearby. By 1998, this method had been refined into a technique dubbed the “grouped answers” method (U.S. GAO, 2006). Subsequent to 1998, U. S. GAO (1999) extended this discussion and labels the technique as the “three card method.” It is intended to allow estimation of the needed statistics while maximizing response privacy and reducing “question threat.”

Droitcour, Larson and Scheuren (2001) discuss in more detail this innovative method, which they call the “three card method.” They provide: (1) basic logic; (2) special features; (3) preliminary testing and results; and (4) variance costs and ways to reduce them. They also show how an immigration group that is currently of special concern—“visa overstays”— might be estimated using a version of the method.

Droitcour and Larson (2002) continue exploring the “three-card” method, which they describe as a technique that the United States Government Accountability Office (GAO) designed as a “grouped answers” approach to estimating irregular migration in a survey. The method directly estimates the number of persons in various “regular” or legal immigration status groups, indirectly estimates the number in sensitive irregular groups, while providing privacy protection. GAO created this methodology because of a lack of

data; without information on immigration status, “policy researchers cannot track trends in employment or other important outcomes (such as subsequent educational attainment, income/poverty status, or family formation experience) for legal immigrants, illegal aliens, or persons of other immigration statuses.

U. S. GAO (2006) reviews the ongoing development of a potential method for obtaining such information: the “grouped answers” approach. In 1998, GAO devised the approach and recommended further study. In response, the Census Bureau tested respondent acceptance and recently reported results. GAO answers four questions: (1) Is the grouped answers approach acceptable for use in a national survey of the foreign-born; (2) What further research may be needed; (3) How large a survey is needed; (4) Are any ongoing surveys appropriate for inserting a grouped answers question series (to avoid the cost of a new survey)? For this study, GAO consulted an independent statistician and other experts, performed test calculations, obtained documents, and interviewed officials and staff at federal agencies. The Census Bureau and DHS agreed with the main findings of this report. DHHS agreed that the National Survey of Drug Use and Health is not an appropriate survey for inserting a grouped answers question. GAO finds that the grouped answers approach is acceptable to many experts and immigrant advocates, with certain conditions, such as (for some advocates) private sector data collection.

Larson (2007) describes the recent method based on this approach, which he now calls the “Two-Card Follow-Up” method, because two different cards list different groups of immigration statuses and follow-up questions. Five key points of the method are: (1) The categories must be mutually exclusive and exhaustive; (2) No respondent is ever asked whether he, she, or anyone else is in a specific sensitive category (for

example, illegal immigrant or “irregular migrant”); in this example, currently “unauthorized.” (3) Follow-up questions are asked of respondents; (4) Two pieces of information are separately provided by two sub-samples of respondents (completely different people — no one is shown both immigration status cards); (5) taking the two pieces of information together — like two pieces of a puzzle — allows indirect estimation of the unauthorized population, but no individual respondent (and no piece of data on an individual respondent) is ever categorized as unauthorized.

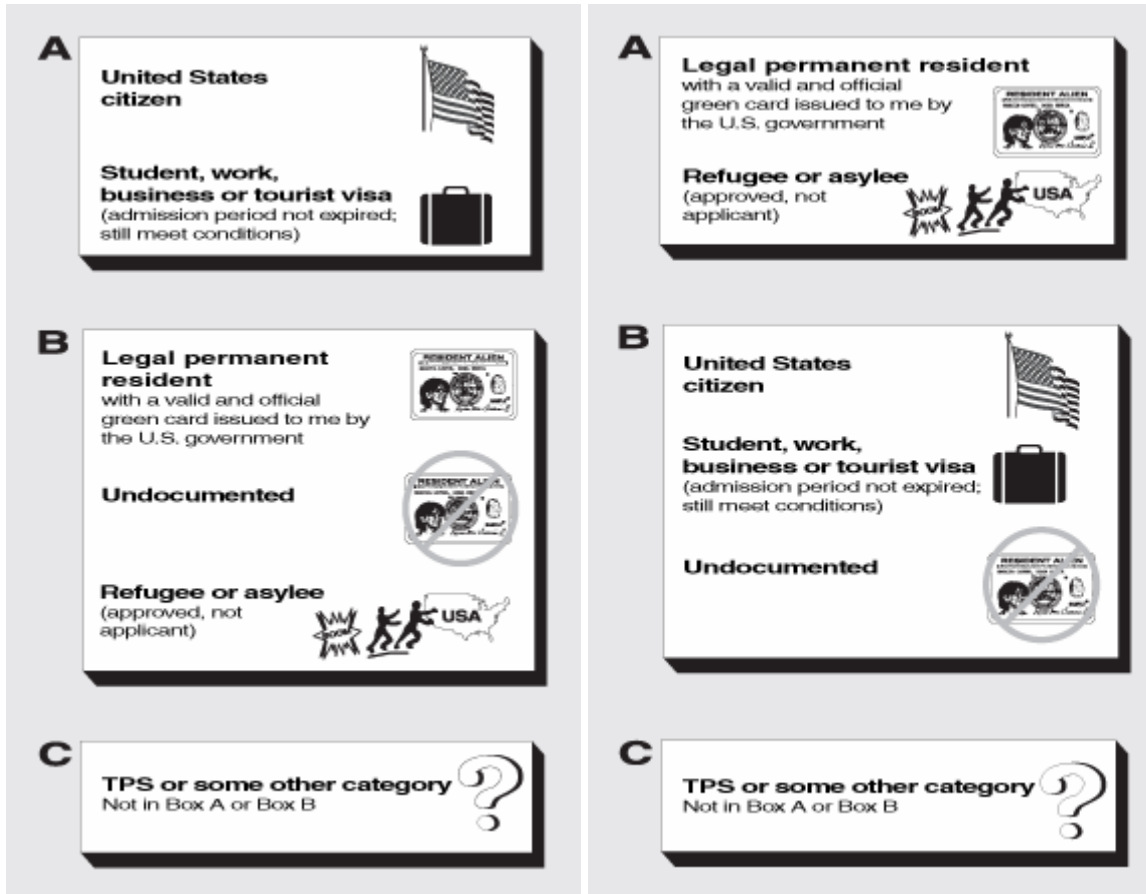
Sabrina Golden (2007) applied GAO’s (GAO, 1999) “two card” method to estimate the number of illegal immigrant workers on projects in the region of Washington, D.C. Golden describes her application of this method as follows. Respondents are shown one of the cards in Figure 1; a random half of the sample is shown card 1, and the other half is shown card 2.

Continuing, Golden says that respondents are asked to pick the box that includes their current immigration status, but not to pick specific categories within the box, just the letter A, B, or C, corresponding to the box that contains their current immigration status. The percentage of illegal immigrants is calculated by subtracting the percentage that picked Box A from one card from the percentage that picked Box B from the other card and adding the percentage that picked box C from either card. This estimate includes the truly unauthorized or illegal immigrants and those with “quasi-legal” status. Both categories are affected by immigration reform and therefore, both categories are relevant to this research. The number of truly unauthorized or illegal immigrants can be calculated by subtracting Box A from Box B, without adding Box C.

Figure 1. Immigration Status Cards

CARD 1

CARD 2



As noted by Golden (2007) and GAO (1999), among others, the basic logic behind the “Two-Card Method” is as follows. The total sample is chosen such that half of the sample is sufficient in order to generate statistically sound estimates. Half of the sample is shown card 1, and the other half of the sample is shown card 2. The half of the

sample that is shown card 1 is used to estimate those respondents that are United States citizens or are present in the U.S. on a valid student, work, business, or tourist visa, i.e. those that pick Box A from card 1. The half of the sample that is shown card 2 is used to estimate those respondents that are United States citizens, are present in the U.S. on a valid student, work, business, or tourist visa, or are unauthorized immigrants, i.e. those that pick Box B. “Quasilegal” immigrants, those that are present in the U.S. through a Temporary Protected Status, those eligible for the Deferred Enforced Departure (DED) program, Nicaraguan and Central American Relief Act beneficiaries, asylum applicants, fiancé, spouse, or child visa applicants – known as adjustment applicants, and Legal Immigrant Family Equity Act (LIFE) section 245(i) beneficiaries are estimated from those that choose Box C from either card 1 or card 2. The percentage of illegal immigrants, then, is calculated by subtracting the estimate of United States citizens and those present in the U.S. on a valid student, work, business, or tourist visa, those that picked Box A from card 1, from the estimate of United States citizens, those present in the U.S. on a valid student, work, business, or tourist visa, and unauthorized immigrants, those that picked Box B from card 2, plus the estimate of “quasi-legal” immigrants, those that picked box C from either card. The number of truly unauthorized immigrants can be calculated by subtracting Box A -card 1 from Box B-card 2, without adding Box C-card 1 or card 2.

Alternatively, Golden(2007) notes that the half of the sample that is shown card 2 may also be used to estimate those respondents that are Legal Permanent Residents (LPR’s) and those that are present in the U.S. under an approved refugee or asylee status, i.e. those that pick Box A from card 2. The half of the sample that is shown card 1 may

be used to estimate those respondents that are Legal Permanent Residents (LPR's), those that are present in the U.S. under an approved refugee or asylee status, and those that are unauthorized immigrants, i.e. those that pick Box B from card 1. Again, "quasilegal" immigrants may be estimated from those that choose Box C from either card 1 or card 2. Then, the percentage of illegal immigrants would be calculated by subtracting the estimate of Legal Permanent Residents (LPR's) and those that are present in the U.S. under an approved refugee or asylee status, those that picked Box A from card 2, from the estimate of Legal Permanent Residents (LPR's), those that are present in the U.S. under an approved refugee or asylee status, and those that are unauthorized immigrants, those that picked Box B from card 1, plus the estimate of "quasi-legal" immigrants, those that picked box C from either card. The number of truly unauthorized immigrants is still calculated by subtracting Box A – card 2 from Box B – card 1, without adding Box C – card 1 or card 2.

Because the total sample is sufficient for half of the sample to produce statistically relevant estimates, it will not matter whether the Box A estimate from card 1 is subtracted from the Box B estimate from card 2 or the Box A estimate from card 2 is subtracted from the Box B estimate from card 1. Both calculations should reveal similar results (Government Accountability Office, 1999).

GAO originally devised this method for the purpose of surveying the foreign-born regarding immigration status. There are five mutually exclusive, exhaustive categories for immigrants: legal permanent residents (LPR) with valid green card, refugees and asylees (persons granted asylum), persons admitted temporarily who

stay legally for more than a year, naturalized U.S. citizens, and illegal or unauthorized immigrants. Recall that this survey method requires two representative samples of the population of interest; one is shown card 1 and the other card 2. The sensitive category of unauthorized is presented with two less sensitive categories in Box B. If respondents choose Box B, no further inquiry is made. If respondents choose Box A, which is composed of 2 less sensitive categories of immigration status, several follow-up questions are asked to be sure that the respondent has chosen Box A correctly. The follow-up questions include asking under which program they received their legal status, country of origin, year of entry, and year they acquired legal status. Box C is comprised of a less-sensitive and rare category among the sample. If respondents choose Box C, several follow-up questions are asked as well to ensure that respondents have chosen the correct category. The cards are arranged so that Box A from card 1 contains the same two less sensitive categories of immigration status appearing with the sensitive category of unauthorized in Box B of card 2 (GAO, 1999, 2006).

Limitations of this method include the necessity to conduct the survey via in-person interview and the large sample required to obtain accurate estimates. Approximately 2,000 respondents are needed for an estimate of the percentage unauthorized with a 90% confidence interval of plus or minus 4 percentage points, assuming 50% of the respondents are unauthorized. If the assumption is that only 30% of the population of interest is unauthorized, then 2,500 survey respondents are required for the same confidence interval (GAO, 2006).

Another method used in direct survey of the foreign-born for the express purpose of determining immigration status is the Residency Status Assignment based on answers

to a series of questions (Marcelli and Lowell, 2005). In this method, residency status is assigned to respondent based on answers to a series of questions. While the question of being unauthorized is never asked outright, the status of immigration is implied by the answers to these questions.

VII. Other Methods for Estimating the Foreign-Born.

Woodrow (1991) used Demographic analysis to produce preliminary estimate for the number of unauthorized residents on April 1, 1990 based on two approaches. The first approach increased the direct estimate of unauthorized immigrants in the November 1989 Current Population Survey (CPS) to allow for CPS and census under-coverage. This is a “Stock-based” method. The second approach employs implicit estimates from carrying forward the alternative estimates for unauthorized residents in 1980 with alternative estimates of change for periods of 1979-1986, 1979-1988, 1979-1989, 1986-1988, and 1986-1989. This is a “flow-based” method.

Bean, King, and Passel (1983) estimated the number of Illegal Migrants of Mexican Origin in the United States by applying a sex ratio-based method. The approach centers on a comparison between the hypothetical sex ratio one would expect to find in Mexico in the absence of emigration to the United States and the sex ratio that is in fact reported in preliminary results from the 1980 Mexican Census. The procedure involves, inter alia, assuming a range of values for the sex ratio at birth and for census coverage differentials by sex in Mexico. Even the combinations of these values most likely to result in large estimates suggest that no more than 4 million illegal migrants of Mexican origin were

residing in the United States in 1980. This method uses “De jure” census data from the U.S. while the data from the Mexican Census are “De facto” counts. At the national level, this difference may not do much confounding, but that is an open research question.

Edmonston and Michalowski (2004) show how the cohort-component method is applicable to the estimation of net immigration, by age, for the total population and for segments of the population, which are fixed (e.g., sex, race, and country of birth) or relatively fixed over time (e.g., mother tongue and religion). This procedure involves the calculation of estimates by age groups on the basis of separate allowances for the components of population change. In preparing estimates by age, the compilation of death statistics by age cohorts to allow for the mortality component is so laborious, even where the basic statistics on death are available, that survival rates are normally used instead. The survival rates may be life table survival rates or so-called national census survival rates.

One defect of this method is that it has a tendency to understate or overstate the number of (implied) deaths during the intercensal period. In an "emigration" country, the initial population in an age cohort overstates the average population exposed to risk during the following intercensal period and the terminal population understates the average population exposed to risk, because some persons emigrate. A more satisfactory estimate of (implied) deaths and net migration may be made, therefore, by (1) “aging” the initial population to the date of the second census; (2) calculating the corresponding "forward" estimate of net migration; (3) "younging" the terminal population to the date of the first census by dividing the terminal population by the survival rate; and (4) calculating the corresponding "reverse" estimate of net migration by subtracting the

initial population from the "younged" population; and (5) averaging the two estimates of net migration in steps (5) and (7).

Edmonston and Michalowski (2004) note that the calculation of deaths to the age cohorts born during the period requires special treatment because exposure is less than the full intercensal period. The forward and reverse survival procedures are then applied in the same way as for the older cohorts, the births in the two 5-year periods being taken as the initial population for the first two age groups. The estimation of deaths for cohorts born during the decade (i.e., under 5 and 5 to 9 years of age at the end of the period in this example) are calculated from the mid-period life table survival rates.

In the event that statistics of deaths of foreign-born persons are lacking, as is the common situation, the number may be estimated by applying appropriate central death rates to the mid-period foreign-born population. This procedure has been worked out by Edmonston and Michalowski (2004) for the foreign-born population of the United States for the period, 1980-90 who also show how estimates of net immigration of the foreign-born by age cohorts are obtained by use of a survival-rate procedure. Edmonston and Michalowski (2004) observe that alternative estimates of net immigration of the foreign-born population employing the survival-rate procedure may be derived by use of national census survival rates instead of life table survival rates.

Massey and Zenteno (1998) specify a set of equations defining a dynamic model of international migration and estimate its parameters by using data specially collected in Mexico. The authors then used it to project a hypothetical Mexican community population forward in time. Beginning with a stable population of 10,000 people, the authors project ahead 50 years under three different assumptions: no international

migration; constant probabilities of in- and out-migration, and dynamic schedules of out- and in-migration that change as migratory experience accumulates. The authors' model quantifies the mechanisms of cumulative causation predicted by social capital theory and illustrates the shortcomings of standard projection methodologies. The failure to model dynamically changing migration schedules yields a 5% overstatement of the projected size of the Mexican population after 50 years, an 11% understatement of the total number of US migrants, a 15% understatement of the prevalence of US migratory experience in the Mexican population, and an 85% understatement of the size of the Mexican population living in the U. S.

Wolter (1990) presents new methods of estimating population size abased on capture-recapture data. The methods exploit knowledge of the sex ratio, males per female, and permit “estimability” even when both time of sampling and marking affect “catchability.” This technique could be used in conjunction with specialized surveys.

VIII. An Evaluation of Methods for Estimating the Foreign-Born.

In this section, the evaluation of methods for estimating the foreign-born is organized into three areas: (1) Data; (2) methods; and (3) administrative structures. Before proceeding, however, I first cover the conceptual framework and major criteria used in the evaluation.

Evaluation Criteria Description

Like most other methods for generating population estimates (See, e.g., Bryan, 2004), it has been possible to evaluate methods for estimating the foreign-born in total by using decennial census counts (admitting, that the decennial census counts stem from the sample-based “long form”). This, however, changes in 2010, when the Census Bureau abandons the long form and uses the ACS as a substitute. Thus, the ACS will be the future “gold standard” against which methods for estimating the foreign-born are evaluated. With this new gold standard comes the difference in residency rules used by the traditional “short form” decennial census (De jure)and the ACS (De facto) and the fact that the ACS is then controlled to numbers that use the same residency rule as the decennial census (De jure).

When it comes to evaluating methods for estimating the foreign-born by status, particularly those who are unauthorized, there is no “gold standard.” Thus, traditional frameworks and criteria used to evaluate population estimates in general require some modification because they inherently assume the presence of a gold standard. However, even though decennial census data provide the most convenient and accurate standard against which to evaluate population estimation methods, there always have been several important considerations that were taken into account before estimates are compared with census values. First, there was often a tendency to assume that earlier and later censuses are completely consistent, but such consistency cannot be taken for granted. Second, subnational areas often differ in geography and populations covered, and census

definitions may have changed as well. Third, where a method was based on a past census that differs from a more recent census against which estimates resulting from the method in question were compared, in any significant way, an accurate evaluation was compromised.

All of this leads up to the point that comparisons of estimates resulting from different methods against the census have to be considered “measures of difference” rather than “measures of error” because it is virtually impossible to precisely determine the degree to which error in the census and error in the estimate contribute to the overall difference. measures, the primary indicator of error was the average absolute percent difference.

Similarly, it is important to note that a direct “method-to-method” comparison is rarely possible when attempting to make a population estimate. Often, what might be the most accurate method may not be practicable due to excessive time, cost and resources. Other hindrances may include unavailability or inconsistency of necessary data. Furthermore, it will be seen, certain methods are better suited to particularly large or small areas of geography. While a certain method may generate “good results” at a national level, they may be wholly inadequate for other levels of geography. Thus the amount of resources available, the level of geography as well as historical accuracy of each method must always be considered.

However, some criteria do apply, including continuity; timeliness of information; refinement; production; cost, and replication. Generally speaking, these criteria can be applied to data, methods, and administrative structures, topics to which I now turn.

Evaluation of Data

Schmidley and Robinson (2003) evaluated CPS nativity data collected between January 1994 and December 2002. Where feasible, they compare these data with data from other sources. They incorporate a limited amount of the information found in "How Well Does the Current Population Survey Measure the Foreign-Born Population in the United States?" which evaluated the March Annual Social and Economic Supplement (ASEC) nativity data 1994 to 1997. The current paper extends the period to 2002 and includes information about the monthly or basic survey.

Skeldon (1987) identifies and describes the main issues to be resolved when designing questions and strategies to collect migration-related data. The strengths and weaknesses of the various approaches are assessed in the light of the data collected by countries in the Asia-Pacific region during the 1980 round of censuses. In the context of the developing countries of the region, the author argues that higher quality and more useful migration data can be captured through questions on last place of previous residence and duration of residence in De facto-based censuses. Variations of, and amplifications to, this approach are considered.

Fawcett and Arnold (1987) argue that surveys provide an effective method for studies of the complex processes that underlie spatial mobility. They identify and discuss eight advantages of surveys that are related to research design and seven advantages that are related to research content. Deficiencies and disadvantages of surveys are also reviewed. Suggestions are made for improving surveys of international migration through better samples and attention to different points in a migration system.

Doug Massey (1987) describes a research approach designed to overcome the limitations of federal immigration statistics and to illuminate the social processes underlying aggregate patterns of migration. He argues that the principal weaknesses of existing data sources are that they under-enumerate and imperfectly measure unauthorized migration; they do not reflect the widespread circularity of modern international movements; they omit variables central to the immigration process; and their cross-sectional collection and tabulation precludes the analysis of immigration as a dynamic process. The ethnosurvey is a research design that ameliorates these problems through five specific design features: multi-method data collection, representative multi-site sampling, multilevel data compilation, life history collection, and parallel sampling. These design features are described, justified, and tied to the broader methodological literature in social science. The ethnosurvey design is illustrated by its recent application to study Mexican migration to the United States, and empirical evidence is presented to show how it corrects the limitations of federal data on immigration.

In a subsequent paper, Massey (1999) evaluates the validity of his proposed ethnosurvey as a method of demographic data collection by analyzing the representativeness of the Mexican Migration Project (MMP) as a source of information on Mexico-U.S. migration. After briefly delineating the philosophy, structure, and organization of the MMP's ethnosurvey design, he describes MMP's public use dataset as well as Mexico's Encuesta Nacional de la Dinamica Demografica (ENADID) as a benchmark for its systematic evaluation. He finds that although the MMP over-represents migrants in the western states and mid-sized communities, it yields a relatively accurate and valid profile of migrants to the United States. A comparison of multivariate models

estimated using MMP and ENADID data suggests that whereas the former's sampling errors are small and yield biases that are substantively unimportant, the latter's potential for specification error and selection bias may seriously compromise results. Massey concludes that his comparison thus validates the ethnosurvey as an accurate and reliable method of data collection and the MMP as a good source of reasonably representative data on authorized and unauthorized migration to the United States.

However, some criteria do apply, including continuity; timeliness of information; refinement; production; cost, and replication. Generally speaking, these criteria can be applied to data, methods, and administrative structures, topics to which I now turn.

Evaluation of Methods

In this section, I evaluate methods under each of the major headings used to organize the techniques for estimating the foreign-born (by status): (1) residual; (2) administrative records; (3) specialized survey; and (4) other. I subdivide the residual method into those that are stock-based and those that are flow-based. I evaluate “assumptions” in addition to timeliness, cost, and inherent strengths and weaknesses.

Evaluation of Stock-based Residual Methods

Assumptions

These methods utilize survey data, census data, or a combination of the two as primary data sources. The (long form) Decennial Census, CPS, SIPP, and, now, the

ACS, all have been used. The underlying assumption for each of them is that sample precision is adequate and that non-sampling errors are minimal relative to the measurement of legal status of the foreign born. Another assumption specific to this method noted by Judson (2006) is that the assignment algorithm accurately measures visa, LPR, and naturalization requirements. Also, the assignment is “100% assignment,” which assumes that everyone with the same characteristics, i.e. matching certain visa requirements, has the same status

As has been noted earlier, the Decennial Census, CPS, and SIPP, on the one hand, use the De jure rule of residency while the ACS uses what amounts to a De facto residency rule. However, when the micro-level ACS data are aggregated to geographic areas, they are controlled to number produced for these areas by the Census Bureau’s annual population estimates program. It does not appear to be the case that ACS data so controlled are used in the stock-based residual methods, which rely on micro-level data. If this is the case, then comparing estimates made by the residual methods relying on the census, CPS, and SIPP with those made using strictly ACS data will yield differences based in part on the different residence rules. This may not be a huge issue at the national level, but at sub-state levels, the effects of these different residency rules could be substantial. Where ACS micro-level data are used in conjunction with micro-level data from the CPS, SIPP, or the (2000) census, it is highly likely that mismatches occur.

Limitations and Strengths

These methods have a number of limitations and strengths. A major limitation is the fact that none of these data sources contain direct questions on legal status, which means that the components are constructed from estimating imputing legal status. Another important limitation assumes that the information used from the microdata actually reflect the visa, LPR, and citizenship criteria. Finally, as noted by Judson (2006), each case matching certain characteristics is allocated as either meeting or not meeting the criteria for the legal status and this may be neither accurate nor necessarily appropriate.

However, CPS, SIPP and ACS microdata represents a strength for both Census Bureau staff and external researchers holding clearances to access micro-level data, because the U.S. Census Bureau is not an administrative or enforcement agency and does not have regular access to other agencies' data.

Another strength is that these methods are flexible. They can easily be adapted to accommodate three important scenarios. First, the requirements for the visa, citizenship, and LPR statuses themselves may change and change very quickly, for instance, by a policy-setting agency. The algorithm method is easily changed to meet these new conditions. Second, the algorithms can be reproduced under alternate assumptions regarding the matching between the microdata information and visa or LPR criteria.

Depending on the micro-level base data, the ACS on the one hand or the Decennial Census and CPS, on the other, these methods will produce estimates of either the De facto or De jure population, respectively. If ACS micro-level data are used in

conjunction with micro-level data from the other sources, then it is not clear if the result is more “De jure than De facto”, or vice-versa.

Evaluation of Flow-based Residual Methods

Assumptions

Many of the same assumptions mentioned in the method text above are also pertinent to this method and depending on the use of the Decennial Census or the ACS, the resulting estimates are either of the De jure or De facto population, respectively

A major assumption underlying this approach is that the components of population change are closely approximated by measuring change in selected administrative or survey data sources. In order to apply the model, Census Bureau demographers estimate each component of population change and legal status category separately. In addition, this method makes the (crucial) assumption that the administrative and survey data that are used to construct demographic flows are comparable; that is, that the time reference, time frame for data production, and concepts can be appropriately compared to one another.

Strengths and Limitations

Using data to approximate the measures of components of change that can be updated on an annual basis could prove to be invaluable as this would be more representative of the process that is actually happening in the population. However, the assumption that there is available data that closely approximates the measure of each of

the components of change within a particular legal status category may prove to be a difficulty and should be viewed as potential and important limitation to the use of this method of estimation. If certain components of the equation cannot be accurately approximated by the data, then it is possible that the residual category will be significantly overestimated, while other legal status categories will be underestimated, since the sum of all legal status categories at time t must be equal to the total foreign born population at time t.

Another issue in regard to the residual method in general is that it tends to cumulate error. As a concrete example, recall again the equation due to Deardorff and Blumerman (2001) that was presented earlier:

$$FB = [L - [M + E] + T + R]$$

where

FB = Foreign-born population

L = Legal Immigrants

M = Mortality to legal immigrants

E = Emigration of legal immigrants

T = Temporary (legal) migrants

R = Residual foreign-born (unauthorized and quasi-legal migrants)

Rearranging the terms yields

$$R = FB - L + M + E - T$$

If each of the elements on the right-hand side of the equation is measured with some level of error, e , (a reasonable assumption), then the residual estimate becomes

$$R = (FB + e_{FB}) - (L + e_L) + (M + e_M) + (E + e_E) - (T + e_T)$$

$$= (FB - L + M + E - T) + (e_{FB} + e_L + e_M + e_E + e_T)$$

which means

$$R - (e_{FB} + e_L + e_M + e_E + e_T) = FB - L + M + E - T$$

In other words, all of the error ends up in the residual estimate. These errors may, of course, offset one another, but there is no way to gain a reliable and valid assessment of this either beforehand or after the fact. Moreover, the errors combine both sampling and non-sampling error. In regard to the sampling error, having small standard errors is critical to the development of reasonable estimates. In regard to the non-sampling error, there is no measure to standard error that allows the assessment of the effects of coverage, non-response, measurement, and recording errors. Moreover, in this implementation the residual method runs the risk of “residual error propagation” in that the term “E” is itself a residual estimate.

In general, the issue of having error accumulate in the estimate is not unique to this particular implementation of the residual method. It also applies, for example to all residual methods in principle, including the residual method for estimating net intercensal migration (Morrison et al., 2004).

Another problematic error with the variants of the residual method evaluated here is that the components tend to be functionally related. This means that an error in one component tends to introduce an error in the opposite direction in another. Unlike the situation of multi-collinearity in a multiple regression model, there is no clear way to assess this in the residual model.

According to Van Hook and Bean (1998), this implementation of the residual method was not employed with data collected prior to 1980 because the 1980 census was the first

decennial census in which a sizable enumerated migrant population could be detected through demographic analysis. Van Hook and Bean (1998) identify three variations of this “residual” method.

Bean et al. (1998) note that while stock and flow estimates of the unauthorized migrant population tended to be unreliable prior to 1980 due in part to lack of methodologies for correcting for biases in the available data sources and otherwise to the fact that these methods tended to be inconsistent in their assumptions and methodologies

This “slippages” between data sources is a significant limitation of this method. Such “slippage” is a result of: (1) Transaction-based data that to-date it has not been possible to convert to a person-based estimate; (2) transitions between categories that are as-yet unaccounted for; and (3) the requirement of various assumptions (e.g., foreign-born emigration) deemed to be excessive. As stated in the description of this method, this means that lacking firm numbers on legal temporary flow (in and out), too much inflow is generated by this method and insufficient outflow, which can easily lead to judgments about what is too much or too little. Perhaps this could be overcome by conducting a special study on I-94 inflow data such that legal temporary residents could be linked to passenger manifests and I-94 outflow data. Transitions to other statuses, might be examined using record linkage methods. The estimates produced by this method appear to be aimed at the De jure population.

Paradies and Barnes (2005) provide a description of a variant of dual-record population estimation (see, e. g., Marks, Seltzer Krotki, 1974; Krotki, 1977), which relies on the availability of specific additional information to relax the assumption of perfect frame specification. This variant is applied to two remote Indigenous

communities in the Northern Territory of Australia, using locally available data sources. Further theoretical exploration of this method is presented along with possible applications in estimating area-enumerated populations and census coverage.

Evaluation of Administrative Structures

In my opinion, it appears that part of the reason for the lack of immigration and emigration data is the fact that the mission of the Department of Homeland Security is primarily aimed what can be broadly described as policing. Data collection appears to have taken not just a back seat, but a seat in the rear of the DHS bus.

Like DHS, The U.S. Census Bureau is part of the executive branch, as is NCHS. Perhaps it is time for the United States to reorganize its scattered data collection efforts into a single agency, as much of the rest of the world has done.

IX. Suggestions

Data

The data needs can be organized into four major areas: immigration, emigration, the De jure foreign-born population and the De facto foreign-born population.

Immigration data are a mess and emigration data are essentially non-existent. It is hard to understand how valid and reliable estimates of the foreign-born, whether on a De jure or De facto basis can be generated without valid and reliable information on immigration and emigration.

In addition to being collected in historical census enumerations, data on the De jure foreign-born population were collected in the modern (since 1950) decennial census enumerations and in the ACS and the SIPP. In the 1980 census, data were even collected on “temporary residents” (National Research Council, 2006: 114). With census 2010, the decennial census will no longer be a source of these data. Given this, it is not clear what direction the CPS and the SIPP will take if they continue to exist beyond 2010. This means that the residual estimates that were produced using data from the decennial census can no longer be done unless one uses the 2000 census as a launch point. Thus, it is an open question if the ACS and SIPP can be used. These points lead to the conclusion that once 2010 rolls around, all estimates of the foreign-born will effectively be those of the De facto population, not the De jure population.

One of the first suggestions I would have made until it was clear that there will no longer be a long form in the decennial census was to understand the effect of the different residency rules used by the decennial census, the CPS, and the SIPP, on the one hand, and the ACS, on the other, and to take these differences into account both when comparing estimates developed from these two different sources and when attempting to use elements of both in developing estimates. However, this appears to now be a moot point. However, it does need to be taken into account when using other data sets such as NIIS, the NCHS death and birth files, and other administrative records. Finally, in conducting special surveys aimed at directly estimating the foreign-born (by status), I suggest that the type of population being estimated needs to be clearly defined. Further, it appears that using the ACS definition of residency would be more valuable than using the decennial census rules since the former leads to comparability between a specialized

survey and the ACS, while the latter does not. Moreover, the ACS could be used to generate both types of estimates. Happel and Hogan (2002) as well as Smith and House (2004) provide suggestions on how this could be accomplished in terms of De jure and “temporary resident” populations and their suggestions could easily be extended to De jure and De facto populations.

Methods

The lack of a gold standard against which to compare status-based estimates of the foreign-born suggest that the only course of action to attempt to have valid and reliable estimates is to construct them from different methods and data sets that while having different strengths and weaknesses that lead to different assumptions underlying the estimates, are reasonably reliable and valid. Thus, I suggest that the existing forms of the residual, administrative records, specialized survey, and “other” methods be continued along with the exploration of new ones,

Any residual methods in the future will be based on the ACS. It is inescapable. I suggest that they continue to be done, but that it is made clear that the ACS rules of residency are different than those found in the “short form” counts of population in the decennial census and, likely in the post-censal estimates (and projections) produced from them. In order to avoid these inconsistencies, I suggest that a uniform set of residency rules be used across all of the federal efforts. Initially, this will cause a great deal of disruption because it will represent a major break with the past. However, it makes no sense to have one major data collection method such as the

‘short form’ decennial census using one set of rules (De jure) and the ACs using another (De facto). Given this, residual methods represent a valuable source of information on the foreign-born (by status). Methods based on the use of administrative records as well as “other” methods also provide valuable information .

I agree with Grieco (2003) who, among others, has called for a large-scale post-census survey on the foreign-born. If this is done, I suggest that the “two card” method be strongly considered because it represents a direct source of information on the foreign-born (by status) and, appears to be the only realistic way to get at direct estimates of the foreign-born by status.

I suggest that the idea I described earlier of using the Social Security Death Master File (SSA DMF) and the National Center for Health Statistics’ Death Index File (NCHS DIF) via a “record matching” process be pursued to identify foreign-born decedents not authorized to be in the United States. It is, as I observed earlier, a research question as to the efficacy of either of the two variations of this proposed method, given that the SSA DMF and NCHS NIF files can be obtained for this purpose, processed in a cost-effective manner, and that a low level of record linkage error is found. To assess each of these three conditions, a small pilot study could be implemented. If the record matching process yields a good estimate of deaths to the unauthorized population at a given point in time by age (geography and sex), then successive sets of the estimates can be used to generate estimates (and projections) using the principles underlying the method for estimating unauthorized immigration due to Edmonston and Michalowski (2004) that was described earlier.

Administrative Arrangements

Perhaps it is time for the United States to reorganize its scattered data collection efforts into a single agency, as much of the rest of the world has done. Having all of the data collection activities in a single agency dedicated solely to this type of activity would enhance both the availability of data needed to estimate the foreign-born (by status) and the estimates themselves. If this is done, for reasons given by El-Badry and Swanson (2007) and Teitlebaum and Winter (198), I suggest that the U.S. Central Statistical Bureau not be located within the executive branch but, rather, within an administrative structure similar to that of the Federal Reserve or the Congressional Budget Office.

Summary

Because there is no gold standard, methods for estimating the foreign-born (by status) can never be subjected to the standard evaluation process used for the general methods of population estimation (Bryan, 2004; Swanson, 1986; Swanson, 1989; Swanson, 2004). Thus, the selection of methods will be based on criteria other than accuracy, such as cost and timeliness, transparency, and so forth. However, there is one approach for which statistical precision can be evaluated, namely a sample survey. If such a survey is undertaken, I believe that the “Two-Card” method should be used because it is the only

technique that is aimed directly at estimating the foreign-born (by status). Moreover, it has also been tested by Golden (2007).

If a large scale “Two-card” survey is done, I believe it would best be accomplished by contracting the work to a non-governmental entity that has the experience and human capital to implement such a survey. The survey could be developed under a guiding body that provides overall management with either the Census Bureau or the Office of Immigration Statistics providing the day-to-day management of the survey. The actual collection and technical details could be done by a major non-government survey organization with the skills and experience to handle such an endeavor. Organizations such as ISR at the University of Michigan and NORC at the University of Chicago come to mind, among others. If this path is taken, I suggest that pilot studies similar to what is done for the Decennial Census (e.g., a series of pilots in different areas, leading up to the full dress rehearsals). While precision does not equate with accuracy in the same sense as is used for other methods of population estimation, it does serve as a substitute, which means that estimates generated by different surveys can be compared for cost, timeliness, and precision. In gearing up for such a survey, I suggest that the Census Bureau work with the NAS and potential contractors (e.g., ISR and NORC) to develop a plan. I further suggest that careful attention be paid to the type of population being estimated and that rules of residency be used that are consistent with the ACS.

Finally, following El-Badry and Swanson (2007) and Teitlebaum and Winter (1998), I suggest that federal data collection activities be centralized under one agency and that this one agency be located outside the executive branch of government with an administrative arrangement similar to the Federal Reserve Board. This would allow the

Census bureau to focus on the timely and accurate production and distribution of data needed for policy making and . At the very least, the recent proposal by Representative Carolyn Maloney (2008) should be examined. It would elevate the Census Bureau to the status of an Independent Agency in the federal government hierarchy, a move that would enhance its ability to focus on the timely and accurate production and distribution of data. Either of these two moves would not change the fact that statistics collected by the government, by their nature, address existing government policies, but perhaps it would open up the U.S. statistical system along the lines suggested by Simpson and Dorling (1999) for the United Kingdom.

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ANNOTATED BIBLIOGRAPHY⁵

BIBLIOGRAPHY I. Background and General Materials

Arnold, F., 1989. "Revised Estimates and Projections of International Migration, 1980-2000." *Policy, Planning and Research Working Papers*, Population and Human Resources Department. Washington, DC: World Bank. This report reviews the World Bank's latest international migration statistics for every country in the world for each five year period from 1980 - 2000. In the early 1980s, net international migration to all receiving countries totaled more than 1.2 million persons a year. The author assumed this figure would gradually decrease to fewer than 900,000 persons a year in the period 1995 - 2000. Mexico was found to be the largest net exporter of international migrants.

Barkin, E., H. Diner, and A. Kraut (Eds.). 2008. *From Arrival to Incorporation: Migrants to the U. S. in a Global Era*. New York City, NY: New York University. Leading immigration experts in history, sociology, anthropology, economics, and political science here offer multiethnic and multidisciplinary perspectives on the challenges confronting immigrants adapting to a new society.

Bean, F., H. Browning, and W. P. Frisbie. 1984. "The Sociodemographic Character of Mexican Immigrant Groups: Implications for Studying Unauthorized Mexicans." *International Migration Review* 18: 672-691. This study uses 1980 PUMS to delineate four Mexican-origin immigrant status groups--post-1975 Mexican-born noncitizens, pre-1975 Mexican-born noncitizens, self-reported naturalized citizens, and native-born Mexican Americans. They argue that the pattern of sociodemographic differences reveals that the first two categories contain a substantial fraction of unauthorized immigrants

Bean, F., G. Vernez, and B. Keely. 1989. *Opening and closing the doors: Evaluating immigration reform and control*. Washington, DC: The Urban Institute Press. This book evaluates the impact of the 1986 Immigration Reform and Control Act (IRCA).

Bean, F.; R. de la Garza. 1988. "Illegal aliens and census counts." *Society* 25 (3): 48-53. This paper examines the issue of including illegal aliens in the 1990 US census counts. It considers the demographic, economic, and social contexts within which this question arises, as well as the legal history of the issue.

Bean, F., R. Cushing, C. Haynes, J. Van Hook. 1997. "Immigration and the social contract." *Social Science Quarterly* 78 (2): 249-268. The authors explain not only why recent migration flows have come to be negatively perceived, but also why they appear increasingly to be seen as violating the prevailing sense of social contract in the United States." The authors conclude that "devising immigration policies that are fair as well as sensitive to their environmental, developmental, trade, and foreign-policy implications

may prove difficult unless the public sense of economic security increases enough to strengthen what appears to be an increasingly fragile sense of social contract.

Bean, F., B. Edmonston, and J. Passel. 1990. *Unauthorized migration to the United States: IRCA and the experience of the 1980s*. Santa Monica, CA: Rand Corporation. The authors note that the major objective of the 1986 Immigration Reform and Control Act (IRCA) was to reduce illegal immigration through two strategies--legalizing immigrants already in the country and reducing future flows to the country through imposing penalties on employers who hire illegal aliens. The success of the legislation will, therefore, be measured at least in part by whether the flow of illegal immigrants to the United States has been reduced. This report considers whether IRCA has succeeded in reducing illegal immigration.

Blakeslee, J. 2008. "Just the Facts: Official Reports, Mass Media and the Politics of Unauthorized Migration Estimates in the United Kingdom and United States." Paper presented at the annual meeting of the Population Association of America, New Orleans, LA. April 17th. Using content analysis of mass media, internet sources, congressional/parliamentary transcripts, and a short survey of demographic professionals working on immigration-related topics, this paper tracks and analyzes estimates of unauthorized migrant populations issued in high profile UK (2004/05) and US (2005/06) reports. The paper examines the numbers within the public discourse, focusing on the relationship among quantitative information on unauthorized migration, its production, the mass media, public opinion and political power in the United Kingdom and the United States.

Bohon, S. 2001. *Latinos in Ethnic Enclaves: Immigrant Workers and the Competition for Jobs*. New York, NY: Garland Publishing. This work explores the competition for jobs between different Latin American immigrant groups in the U.S. economy. The author looks at occupational status attainment among Latino groups in Miami and three other U.S. cities with flourishing Latino enclaves.

Borjas, G. 1991. "Immigrants in the U.S. Labor Market: 1940-1980." *American Economic Review* 81: 287-291. This paper explores the extent and causes of the decline in immigrant skills [in the United States] during the postwar period. Prior to 1965, immigration to the United States was guided by the national-origins quota system. The empirical analysis shows that a single factor, the changing national origin mix of the immigrant flow, is mainly responsible for the decline in immigrant skills.

Bouvier, L., H. S. Shryock, and H. Henderson. 1977. "International Migration: Yesterday, Today, and Tomorrow." *Population Bulletin* 32 (4). A look at the past, present (as of the publication date) and future of international migration, with some prescient points.

Carter, S., and R. Sutch. 1999. "Historical Perspectives on the Economic Consequences of Immigration into the United States." pp. 319-341 in C. Hirschman, P. Kasinitz, and J. DeWind (Eds). *The Handbook of International Migration: The American Experience*.

New York: Russell Sage Foundation. This paper highlights the distinctive features of the theoretical approach taken by scholars who analyzed the impacts of the mass migration into the United States in the two decades preceding World War I. Taking a long-run perspective, they identified many aspects of the mass immigration that were beneficial from the point of view of the resident population.

Castles, S., and M. Miller. 2003. *The Age of Migration: International Population Movements in the Modern World, 3rd Edition*. New York, NY: Guilford. This book global perspective on the nature of migration movements, why they take place, and their effects on industrialized countries and the developing world. The role of migration in the formation of ethnic minority groups is examined, as is the impact of growing ethnic diversity on economies, cultures, and political institutions.

Cornelius, W. 1989. "Impacts of the 1986 US Immigration Law on emigration from rural Mexican sending communities." *Population and Development Review* 15(4): 689-705. From the perspective of traditional labor-exporting communities in rural Mexico, this article examines how the 1986 US Immigration Reform and Control Act (IRCA) has affected perceptions of the US labor market, the propensity to migrate, settlement patterns in the US, and the economies of migrant families and their home communities. Using survey data from three communities, the author finds that most residents--including prospective 1st-time unauthorized migrants to the US--continue to view US labor markets as relatively accessible, with or without legal entry documents, even though employer sanctions have increased the perceived difficulty of finding work in the U.S.

Cornelius, W., P. Martin, and J. Hollifield (Eds). 1994. *Controlling Immigration: A Global Perspective*. Palo Alto, CA: Stanford University Press. This book provides a systematic, comparative study of immigration policy and policy outcomes in industrialized democracies. In-depth examinations of selected countries address why certain immigration control measures were selected and why these measures usually failed to achieve their stated objectives.

Costanzo, J., C. Davis, and N. Malone. 2002. *Guide to International Migration Statistics: The Sources, Collection, and Processing of Foreign-Born Population Data at the U.S. Census Bureau. Population Division Working Paper No. 68*. Washington DC: U.S. Census Bureau. A comprehensive guide to data at the US Census Bureau on the foreign-born and international migration.

Crane, K., B. Asch, J. Heilbrunn, and D. Cullinane. 1990. *The Effects of Employer Sanctions on the Flow of Unauthorized Immigrants to the United States*. Santa Monica, CA: RAND. This report assesses whether the Immigration Reform and Control Act (IRCA) of 1986 succeeded in significantly reducing the flow of unauthorized immigrants to the United States by the end of fiscal year 1989. Data include entry indicators (apprehensions, visas, and applications) and economic indicators (including a survey of U.S. labor markets in immigrant-dependent industries, and estimates of the change in employer demand for legal foreign workers). None of the data sets provides conclusive

evidence but, taken together, the preponderance of the evidence points to some decline in the flow.

Cresdson, J. 1983. *The Tarnished Door*. New York City, NY: Times Books. This book by a (Pulitzer prize winning) journalist uses data and first-hand accounts to look at the benefits of costs of immigration to the US and the immigrants themselves. The author finds that immigrants bring more to the US economy than they take from it.

DaVanzo, J. 1980. *Microeconomic Approaches to Studying Migration Decisions*. Santa Monica, CA: RAND. This is an introduction to the main ideas and concepts of microeconomic models for studying migration decision-making. It summarizes and critiques the main empirical approaches used to test these model and summarizes their principal findings, while also highlighting the resulting implications for the design of surveys to provide data suitable for estimating microeconomic models of migration.

Durand, J., and D. Massey. 2003. *Clandestinos: Migración México-Estados Unidos en los Albores del Siglo XXI*. México, D.F.: Editorial Porrúa. This book seeks to interpret and understand the origins and effects of unauthorized immigration at the end of the 20th century and suggests that a new phase will occur as we move into the 21st century.

Donato, K., J. Durand, and D. Massey. 1992. "Stemming the tide? Assessing the deterrent effects of the Immigration Reform and Control Act." *Demography* 29 (2): 139-157. This study uses a new source of data to assess the degree to which the Immigration Reform and Control Act (IRCA) deterred unauthorized migration from Mexico to the United States. Data were collected from migrants interviewed in seven Mexican communities during the winters of 1987 through 1989, as well as from out-migrants from those communities who subsequently located in the United States. The authors conducted time-series experiments that examine changes in migrants' behavior before and after passage of the IRCA in 1986 were not able to detect any evidence that IRCA significantly deterred unauthorized migration from Mexico.

Durand, J., D. Massey, and E. Parrado. 1999. "The New Era of Mexican Migration to the United States." *Journal of American History* 86(2): 518-536. The postwar model of industrial growth based on internal market development came undone in the early 1970s, and over the course of the next decade it was progressively abandoned in favor of a new economic model based on international trade. These changes came earliest in Mexico's northern border region, where in the 1970s the government launched an ambitious industrialization program based on export processing in a special border-area trade zone that initiated a wave of rapid economic and demographic growth along the border.

Durand, J., W. Kandel, E. Parrado, and D. Massey. 1996 "International Migration and Development in Mexican Communities." *Demography* 33 (2): 249-64. Using the conceptual model of the new economics of migrations and neoclassical economics, the study examines the individual, household, community, and macroeconomic determinants of migrants' savings and remittances. Data were obtained with ethnosurvey methods from winter samples in 1982-83 and 1987-92 from 30 migrant-sending communities in

Mexico. Findings indicate that community factors were strong determinants of saving decisions and remittance decisions.

Edmonston, B. (Ed). 1996. *Statistics on U. S. Immigration: An Assessment of Data Needs for Future Research*. Washington, DC: National Academy Press. This is the result of a workshop that explored data collection and data preparation on immigration in the United States. One purpose was to assist the Immigration and Naturalization Service in developing a statistical information system, as required by the Immigration Act of 1990. The other purpose was to suggest possible improvements to the data collection and analysis efforts of federal statistical agencies and the social science research community. Using as a basis the presentations and discussions that took place, the committees made conclusions and recommendations.

Edmonston, B. and M. Michalowski. 2004. "International Migration" pp. 455-492 in J. Siegel and D. Swanson (Eds). *The Methods and Materials of Demography, 2nd Edition*. Amsterdam, The Netherlands, Elsevier Academic Press. A summary of the methods and materials used in studying international migration.

Ellis, M., and R. Wright. 1998. "When Immigrants are not Migrants: Counting Arrivals of Foreign-Born Using the U. S. Census." *International Migration Review* 32 (1): 127-144. This paper compares characteristics of recent immigrant arrivals in the United States using two measures from the decennial U.S. census: the came-to-stay question and the migration question. Among recent arrivals, defined as those who reported they came to stay in the quinquennium preceding the census, a large number were resident in the United States five years before the census date.

Fix, M., and J. Passel. 1994. *Immigration and Immigrants: Setting the Record Straight*. Washington, DC: The Urban Institute. This report is aimed at providing an accepted factual base and framework for thinking about immigration issues can provide a common starting point from which to assess different policy alternatives. It sets forth a number of overarching points to guide thinking about immigration and lays out the facts on four fundamental questions.

Fuchs, L. 1984. "Cultural Pluralism and the Future of American Unity: The Impact of Illegal Aliens." *International Migration Review* 18 (3): 800-813. This paper explores the question of the impact of illegal migration on American unity and cultural pluralism in the US. The author takes special notice of the illegal migration of Spanish-speaking workers and hypothesizes that the behavior of their descendants will not differ from that of the descendants of other immigrants, legal or illegal, in ways that disrupt fundamental patterns of American political unity and cultural pluralism.

Garcia y Greigo, M. 1987. "International Migration Statistics in Mexico." *International Migration Review* 21 (4): 1245-1257. This research note reviews available sources of that information--arrival and departure statistics, population censuses, refugee censuses, and survey data--and concludes that most of them are relatively weak. The movement of Mexican nationals is also poorly documented in Mexico. Policy-makers and researchers

will have to continue relying on ad hoc surveys to answer the most pressing questions on international migration and Mexico.

Gibson, C., and E. Lennon. 1999. *Historical Census Statistics on the Foreign-Born Population of the United States: 1850 to 1990*. Population Division Working Paper No. 29. Washington, DC: U. S. Bureau of the Census. A comprehensive guide to information on the foreign-born in the US censuses taken from 1850 to 1900.

Glick, J., F. Bean, and J. Van Hook. "Immigration and changing patterns of extended family household structure in the United States: 1970-1990." *Journal of Marriage and the Family* 59 (1): 177-191. The long-term downward trend in the percentage of extended family households in the U.S. came to a halt during the 1980s, a change that coincided with a growing gap between immigrants and natives in the percentages of households adopting extended family structures. Using 1970, 1980, and 1990 census data, this research finds that immigration explains only a little of the total increase, but that the increasing differential between immigrants and natives during the 1980s resulted from increases in horizontally extended households among immigrants.

Global Commission on International Migration. 2005. *Migration in an Interconnected World: New Directions for Actions*. Geneva, Switzerland: Global Commission on International Migration (Available online, <http://www.gcim.org/en/finalreport.html> , last accessed April 2008). A broad report on international trends in migration.

Goering, J. 1991. The Causes of Unauthorized Migration to the United States: A Research Note." pp. 189-213 in S. Weintraub (Ed.) *Immigration and Development*. Westport, CT; Greenwood Press. This paper examines unauthorized migration to the US from the Western Hemisphere, principally Mexico, in 1975 and 1980 n. The author concludes that deterioration in economic conditions produce higher levels of unauthorized entry.

Goering, L. 1989. "The 'Explosiveness' of Chain Migration: Research and Policy Issues." *International Migration Review* 23 (Winter): 797-813. This is an introduction to Volume 23, Number 4, of the *International Migration Review*, which focuses on the legislative and social science interface concerning the complex issue of whether the current system of United States legal immigration is promoting or facilitating an 'explosive' multiplication of immigrants. The purpose of this collection of articles is to present the most current evidence and policy analyses of the size and composition of the immigration 'multiplier.'

Gozdziak, E., and S. Martin (Eds.). 2005. *Beyond the Gateway: Immigrants in a Changing America*. New York, NY: Lexington Books. This book assesses the ways that immigration into new U.S. destinations has reshaped rural, urban, and suburban landscapes. The aim is to recognize practices that receiving communities and immigrant groups had developed to work together more effectively.

Greenwood, M., J. McDowell, and E. Trabka. 1991. "Conducting descriptive and analytical research with the Immigration and Naturalization Service Public Use Tapes." *Journal of Economic and Social Measurement* 17:131-153. This paper discusses the INS Public Use Microdata files and provides a detailed description of the information available on them, an account of the frequency and severity of certain flaws in the data, and a discussion of possible methods for correcting these flaws. The paper also discusses a number of strengths and weaknesses]of the data for descriptive and analytical research, and it provides several suggestions for research projects that could be carried out with the INS PUMS data.

Grieco, E. 2003. "Census 2010 and the Foreign Born: Averting the Data Crisis." *Migration Policy Institute Policy Brief* 1 (February): 1-11. The author argues that at a time when the need for high-quality data on the foreign born is at its highest, the likelihood that the available census and survey data will continue to exist is at its lowest. She provides a summary of a 2002 meeting on issues related to the decennial census and federal surveys related to international migration and the foreign-born and provides four major recommendations: (1) full and continuous funding for the ACS; (2) adding key questions to the ACS, CPS, and decennial census; (3) making changes to the CPS and SIPP to improve the analytical value of data available for studying the immigrant population; and (4) the establishment within the US Census Bureau of a department to focus solely on migration statistics.

Haines, D., and K. Rosenblum (Eds). 1999. *Illegal Immigration in America: A Reference Handbook*. Westport, CT: Greenwood Press. This book provides a comprehensive review up to its date of publication, 1999. It covers illegal immigrants from Mexican border crossers to Central American refugees, illegal Europeans, and smuggled Chinese. The book is divided into four parts: Concepts, Policies, and Numbers; The Migrants and Their Work; The Responses; and Illegal Immigration in Perspective.

Hansen, K., and A. Bachu. 1995. "The Foreign-Born Population: 1994." *Current Population Reports P20-486*. Washington, DC: U. S. Census Bureau. This is a descriptive report using data from The Current Population Survey's initial collection of data on nativity in 1994. The foreign-born population in this report includes some unauthorized immigrants, refugees, and temporary residents such as students and temporary workers as well as the legally admitted.

Hanson, V. 2003. *Mexifornia: A State of Becoming*. New York, NY: Encounter Books. The author sees a huge problem looming with lack of assimilation. He proposes four solutions: (1) continuing De facto open borders but insisting on rapid acculturation; (2) patrolling the border effectively and reducing legal immigration; (3) imposing "sweeping restrictions on immigration" and ending Mexican chauvinism in the U.S.; and (4) allowing present policies to make California increasingly mirror an unreformed Mexico.

Hatton, T., and J Williamson. 1998. *The Age of Mass Migration: Causes and Economic Impact*. Oxford, UK : Oxford University Press. This book provides an economic –based

analysis of the migration from Europe to the Western Hemisphere in the 19th and 20th centuries.

Heer, D. 1996. *Immigration in America's Future: Social Science Findings and the Policy Debate*. Boulder, CO: Westview Press. This study reviews current data and trends in immigration in the United States. It attempts to demonstrate how social science findings can help the informed citizen make rational choices about future immigration legislation designed to influence those trends. The book concludes with some proposals for changes in immigration laws.

Hull, D. 2007. "Introduction: How Many Foreign Nationals Actually Live in the U. S. Illegally?" *The Social Contract* (4): 212-215. (available online, http://www.thesocialcontract.com/artman2/publish/tsc_17_4/index.shtml , last accessed April 2008). This article serves as an introduction to the summer 2007 issue of *The Social Contract* by stating the author's belief that official U.S. Census Bureau estimates of the number of illegal aliens living in the U.S. is low. In the special issue are articles that contradict official estimates of illegal aliens using various methodologies and data.

International Organization for Migration. 2006. "World Migration 2005: Costs and Benefits of International Migration." *Volume 3 IOM World Migration Report Series*. Geneva, Switzerland: International Organization for Migration. (available online, <http://www.iom.int/jahia/cache/bypass.pid/8?entryId=932> , last accessed April 2008). This volume analyzes the effects of globalization, trade liberalization, economic integration and the widening gap between rich and poor nations on migration flows. It attempts to identify key issues facing policy makers in migrant origin, destination, and transit countries.

Jasso, G., and M. Rosenzweig. 1990. *The New Chosen People: Immigrants in the United States*. New York City, NY: Russell Sage Foundation. This study is one in a series presenting analyses of data from the 1980 census. Its focus is on the foreign-born population resident in the United States in the last two decades, 1960-1980 and compares this group with: (1) the foreign-born population in 1900 and 1910; and (2); and with the native-born population in both time periods.

Jasso, G., and M. Rosenzweig. 1987. "Using National Recording Systems for the Measurement and Analysis of Immigration to the United States." *International Migration Review* 21 (4): 1212-1244. This article discusses the kinds of data required to increase scientific knowledge about US immigration and, in light of those requirements, assesses the principal currently available data sets and makes recommendations for improving the data environment. The authors propose both a new data-collection effort and a set of enhancements to existing data sources.

Jennissen, R. 2007. "Causality Chains in the International Migration Systems Approach." *Population Research and Policy Review* 26 (4): 411-426. This article aims to be a first attempt to construct a theoretical framework for the study of international migration and to incorporate causalities in the international migration systems approach. The causalities

in this framework are derived from different international migration theories. The various positions of these whole theories within the framework are shown as causality chains.

Kraly, E. 1998. "Emigration: Implications for U. S. Immigration Policy Research." pp. 587-618 in *Migration Between Mexico and the United States: Binational Study, Vol. 2 Research Reports and Background Materials*. Mexican Ministry of Foreign Affairs and the U. S. Commission on Immigration Reform: Mexico City and Washington, DC. This paper considers emigration as an immigration policy issue for the United States. The general argument is that national immigration policy would be more effectively conceptualized, crafted and implemented with a better understanding of the dynamics of emigration among international migrants coming to the United States.

Kraly, E., and K. Gnanasekaran. 1987. "Efforts to Improve International Migration Statistics: A Historical Perspective." *International Migration Review* 21 (4): 967-995. This article surveys the history of official initiatives to standardize international migration statistics by reviewing the recommendations of the International Statistical Institute, International Labor Organization, and the UN, and reports a recently proposed agenda for moving toward comparability among national statistical systems. It concludes that a three-pronged approach is needed from the international statistical community for this purpose.

Kritz, M. 1987. "International Migration Policies: Conceptual Problems." *International Migration Review* 21 (4): 947-964. The author reviews national concepts and policies of migration and examines how nation-states approach migration and how they define who is a migrant. The author also argues that the concepts employed by countries in their immigration policies frequently do not correspond to the reality, making it necessary to examine the actual context.

Kritz, M., L. Lim, and H. Zlotnik (Eds.) 1992. *International Migration Systems: A Global Approach*. Oxford, England: Clarendon Press. This book contains a selection of 18 papers, 15 of which were presented at a seminar entitled International Migration Systems, Processes, and Policies, which was held in Malaysia, in September, 1988 and organized by the IUSSP's Committee on International Migration in collaboration with the University of Malaya. This book is aimed at understanding of how international migration is changing in today's world and why it is important to look jointly at sending and receiving countries and comparatively across migration systems.

Larsen, L. 2004. "The Foreign-Born Population in the United States: 2003." *Current Population Reports P20-555*. Washington, DC: U. S. Census Bureau. Using data from the 2003 social and economic supplement to the Current Population Survey, this research brief provides a profile of demographic and socioeconomic characteristics of the foreign-born US population and compares these characteristics to those of the native born population. It also discusses the variation in these characteristics among the foreign-born.

Le May, M. 1987. *From Open Door to Dutch Door: An Analysis of U. S. Immigration Policy Since 1820*. New York City, NY: Praeger. This book discusses the forces that

have shaped United States immigration policy as well as its changes and where it is headed in the future. The author presents a historical overview of U.S. immigration policy, and examines both the reasons behind each major change in policy and the impact of each change on the composition of the immigrant population. Particular attention is given to four major factors: economics, race, nationalism, and foreign policy.

Levine, D., K. Hill, and R. Warren (Eds.). 1985. *Immigration Statistics: A Story of Neglect*. Washington, DC: National Academy Press. This is the report of the National Research Council's Panel on Immigration Statistics established in 1982. The main purpose of this report is to specify the data requirements and to recommend the practical steps that must be taken to place future debate about immigrant populations on a solid base of statistical information. The report includes a historical review of U.S. immigration policy, an analysis of the INS, a review of other official government sources of data on immigration, a review of nongovernmental sources of data, a discussion of data on refugees, an assessment of the costs and benefits of improving the statistical system, and the Panel's main recommendations.

Lindstrom, D. 1996. "Economic Opportunity in Mexico and Return Migration from the United States." *Demography* 33 (3): 357-74. This study estimates the hazard of return on first and last trip to the US using exponential, Weibull, Gompertz, and Box-Cox hazard models, with and without unobserved heterogeneity. Data were obtained from Durand and Massey on all sons born between 1954 and 1973 who traveled to the US between 1970 and 1991 from sample rural communities in Jalisco, Michoacan, Guanajuato, and Nayarit states in Mexico. Economic conditions in the communities were obtained from 1970, 1980, and 1990 Mexican census data. The results suggest that there were factors other than economic conditions of the place of origin that affected the hazard rate.

Loeza T., E., C. Planck, A. Remedios Gómez, S. Martin, B. L. Lowell, and D. Meyers (editors), with contributions by F. D. Bean, R. Corona, R Tuirán, K. Woodrow-Lafield, J. Bustamante, G. Jasso, J. E. Taylor, P. Trigueros, A. Escobar Latapí, P. Martin, K. Donato, G. Lopez Castro, M. Tienda, G. Verduzco, M. Greenwood, K. Unger, F. Alba, S. Weintraub, R. Fernández de Castro, M. García y Griego. 1997. *Binational Study on Migration between Mexico and the United States*. Washington, DC: U. S. Commission on Immigration Reform (and, in Spanish, Mexico, DF: Mexican Ministry of Foreign Affairs). (Available online, <http://www.utexas.edu/lbj/uscir/binpap-v.html>, last accessed, April 2008). Three volumes of this study cover five subject areas: quantification of migration; characteristics of migrants; factors that influence migration; effects of migration; and responses to migration.

Lollock, L. 2001. "The Foreign-Born Population in the United States: March 2000." *Current Population Reports, P20-534*. Washington, DC: U.S. Census Bureau. Using data from the March, 2000 collection of the Current Population Survey, this research brief provides a profile of demographic and socioeconomic characteristics of the foreign-born US population and compares these characteristics with the native population. It also discusses the variation in these characteristics among the foreign-born.

Malone, N., K. Beluja, J. Costanzo, and C. Davis. 2003. "The Foreign Born Population: 2000." *Census 2000 Brief*. Washington, DC: U. S. Census Bureau. This report, part of a series that presents population and housing data collected by Census 2000, describes the distribution of the foreign born population in the United States, regions, states, counties, and places with populations of 100,000 or more.

Mañin, G., and B. Mañin. 1991. *Research with Hispanic Populations*. Newbury Park, CA: Sage Publications. This book is aimed at providing insights into the issues, problems, difficulties, and realities of conducting market or consumer research with Hispanic populations. The authors explore ways to overcome the problems researchers may encounter in collecting and interpreting data generated from Hispanic studies and discuss translation issues, culturally appropriate research procedures, the measurement of moderating variables such as acculturation, language preference, and generation.

Martin, P. 1994. "Comparative Migration Policies." *International Migration Review* 28 (1): 164-170. This paper summarizes a conference that discussed migration policies in effect for France, Italy, Great Britain, and Germany.

Martin, P. 1993. *Trade and Migration: NAFTA and Agriculture*. Washington, DC: Institute for International Economics. This study examined the effect of the North American Free Trade Agreement (NAFTA) on Mexican migration to the United States. The author estimates that NAFTA will increase migration by as many as 100,000 persons annually. He argues that NAFTA will prevent even more migration over the longer term by stimulating economic growth and job creation within Mexico and proposes a variety of ways in which the federal government should assist state and local governments that will be affected by increased immigration.

Martin, P. and E. Midgley. 1999. "Immigration to the United States." *Population Bulletin* 54 (2). Washington, DC: Population Reference Bureau. The authors identify three reasons why immigration became a subject of debate in the 1990s: (1) the number of immigrants is rising from its low point in the 1940s; (2) today's immigrants differ significantly in ethnicity, education and skills from native-born Americans; and (3) no political consensus exists on whether immigrants are assets or liabilities to U.S. society.

Martin, P. and J. Widgren. 2002. "International Migration: Facing the Challenge." *Population Bulletin* 57 (1). Washington, DC: Population Reference Bureau. This report explains the reasons for international migration, covers the controversy of such migration, and suggests how migration can be managed more effectively in the 21st century. It also includes statistics on migration in selected countries and regions.

Martin, P., and J. Widgren. 1996. "International Migration: A Global Challenge." *Population Bulletin* 51 (1). Washington, DC: Population Reference Bureau. Trends in international migration are presented in this multiregional analysis and external and internal are identified for countries. This report also presents some ways that countries can manage migration or reduce the pressures which force people to migrate. The authors

suggest that sustained reductions in migration pressure are a better alternative than the quick fixes that may invite the very much feared mass and unpredictable movements.

Massey, D. 2007. "Understanding America's Immigration Crisis." *Proceedings of the American Philosophical Society* 151 (3): 309-327. The author points out that NAFTA has a fundamental inconsistency in attempting to control the flow of labor across the US border while allowing goods and money to flow much more freely. He argues that the 'crises' is largely manufactured by government agencies and the media and provides recommendations for ameliorating this 'crisis.'

Massey, D. 2005. *Backfire at the Border: Why Enforcement without Legalization Cannot Stop Illegal Immigration*. Washington DC: The Cato Institute. The author argues that America's immigration and border policies have backfired and increased the increase in the unauthorized US population. He argues that labor and people should be allowed to flow more freely across national borders among the NAFTA countries.

Massey, D. 2004. "Social and Economic Aspects of Immigration." *Annals of the New York Academy of Science* 1038 (December): 206–212. The author argues that every developed country in the world today has become De facto a "country of immigration" and that as a result of the contradictions of U.S. policy during the 1990s, what used to be a circular flow of able-bodied male workers has been transformed into a permanent migrant migration of families, which will have profound effects on American society for years to come.

Massey, D. 1999. "Why Does Immigration Occur? A Theoretical Synthesis." pp. 34-52 in C. Hirschman, P. Kasinitz, and J. DeWind (Eds). *The Handbook of International Migration: The American Experience*. New York, NY: Russell Sage Foundation. The author discusses and unifies different migration theories.

Massey, D., and J. Durand. (Eds.) 2004. *Crossing the Border: Research from the Mexican Migration Project*. New York City, NY: Russell Sage Foundation. Using data from the Mexican Migration Projects, authors of chapters in this book identify the people that migrate to the United States from Mexico and why they come. They also examine the effectiveness of U.S. migration policy in meeting its objectives.

Massey, D., and K. Espinosa. 1997. "What's Driving Mexico-U. S. Migration? A Theoretical, Empirical, and Policy Analysis." *American Journal of Sociology* 102 (4): 939-999. Using data gathered in 25 Mexican communities, the authors link individual acts of migration to 41 theoretically defined individual, household, community, and macroeconomic-level predictors. The indicators vary through time to yield a discrete-time event-history analysis. The authors find that Mexico-U.S. migration stems from three mutually reinforcing processes: social capital formation, human capital formation, and market consolidation.

Massey, D., J. Durand, and N. Malone. 2002. *Beyond Smoke and Mirrors: Mexican Immigration in an Era of Economic Integration*. Russell Sage Foundation: New York.

This book provides an essential "user's manual" for readers seeking a historical, theoretical, and substantive understanding of how U.S. policy on Mexican immigration evolved to its current state. It offers suggestions on how to change US immigration policies.

Massey, D., and E. Parrado. 1998. "International Migration and Business Formation in Mexico." *Social Science Quarterly* 79 (1): 1-20. The impact of international migration on economic development in the country of origin is examined with data on 30 Mexican communities and U.S. destination areas using event history analysis. The results indicate that the receipt of U.S. earnings by households and communities significantly increases the odds of business formation and productive investment.

Massey, D., and E. Parrado. 1994. "Migradollars: The Remittances and Savings of Mexican Migrants to the USA." *Population Research and Policy Review* 13 (1) 3-30. Using data from 22 communities, the authors estimate that US\$ 24 million in migradollars flowed into the sample communities during the survey year. They estimate that the total flow is US\$ 2 billion for Mexico as a whole and conclude that migradollars play an extremely important role in Mexican economic production.

Massey, D., and J. Taylor. 2004. *International Migration: Prospects and Policies in a Global Market*. Oxford, UK: Oxford University Press. This study offers a comprehensive survey of global patterns of international migration and the policies employed to manage the flows. It argues that international migration is rooted in the expansion and consolidation of global markets. The insertion of non-market societies into global networks of trade unleashes structural transformations that displace people to create migrants.

Massey, D., J. Arango, G. Hugo, A. Koucouci, A. Pellegrino, and J. Taylor. 1998. *Worlds in Motion: Understanding International Migration at the End of the Millenium*. Oxford, UK: Oxford Univ. Press. This book is aimed at creating a comprehensive theory of international migration. Various theories are tested by applying them to the relationship between international migration and economic development. The book concludes by offering an empirically-grounded theoretical synthesis.

Massey, D., R. Alarcón, J. Durand, and H. González. 1987. *Return to Aztlan: The Social Process of International Migration from Western Mexico*. Berkeley, CA: University of California Press. This book analyzes the social process of international migration through an intensive study of four carefully chosen Mexican communities. It combines historical, anthropological, and survey data to construct a comprehensive picture of the social dynamics of contemporary Mexican migration to the United States.

Massey, D., D. Arango, G. Hugo, A. Kouaouci, A. Pellegrino, and J. Taylor. 1993. "Theories of International Migration: A review and Appraisal." *Population and Development Review* 19 (3): 431-465. The aim of this paper was the generation and integration of current theories that clarify basic assumptions and hypotheses of the

various models. Theories were differentiated as explaining the initiation of migration and the perpetuation of international movement.

McCarthy, K. 1983. *Interdependence in the U.S.-Mexican Borderlands: an Irresistible Dynamic or Fragmented Reality?* Santa Monica, CA: RAND. This paper reexamines the phenomenon of borderlands interdependence in an attempt to distinguish the rhetoric from the reality. Focusing on the exchange relationships (socio-cultural, economic, and political) that promote interdependence as well as the characteristics and motives of the parties to the exchange, it reviews the current situation in the borderlands and considers longer-range trends and their implications both for the border and for the wider range of bilateral U.S. and Mexican relations.

McCarthy, K., and R. Valdez. 1986. *Current and Future Effects of Mexican Immigration in California*. Santa Monica, CA: RAND. The authors constructed a demographic profile of the immigrants, examined their economic effects on the state, and described their socioeconomic integration into California society. They developed models of both the immigration and integration processes, and then used the models to project future immigration flows. The report's major conclusion is that the widespread concerns about Mexican immigration are generally unfounded.

Mulder, T., F. Hollmann, L. Lollock, R. Cassidy, J. Costanzo and J. Baker. 2001. "U.S. Census Bureau Measurement of Net International Migration to the United States: 1990 to 2000." *Population Division Working Paper # 51*. Washington, DC: U.S. Bureau of the Census (Available online, <http://www.census.gov/population/www/documentation/twps0051.html> , last accessed, January, 2008). This paper provides a detailed discussion of the definitions, methodologies, assumptions, and data sources used to measure net international migration for purposes of producing annual population estimates. It includes a brief description of estimates for geography and demographic characteristics. Following the discussion of the sub-components of net international migration, the strengths and limitations of each are presented along with potential research and developments.

Murdock, S. 2006. "The Potential Effects of Legal and Unauthorized International Migration on the Census and other Data sources in the United States: Methodological and Policy Issues in 2010 and Beyond." *Journal of Economic and Social Measurement* 31 (3-4): 207-220. The focus in this article is on how the accurate measurement of international migration may affect the accuracy and utility of the 2010 Census and other data sources and on what steps might be taken to minimize such effects. The paper concludes with recommendations for addressing the effects of inaccurate measurement.

Passel, J., R. Clark, and M. Fix. 1997. "Naturalization and Other Current Issues in U.S. Immigration: Intersections of Data and Policy," by Jeffrey S. Passel, Rebecca L. Clark, and Michael Fix. pp. 1-10 in *Proceedings of the Social Statistics Section, American Statistical Association*. Alexandria, VA: American Statistical Association. This hard-to-locate item is a rare look at the quantitative evidence of misreporting of citizenship.

Portes, A. 1997. "Immigration Theory for a New Century: Some Problems and Opportunities." *International Migration Review* 31 (4): 799-825. This paper examines some of the pitfalls in contemporary immigration theory and reviews some of the most promising developments in research in this field. Misunderstandings about the meaning and scope of scientific theorizing in this field of research are discussed.

Portes, A., and R. Rumbaut. 1990. *Immigrant America: A Portrait*. Berkeley, CA: University of California Press. The authors present an overall picture of immigration in the United States. The first chapter describes migrant characteristics and countries of origin. The following chapters explore points of destination, patterns of settlement, and the formation and function of new ethnic communities in urban areas; the incorporation of immigrants in the U.S. economy; immigrant politics; psychological aspects of immigration; the learning of English; and the origins of illegal immigrants.

Redstone, I., and D. Massey. 2004. "Coming to Stay: An Analysis of the U. S. Census Question on Immigrants' Year of Arrival." *Demography* 41 (4): 721-738. Using the New Immigrant Survey Pilot, the authors compare answers to the census question on year of arrival in the United States with answers to questions about the dates and durations of earlier U.S. trips. They find that the year identified by the census does not correspond to the year of either the first or the last U.S. trip.

Reichert, J., and D. Massey. 1979. "Patterns of U.S. Migration from a Mexican Sending Community: A Comparison of Legal and Illegal Migrants." *International Migration Review* 13 (4): 599-623. This paper analyzes differences between legal and illegal Mexican migration to the United States as reflected by the migrant population of a rural, mestizo town in Michoacán, Mexico, in which 75 percent of families send migrants north on a periodic basis. Compared to illegal migrants, it was found that legal migrants, or holders of U.S. resident visas, tended to migrate in larger groups and were much more likely to be accompanied by wives, children, and non-working dependents. The average period of time spent away from home by legal migrants each year also tended to be significantly less than that of illegal migrants. Finally, legal migrants demonstrated far greater mobility while in the United States than illegal migrants, both in terms of distances traveled and frequency of movement.

Rolph, E. 1992. *Immigration Policies: Legacy from the 1980s and Issues for the 1990s*. Santa Monica, CA: RAND. This report focuses on the policy instruments that have shaped and will shape the size and composition of immigration flows. It outlines the context for the unprecedented amount of immigration legislation enacted during the 1980s; documents the material provisions of three major immigration statutes (the Refugee Act of 1980, the Immigration Reform and Control Act of 1986, and the Immigration Act of 1990); describes the immediate effects of the statutes on the characteristics of immigrant flows; and examines the implications of these consequences.

Samora, J. 1971. *Los Mojados: The Wetback Story*. West Bend, IN: University of Notre Dame Press. An examination of the process of illegal migration, its origins and consequences for the U.S. It includes personal accounts.

Simmons, A. 1987. "The United Nations Recommendations and Data Efforts: International Migration Statistics." *International Migration Review* 21 (4): Special Issue: 996-1016. This article reviews the UN's efforts to improve international migration statistics. It described the challenges faced by the UN, the direction in which this effort is going, gaps in the current approach, and priorities for future action. It finds that the content of the UN recommendations has changed in the past and seems to be moving toward further changes, which are correlated with shifts in the overall context of world social-economic affairs and related transformations in international travel and migration patterns.

Simpson, A. 1984. "The Politics of Immigration Reform." *International Migration Review* 18 (3): 486-504. This paper discusses the politics of the "Simpson-Mazzoli" Immigration Reform and Control Act, previous immigration legislation, current counterproposals for US immigration policy, and the political realities of immigration reform.

Simon, J. 1984. "Nine Myths About Immigration." *Backgrounder* #326: The Heritage Foundation. (Available online, http://209.85.173.104/search?q=cache:FQFJ2wUH3_0J:www.heritage.org/Research/Religion/bg326.cfm+immigrants+%22Howard+Goldberg%22&hl=en&ct=clnk&cd=8&gl=us, last accessed March 2008). In the context of the consideration of the Simpson-Mazzoli bill to reform immigration laws, the author observes that much of the discussion is driven by myths. He attempts to dispel these myths by citing research.

Smith, J., and B. Edmonston (Eds.). 1998. *The Immigration Debate: Studies on the Economic, Demographic and Fiscal Effects of Immigration*. Washington, DC: National Academy Press. Most of the papers in this monograph were commissioned by the National Research Council's expert panel on immigration. The book is aimed at addressing the effect of immigration on (1) the future size and composition of the U.S. population, (2) the U.S. economy and its workers, and (3) the fiscal balances of federal, state, and local governments.

Smith, J., and B. Edmonston (Eds.). 1997. *The New Americans: Economic, Demographic, and Fiscal Effects of Immigration*. Washington, DC: National Academy Press. This report by the National Research Council's Panel on the Demographic and Economic Impacts of Immigration examines three issues: (1) the influence of immigration on the overall economy, especially national and regional labor markets; (2) the overall effects of immigration on federal, state, and local government budgets; and (3) the effects of immigration on the future size and makeup of the nation's population over the next 50 years? Also included is background information on immigration policies and practices and data on where immigrants come from, what they do in America, and how they will change the nation's social fabric in the decades to come.

Stark, O., and J. Taylor. 1989. "Relative Deprivation and International Migration." *Demography* 26:1-14. Both a theoretical basis and empirical evidence are presented to support that international migration decisions are influenced by relative and absolute income considerations. Data from a recent survey of rural Mexican households was used to explore empirically the roles of absolute income and relative deprivation in explaining Mexico to US migration. The study finds that relative deprivation plays a significant role in Mexico to US migration decisions.

Tanton, J., D. McCormack D, and J. Smith. (Eds.) 1996. *Immigration and the Social Contract: the Implosion of Western Societies*. Brookfield, VT: Avebury. The focus of the collection is on the question of whether the United States can continue as a viable and humane society in the face of large-scale and relatively uncontrolled immigration particularly of those who are poor, uneducated, and unskilled. The editors suggest that contemporary U.S. governments have failed to uphold Article IV, Section 4 of the Constitution, which guarantees to individual states protection against invasion and domestic violence.

Todaro, M. 1969. "A Model of Labor Migration and Urban Unemployment in Less-developed Countries." *The American Economic Review* 59:138-148. A probabilistic approach is incorporated into a model of the determinants of urban labor demand and supply in order to estimate the equilibrium proportion of the urban labor force that is not absorbed by the modern industrial economy. The author argues that it provides an explanation of the effects of industrial expansion, productivity growth, urban-rural income differentials on the size and rate of increase in labor migration.

Todaro, M., and L. Maruszko, L. 1987. "Illegal migration and US Immigration Reform: A conceptual framework." *Population and Development Review* 13(1): 101-114. This paper presents a conceptual framework for analyzing international illegal migration from developing countries that postulates that the decision to migrate is some function of the expected income differential between the home and destination countries. The model implies that illegal migration responds to a variety of economic and noneconomic variables that are either negligible or nonexistent in an analysis of internal domestic and legal international migration. The model is used to evaluate the impact of the 1986 Simpson-Rodino Immigration Reform and Control Act designed to curb the inflow of illegal migrants through the imposition of employer penalties and increased border apprehension. The evaluation finds defects in the Act.

United Nations. 2005. *Trends in Total Migrant Stock: the 2005 Revision*. New York, NY: Population Division, Department of Economic and Social Affairs, United Nations. This report describes trends in migration. One finding is that between 1960 and 2005 the number of international migrants in the world more than doubled, passing from an estimated 75 million in 1960 to almost 191 million in 2005, an increase of 121 million over 45 years.

United Nations Population Fund. 2005. *International Migration and The Millennium Development Goals: Selected Papers of the UNFPA Expert Group Meeting, Marrakech, Morocco*, May 11-12. New York, NY: United Nations Population Fund. The report is a compilation of selected papers presented at the meeting together with a synopsis of the discussion highlighting some of the more salient points raised by the experts. It also reflects an attempt to spur the debate further by suggesting possibilities for programmatic activities in the areas of data and research, policy and capacity development.

U. S. Commission for the Study of International Migration and Cooperative Economic Development. 1990. *Unauthorized Migration: An Economic Development Response*. Washington, DC: U. S. Commission for the Study of International Migration and Cooperative Economic Development. This is the report of a commission established by the U.S. Congress in the Immigration Reform Control Act of 1986 to examine the conditions in countries that contribute to unauthorized immigration to the United States and to explore mutually beneficial, reciprocal trade and investment programs to alleviate such conditions. The report includes a number of recommendations that are designed to reduce the pressures in countries of origin for unauthorized immigration to the United States, primarily involving the expansion of trade between those countries and the United States. The emphasis is on assessing the impact on unauthorized immigration of any trade or development policy under consideration.

U. S. GAO. 2008. *Visa Waiver Program: Limitations with Department of Homeland Security's Plan to Verify Departure of Foreign Nationals*. GAO-08-458T. Washington, DC: United States General Accountability Office. This study is based on a review of relevant legislation, regulations and agency operating procedures, and prior GAO reports on the Visa Waiver Program and immigrant and visitor entry and exit tracking systems, as well as on discussions with federal agency officials. It finds flaws in the U. S. Department of Homeland Security's program to verify departures of foreign nationals.

U. S. GAO. 2007. *Immigration Benefits: Additional Efforts Needed to Help Ensure Alien Files Are Located when Needed*. GAO-07-85. Washington, DC:

United States General Accountability Office. To document the interactions of aliens with the Department of Homeland Security's (DHS) United States Citizenship and Immigration Services (USCIS) and other government entities, USCIS creates alien files. GAO found that of the naturalization applications adjudicated in 2005, about 30,000--or about 4 percent of them-- may have been adjudicated without alien files.

U. S. GAO. 2006. *Social Security Administration: Procedures for Issuing Numbers and benefits to the Foreign-Born*. GAO-06-253T. Washington, DC: United States General Accountability Office. In responding to a request to describe how the Social Security Administration determines who is eligible for a social security number and who is eligible for Social Security benefits, GAO found weaknesses in how numbers are assigned and issued and recommended that computer matches with foreign countries to avoid making payments to ineligible individuals.

U. S. GAO. 2006. *Illegal Immigration: Border-Crossing Deaths Have Doubled Since 1995; Border Patrol's Efforts to Prevent Deaths Have Not Been Fully Evaluated*. GAO-06-770. Washington, DC: United States General Accountability Office. The Border Patrol implemented the Border Safety Initiative (BSI) in 1998 with the intention of reducing injuries and preventing deaths among migrants that attempt to cross the border illegally. GAO assessed: (1) Trends in the numbers, locations, causes, and characteristics of border-crossing deaths. (2) Differences among the Border Patrol sectors in implementing the BSI methodology. (3) The extent to which existing data allow for an evaluation of the effectiveness of the BSI and other efforts to prevent border-crossing deaths.

U. S. GAO. 2005. *Taxpayer Information: Options Exist to Enable Data Sharing Between IRS and USCIS but Each Presents Challenges*. GAO-06-100. Washington, DC: United States General Accountability Office. GAO assessed data sharing in regard to (1) tax compliance if businesses applying to sponsor immigrant workers are required to meet tax filing and payment requirements, and (2) the accuracy and timeliness of USCIS's immigration eligibility decisions if it obtained tax data from IRS to help ensure business sponsors meet eligibility criteria. In general, the more that data sharing could be done electronically, the more efficient the data sharing could be. However, achieving electronic data sharing may take longer than paper-based processes due to legal, technological, and cost challenges.

U. S. GAO. 1998. *Immigration Statistics: Information Gaps, Quality Issues Limit Utility of Federal Data to Policymakers*. GAO/GGD-98-164. Washington, D.C.: United States Government Accounting Office. This report identifies: (1) policy-related information needs for immigration statistics; (2) federal statistics (and information gaps) on the full range of demographic concepts relevant to immigration policy decisions

and determines what is known about the quality of these statistics; and (3) strategies for improving immigration statistics.

Valdez, R., K. McCarthy, and C. Moreno. 1987. *An Annotated Bibliography of Sources on Mexican Immigration*. Santa Monica, CA: RAND. This brief essay plus bibliography reviews the literature on Mexican immigrants, their economic and social effects on California, the assimilation of their children into California society, and possible future levels of immigration. This note lists the information consulted and highlights the principal issues raised in that literature and the major questions that remain to be answered.

Vernez, G., and K. McCarthy. 1996. *The Costs of Immigration to Taxpayers: Analytical and Policy Issues*. Santa Monica, CA: RAND. This report reviews the estimates of the net fiscal costs of immigration made by several recent and well publicized studies--at the national, state, and local levels. It examines the differences among these estimates and makes suggestions about what should be done to develop more credible estimates.

Waldinger, R. (Ed.) 2001. *Strangers at the Gates: New Immigrants in Urban America*. Berkeley: University of California Press. This book stresses two themes: (1) the importance of understanding that immigration today is fundamentally urban; and (2) the equally important fact that immigrants are now flocking to places where low-skilled workers--regardless of ethnic background--are in particular trouble. The book points out strengths and weaknesses in the sociological and economic approaches to understanding immigration.

Waldorf, B. 1996. "The Internal Dynamic of International Migration Systems." *Environment and Planning A* 28 (4): 631-650. This paper provides a conceptualization of international migration networks that can be used both to identify and integrate the internal components of migration systems, and formalize the relationships in an analytic model of the internal network dynamic. Empirical results suggest that as a migration system matures, network variables have an increasing impact on the attraction of immigrants, while the impact of economic factors declines.

Walsh, J. 2007. "Illegal Aliens: Counting the Uncountable." *The Social Contract* (4): 216-223. (Available online, http://www.thesocialcontract.com/artman2/publish/tsc_17_4/index.shtml , last accessed April 2008). The author argues that all existing estimates of the unauthorized are too low, whether done by the Census Bureau and by national surveys, governmental agencies, non-government statistics-keeping agencies, philanthropic organizations, religious charities, and immigrant advocates. The author states that the number is closer 40 million rather than 7 to 20 million.

Wasem, R. 2004. "Unauthorized Aliens in the United States: Estimates Since 1986." Congressional Research Service, Order Code No. RS21938, September 14. Washington, DC: U. S. Congressional Research Service. Estimates derived from the March Supplement of the Current Population Survey indicate that the unauthorized resident

alien population has risen from 3.2 million in 1986 to 9.3 million in 2002. The study concludes that a constellation of factors have contributed to the increase in unauthorized resident aliens, including the “push-pull” of a prosperous economy, the inadvertent consequence of border enforcement policies that have curbed the fluid movement of migrant workers, and the backlogs in processing immigrant petitions.

White, M., F. Bean, and T. Espenshade. 1990. “The US 1986 Immigration Reform and Control Act and unauthorized migration to the United States.” *Population Research and Policy Review* 9 (2): 93-116. Analyzing a monthly time series of Border Patrol apprehensions from January 1977 to September 1988 within the context of a multivariate statistical model, the authors find that INS resources, Mexican population growth, comparative economic conditions on both sides of the border, and seasonal factors related to the agricultural planting and harvesting cycle are all determinants of border apprehensions and, by implication, of the flow of unauthorized migrants to the United States.

Woodrow-Lafield, K. 2008. “Dimensions of Net Unauthorized Migration over Three Decades.” Paper presented at the annual meeting of the Population Association of America. New Orleans, LA. April 17th. The paper discusses the uncertainties in methods used to estimate the foreign born and the unauthorized in the U.S. and finds that component-based estimates for net legal migration are vulnerable to biases on period of arrival, inclusion of residents not yet adjusted, and accounting for return migration. These errors and any inadequacies of the foreign-born estimate affect accuracy of unauthorized migration estimates as residuals, particularly with more detailed characteristics. The paper recommends new strategies for making these estimates along with expanded data collection.

Word, D. 1992. “The Census Bureau Approach For Allocating International Migration to States, Counties, and Places: 1981-1991.” *Population Division Working Paper No. 1*. Washington, DC: U.S. Census Bureau. This paper describes the formulas, procedures, and assumptions used to allocate international migration for purposes of population estimates. It also covers definitions and terms associated with immigration.

Zlotnik, H. 1987. “Introduction: Measuring International Migration: Theory and Practice.” *International Migration Review* 21 (4): v-xii. This paper introduces the special issue of this journal that is focused on the area of migration research concerned with the measurement and quantification of the phenomenon.

Zlotnik, H. 1987. “Workshop on International Migration Data: Their Problems and Use.” *International Migration Review* 21 (4): 1541-1550. This paper summarizes the outcome of the workshop, which consisted of five sessions focused on, respectively: (1) defining international migration and the influence of national migration policies on data collection systems; (2) efforts by organizations and countries to share information and increase the comparability of available data; (3) the description and assessment of national recording systems as sources of information on international migrants; (4) the development of

methodology to measure or study migration; and (5) a general discussion of the data needs identified and their implications for data collection.

BIBLIOGRAPHY II. Population Estimation: General Methods

Akkerman, A. 2000. "On the Leontief Structure of Household Populations." *Canadian Studies in Population* 27(1): 181-194. The author considers the age distribution of all persons in households and the age distribution of household-heads and shows that formal relationship holding between the two age distributions is equivalent to the input-output relationship in the Leontief model of the open economy. The notions of household composition and household accommodation which have emerged independently over the past two decades, are shown to be formally linked within this relationship.

Alcantara, A. 1999. "Assessment of IRS Tax returns Migration Coverage in New Mexico." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). Using the housing unit method, the author evaluates how well the IRS tax return method estimates migration in the three counties in Metropolitan Albuquerque. She uses data on building permits, manufactured and mobile homes as well as occupancy rates by type of unit will be collected for the period between 1996 and 1997 for this test. Results of the estimates based on the housing unit method are compared with the migration flows implied by the IRS data for the same time period.

Alho, J. 1994. "Analysis of Sample-based Capture-Recapture Experiments." *Journal of Official Statistics* 10: 245-256. Heterogeneous capture probabilities and logistic regression are used to model the estimation of population totals in a sample based capture-recapture experiment. Some aspects of experiments that combine a census with a sample (such as the U.S. Post Enumeration Survey) are studied. The role of sampling weights in the estimation of capture probabilities is considered and the author shows how purely sample based estimators can be combined with the census estimates to reduce variance. Logistic catch effort models are applied to the optimal allocation of resources to the sampling part and the capture-recapture part of the experiments. The author shows with an analytical example that there can be a genuine trade-off between the two sources of error.

Alho, J. 1990. "Logistic Regression in Capture-Recapture Models." *Biometrics* 46: 623-635. The effect of population heterogeneity in capture-recapture, or dual registration, models is discussed. An estimator of the unknown population size based on a logistic regression model is introduced, which allows different capture probabilities across individuals and across capture times. The resulting population estimator is shown to be

consistent and asymptotically normal. A variance estimator under population heterogeneity is derived. The finite-sample properties of the estimators are studied via simulation and an application is presented.

Alho, J., M. Mulry, M. Wurdeman, and J. Kim. 1993. "Estimating Heterogeneity in the Probabilities of Enumeration for Dual-system Estimation." *Journal of the American Statistical Association* 88: 1130-1136. The authors show how conditional logistic regression can be used to estimate the probability of being enumerated in a census and apply the model to the 1990 Post-Enumeration Survey (PES) in the United States. They discuss some special problems caused by the fact that the PES sample area is open to migration between the captures and consider the effect of data errors in estimation. They characterize hard-to-enumerate populations and give some tentative estimates of correlation bias.

Alvey, W. and F. Scheuren. 1982. "Background for an Administrative Record Census." pp. 137-146 in 1982 *Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. The paper examines in a general way the Federal administrative record systems that might be employed in conducting a population census. The focus of the description given is on the extent to which these systems could be used together to obtain population census counts. Sections I through V describe the various microdata files, touching on coverage and content issues. Section VI discusses the basic methodology proposed, raising some of the major linkage issues to be considered. Finally, in Section VII, an agenda for researching the proposal is suggested.

Anderton, D., J. Conaty, and T. Pullum. 1983. "Population Estimates from Longitudinal Records in Otherwise Data-Deficient Settings." *Demography* 20: 273-284. The authors present and evaluate models which derive population parameters for the population subgroup underlying such longitudinal data; using the distribution of individual times until 1st recorded event within a measurement interval, population parameters are estimated which provide basic denominator data for analyzing event occurrence. The use of the models is demonstrated and evaluated through an application to genealogical records for a 19th century population. The models evaluated in this paper are not robust and appear sensitive to both measurement errors and model assumptions regarding trapping probabilities.

Arthur, W., and T. Espenshade. 1988. "Immigration Policy and Immigrants' Ages." *Population and Development Review* 14 (2): 315-326. The effect of age of immigrants on eventual stationary population size, in countries whose native population is below replacement, is analyzed. From the extreme examples of limiting ages of immigrants to ages 50-54, or to 10-14 years, an ultimate population size difference of 1:23 would ensue, 14.4 million to 328.3 million. More realistic 5-year shifts in median ages of U.S. immigrants would make a much smaller difference in the short term, about 25 million. In the long term of several hundred years this age difference would have a substantial effect on population size. Migrants contribute to the size of the ultimate stationary population by their presence and through offspring they produce. This effect is highly non-linear,

with a greater impact when immigration is concentrated in the childbearing age. Another observable effect is the median age of the population.

Atchley, R. 1968. "A Shortcut Method for Estimating the Population of Metropolitan Areas." *Journal of the American Institute of Planners* 34: 259-262. In this article a variation of the vital rates method, the Age-Color-Specific Death Rate (ACSDR) Method, is offered as a short-cut method for providing an immediate estimate of the current population of a metropolitan area. Comparisons show that estimates made by this method tend to deviate only slightly from those made by other more laborious methods. The limitations of the ACSDR Method are noted, and it is concluded that this method can provide a quick and reasonably accurate provisional estimate, but that it is not suitable as a general substitute for more intensive methods of estimating metropolitan populations.

Batutis, M. 1993. "Evaluation of 1990 Population Estimates and the Future of the Census Bureau Sub-national Estimates Program." *Proceedings of the Social Statistics Section*, Alexandria, VA: American Statistical Association. First, this paper establishes a historical context for the 1990 evaluation program. In so doing, the paper attempts to show how the philosophy toward population estimates, as explicated in official publications, has shaped the current evaluation program. Second, the paper attempts to show, in broad outline, the changes in philosophy that are required to move the population estimates program toward the year 2000 and beyond.

Batutis, M., and R. Scardamalia. 1982. "Population Estimates for New York Counties by the Component Method II." pp. 133-136 in 1982 *Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. The use of the component method II model for estimating U.S. population at state and county levels is evaluated using 1980 census data for New York State. The component method II is shown to fail because of the failure of the key assumption underlying the method, namely unvarying Residual Migration Adjustment Factors (RMAF). The usefulness of the method is in serious doubt unless a way can be found to update the RMAF as part of the estimating process.

Becker, P. 1999. "Using the Master Address File to Estimate the Population for Small Areas." Paper presented at the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). The author starts by observing that the Census Bureau has moved from population-based methods to housing unit methods for purposes of estimating sub-county population because population-based methods have suffered from seriously inadequate data sources and high levels of geocoding error. Housing units, already located on the ground, provide a better data set with little geocoding error. However, the author points out that housing-based methods are flawed as well. The author examines the use of the Master Address File to provide housing required for the housing unit method of population estimation and discusses issues that need to be resolved before it can be used as a source of population estimates.

Belcher, D. 1921 "A Method of Estimating the Population of Continental United States for Inter-censal Years." *Journal of the American Statistical Association* 17: 994-998. The author shows how one can use interpolative methods to estimate the US population between decennial census counts.

Bell, W. 1993. "Using Information from Demographic Analysis in Post-Enumeration Survey Estimation." *Journal of the American Statistical Association* 88 (423):1106-1118. Population estimates from the 1990 Post-Enumeration Survey (PES), used to measure decennial census undercount, were obtained from dual system estimates (DSE's) that assumed independence within strata defined by age-race-sex-geography and other variables. The author considers several alternative DSE's, and used DA results for 1990 to apply them to data from the 1990 U.S. census and PES.

Besbeas, P., Freeman, S. N., Morgan, B. J. T., Catchpole, E. A. 2002. "Integrating Mark-Recapture-Recovery and Census Data to Estimate Animal Abundance and Demographic Parameters." *Biometrics* 58:540-547. The authors show how a state-space model for census data in combination with the usual multinomial-based models for ring-recovery data provide estimates of productivity not available from either type of data alone.

Bogue, D. 1950. "A Technique for Making Extensive Population Estimates." *Journal of the American Statistical Association* 45: 191-193. This paper introduces the vital statistics method for making population estimates. It shows how it can be employed at the sub-national level.

Bogue, D., and B. Duncan. 1959. "A Composite Method for Estimating Post-censal Population of Small Areas by Age, Sex and Color." *Vital Statistics Special Reports, Vol. 47, No. 6*. This paper introduces a method of making total population estimates by first using the vital statistics method to estimate the numbers in age (sex and race) groups and then adding the numbers to get the total population.

Bourgeois-Pichat, J. 1971. "Stable, Semi-stable Populations, and Growth Potential." *Population Studies* 25: 235-254. Starting from the definition of a Malthusian population given by Alfred J. Lotka, the author recalls how the concept of stable population is introduced in demography, first as a particular case of stable populations, and secondly as a limit of a demographic evolutionary process in which female age-specific fertility rates and age-specific mortality rates remain constant. Then he defines a new concept: the semi-stable population which is a population with a constant age distribution. He shows that such a population coincides at any point of time with the stable population corresponding to the mortality and the fertility at this point of time. In the remaining part of the paper it is shown how the concept of a stable population can be used for defining a coefficient of inertia which measures the resistance of a population to modification of its course as a consequence of changing fertility and mortality.

Bousfield, M.V. 1977. "Inter-censal Estimation Using a Current Sample and Census Data." *Review of Public Data Use* 5: 6-15. The author was among the first to describe

the use of raking to force the marginal totals of a two-way sample table to match census totals. She shows how it can be used to generate population estimates.

Bouvier, L. 1971. "Estimating Post-Censal Populations of Counties." *Journal of the American Institute of Planners* 37 (1): 45-46. The author applies the vita rates method to estimate the population of Rhode Island and its counties. He demonstrates that this intercensal technique can produce relatively accurate results for states and small units.

Bouvier, L., D. Poston, and N. Zhai. 1991. "Population Growth Impacts of Zero Net International Migration." *International Migration Review* 31 (2): 294-311. This article examines the assumption that the effect of zero net international migration on the population of the United States. Examining the direct, indirect, total, and negative demographic impacts of zero net international migration through simulations with demographic data, the authors demonstrate that zero net international migration is not the same and therefore does not have the same demographic results and implications as zero international migration. They conclude that zero net international migration should not be confused with zero international migration.

Bracken, I. 1991. "A Surface Model Approach to Small Area Population Estimation." *Town Planning Review* 62(2):225-37. The author applies a surface model approach to the estimation of small-area population and household characteristics and argues that the representation of population-related information by means of surface concepts offers a way to overcome many of the limitations of traditional, 'fixed' zone-based methods. The author suggests that the method can be applied to the estimation of population at local levels and gives ideas on how to accomplish this.

Brass, W. 1968. *The Demography of Tropical Africa*. Princeton, NJ: Princeton University Press. Divided into two major parts (basically data/methods and case studies) this book contains descriptions of model life table methods that can be used to estimate populations. Of particular note is the inclusion of Brass's two parameter model life table system.

Brass, W. 1975. *Methods for Estimating Fertility and Mortality from Limited and Defective Data*. Chapel Hill, NC: The University of North Carolina. This monograph contains a series of papers on indirect estimation methods that were otherwise difficult to obtain. The papers deal with a simple approximation for the time-location of estimates of child mortality from proportions dead by age of mother, further simplification of time location estimates for survivorship of adult relatives reported at a survey, the derivation of life tables from retrospective estimates of child and adult mortality, the relation between numbers of living mothers and numbers of living children, P-F synthesis and parity progression ratios, mortality in China using data from the 1982 census, and childhood mortality estimated from reports on previous births given by mothers at the time of a maternity.

Brown, H. 1955. "A Technique for Estimating the Population of Counties." *Journal of the American Statistical Association* 50: 323-343. The author shows how school enrollment

data can be used together with census correction factors to develop county population estimates.

Brown, W. 1999. "Use of Property Tax Records and Household Composition Matrices to Improve the Household Units Method for Small Area Population Estimates." Paper presented at the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). This paper reports on a pilot effort in a single county to use property tax records in place of housing permits for building and demolition to improve count of housing units. In addition the property tax records include an x-y coordinate for spatially locating the housing unit structure. This enables the housing units to be geocoded to Census Blocks, as well as to non-Census geographic areas such as watersheds. Finally, the use of household composition matrices yields improved estimates of persons per household for small areas. The household composition matrices contain a refined measure of persons per household built from cells of persons per household cells by age of person and age of householder. The improved housing unit method is demonstrated for Census Block groups.

Brown, W., and R. Scardamalia. 1991. "Estimating County Population by Age, Sex and Race: A State Perspective." *1990 Working Paper Series, No. 2.03*. Ithaca, NY: Department of Rural Sociology, Population and Development Program, Cornell University. The authors review a methodology used by the U.S. Census Bureau to prepare national estimates of county population by age, sex, and race. They then evaluate its applicability to preparing state estimates of county population, using data for New York State.

Brunsmann, H. 1955. *The Estimation of Population Changes for New York City*. New York, Russell Sage Foundation. This monograph covers the recommendations made to the Mayor by the Committee on Statistical Programs for the City of New York on how to estimate and project the population of New York City and its sub-areas. It lists 21 data sources and finds that 15 of them are currently available. It discusses how to obtain the additional data needed to carry out the recommendations.

Bryan, T. 2004. "Population Estimates." pp. 523-560 in J. Siegel and D. Swanson (eds.) *The Methods and Materials of Demography, 2nd Edition*. New York City, NY: Elsevier Academic Press. This chapter provides an overview of the methods used to make population estimates in countries with well developed vital registration, census, and other systems. It provides the formulas and the data needed for these methods and gives examples.

Burch, T. 1970. "Some Demographic Determinants of Average Household Size: An Analytic Approach." *Demography* 7: 61-69. This paper is to investigate the influence of demographic variables on average household size under different family systems--nuclear, extended and stem. The results indicate that under all family systems, average household size is positively correlated with fertility, life expectancy, and average age at marriage.

Burghardt, J., and V. Geraci. 1980. "State and Local Annual Population Estimation Methods Employed by the Bureau of the Census." *Review of Public Data Use* 8 (4): 339-354. This provides an overview of the population estimation methods used by the US Census and evaluates various population estimates prepared in the 1960s and 1970s using examples from Texas.

Byerly, E. 1990. "State and Local Agencies Preparing Population and Housing Estimates." *Current Population Reports, Series P-25, No. 1063*. Washington, DC: US Government Printing Office. This report presents the results of a mail survey of 1,049 State and local public agencies conducted from June to December 1989. The voluntary survey was intended to inventory official State and local governmental and other public agencies making estimates of population and/or housing units and the methods they use. An extensive bibliography of population estimation methods is included in the report.

Byerly, E. 1989. "State Population and Household Estimates, with Age, Sex, and Components of Change." *Current Population Reports, Series P-25, No. 1044*. Washington, DC: US Government Printing Office. This report contains provisional US state estimates of: (1) the resident and civilian populations and of households for July 1, 1987; (2) revised annual population and household estimates for July 1, 1981-1986; and (3) components of population change for the 1980-1987 period. Also shown are annual age estimates and median age of the resident population of states, 1981-1987, by sex for 10-year age groups and selected broad age groups.

Byerly, E. 1984. "Estimates of the Population of States: 1970 to 1983." *Current Population Reports, Series P-25, No. 957*, pp 4-7. Washington, DC: US Government Printing Office. This report contains revised estimates of the resident and civilian population of states for July 1, 1981, and July 1, 1982, and provisional estimates for July 1, 1983, together with provisional components of population change for the period April 1, 1980 to July 1, 1983. Revised annual inter-censal estimates for July 1, 1971, to 1979 are also presented, as well as components of population change for 1970 to 1980.

Byerly, E. and K. Deardorff. 1995. "National and State Population Estimates: 1990 to 1994." *Current Population Reports, P25, No. 1127*, US Bureau of the Census. Washington, DC: US Government Printing Office. This report begins with a brief section highlighting 1990 to 1994 population trends, which is followed by a section describing methodology. The report concludes with detailed tables of U.S., region, division, and State population estimates for 1990 to 1994.

Cai, Q. 2007. "New Techniques in Small Area Population Estimates by Demographic Characteristics." *Population Research and Policy Review* 26 (2): 203-218. This paper explores methods for population estimates by age, sex, race, and Hispanic origin at the census tract level for Multnomah County, Oregon, including the use of building permits to indirectly estimate migration and examining the changes in age/sex structure using the American Community Survey.

Camarota, S., and J. Capizzano. 2004. *Assessing the Quality of Data Collected on the Foreign Born: An Evaluation of the American Community Survey (ACS), Pilot and Full Study Findings*. Unpublished Report. Sabre Systems, Inc. (Available online, http://www.sabresystems.com/whitepapers/CIS_whitepaper.pdf, last accessed January, 2008). This study presents findings from an evaluation of the foreign-born data collected during 1999 in Harris and Fort Bend Counties, Texas, and an evaluation of the foreign-born data from the 2000 ACS national sample, known as the Census 2000 Supplementary Survey (C2SS). This study was designed to review ACS data collection procedures and to assess the quality of ACS foreign-born data collected both in a sampling area with a high concentration of foreign born and in the nationally representative ACS sample.

Carmen, A., and J. Somoza. 1965. "Survey Methods, Based on Periodically Repeated Interviews, Aimed at Determining Demographic Rates." *Demography* 2: 289–301. The authors present the results of a special survey designed to permit data to be obtained in the less developed countries, estimating natality and mortality, calculated within a level of acceptable confidence. The advantages and limitations of the method are discussed.

Carrier, N., and J. Hobcraft. 1971. *Demographic Estimation for Developing Societies*. London, UK: Population Investigation Committee. London School of Economics. This manual is designed to detect and reduce errors in demographic data. It also serves as a guide for using age distributions to estimate fertility and mortality. It has an extensive set of tables generated by the three-parameter stable model, which is the main purpose of the book.

Castro, L., and A. Rogers. 1983. "What the Age Composition of Migrants Can Tell Us." *Population Bulletin of the United Nations* 15: 63–79. This paper aims at demonstrating how the regularities that appear in migration age compositions can be summarized in a useful manner and to suggest what such regularities may be telling us about patterns of natural increase, family relationships, and mobility levels among migrants. The authors propose procedures for adopting model migration schedules to infer migration patterns in the absence of accurate migration data.

Cavanaugh, F. 1981. "The Census Bureau's 1980 Census Test of Population Estimates," in *Small-Area Population Estimates -Methods and Their Accuracy and New Metropolitan Area Definitions and Their Impact on the Private and Public Sector, Series GE-41, No. 7*. Washington, DC, Government Printing Office. The author provides results of the Census Bureau's tests of the accuracy of the methods it used for population estimation during the 1970s.

Cerone, P. 1987. "On Stable Population Theory with Immigration." *Demography* 24 (3): 431-438. The paper extends stable population theory to include a constant stream of immigration. It is shown that under a constant stream of immigration, the population will asymptotically tend toward a constant, linear, or exponential behavior, depending on whether the fertility behavior is below, equal to, or above replacement level. All of the parameters are determined in terms of the characteristics of the population at the origin.

Chamberlain, A. 2006. *Demography in Archaeology*. Cambridge, England: Cambridge University Press. After describing features of demography and its use in archaeology, the author covers methods that can be used to develop estimates of historical populations and their characteristics. He concludes the book with a discussion of the relevance of demography to archaeology and his views on future challenges.

Chandra Sekar, C. and W. E. Deming. 1949. "On a Method of Estimating Birth and Death rates and the Extent of Registration." *Journal of the American Statistical Association* 44: 101-115. A mathematical theory is presented which, when applied to a comparison of the registrar's lists of births and deaths with a list obtained in a house-to-house canvass, gives an estimate of the total number of events over an area in a specified period. It also gives the extent of registration. In a test of the method done in India in 1947, it was found that the estimated total number of events for the area is usually greater when the estimate is built up by summing the totals for individual groups than when it is computed at once for the aggregated population. This observation, according to the theory, confirms positive dependence and indicates that the greater figure is closer to the truth.

Chattopadhyay, M., P. Lahiri, M. Larsen, and J. Reimnitz. 1999. "Composite Estimation of Drug Prevalences for Sub-State Areas." *Survey Methodology* 25: 81–86. A hierarchical model is proposed to address problems found with variances in both synthetic and design-based survey estimates of drug use. The authors propose Empirical Bayes composite estimators, which incorporate survey weights, of drug use prevalence and jackknife estimators of their mean squared errors, to overcome these issues and illustrate the use of these estimators.

Chaudhuri A. and T. Christofides. 2006. "Item Count Technique in Estimating the Proportion of People with a Sensitive Feature." *Journal of Statistical Planning and Inference* 137 (2): 589 -593. In assessing the prevalence of a sensitive attribute like habitual heroin consumption in a community of people, indirect questioning is a necessity to extract truth on ensuring protection of privacy. The current literature seems to need supplementary specification of a relevant practical and theoretical justification for one possibility by what is called an Item Count Technique. This method can be easily incorporated in large scale sample surveys where the medium of collecting information is a structured questionnaire. This feature will make this technique attractive to social survey researchers. In this article we present an amendment to the currently available technique rendering it well-equipped with a provision to protect privacy and also a sound theoretical foundation.

Childers, D., and H. Hogan. 1984. "The IRS/Census Direct Match Study—Final Report." *SRD Research Report No. Census/SRD/RR-84/11*. Statistical Research Division, Bureau of the Census. Washington, DC: U. S. Department of Commerce. This paper reports on a study to investigate the feasibility of using the Internal Revenue Service Individual Master File (IRWIMFI) as a frame for matching to the census in order to estimate gross under-coverage in the census, and to examine the difficulties in tracing individuals to the census using the IRS/IMF address. The authors conclude that the study has demonstrated

that the problems of post office boxes, rural routes, and business addresses can be overcome with proper follow-up procedures and that the potential of this sampling frame is immense.

Chu, S. 1974. "On the use of Regression Method in Estimating Regional Population." *International Statistical Review* 42 (1): 17-28. The author examines the mathematical foundation of the ratio-correlation model and finds it "peculiar," with such drawbacks as the interdependence of shares and the fact that its coefficients are constant between census counts. He then proposes using past growth rates instead of shares in the model and extends this through stratification. He tests his idea using 1960 census data for the US states (using models constructed from 1940 and 1950 data) and finds that ratio-correlation model under-estimates fast growing states and over-estimates slow growing states, but that the overall reduction in the MAPE is only from 6.87 percent to 6.79 percent for the states.

Clogg, C., J. Schockey, and S. Eliason. 1990. "A General Statistical Framework for the Adjustment of Rates." *Sociological Methods and Research* 19 (2): 156-195. The authors present a general framework integrates standardization procedures common in demography, biometrics, and other areas with statistical methodology for the analysis of log-linear models. A family of rate-adjustment methods is derived from the log-linear model; the conventional method of direct standardization is a special case. Extensions of earlier methods include (a) adjustment for three-factor interaction, (b) adjustment for marginal association between composition and group, (c) adjustments that use a standard group, and (d) adjustments that control for both marginal composition-group interaction and three-factor interaction. Statistical inference for adjusted rates is facilitated in several ways: (a) by presenting key hypotheses that can be tested routinely with log-linear methods, (b) by efficient point and interval estimation of rates, (c) by assessing the sampling variability of absolute or relative comparisons of rates across groups, and (d) by smoothing the data. Examples illustrate the flexibility of the proposed framework.

Coale, A. 1984. "Construction of a life table from accurate enumeration of a closed population in two censuses." *Population Index* 50 (2). This paper outlines how census survival ratios can be used with assumptions to develop a life table.

Coale, A. 1965. "Estimates of Average Size of Household." pp. 64-69 in A. Coale, L. Fallers, M. Levy, D. Schneider, and S. Tompkins (Eds.) *Aspects of the Analysis of Family Structure*. Princeton, NJ: Princeton University Press. The author provides a demographic perspective on the determinants of average household size.

Coale, A. 1971. *The Growth and Structure of Human Populations: A Mathematical Investigation*. Princeton, NJ: Princeton University Press. This book considers the relationship between levels, age patterns, and time patterns of fertility and mortality and the growth and age composition of populations. Instead of simply providing demographers with the mechanical implements to calculate age distribution, birth and death rates, and rates of increase, the author attempts to explain how age structures are formed and vital rates determined.

Coale A., and P. Demeny. 1966. *Regional Model Life Tables and Stable Populations* Princeton, N.J.: Princeton University Press. This first edition provides model tables for which the terminal open-ended age group is 80 years and life expectancies that ended at age 77.5. This works well for populations with high mortality, but not so well for populations with low mortality. The tables presented in this book are in two principal forms: model life tables and model stable populations.

Coale, A., and N.W. Rives. 1973. "A Statistical Reconstruction of the Black Population of the United States 1880-1970: Estimates of True Numbers by Age and Sex, Birth Rates, and Total Fertility." *Population Index* 39 (1): 3-36. This paper describes new procedures that the authors have used to reconstruct the black population, distributed by age and sex, from 1880 to 1970. The authors take advantage of minimal international migration for this population and use the mechanics of the age structure and growth of a closed population to generate the estimates.

Coale, A., and J. Trussell. 1996. "The development and use of demographic models." *Population Studies* 50: 469-484. The authors examine two classical demographic models--conventional life tables and stable populations--and a modern generalization of stable population theory and discuss mathematical models of conception and birth. The authors examine the use of demographic models in forecasting future mortality, nuptiality, and fertility and in population projection. They conclude with observations about the purposes and uses of demographic models.

Coale, A., P. Demeny, and B. Vaughan. 1983. *Regional Model Life Tables and Stable Populations*. Princeton, NJ: Princeton University Press. This second edition incorporates an extension in the range of the original tables that will be particularly useful in applications to populations with low mortality. In the second edition, "the life tables and stable populations are tabulated by five-year age intervals to age 100, in all but the highest mortality levels, in which the last five-year tabulation is from 90 to 95. The greatest expectation of life at birth is now 80 years (for females) rather than 77.5." As was the case in the first edition (1966), the tables are presented in two principal forms: model life tables and model stable populations.

Cohen, M. 1991. "Statistical Matching and Microsimulation Models." pp. 62-85 in C. F. Citro and E. Hanushek (Eds.) *Improving Information for Social Policy Decisions: The Uses of Microsimulation Modeling, Volume II: Technical Papers* Washington, DC: National Academy Press. The author discusses the strengths and weaknesses of 'distance' functions as a means of record-matching, as well as those of a matching method based on variance-covariance analysis.

Coleman, C., and D. Swanson. 2007 "On MAPE-R as a Measure of Cross-Sectional Estimation and Forecast Accuracy." *Journal of Economic and Social Measurement* 32 (4): 219-233. The authors show that MAPE-R can be calculated simply, thus overcoming the cumbersome calculation procedure used in its introduction and noted as a feature needing correction. They find this closed form expression for MAPE-R to be a member

of the family of power mean-based accuracy measures. While further lines of research are called for, nothing in their examination of MAPE-R rules out its use.

Congdon, P. 1989. "An Analysis of Population and Social Change in London Wards in the 1980s." *Transactions of the Institute of British Geographers* N.S. 14: 478-491. This paper discusses the estimation and projection of small area populations in London, and considers trends in inter-censal social and demographic indices which can be calculated using these estimates. Trends in spatial inequality of such indicators during the 1980s are analysed and point to continuing wide differentials. A typology of population and social indicators gives an indication of the small area distribution of the recent population turnaround in inner London, and of its association with other social processes such as gentrification and ethnic concentration.

Cook, T. 1998. "Overnight Visitor Counts in Australia and Their Implications for Population Estimation." *People and Place* 6 (1):60-70. The author points out that on the night of the 1996 Census, 5.4 per cent of the people counted in Australia were staying away from home (visitors), compared to 4.6 per cent in 1986. She goes on to note variations by state and comments on the measurement of overseas visitors.

Cook, T. 1996. "When ERPs Aren't Enough: A Discussion of Issues Associated with Service Population Estimation." *Working Paper 96/4*. Demography Section, Australian Bureau of Statistics, Belconnen, ACT, Australia. The author discusses the shortcomings of the Estimates of Resident Population (ERP) for many planning purposes and infrastructure needs in Australia. She notes that while population estimates based on place of 'usual residence' are conceptually sound and are favored over 'place of enumeration' estimates by many international statistical agencies, the relevance of 'usual residence' based estimates to some users is limited by the level of population mobility hidden within these estimates. She covers the issues involved in estimating 'service (De facto) populations for the Australian Bureau of Statistics.

Courgeau, D, V. Nedellec, and P. Empereur-Bissonnet. 2000. "Duration of Residence in the Same Dwelling. A Test of Measurement Using Electricity Utility Company Records." *Population* 12: 335-342. The authors report on the use of accounts records maintained by France's national electrical provider, EDF, to estimate moving and migration.

Cowan, C., and D. Malec. 1986. "Capture-recapture Models when Both Sources have Clustered Observations." *Journal of the American Statistical Association* 81: 347-353. Capture-recapture models assume that individuals in the population are captured one at a time and independently of each other. There are often situations, however, where individuals are captured in small clusters or groups. This paper provides a model that allows individuals to be captured in groups; the EM algorithm is used to estimate parameters in the model that include capture probabilities and the size of the population under study.

Cox, P. 1970. *Demography, 4th Edition*. Cambridge, UK: Cambridge University Press. A text and reference book that covers major theories and methods used in demography. It includes a chapter on population projections.

Creech, J. W., and D. K. Sater. 1999. "Assessment of the Coverage of the Population by Exemptions Represented on Individual Income Tax Returns for Tax Year 1989." Unpublished Paper. Population Division, Bureau of the Census. Washington, DC: U.S. Census Bureau. The authors find that about 85 to 90 percent of the population is covered by tax returns, but with significant geographic variation. In one state they find only 80 to 85 percent coverage and in many small counties, the coverage is under 70 percent.

Crosetti, A., and R. Schmitt. 1956. "A Method of Estimating the Inter-censal Population of Counties." *Journal of the American Statistical Association* 51: 587-590. This paper describes and applies the ratio-correlation method to the estimation of county populations in Washington State for the year 1940. It finds that the method is more accurate than four other methods.

Darroch, J. 1961. "The Two-Sample Capture-Recapture Census When Tagging and Sampling Are Stratified." *Biometrika* 48, 241-260. The author starts by recalling the capture-recapture argument used for the simplest type of experiment with only two samples and negligible death and emigration rates and then proceeds to argue since that the probability of "capture" is not uniform over a region, stratification could be employed in both the first and second samples to improve estimation methods when the probability of being captured in the second sample does not hold.

Darroch, J. 1959. "The Multiple-recapture Census II. Estimation When There is Immigration or Death." *Biometrika* 46: 336-351. This paper treats the multiple-recapture census for which the population is not closed. The aims of this paper are to provide exact, fully stochastic models for the observed frequencies of individuals, to show how simply these frequencies naturally group themselves, and to obtain estimates of the unknown parameters. When there is immigration only or death only, the estimates are shown to be asymptotically efficient and their variances are found. In addition, a method of performing tests on the values of the parameters is given. When both immigration and death are operating, on the other hand, the complexity of the probability density prevents us from going further than obtaining the estimates and merely indicating how their variances can be found.

Darroch, J. 1958. "The Multiple-recapture Census I: Estimation of a Closed Population." *Biometrika* 45: 343-359. This paper treats the multiple-recapture census for which the population is closed both to augmentation from outside and departure from inside and the number of samples is fixed.

Davis, S. 1994. "Evaluation of Post-censal County Estimates for the 1980s." *Population Division Working Paper No. 5*. Washington, DC: U. S. Census Bureau. This paper examines various issues concerning the evaluation of the official population estimates prepared for U.S. counties. It groups counties by size and growth and identifies which types of counties had better estimates.

Davis, S. 1988. "Methodology for Experimental County Population Estimates for the 1980s." *Current Population Reports, P-23, No. 158*. Washington, DC: U. S. Government Printing Office. This report briefly describes the procedures used in developing county population estimates in the 1980s by the Census Bureau, and indicates changes to the methodology previously used. The methodology used is a cohort-component projection technique in which actual data for the components are substituted for projected values whenever possible and totals are controlled to available estimates by age, sex, race, and geographic area. The Census Bureau considers these estimates experimental because they had not been tested fully against a census.

DeGuilbert-Lantoine, C. 1987. "Estimating Intercensal Populations in French Departments." *Population* 42 (6): 881-909. The author explains that the population in each French département has been estimated in each intercensal year from exact information on natural population movement, together with estimates of net migration, which were based on migration trends during the past. She notes that the quality of the results varied: a comparison between the results obtained and the populations enumerated in the Census of 1982 showed significant discrepancies for certain départements, particularly the Ile-de-France. Having considered the accuracy of the French estimates, estimation methods used in the United States, she studies, and an attempt is made to evaluate the extent to which the French estimates could be improved by applying some of the American methods. The method she selected consisted of estimating total migration from school enrolment data. She assumed that the relation between school enrolment and total migration observed during the previous intercensal period remained unchanged in each département, and net migration is then estimated. The author found that applying this method to all French départements for the period 1975-82 tended to produce more accurate results than the old method. The method can, she argues, be considered as a useful complement to the estimation methods used by INSEE.

Deming, W.E., and N. Keyfitz. 1967. "Theory of Surveys to Estimate Total Population," pp. 141-144 in *Proceedings of the World Population Conference, Belgrade, 1965, Vol. 3*. New York City, NY: United Nations. This paper discusses some of the statistical problems encountered in estimating by sampling the total number of a population, without benefit of a previous census, and presents a device for this purpose which may have other uses as well. The authors consider two kinds of situations: (a) the population is fixed, each person being nominally attached in some recognizable manner to a fixed location, such as a dwelling unit; (b) the population is mobile – here today, somewhere else tomorrow. Some theory for the moving population is introduced.

Devine, J. and C. Coleman. 2003. "People Might Move but Housing Units Don't: An Evaluation of the State and County Housing Unit Estimates." *Population Division Working Paper Series No. 71*. Washington, DC: U. S. Census Bureau. This report presents an evaluation of estimates of total housing units for the Nation, states, and counties produced by the Population Division of the Census Bureau. The comparison of the April 1, 2000 estimates to the April 1, 2000 decennial census counts forms the basis for this report. The evaluation found that the 2000 state and county level housing unit estimates developed from building permit, mobile home shipment, and demolition data

performed with a degree of accuracy similar to the state and county April 1, 2000 population estimates produced by the Population Division of the Census Bureau.

Diffendal, G., et al. 1987. "Comparison of Adjustment Methods for Census Undercount in Small Areas." pp. 56-65 in *Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. The authors compare synthetic and regression techniques for adjusting small area data. Examples are provided using data from California, Mississippi, New Jersey, and North Dakota.

Diffendal, G., S. Ogunwole, and A. S. Smith. 1999. "Applying Data from the American Community Survey (ACS) and the Master Address File (MAF) to the Inter-censal Population Estimates Program." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). This paper addresses some of the significant issues involved in integrating the Inter-censal Population Estimates program and the American Community Survey. It uses two cases studies will detail research underway since the introduction of the ACS with four communities in 1996. In the first case study, the ACS results are compared to county population estimates by age, sex, race and Hispanic origin. In the second, ACS results are with sub-county population estimates. Both case studies conclude with a discussion of how the Inter-censal Population Estimates program and the American Community Survey can inform one another in the future.

Eberle, G. 1938. "Population Estimates of Local Communities and Economic Planning." *Journal of the American Statistical Association* 33: 701-703. The author classifies the population by permanent and non-permanent residence and provides six governing rules for making estimates and determining population changes in urban communities for these types of population.

Eldridge, H. 1947. "Problems and Methods of Estimating Post-censal Population." *Social Forces* 24: 41-46. The author identifies three types of estimates that need to be made for the U.S., De jure, De facto, and troops overseas. She then discusses the methods and data – including ration books – that could be used to make these estimates.

Ericksen, E. 1973. "A Method for Combining Sample Survey Data and Symptomatic Indicators to obtain Population Estimates for Local Areas." *Demography* 10: 137-160. In this paper, a new method of post-censal estimation is presented in which the symptomatic information is combined with sample data by means of a regression format. Combining symptomatic information on births, deaths, and school enrollment with sample data from the Current Population Survey, county estimates of population growth were computed by means of the new method for the post-censal period after 1960. These estimates were tested for accuracy by comparison with a set of special censuses which were conducted between 1964 and 1967 in 75 counties. The results of this test are promising, but not conclusive.

Erickson, E. 1974. "A Regression Method for Estimating Population Changes of Local Areas." *Journal of the American Statistical Association* 69: 867-875. A regression method is presented in which current sample data and symptomatic information are combined to estimate post-censal populations for local areas. This procedure was tested for counties and states using 1970 Census data, and the resulting estimates were found to be more accurate than estimates computed by standard demographic procedures for the same period. The ratio-correlation estimates were the most accurate series of standard estimates. When this series was added to the set of symptomatic information used in the regression method, further increases in accuracy were obtained.

Ericksen, E., and J. Kadune. 1985. "Estimating the Population in a Census Year: 1980 and Beyond." *Journal of the American Statistical Association* 80: 98-109. The authors argue that decennial census results should not be viewed as counts to be reported directly, but as data to be used in estimating the population and its characteristics. They propose methods by which the results of the 1980 census could be so analyzed using both other nationally collected information currently available at the Census Bureau and locally collected information especially likely to be needed in areas where undercount rates are high.

Espenshade, T. and J. Tayman. 1982. "Confidence Intervals for Post-censal State Population Estimates." *Demography* 19 (2): 191-210. This paper develops a methodology for constructing confidence intervals around post-censal state population estimates. Using regression equations, forecast intervals are derived around the average age-specific death rates over the post-censal estimation period. These results, combined with the number of post-censal deaths and the most current census counts, are translated into confidence intervals for the age structure. 2 approaches are offered for constructing total population confidence intervals. 1 examines a simulated distribution while the other focuses on the mathematical derivation of population means and variances. The methodology is illustrated by deriving statistically desirable confidence intervals around the July 1, 1975 population of Florida.

Espenshade, T., F. Hobbs, and L. Pol. 1981. "An Experiment in Estimating Post-censal Age Distributions of State Populations from Death Registration Data." *Review of Public Data Use* 9: 97-114. This article sets out a method of disaggregating post-censal estimates of total state population into five-year age categories. The central assumption is that the age pattern of temporal mortality change in a particular state is the same as that in the U.S. as a whole. Data on the number of deaths in each age interval, combined with assumptions about death rates, then indicate the size of the corresponding base population. The method is applied to the State of Florida and comparisons with the 1970 Census for Florida reveal good agreement, especially for ages 15 and older.

Espenshade, T., L. Bouvier, and W. B. Arthur. 1982. "Immigration and the stable population model." *Demography* 19 (1): 125-133. The authors extend stable population theory to include immigration. The central finding is that, as long as fertility is below replacement, a constant number and age distribution of immigrants (with fixed fertility and mortality schedules) leads to a stationary population. Neither the level of the net

reproduction rate nor the size of the annual immigration affects this conclusion; a stationary population eventually emerges.

Ewbank, D. 1981. *Age Misreporting and Age-Selective Underenumeration: Sources, Patterns, and Consequences for Demographic Analysis*. Washington, DC: National Academy Press. This is a comprehensive review of the literature dealing with age misreporting and age-selective under-enumeration in demographic data collection. It describes the errors and how they can be identified and handled.

Fay, R. 1987. "Application of multivariate regression to small domain estimation." pp. 91-102 in R. Platek, J.N.K. Rao, C.E. Sarndal, and M.P. Singh (eds.) *Small Area Statistics*. New York: Wiley. The estimates of the small area parameters can profitably 'borrow strength' from data on related multiple characteristics and/or auxiliary variables from other neighboring areas through appropriate models. The author proposes doing this by using multivariate regression for small area estimation of multiple characteristics.

Fay, R. 1974. *Statistical Considerations in Estimating the Current Population of the United States*. Ph.D. Dissertation, Department of Statistics. Chicago, IL: University of Chicago. This dissertation assesses Demographic Analysis as a technique for estimating the U.S. population.

Fay, R. and R. Herriot. 1979. "Estimates of Income for Small Places: An Application of James Stein Procedures to Census Data." *Journal of the American Statistical Association* 74: 269-277. An adaptation of the James-Stein estimator is applied to sample estimates of income for small places (i.e., population less than 1,000) from the 1970 Census of Population and Housing. The adaptation incorporates linear regression in the context of unequal variances. Evidence is presented that the resulting estimates have smaller average error than either the sample estimates or an alternate procedure of using county averages.

Feeney, G. 1990. "Untilting age distributions: A transformation for graphical analysis." *Asian and Pacific Population Forum* 4(3):13-20. This article presents a new approach to the plotting of age distribution data. 'Untilting' is a way of transforming data that vary systematically from very high to very low values so as to show local variation more clearly. The article derives an untilting transformation from the formal structure of age distributions. The transformation turns out to be closely related to two familiar demographic techniques, reverse-survival estimation of births and birth rates, and comparison of observed with stable age distributions. The ideas are illustrated by application to age distributions from the 1979 and 1989 censuses of Vietnam.

Feeney, G. 1970. "Stable Age by Region Distributions." *Demography* 7(3): 341-348. This paper is aimed at exploring the nature of stable compositions, the interrelation among their various components, and their relation to fertility, mortality, and mobility patterns that generate them. If the pattern of fertility, mortality and interregional migration exhibited by the United States population during 1950-60 were to continue in the future, the proportions of persons in the various age groups and regions would

fluctuate from decade to decade. These fluctuations would become less marked with time, however, and eventually all the proportions would stabilize at certain fixed values. This collection of values may be called a stable age by region composition corresponding to the given schedule of fertility, mortality and migration. The same phenomenon may be observed when individuals move between socioeconomic categories as, for example, socioeconomic status or educational attainment levels. The substantial differences between these various situations conceal remarkable similarities. In each case the continued operation of schedules of fertility, mortality and mobility between categories may result in a stable composition.

Feeney, D., J. Hibbs., and R. Gillaspay. 1995. "Ratio-correlation Method." pp. 118-136 in N. W. Rives, W. Serow, A. Lee, H. Goldsmith, and P. Voss (Eds). *Basic Methods for Preparing Small-Area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. The paper provides an overview of the ratio-correlation method and gives examples of its use in Minnesota.

Fellegi, I. and A. Sunter. 1969. "A Theory for Record Linkage." *Journal of the American Statistical Association* 64: 1183-1210. The authors develop a mathematical model to provide a theoretical framework for a computer-oriented solution to the problem of recognizing those records in two files which represent identical persons, objects or events (said to be matched). A theorem describing the construction and properties an optimal linkage rule and two corollaries to the theorem which make it a practical working tool are given.

Felton, G. 1986. "Evaluation of Population Estimation Procedures for Counties: 1980." *Current Population Reports P-25, No. 984*. Washington, DC: US Government Printing Office. This is the last in a series of reports presenting the results of the evaluation of population estimation procedures used by the US Census Bureau during the 1970s. It covers a summary of earlier county population evaluations, a discussion of problems with the 1980 estimates evaluation, and suggests changes that should be made for the 1980 decade.

Findley, S. and H. Reinhardt. 1980. "Nonlinear Estimation of Household Size: The Minnesota Housing Unit Method." Paper presented at the annual meeting of the Population Association of America, Denver, CO. Data from the 1977 Minnesota household survey are used to determine housing categories and size of place distinctions to estimate household size (PPH) and vacancy parameters. Using evidence from California and Washington, the authors determine that PPH change during the 1970s had been non-linear.

Folsom, R., B. Greenberg, D. Horvitz, and J. Abernathy. 1973. "The Two Alternate Questions Randomized Response Model for Human Surveys." *Journal of the American Statistical Association* 68 (343): 525-530. The authors introduce a model that is applicable when the population proportion with a non-sensitive attribute is not known in advance and two samples are required to estimate the population proportion with a sensitive attribute. It

consists of using the sensitive question and two non-sensitive alternate questions in each sample, yielding two unbiased estimates.

Fonseca, L., and J. Tayman. 1989. "Post-censal Estimates of Household Income Distribution." *Demography* 26(1): 149-159. This method of estimating household income distributions uses the lognormal probability curve as a model. The lognormal curve is calibrated to census data and post-censal estimates of median income and income standard deviation are used to solve for proportionate income distribution. The paper concludes by discussing the method's utility and information sources which can be used to update median income and income standard deviation during the post-censal period.

Frisén, C. 1958. "Effectiveness of Our Tools for Estimating Population Change in Small Areas," pp. 229-232 in *Proceedings of the American Statistical Association, Social Statistics Section*. Alexandria, VA: American Statistical Association. The author provides a two part classification for assessing how functional population estimation methods are from the perspective of government: (1) a framework for examining symptomatic data; and (2) the estimation techniques themselves. He uses this to examine the vital rates method (by age race and sex) for age estimation and utility hookups for use in the housing unit method.

Fuller, W. 1991. "Small Area Estimation as a Measurement Error Problem." pp. 333-352 in T. Kaul and J. Sengupta (Eds.) *Economic Models, Estimation, and Socioeconomic Systems: Essays in Honor of Karl A. Fox*. Amsterdam, The Netherlands: Elsevier Science Publishers. A discussion of how to combine model based approaches and probability (sample) based approaches to reduce variance and gain information through "borrowed strength."

Galdi, D. 1985 "Evaluation of 1980 Subcounty Population Estimates." *Current Population Reports. P25, No. 963*. Washington, DC: U. S. Government Printing Office. This report presents an evaluation of estimates of total population for approximately 36,000 subcounty areas in the U.S using 1980 decennial census counts.

Galvez, J., and C. McLarty. 1996. "Measurement of Florida Temporary Residents Using a Telephone Survey." *Journal of Economic and Social Measurement* 22 (1): 25-42. This paper examines methodologies reported in the literature for estimating temporary migrants and suggests an 'add-on' telephone survey design that is replicable. Results from a cross section of a Florida telephone survey are compared to results obtained using a similar instrument in Arizona. The telephone survey promises both cost effectiveness and a design that can be repeated in different locations.

Ghosh, M., and J. N. K. Rao. 1994. "Small Area Estimation: an Appraisal." *Statistical Science* 9: 55-93. The present article is largely an appraisal of some of the methods that "borrow strength" from related areas to find more accurate estimates for a given area or sets of areas. The methods include synthetic, sample size dependent, empirical best linear unbiased prediction, empirical Bayes and hierarchical Bayes estimation. The performance of these methods is also evaluated using some synthetic data resembling a

business population. Empirical best linear unbiased prediction, as well as empirical and hierarchical Bayes, for most purposes, seem to have distinct advantage over other methods.

Gibson, C. 1988. "Estimates of Household, for Counties: July 1, 1985." *Current Population Reports, Series P-23, No. 156*. Washington, DC: U.S. Bureau of the Census. The author describes the methodology used by the Census Bureau to estimate households at the county level. He discusses group quarters and the adult population in households. Tables provide estimates of the number of households and the average number of persons per household by county and county equivalent. An appendix contains corrections to the 1980 census counts of population and housing units for selected states and counties.

Gibson, C. 1986. "Post-censal estimates of households by size and type for states and of total households for counties." Paper presented at the Population Association of America Annual Meeting, San Francisco. This paper examines a demographic approach to sub-national household estimates which assumes that national trends in the average adult population per household and in the distribution of households by type and by size occur at the sub-national level. The assumption is tested for the 1970-1980 decade using US census data. Results show that, for states, the mean absolute error is lowest for the 20 years and up population (.69%), followed by the 18 years and up population (.76%), the 15 years and up population (1.05%), and all ages (1.61%). Counties show a lower mean error for the 18 and up group (1.47%), followed by the 20 and up (1.59%), the 15 and up (1.7%), and all ages (2.95%).

Goldberg, D., V. R. Rao, and N. K. Namboodiri. 1964. "A Test of the Accuracy of Ratio-Correlation Population Estimates." *Land Economics* 40 (1): 100-102. This paper reports the results of testing the ratio-correlation method for the 83 counties of Michigan using 1960 census data. The results suggest that the method performs well.

Goldstein, S. 1954. "City Directories as Sources of Migration Data." *American Journal of Sociology* 69 (2): 169-176. The city directories of Norristown, Pennsylvania, were analyzed to determine their usefulness for the study of migration and occupational mobility. Tests showed that they provided a complete enumeration of the city's population and its occupational composition. Death certificates identify persons who disappeared from directory listings through death, and birth certificates and school records identify those who first appeared in the listings upon arriving at the minimum age for inclusion. Then, by the method of residues, the remainder were classified as either out-migrants or in-migrants. Thus, through corroborative use of diverse sources, American demographers have a valid substitute for the system of continuous population registers found in several European countries.

Gonzalez, M., and C. Hoza. 1978. "Small Area Estimation with Applications to Unemployment and Housing Estimates." *Journal of the American Statistical Association* 79: 7-15. The purpose of this study is to investigate methodologies for constructing intercensal estimates of various characteristics of the population for small areas. The proposed methodology is illustrated mainly in the context of unemployment estimates, with one

section utilizing dilapidated housing estimates. Alternative synthetic estimates of unemployment based on the 1970 Census 20-percent sample are investigated and their relative error is analyzed. The reliability of the synthetic estimates is discussed in the context of dilapidated housing estimates. Two types of regression models are studied, and the improvements obtained by excluding outliers from the regression are discussed.

Greenberg, B., A. Abdul-Ela, W. Simmons, and D. Horvitz. 1969. "The Unrelated Question Randomized Response Model: Theoretical Framework." *Journal of the American Statistical Association* 64 (326): 520-539. This paper develops a theoretical framework for the unrelated question randomized response model suggested by W. R. Simmons. It provides a method for allocating the total sample to each of the two sub-samples required by the method and recommendations on choosing values of the parameters that can be assigned by the researcher using this method.

Habermann, H. 2006. "Research to Improve Population Estimates" Part of a presentation by H. Habermann at the Spring (May 18th -19th) 2006 meeting of the Census Advisory Committee for Professional Associations (CACPA). An overview of research on population estimation methods underway at the Census Bureau with criteria for developing methods.

Hamilton, C. H. 1967. "The Vital Statistics Method of Estimating Net Migration by Age Cohorts." *Demography* 4 (2): 464-487. The focus of this paper is the development and testing of a method of estimating deaths which occur during a decade of aging birth and death cohorts. The results obtained by using the Vital Statistics (VS) method for age cohorts show that (1) the average census survival rate (CSR) method generally yields algebraically lower estimates of net migration than does the VS method; but (2) there are some striking exceptions which are apparently associated with errors in census enumeration by age, sex, and color. The exclusive use of the VS method in estimating net migration for age cohorts may lead to substantial error. The author notes that the magnitude of these errors in estimating net migration, as well as in census enumeration, can be roughly approximated if it is assumed that the use of the CSR method yields reasonably accurate estimates of net migration.

Hamilton, C. H. 1964. "Comparison of two formulas in making population estimates." *Rural Sociology* 29: 426-431. The author compares the geometric and exponential methods of extrapolation for purposes of population projection or estimation. He notes that George Barclay's portrayal of them can lead to confusion.

Hamilton, C. H., and J. Perry. 1962. "A Short Method for Projecting Population by Age from One Decennial Census to Another." *Social Forces* 41 (December): 163-170. The logical basis and mathematical character of a short method for making population projections by age from one decennial census to another is discussed. The method is based on the assumption that age-specific vital rates and migration rates of the recent past will continue unchanged from one decade to the next. The method includes techniques for making projections of the population under 10 years of age at the end of the decade ahead.

Hamilton, C. H., and F. Henderson. 1944. "Use of the Survival Rate Method in Measuring Net Migration." *Journal of the American Statistical Association* 39: 197-206. This paper seeks to demonstrate the superiority of the census survival method over life table survival methods in estimating net migration over inter-censal periods and to show how census survival rates can be adjusted for states and counties.

Hammer, R., P. Voss, and R. Blakely. 1999. "Spatially Arrayed Growth Forces and Small Area Population Estimates Methodology." Paper presented at the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD: (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June, 2007). This paper attempts to quantify the spatial growth forces acting upon minor civil divisions, as well as other small areas such as census tracts and block groups, and incorporate these forces into population estimation methods.

Happel, S., and T. Hogan. 1987. "Estimating the Winter Resident Population of the Phoenix Area" *Applied Demography* 3: 7-8. This paper described a survey-based method for estimating De facto populations that is applied to seasonal residents of Phoenix, Arizona.

Hauser, P., and B. Tepping. 1944. "Evaluation of Census Wartime Population Estimates and of Predictions of Postwar Population Prospects for Metropolitan Areas." *American Sociological Review* 9: 473-480. This paper describes the use of war ration books to estimate the population for US metropolitan areas during World War II.

Healy, M. 1982. "Using Administrative Records: Introduction and Basic Procedures." pp. 27 –37 in in E. S. Lee and H. F. Goldsmith (Eds.), *Population Estimates: Methods for Small Area Analysis*. Beverly Hill, CA: Sage Press. The author describes the component technique used by the U.S. Census Bureau to estimate population, one that uses 'administrative records' (IRS files) to estimate the migration component. She focuses on small areas - places and census tracts - and concludes that the production of 'administrative records' based population estimates for these types of geographies was unfeasible at the time of her writing.

Heer, D., and P. Herman. 1990. "Estimating the population of Los Angeles County Census Tracts by Ethnicity." pp. 83-88 in *1990 Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. This study presents a methodology for estimation of population under 15 and 15-44 years, 45-64 years, and 64 and over years by sex and by census tract for 20 different ethnic groups. The innovation from traditional methodologies that would be inaccurate at the tract level involved expected values from a linear regression equation relating births (or deaths) in each year between 1980 and 1986 to time as the independent variable. Sample error is diminished by not recording the actual increase. Population estimates, the absolute change in population, and percent change in population are specified, as well as comparisons to the US Bureau of census estimates and the 1986 Test Census for Central Los Angeles. The US Bureau of Census estimates differed markedly for the Hispanic Population. The

author's explanation is that the difference is due primarily to the assumption in the US Census that the rate of immigration was the same between 1975 and 1980, and 1980 and 1985. The difference between the Test Census, 56 tracts and 5 ethnic groups, is possibly related to differences in estimation of the Hispanic undercount. After a walking tour of tract 5309, the authors concluded that there was substantial evidence of undercount in the Test Census due to an undercount of housing units in backyards. With a Test Census showing an Hispanic neighborhood decline yet a 32% Hispanic County population increase, the author believes their figures indicate a low-income housing shortage and population increase in predominately Hispanic tracts and only a 19% countywide population increase

Heeringa, S. 1982. "Statistical Models for Small Area Estimation." pp. 126-132 in *Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. The author describes how small area estimates can be developed from sample survey data.

Hepburn, G., T. Mayor, and J. Stafford. 1976. "Estimation of Market Area Population from Residential Electrical Utility Data." *Journal of Marketing Research* 13 (3): 230-236. An ability to project current population in small market trading areas is critical to many types of market research. The use of selected utility data to estimate current population in small geographic areas is evaluated.

Hill, K., H. Zlotnik, and J. Trussell. 1981. *Demographic Estimation: A Manual on Indirect Techniques*. Washington, DC: National Academy of Sciences Press. This is a manual published by the Committee on Population and Demography of the National Research Council on various technologies for estimating fertility and mortality from incomplete or inadequate data. Each chapter describes the basic method of estimation, assumptions on which it is based, the data required for its application, the method of application, and a sample application of the method to an actual set of data from a developing country. The following methods of estimation are covered: 1) estimation of fertility from information on children ever born; 2) estimation of childhood mortality from information on children ever born and children surviving; 3) estimation of adult survivorship from information on orphanhood and widowhood data; 4) estimation of adult mortality from distribution of deaths by age data; 5) life table data; 6) age distributions used for fertility or mortality estimations; 7) reverse survival information; and 8) successive census age distributions.

Hogan, H. 2008. "Measuring Population Change Using the American Community Survey." pp. 13-30 in S. Murdock and D. Swanson (Eds.). *Applied Demography in the 21st Century*. Dordrecht, The Netherlands, Springer. This chapter provides an overview of ways that the American Community Survey could be used in conjunction with population estimates to measure population characteristics and their change.

Hogan, H., and C. Cowan. 1980. "Imputations, Response Errors, and Matching in Dual System Estimation." pp. 263-268 in *Proceedings of the Section on Survey Research Methods*. Alexandria, VA: American Statistical Association. The authors propose a

simple solution when imputations create problems for matching that is needed in dual system estimation. Their proposed solution - one should determine the number of non-matchable cases and subtract them from the counts of both systems. The paper discusses this proposed solution.

Hoque, N. 2008. "An Evaluation of Population Estimates for Counties and Places in Texas for 2000." pp. 125-148 in S. Murdock and D. Swanson (Eds.) *Applied Demography in the 21st Century*. Dordrecht, The Netherlands, Springer. The author compares the estimates done in 2000 for Texas counties and cities by the Texas Demographer's office with Census 2000 results. The estimates were generated by three methods, Component Method II, ratio-correlation, and the Housing Unit Method. The author also provides descriptions of the methods and the context in which the estimates were done. The results suggest that averaged estimates perform better than estimates done by one method separately.

Hough, G., and D. Swanson. 2006. "An Evaluation of the American Community Survey: Results from the Oregon Test Site." *Population Research and Policy Review* 25(3): 257-273. Using a loss function analysis and other tools, this paper reports preliminary findings from a comparison of ACS and Census 2000 results in Multnomah County, Oregon, one of five national "local expert" test sites set up to compare ACS data collected at the time of Census 2000. The preliminary findings suggest that there are notable differences between some of the corresponding variables found in the ACS and Census LF that require more detailed examination. For example, the loss function analysis reveals notable differences for race and disability variables. In other comparisons of corresponding variables between ACS and Census 2000, differences are found within each of the four major areas of interest: (1) demographic characteristics, (2) social characteristics, (3) economic characteristics, and (4) housing characteristics, with housing characteristics showing the least similarity overall. These results also suggest that more detailed examinations are needed to understand differences between corresponding variables collected by ACS and the Census.

Hough, G., and D. Swanson 1998 "Toward an Assessment of Continuous Measurement: A Comparison of Returns with 1990 Census Returns for the Portland Test Site." *Journal of Economic and Social Measurement*. 24: 295-308. This paper is part of the initiation of an empirically-based discussion of the capability of the American Community Survey (ACS) to provide small area data comparable in quality to that provided by the census long form, the current gold standard for detailed, small area data. We compare mail return rates of the 1996 ACS to the 1990 mail return rates of the census long form for tracts in the test site and find that overall return rates are virtually the same--69 percent. However, ACS return rates are higher than those of the 1990 long form in that quartile of the tracts where the return rates for the long form were the lowest and lower in that quartile of the tracts where the long form rates were the highest.

Howe, A. 1999. "Assessing the Accuracy of Australia's Small-Area Population Estimates." *Journal of the Australian Population Association* 16(1-2): 47-63. This paper describes the process and methods used by the Australian Bureau of Statistics to assess

the accuracy of its after population estimates. It notes, however, there appears to be no straightforward method of assessing these estimates. Errors that occur with population estimates can be attributed to several factors, both broad and specific to individual areas. These factors include inherent characteristics of the region, such as population size and growth rate; changes in the geographic boundaries; quality of input data; estimation method; and adjustments to controls totals (state populations).

Ingram, D., J. O'Hare, F. Scheuren, and J. Turek. 2000. "Statistical Matching: A New Validation Case Study." Paper presented at the 2000 Joint Statistical Meetings, Indianapolis, IN, August 5–11. This paper employs data from the National Survey of American Families (NSAF) to assess the effect of violations of the conditional independence assumption on associations of health related measures and income measures observed in a data set constructed by statistically matching the National Health Interview Survey (NHIS) and the Current Population Survey (CPS). Contingency tables constructed from NSAF are compared with similar tables from the statistically-matched CPS/NHIS data sets. Chi-squared tests of independence applied both to the NSAF and CPS/NHIS contingency tables assess the extent to which associations between health and income variables were preserved in the statistically matched file. Implications for the use of the statistically matched data sets are explored and conjectures about the importance of failures in the conditional independence assumption in practical micro-simulation modeling settings are made.

Irwin, R. 1985. "County Inter-censal Estimates by Age, Sex, and Race: 1970-1980." *Current Population Reports P-23, No. 139*. Washington, DC: US Government Printing Office. This report describes the methodology used to develop a computer file of estimates of the population of U.S. counties by age, sex, and race for each year from 1970 to 1979. The report includes an evaluation of the quality of the estimates. The estimates presented on the tape are for 5-year age groups to age 85 and over for the total, White, and Black populations by sex. Census detail in both 1970 and 1980 was modified to permit consistent estimates throughout the decade. The age and sex detail in the 1980 census was not changed, but nearly 6 million persons of Spanish origin were moved out of the category "Other" (race not specified), the vast majority being transferred to White. A similar but much smaller modification was made in 1970. The Black population was not affected by the 1970 procedures and was increased only slightly in 1980. In addition to the inter-censal estimates from 1970 to 1979, the computer file contains the 1970 and 1980 census detail as modified, along with an extrapolation to July 1, 1980.

Irwin, R. 1976 "National Census Survival Rates in Population Projections for Small Areas." Paper presented at the annual meeting of the Population Association of America, Montreal Quebec, Canada. This long and highly specialized study demonstrates that if migration estimates obtained with national census survival rates are utilized in population projections done with life table survival rates, a substantial and very obvious misrepresentation will derive in calculating the age distribution of the projected population. Such misrepresentation can be avoided by using, instead of the life table survival rates, the national census survival rates adjusted according to future changes in

expected mortality. The study demonstrates this theory by using adjusted national census survival rates for population projections for the years 1970-80.

Isaki, C. and L. Shultz. 1987. "Report on Demographic Analysis Synthetic Estimation for Small Areas." *SRD Research Report Number Census/SRD/RR-87/03*. Washington, DC: U.S. Bureau of the Census. (Available online, <http://www.census2010.gov/srd/papers/pdf/rr87-03.pdf>, last accessed May 2008). This report summarizes the work of the Census Undercount Adjustment for Small Area group as it pertains to Demographic Analysis (DA) Synthetic estimation. The papers include comparisons of the performance of the Demographic Analysis synthetic estimator with other estimators. In this report, the authors restrict discussion to the DA synthetic estimator and comparisons to the Census using various "measures of improvement" and "truths". The "measures of improvement" include mean absolute relative error as well as other indicators of performance such as errors in apportionment when compared to the "truth". The sources used to represent "truth" were the results of the 1980 Post-Enumeration Program (PEP) as well as constructed populations based on the 1980 Census.

Isaki, C. and L. Shultz, P. Smith, and G. Diffendal. 1985. "Small Area Estimation Research for Census Undercount – Progress Report." *SRD Research Report Number Census/SRD/RR-85/07*. Washington, DC: U.S. Bureau of the Census. (Available online, <http://www.census2010.gov/srd/papers/pdf/rr85-07.pdf>, last accessed May 2008). This report summarizes work to-date on the examination of adjusting the total population count for undercount (because it is the first characteristic that is to be produced from the decennial census). The focus is in three general directions: (1) results of the 1980 PEP (Post Enumeration Program); (2) demographic analysis results for 1980; and (3) using the 1980 census data to simulate and evaluate the performance of potential adjustment methodologies. The remainder of the paper describes the limitations of the data tools previously mentioned, describes the adjustment methodologies being investigated and provides the results of our work to-date.

Isserman, A. 1993. "The Right People, the Right Rates: Making Population Estimates and Forecasts with an Interregional Cohort-Component Model." *Journal of the American Planning Association* 59: 45-64. This article offers suggestions for making the technical choices required in a given forecast choices in order to create a more thoughtful population forecasting process. Emphasis is on an interregional cohort-component approach made possible by newly available in-migration and out-migration data for all U.S. counties. The interregional approach avoids conceptual problems and biases of conventional net migration approaches and can be used to make county population estimates, projections, and forecasts. Sample spreadsheets with formulas demonstrate the procedures for calculating rates and making projections. Population projections for fifty-five counties illustrate the effects of several methodological choices

Jarosz, B. 2008. "Using Assessor Parcel Data to Maintain Housing Unit Counts for Small Area Population Estimates." pp. 89-102 in S. Murdock and D. Swanson (Eds.) *Applied Demography in the 21st Century*. Dordrecht, The Netherlands, Springer. This paper

describes the reasons why the San Diego Association of Governments switched from census and permit data to county assessor records to build housing unit files for purposes of estimating population by the Housing Unit Method. It describes the advantages of using the county assessor data as well as the disadvantages and difficulties they entail. It concludes with a description of the uses to which the data will be put, notably in the micro model known by the acronym of PECAS.

Judson, D. 2000. "The Statistical Administrative Records System and Administrative Records Experiment 2000." Paper presented at the National Institutes of Statistical Sciences Data Quality Workshop, Morristown, NJ, November 30th – December 1st . This paper provides some general principles for using administrative records properly And gives an overview of the US Census Bureau's StARS/AREX program, along with its history, goals and design. It concludes with some applications and evaluations of StARS 1999 and StARS 2000 versus Census 2000.

Judson, D., and M. Bauder. 2002. "Evaluating the Ability of Administrative Records Databases to Replicate Census 2000 Results at the Household Level." Paper presented at the Annual Meeting of the American Statistical Association, New York City, NY, August 11th - 15th. The authors report on the results of the AREX experiment, which was designed to gain information about the feasibility of an administrative records (AR) census that was conducted in two areas of the United States in 2000. The authors report that 81.4 % of the census addresses linked on a one-to-one basis with an AREX address. They recommend that the Census Bureau: continue improving computerized record linkage, develop methods to reduce the time lag of AR data; test AR data for substitution and imputation purposes in future census tests; continue to improve race and Hispanic ethnicity modeling and imputation, and explore new uses of modeling.

Judson, D., and C. Popoff. 2004. "Appendix C, Selected General Methods." Pp. 677-732 in Siegel and D. Swanson (eds.) *The Methods and Materials of Demography, 2nd Edition*. Amsterdam, The Netherlands: Elsevier Academic Press. This describes a range of topics associated with measurement and analysis, none of which is strictly demographic. It covers sampling, interpolation, adjustment of data to marginal distributions, the role of computer models in demographic research, the use of matrix methods in demography, micro-simulation, and system dynamic models, regional demographic- economic models.

Judson, D., C. Popoff, and M. Batutis. 2001. "An Evaluation of the Accuracy of U.S. Census Bureau County Population Estimation Methods." *Statistics in Transition* 5: 185-215. The authors focus on biases in the administrative records, which are used to estimate population changes, as clues to finding the possible reasons for over- and under-estimated counties. They examine, in detail, the sources of data used in the Census Bureau's methodology for reasons why there might be a systematic bias based on the circumstances under which data are gathered - either by the agency responsible for the administrative record used or by the person who will report. They test for these biases by using indicative economic and demographic data contained in the Bureau of the Census USA Counties 1994 release and identify causes of discrepancies in estimates that are systematic to the methodology, which suggest the direction and likely magnitude of the

discrepancy. They report that their results are completely consistent with a priori hypotheses.

Kadane, J., and E. Ericksen. 1984. "Revised Estimates of State and Central City Populations on Census Day, 1980." pp. 208-210 in *1984 Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. This paper uses information gathered by the U.S. Census Bureau for evaluation of the 1980 Census in order to give improved estimates of the population for 16 central cities and 50 states and remainders of states. The hierarchical model used to estimate the undercount is reviewed.

Katzoff, M., and D. Malec. 1983. "Application of Some Common Spatial Models to Population Data." pp. 522-524 in *1983 Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. This paper demonstrates the application of some results of a study of models and methods for assessing spatial autocorrelation in the context of small-area post-censal estimation to the problem of estimating county population sizes in the years following a U.S. Decennial Census.

Kilss, B., and W. Alvey. 1984 (Eds.) *Statistical Uses of Administrative Records: Recent Research and Present Prospects Vol I and Vol. II*. Washington, DC: U. S. Department of Treasury, Internal Revenue Service. This two volume set can be viewed as a handbook on the statistical use of administrative records. It provides six goals for statistical uses of administrative records, discusses developments up to the 1980s that were relevant to these recommendations, and describes elements of a strategy designed to achieve the six goals.

Kimpel, T., and T. Lowe. 2007. "Estimating Household Size for use in Population Estimates." *Population Estimates and Projections Research Brief No. 47*. Olympia, WA: Washington State Office of Financial Management. This Brief revisits a topic developed in Research Brief No. 10 where a regression procedure was developed using administrative data to update household size—a key variable used in local population estimates based on the Housing Unit Method. The authors find that generally the most accurate population estimates come from using several procedures and understanding the biases in each.

Kintner, H., and D. Swanson. 1993 "Measurement Errors in Census Counts and Estimates of Inter-censal Net Migration." *Journal of Economic and Social Measurement* 19 (2):97-120. The authors present a method for generating confidence intervals around estimates of inter-censal net migration, made using the life table survival method, that incorporate estimates of census measurement errors. The life table survival method applies a life table to a census count to project survivors at some past or future time points. Net migration is then estimated as the difference between the projected number of survivors and the enumerated population at that time. The authors present confidence intervals based on mean square error, the sum of the variance, and squared bias. It is assumed that random variation in the number of net migrants in an age-sex group is due to random variation in mortality rates and to measurement errors in census counts. The authors illustrate the technique using data from a small area in Alaska.

Kitagawa, E. 1980. *Estimating Population and Income of Small Areas*. Washington, DC: National Academy Press. This monograph represents the work of the Panel on Small Area Estimates of Population and Income, which was charged with evaluating the Census Bureau's procedures for making post-censal estimates of population and per capita income for local areas. The Panel found that the methods used by the Census Bureau were generally sound, but found that directionally biased estimates and large random errors for some areas. The Panel made eight recommendations.

Kitagawa, E., and B. Spencer. 1981. "On Estimating Population and Income for Local Areas." *Statistical Reporter* 81 (8): 377-381. The authors summarize the highlights of a 1980 report prepared by the Panel on Small-Area Estimates of Population and Income to evaluate the procedures used by the U.S. Bureau of the Census in making post-censal estimates of population and per capita income for local areas.

Krótki, K. 1978. (Ed.) *Developments in Dual System Estimation of Population Size and Growth*. Edmonton, Alberta, Canada: University of Alberta Press. This book explores the collection of vital statistics and the estimation of population size by two independent systems, and comparing the results on a name-by-name basis. This book discusses a number of theoretical issues related to dual-systems of data collection, practical problems that arise in carrying out such systems, reports in detail on selected surveys (particularly in Africa where vital statistics systems are notably weak), and summarizes actual surveys as well as the state of the art.

Lahiri, S. 1999. "Future Population Estimates in Destable Populations." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). In using the Hamilton-Perry method, one needs life table survival ratios and an assumption of the equality between the census survival ratios and the corresponding life table survival ratios. The author has shown elsewhere that such an equality holds good only when the population under study is either stationary or stable and therefore proposes a method that neither requires the knowledge of life table survival ratios nor the assumption of equality between the census survival ratios and the corresponding life table survival ratios. The technique proposed here assumes that the population under study is closed to migration, and it further requires the knowledge of age-specific growth rates, which can be estimated using earlier census enumerations over two or three inter-censal periods.

Land, K., and G. Hough. 1986. "Improving the accuracy of inter-censal estimates and post-censal projections of the civilian noninstitutional population: a parameterization of institutional prevalence rates." *Journal of the American Statistical Association* 81: 62-74. This article examines the empirical validity of the assumption that the age-, sex-, and race-specific proportions of the population that are institutionalized--as estimated by the last census--remain constant until the next census by using data from the decennial censuses for 1940-1980 and, in light of substantial decade to decade changes in the age patterns of the institutional proportions for sex- and race-specific populations, seeks to

develop alternative methods. To pursue the latter objective, parametric curves are fit to the age-specific institutional proportions for each population for each decade. A study of the observed historical variation in the parameters of these curves then leads to some suggestions about how their shapes can be estimated between censuses and projected beyond the latest available census to provide more accurate estimates and projections of the civilian non-institutional population.

Lee, E., and H. Goldsmith (Eds.). 1982. *Population Estimates: Methods for Small Area Analysis*. Beverly Hills, CA: Sage Publications. This monograph compiles papers presented at the Small Area Estimation Conference sponsored by the U.S. National Institute of Mental Health and held in Annapolis, Maryland, in November 1978. Ten papers by various authors are included, together with a series of evaluations and synopses by the editors. The overall theme of the papers is exploring new ways to estimate population numbers and characteristics. The following procedures are introduced and discussed: use of administrative records, synthetic approaches, surveys, simulations, and area cohort studies. The geographical focus of the studies is on the United States.

Long, J. 1993. "An Overview of Population Estimation Methods." pp 20-1 to 20-5 in D. Bogue, E. Arriaga and D. Anderton (Eds.) *Readings in Population Research Methodology* (Vol. 5), Chicago: United Nations Population Funds and Social Development Center. This paper notes that population estimates require choosing appropriate benchmarks (or auxiliary data) in estimating the population change since the last census. It classifies methods into two general types, flow and stock. Flow methods, which are also known as component methods, because they require estimation of each component of population change since the last census. Stock methods relate changes in population size since the last census to changes in other measured variables: the number of housing units, automobile registrations, total number of deaths (and births), and tax returns. A special case is known as the regression or ratio-correlation method. Another commonly used population stock method at the sub-national level is the housing unit method. Finally, the paper notes that estimation methods are used in combination.

Long, J. 1993. "Post-censal Population Estimates: States, Counties, and Places." *Population Division Working Paper Number 3*. Washington, DC: U.S. Bureau of the Census. (Available online, <http://www.census.gov/population/www/documentation/twps0003.html>, last accessed, March, 2008). This paper described the population estimates program of the U.S. Census Bureau and its history. It describes methods and their data sources and concludes that population estimates are an integral part of the U.S. statistical system. It also contains a short bibliography.

Lowe, T. 1988. "A Resurrection: The Potential of Postal Survey Data in Improving Housing Unit Population Estimates for Local Areas." Paper presented at the annual meeting of the Population Association of America., New Orleans, LA. The accuracy of postal survey data in reporting residential housing unit occupancy estimates was compared to that of 1970 and 1980 U.S. census data for 26 Washington State cities. These postal surveys were conducted by the Federal Department of Housing and Urban

Development in the 1970s within 2 months of collection of census data. Results are given in terms of absolute error of vacancy rates. Postal surveys almost always show lower vacancy rates than census data because they do not include unfinished or new units, or concealed unoccupied conversions in single family homes. Suburban single family housing generally has the highest occupancy rates. Postal data are much more accurate than census data when occupancy rates are variable, as in cities near military bases, and in multi-unit structures. This variability precludes the use of an adjustment factor in most cases. Adjusted postal occupancy rates were more accurate when city and postal boundaries corresponded and remained stable. The results of this study indicate the potential value of postal survey data when occupancy rates vary.

Lowe, T., and M. Mohrman. 2004. "The Pasco Project: An Opportunity to Identify Sources of Sample Bias." *Applied Demography* 17(1): 6-8. This paper describes the procedures, including GIS, that were used to develop a sample frame to be used in a re-assessment of the Housing Unit Method –based estimate of the city of Pasco for purposes of Washington State’s annual population estimation program. In conclusion, it notes that an accurate list of housing units (e.g., the Master Address File) is a necessity for the American Community Survey.

Lowe, T., and M. Mohrman. 2003. "Using a Geographic Information System in a Population Estimate Program: The Pasco Case." *Population Estimates and Projections Research Brief No. 21*. Olympia, WA: Washington State Office of Financial Management. This paper describes the GIS procedures that were used to develop a sample frame to be used in a re-assessment of the Housing Unit Method –based estimate of the city of Pasco for purposes of Washington State’s annual population estimation program.

Lowe, T., and M. Mohrman 2003. "Use of Postal Delivery Data in the Population Estimate Process." *Population Estimates and Projections Research Brief No. 18*. Olympia, WA: Washington State Office of Financial Management. This Brief extends the evaluation of postal vacancy/occupancy rates presented in Research Brief No.17. It examines the relationship between vacancy trends in postal data versus census data, describes how the postal rates were used in the 2003 estimation process using the Housing Unit Method, and identifies avenues for further evaluation.

Lowe, T., M. Mohrman, and D. Brunink. 2003. "Developing Postal Delivery Data for use in Population Estimates." *Population Estimates and Projections Research Brief No. 17*. Olympia, WA: Washington State Office of Financial Management. This case study underscores the problems inherent in developing address lists for census and sample purposes. The findings in this case study led the authors to caution that the ACS may have substantial coverage errors unless a great deal attention is paid to its frame, an extract of the Master Address File.

Lowe, T., et al. 2000. "Occupied versus Rented: Census and Real Estate Occupancy Rates and their use in Population Estimates." *Population Estimates and Projections Research Brief No. 9*. Olympia, WA: Washington State Office of Financial Management.

This Brief identifies differences in the definition of “occupied” as used by the federal Bureau of the Census and local Real Estate Surveys. It also provides a simple procedure for adjusting the real estate survey data for use in the estimation process.

Lowe, T., et al. 2000. “Developing Trends in Household Size for use in Population Estimates.” *Population Estimates and Projections Research Brief No. 10*. Olympia, WA: Washington State Office of Financial Management. This Brief illustrates a regression procedure using administrative data that can be used to update household size in the Housing Unit Method.

Lowe, T., D. Pittenger, and J. Walker. 1977. “Making the Housing Unit Method Work: A Progress Report.” Paper presented at the annual meeting of the Population Association of America, St. Louis, MO. This paper describes the procedures used by the Washington State Office of Financial Management in its statewide program for using the Housing Unit Method to annually estimate the populations of Washington’s cities and towns. It notes challenges and ways to overcome them.

Lowe, T., J. Weisser, and B. Myers. 1984. “A Special Consideration in Improving Housing Unit Estimates: The Interaction Effect. Paper presented at the annual meeting of the Population Association of America, Minneapolis, MN. The authors observe that of some of the terms in the equation for the Housing Unit Method are themselves correlated and discuss how this can be dealt with in using the Housing Unit method to estimate population. They specifically point to the interaction of average household size and structure type.

Lunn, D., S. N. Simpson, I. Diamond, and L. Middleton. 1998. “The Accuracy of Age-specific Population Estimates for Small Areas in Britain.” *Population Studies* 52 (3): 327-344. This paper presents a multi-level statistical analysis of the accuracy of age-specific population estimates made for British local authorities in 1991. The aim of this work was to identify the factors that influence accuracy, and to investigate how these influences interact. The analyses showed that the following area characteristics are key factors: true population size; inter-censal population change; and percentages of unemployed residents, armed forces residents, and students. In addition, the authors found that the overall type of method used to calculate estimates is important, and that its effect varies both with area characteristics and with age-group.

Mandell, M., and J. Tayman. 1982. “Measuring Temporal Stability in Regression Models of Population Estimation.” *Demography* 19: 135-146. This paper introduces an empirical indicator designed to measure the temporal stability of regression models used to produce sub-national population estimates. An analysis of 67 counties in Florida centers on 1970 total population estimates generated from ratio-correlation and difference-correlation models. Comparisons are made between 8 different regression specifications and employ a quantitative measure of relative estimate accuracy. The major findings are that variable measurement and type are important determinants of estimate accuracy, and although temporal stability of the coefficients impacts estimation errors, the influence is not as pervasive as is suggested in the literature.

Marker, D. 1999. "Organization of Small Area Estimators Using a Generalized Linear Regression Framework." *Journal of Official Statistics* 15: 1-24. In this article existing small area estimators are described, including Bayesian ones that have been proposed. A literature review is conducted for the estimators. The estimators are then organized from a general linear regression perspective, summarizing and showing where certain methods can be viewed as minor variations or generalizations of others. This includes a derivation of the conditions under which it is possible to view synthetic estimation as a form of regression. The article is aimed at pulling together the wide range of approaches that have been used for small area estimation.

Marks, E., W. Seltzer and K. Krotki. 1974. *Population Growth Estimation: A Handbook of Vital Statistics Estimation*. New York City, NY: The Population Council. The purpose of this handbook is to provide: an explanation of what the PGE technique is, some information on experiences around the world in its use, guidance on the general planning and the detailed design of a "Population Growth Estimation (PGE) study, including questions of cost, examples of procedures that may serve as models (even though imperfect ones) for the preparation of actual procedures, and a methodology for dealing with the inevitable weaknesses in the procedures used and in the estimates prepared. The PGE approach as used in the measurement or evaluation of vital statistics has three distinct features: the collection of reports of vital events by two quasi-independent data gathering procedures; the case-by-case matching of the reports in the two systems to determine which events are reported by both systems, and the preparation of an estimate of the number of events adjusted for omissions, or an estimate of the relative completeness of either system, on the basis of the match rates obtained. All three factors must be present for the study to be classified as one using the PGE approach.

Marquis, K., S. Wetrogan, and H. Palacios. 1996. "Towards a U.S. Population Database from Administrative Records." Unpublished Paper, U.S. Census Bureau (Available online, <http://www.census.gov/srd/papers/pdf/km9601.pdf>, last accessed May, 2008). This paper raises some orientation issues concerning a national database, provides some early results related to some of these issues, and discusses next steps for moving ahead with database building.

Martin, E. 2007. "Strength of Attachment: Survey Coverage of People with Tenuous Ties to Residences." *Demography* 44 (May): 427-440. The author discusses the effect of using more inclusive probes and questions used to compile the roster of household residences and concludes that tenuously attached people to a given household are likely to be omitted from the typical survey roster. She suggests that further experimentation using larger samples is needed to evaluate how inclusive survey procedures should be to adequately represent segments of the population with tenuous attachments and advises that this research may lead to improved survey measurements of important demographic subgroups that are currently poorly represented and measured in surveys and the census."

Martin, J., and W. Serow. "Estimating Characteristics using the Ratio-Correlation Method." *Demography* 15 (2): 223 - 233. Studies of the relative accuracy of methods of estimating the population at the sub-state level have generally found that the greatest degree of accuracy is provided by the ratio-correlation, or regression, method. This paper reports on research aimed at evaluating the effectiveness of this method in estimating the age and race composition of populations at the sub-state level. In addition to the basic multiple regression equation, variants such as stratification and the averaging of estimates from simple regression equations are also tested. For Virginia localities the most satisfactory results are generated by the non-stratified multiple regression equation.

Mason, A. 1996. "Population and Housing." *Population Research and Policy Review* 15 (6): 419-435. This paper assesses how population growth affects the housing sector and, in turn, economic development. Among other questions, the author examines how population growth increases the demand for residential land, housing, and urban infrastructure? Demographic methods were critical to answering the questions, especially assessing the impact of population growth on the demand for housing.

Massey, D., and R. Zenteno. 1999. "The Dynamics of Mass Migration." *Proceedings of the National Academy of Sciences*. 96 (Social Sciences): 5328-5335. The authors specify a set of equations defining a dynamic model of international migration and estimate its parameters by using data specially collected in Mexico. They then use it to project the a hypothetical Mexican community population forward in time. The authors argue that the model quantifies the mechanisms of cumulative causation predicted by social capital theory and illustrates the shortcomings of standard projection methodologies. The failure to model dynamically changing migration schedules yields a 5% overstatement of the projected size of the Mexican population after 50 years, an 11% understatement of the total number of U.S. migrants, a 15% understatement of the prevalence of U.S. migratory experience in the Mexican population, and an 85% understatement of the size of the Mexican population living in the United States.

McCarthy, K., A. Abrahamse, and C. Hubay. 1982. *The Changing Geographic Distribution of the Elderly: Estimating Net Migration Rates with Social Security Data*. Santa Monica, CA: RAND. This report presents a procedure that state and local planning agencies can use to monitor the movement of elderly persons into and out of individual U.S. counties. The procedure uses readily available Social Security data to produce accurate estimates of elderly net migration rates. The report describes the procedure's method and rationale, documents the formal estimation model, explains how to apply the model, and furnishes an illustration to guide the user.

McHenry, J. 1999. "A Local Alternative to Demographic Data Vendor Population and Household Estimates – Applying a Modified Housing Unit Approach to Individual Households." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). The author proposes a solution to problems encountered with small area data purchased from vendors that uses readily available local data combined with the housing

method. Purchasers of small-area demographic data from national data vendors confront three interrelated problems. He tests his proposed solution using 1998 Miami-Dade County tax assessor records and complementary data and argues that the resulting population and household estimates compare very favorably to estimates sold by national demographic data vendors.

McHugh, K. 1990. "Seasonal Migration as a Substitute for, or Precursor to, Permanent Migration." *Research on Aging* 12 (2): 229-245. This article examines conditions under which seasonal movement serves as a substitute for, or precursor to, permanent migration among winter visitors to recreational vehicle (RV) parks in the Phoenix, Arizona area. Ties to the home community, ties to the seasonal residence, demographic characteristics, and commitment to a mobile lifestyle are specified as determinants of expectations of moving to Phoenix on a permanent basis. The model is tested using survey data for a sample of 1,001 winter visitors in Phoenix RV parks. Results of a discriminant analysis indicate that place ties and position in the life cycle condition expectations of permanently migrating to a seasonal residence.

McKibben, J. 2007. "The Use of School Enrollment Data to Estimate Undercount in Small Areas." Paper presented at the Applied Demography Conference, San Antonio, TX, January 8th. This paper shows how enrollment data can be used in an age-sex pyramid to estimate census coverage by examining ratios of school age children to adult age groups in which their parents are located.

McKibben, J. 1988. "Evaluating the Accuracy of County Population Estimates Using the Reverse Demographic Accounting Method." Paper presented at the annual meeting of the Population Association of America, New Orleans, LA. The author examines the accuracy of the U.S. Bureau of the Census's 1975 county population estimates for Indiana by comparing them with "Expected Census" figures generated by the reverse demographic method. This method develops "expected" 1975 census figures by algebraically subtracting the reported number of net migrants for the period 1975-1980 from the reported 1980 census count and adding to this figure reported deaths and subtracting reported births for the same period. The results reveal that the Bureau's population estimates tend to underestimate rural and overestimate urban counties in Indiana for 1975. Furthermore, only 20 of Indiana's 92 counties had less than a 5 percent absolute error, while 80 percent of the counties with errors in excess of 5 percent absolute error were rural.

McKibben, J. and D. Swanson. 1997. "Linking Substance and Practice: A Case Study of the Relationship between Socio-economic Structure and Population Estimation." *Journal of Economic and Social Measurement* 24: 135-147. The authors argue that at least some of the shortcomings in accuracy of population estimates would be better understood by linking these methods with the substantive socio-economic and demographic dynamics that clearly must be underlying the changes in population that the methods are designed to measure. They provide a case study of Indiana over two periods, 1970-1980 and 1980-1990, which was selected because a common population estimation method exhibits a common problem over the two periods: its coefficients change. The authors link these

changes to Indiana's transition to a post-industrial economy and describe how this transition operated through demographic dynamics that ultimately affected the estimation model.

McVey, W. 1974. *An Empirical Assessment of a Modified Censal Ratio Estimation Technique*. Ph.D. Dissertation, Department of Sociology, University of Alberta, Edmonton, Alberta, Canada. The author examines the censal ratio technique in the context of broader models and suggests modifications that his data support as improvements in accuracy and efficiency.

Morrison, P. 1982. "Different Approaches to Monitoring Local Demographic Change." *RAND paper P-6743*. Santa Monica, CA: RAND Corporation. This paper is concerned with the problem of how to update demographic variables for small areas in the United States in the years following the decennial census. As background to considering the merits of a newly-proposed survey-based procedure, the author reviews various other conventional approaches to post-censal estimation--trend extrapolation, component analysis, and the use of symptomatic data. He then considers the survey approach as a complement to these other approaches.

Mulry, M., and B. Spencer. 1993. "Accuracy of the 1990 Census and Undercount Adjustments." *Journal of the American Statistical Association* 88 (423): 1080-1091. This article describes the total error analysis and loss function analysis done by the U.S. Census Bureau when it recommended to its parent agency, the U.S. Department of Commerce that the 1990 census be adjusted for net undercount. In its decision not to adjust the census, the Department of Commerce cited different criteria than aggregate loss functions. Those criteria are identified and discussed.

Mulry, M., and B. Spencer. 1991. "Total Error in PES Estimates of Population." *Journal of the American Statistical Association* 86 (416): 839-63. The authors describe a methodology for estimating the accuracy of dual systems estimates (DSE's) of population, census estimates of population, and estimates of undercount in the census. The DSE's are based on the census and a post-enumeration survey (PES). They apply the methodology to the 1988 dress rehearsal census of St. Louis and east-central Missouri and we discuss its applicability to the 1990 U.S. census and PES. The methodology is based on decompositions of the total (or net) error into components, such as sampling error, matching error, and other non-sampling errors. Limited information about the accuracy of certain components of error, notably failure of assumptions in the 'capture-recapture' model, but others as well, lead the authors to offer tentative estimates of the errors of the census, DSE, and undercount.

Murdock, S., and D. Swanson (Eds). 2008 *Applied Demography in the 21st Century*. Dordrecht, The Netherlands: Springer. A compendium of selected refereed papers presented at the 2007 Applied Demography Conference. The book offers 21 chapters organized into five major sections: (1) data use and measurement issues; (2) population estimates and projections; (3) applied demography and health; (4) the breadth of applied demography; and educating the applied demographer.

Murdock, S., and D. Ellis. 1991. *Applied Demography*. Boulder, CO: Westview Press. This is an introductory text designed to show the application of demographic techniques in such areas as real estate, marketing, and regional and services planning. It includes chapters on demographic concepts and trends, data sources and the principles of data use, basic methods and measures of applied demography, and methods for estimating and projecting populations. The geographical focus is on the United States.

Murdock, S., H. S. Hwang, and R. Hamm. 1995. "Component Methods." pp. 10-53 in N. W. Rives Jr., W. J. Serow, A. S. Lee, H. F. Goldsmith, and P. R. Voss (Eds.) *Basic Methods for Preparing Small-area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. This chapter provides an overview of component methods. It is divided into three sections: (1) the conceptual framework of component method estimation, its sources of data, widely used methods, and key assumptions; (2) general guidelines for using component methods; and (3) an evaluation of the relative strengths and weaknesses of component procedures and the common problems encountered in their use.

Myers, D. (Ed.). 1990. *Housing Demography: Linking Demographic Structure and Housing Markets*. Madison, WI: University of Wisconsin Press. This book consists of 13 papers selected to bridge the gap between the separate analysis of population data and housing data in the United States. The approach is interdisciplinary, involving demography, economics, geography, sociology, and urban planning. A major objective of the book is theory building. The papers are grouped under three main headings: linking housing characteristics with household composition, life course and cohort models of housing choice, and housing consumption among the elderly.

Myers, D., and A. Doyle. 1990. "Age-specific Population-per-Household Ratios: Linking Population Age Structure with Housing Characteristics." pp. 109-130 in D. Myers (ed.) *Housing Demography: Linking Demographic Structure and Housing Markets*. Madison, WI: University of Wisconsin Press. The authors develop a demographic framework for determining Persons per household and propose models for estimating these values with the age structure of the household population.

Namboodiri, N. K. 1972. "On the Ratio Correlation and Related Methods of Sub-national Population Estimation" *Demography* 9: 443-453. This paper recognizes that the ratio-correlation method is one of several methods currently being used in the United States for making post-censal estimates of sub-national units such as states and counties. The author conjectures that it seems to have been commonly presumed by those writing on the subject that the working of the ratio-correlation method can be understood simply on the basis of the multiple regression theory. That this common notion may sometimes be untenable is demonstrated in this paper. The author points out that the ratio-correlation method of sub-national population estimation has certain characteristic features that make its application fall sometimes outside the usual contexts in which the conventional multiple regression theory is applicable. A number of alternatives to the ratio-correlation method are suggested. Some of the alternatives suggested are shown to yield relatively

more accurate results when used for estimating post-censal populations of North Carolina counties.

Namboodiri, N. K., and N. Lalu. 1971. "The Average of Several Simple Regression Estimates as an Alternative to the Multiple Regression Estimate in Post-censal and Inter-censal Population Estimation: A Case Study." *Rural Sociology* 36: 187-194. The authors find that averaging the population estimates produced by several simple regression models increases accuracy.

Newell, C. 1988. *Methods and Models in Demography*. London, UK: Belhaven Press. This book outlines the methods used to study population structure and change by presenting the major descriptive and analytical models developed by demographers to investigate the interrelationships between fertility, age, structure, and mortality. With illustrations, tables, and data drawn from a wide range of countries in both the developed and developing world, it explicates the potential uses and limitations of the current models for population analysis, estimation, and forecasting.

Norris, D., M. Britton, and R. Verma. 1982. "The use of Administrative Records for Estimating Migration and Population." pp. 245-259 in *1982 Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. This paper gives an overview of the current methods and data sources used to prepare the Canadian sub-national population estimates, with particular emphasis on the migration components. The differences between the June 1981 post-censal population estimates and the 1981 Census Population counts are presented, with similar comparisons for 1976 and 1971. Then the results of the examination of some possible refinements to the current methodology are outlined, followed by a discussion of some of the issues involved and future work planned.

Office of Management and Budget. Statistical Policy Office. 1993. "Indirect Estimators in Federal Programs." *Statistical Policy Working Paper 21*. Federal Committee on Statistical Methodology. Subcommittee on Small Area Estimation. Washington, DC: Office of Management and Budget. This monograph comprises the eight reports which from a 1991 meeting by the Federal Committee on Statistical methodology that describe the use of indirect estimators and they are based on case studies from a variety of federal programs.

O'Hare, W. 1980. "A Note on the use of Regression Models for Making Population Estimates." *Demography* 17: 341-343. Evidence which has emerged in the past few years indicates that the relative accuracy of population estimates derived from the ratio-correlation method and the difference-correlation method varies from state to state. In assessing the possible reasons why neither technique is uniformly more accurate, attention is focused on the temporal instability of the statistical relationships between symptomatic indicators and population change. The author concludes that further improvement in population estimates based on regression techniques is likely to be limited until demographers derive means of measuring and adjusting for these temporal changes.

O'Hare, W. 1976. "Report on a Multiple Regression Method for Making Population Estimates." *Demography* 13: 369-379. This paper re-introduces the 'difference-correlation method of making population estimates first reported by Schmitt and Grier in 1966. The author uses it to produce population estimates for the counties of Michigan and finds that it produces estimates with a smaller mean percentage error than estimates produced by the ratio-correlation method. The author notes that differences of proportions which are used in the difference-correlation method will always have means of zero, while the ratios used in the ratio-correlation method have means which vary. Higher inter-correlations among the variables and increased temporal stability of the inter-correlations are two advantages of using differences rather than ratios.

Oshungade, I. 1986. "Use of Percentage Change in Small Area Statistics." *The Statistician* 35: 531-545. This paper presents a method for predicting the postcensal estimates for small area statistics. The method regressed the percentage changes in the dependent variable on the percentage changes in the symptomatic (independent) variables for a sample of some areas over two censuses to estimate the postcensal values for all the areas. The method can use raw and transformed data and has been used to estimate population values for 83 enumeration areas of Colchester District in 1981.

Palit, C., P. Voss, H. Krebs, and B. Kale. 1982. "Population Estimation from Administrative Records." pp. 261-277 in *1982 Proceedings of the Social Statistics Section*. Alexandria, VA: American Statistical Association. The authors discuss the estimation of U.S. population from administration records, which are defined as "data which are routinely collected by some other agency for non-demographic purposes." Possible sources of error are examined, with a focus on lack of quality control and on variation in quality over time. The use of various smoothing or filtering procedures in order to reduce error is explained.

Perrone, S. 2008. "Address Coverage and Improvement and Evaluation Program – 2005 National Estimate of Coverage of the Master Address File." pp. 37-85 in S. Murdock and D. Swanson (Eds.) *Applied Demography in the 21st Century*. Dordrecht, The Netherlands, Springer. The author reports on the Master Address File (MAF) portion of the U.S. Census Bureau's 'Address Coverage Improvement and Evaluation Program.' She provides annual calculations, 2000-2005, of the national coverage of housing unit counts and updates the 2000 baseline accordingly. She compares the estimated true housing unit count to annual housing counts from the MAF. She concludes that maintaining an accurate list of addresses continues to be a challenge.

Pitkin, J. 1992. "A Comparison of Vendor Estimates of Population and Households With 1990 Census Counts in California." *Applied Demography* 7(1):5-8. This study compares the 1990 U.S. population estimates of four national demographic data vendors with the actual counts of the 1990 Census. It was performed for a consortium of three public utility companies in California. In addition to total population, this study evaluates the estimates of three other demographic variables: (1) number of households; (2) population

of Spanish origin; and ((3) white population. Differences in accuracy are found among the vendors and between variables. On average, the estimates were most accurate for total population, considerably less so for race (white population) and households and by far the least accurate for Hispanic population.

Pitken, J. 2008. "U.S. Immigration in the Rear View Mirror." Paper presented at the annual meeting of the Population Association of America, New Orleans, LA. This paper uses reverse survival for estimating annual immigration prior to 2000 on a basis that is consistent with 2000 census counts. This new method is based on responses to the census question on Year of Entry that was asked of foreign-born persons in 2000. Although a similar question had been asked in earlier (1980, 1990, 2000) censuses, the 2000 census questionnaire for the first time asked for a response in terms of an exact year rather than a period of years. The advantage of this method is that it is, by definition, consistent with 2000 population counts.

Pittenger, D. 1982. "Critique of Administrative Record Procedures." pp. 39-42 in E. S. Lee and H. F. Goldsmith (Eds.), *Population Estimates: Methods for Small Area Analysis*. Beverly Hill, CA: Sage Press. The author extends a critique by M. Healy in this same volume by citing additional problems with using the 'administrative records method' (IRS files) to estimate internal migration in the U.S. He points out that a properly done Housing Unit Method done in conjunction with this technique could overcome some of these problems.

Pittenger, D. 2004. "Use of Census Data and City Housing Reports in Creating Housing-Unit Demolition Rates." *Population Estimates and Projections Research Brief No. 28*. Olympia, WA: Washington State Office of Financial Management. The author assesses if census data can be used as a possible source for creating rates of housing unit losses in areas where losses (e.g., demolitions) are not reported. He finds that because of the ignorance of many census respondents' to accurately report "year structure built", that census-based housing cohort loss data are not reliable either for benchmarking housing stock by age or for creating loss rates by age of unit. He concludes that for the purposes of estimating losses for county of municipal sub-areas in Washington, it seems better to use or adapt rates based on city demolition reports.

Pittenger, D. 1977. "Population Forecasting Standards: Some Considerations Concerning Their Necessity and Content." *Demography* 14 (3): 363-368. This paper discusses the nature of population forecasting and provides guidelines for standards that are in line with good professional practice yet do not stifle creativity or technical advances.

Plane, D. and P. Rogerson. 1994. *The Geographical Analysis of Population, with Applications to Planning and Business*. New York City, NY: John Wiley and Sons. This textbook concentrates on both applied demographic and planning techniques which rely upon geographical aspects of population data. It describes methods used to assess the impact of population change on facility demand, school enrollment, changes in product market, transportation and recreation demand forecasting. It contains problems for training students and has solutions to these problems with actual data.

Platek, R., J. Rao, C. Särndal, and M. Singh. 1987. *Small Area Statistics: An International Symposium*. New York City, NY: John Wiley and Sons. This book contains the papers from the symposium. It is divided into five sections: (1) policy issues; (2) population estimation for small areas; (3) theoretical developments; (4) the use of small area estimation by agencies and other organizations; and (5) a panel discussion. The second section contains discussion of regression and other models for small area population estimation.

Pollard, A., F. Yusuf, and G. Pollard. 1991. *Demographic Techniques, 3rd Edition*. Sydney Australia: Pergamon Press. This monograph is an introduction to demographic techniques for students who have a general interest in population studies. Exercises at the end of each chapter allow students to attempt practical problems. Sources of demographic data and statistics, basic demographic measures, the use of life tables, and the applications of stationary population models are reviewed. All aspects of mortality (cause of death, death rates, infant and maternal mortality), and fertility (family size, natural increase, fertility schedules, and differential fertility) are covered in detail. Other topics include stable population and population models, population projections, demographic sample surveys, multiple-decrement tables, testing the accuracy of demographic data, and estimating demographic measures from incomplete data.

Popoff, C., and D. Judson. 2004. "Some Methods of estimation for Statistically Underdeveloped Areas." Pp. 603-641 in J. Siegel and D. Swanson (eds.) *The Methods and Materials of Demography, 2nd Edition*. Amsterdam, The Netherlands: Elsevier Academic Press. This chapter covers techniques for making estimates from deficient data. The methods include stationary, stable and quasi-stable population techniques, samples, and dual system estimators.

Pozzi, F., Small, C., and G. Yetman. 2003. "Modeling the distribution of human population with night-time satellite imagery and gridded population of the world." *Earth Observation Magazine* 12(4): 24–30. The authors use the "World Stable Lights" dataset as a potential means to refine the spatial detail of the population dataset. They compared the Log10 of population density to the nighttime light frequency for sample of regions of the world with spatially detailed administrative data and found a consistent relationship between population density and light frequency. Based on this relationship, they developed a transfer function to relate light frequency to population density and a mass-conserving algorithm that relocates fractions of populations within large administrative units to locations of lighted settlements.

Prasad, N., and J. N. K. Rao. 1990. "The Estimation of the Mean Squared Error of Small-Area Estimators." *Journal of the American Statistical Association* 85 (409): 163-171. The authors investigate three small area models that are all special cases of a mixed linear model involving fixed and random effects. Using Henderson's general theory a 2-stage estimator of a small-area mean under each model is found. Results of a Monte Carlo study on the efficiency of 2-stage estimators and the accuracy of the proposed approximation to Mean Square Error (MSE) and its estimator are summarized. The

authors find that the MSE approximation provides a reliable measure of uncertainty associated with a 2-stage estimator as well as asymptotically valid confidence intervals on a small area mean as the number of small areas tends to infinity.

Preston, S. 1993. "The Contours of Demography: Estimates and Projections." *Demography* 30 (4): 593-606. The author discusses the scope of the field of demography and notes that the techniques for performing research in demography was improving more rapidly than in other areas of social science. The author identifies several areas of research in which demographers can be expected to be asked for answers from various clients, including voluntary international migration – a prescient inclusion.

Preston, S., P. Heuveline, and M. Guillot. 2001. *Demography: Measuring and Modeling Population Processes*. Oxford, UK: Blackwell. Besides the usual materials and methods, found in a demography textbook or reference book, this one contains three chapters of interest: (1) evaluating data quality; (2) stable population theory, and (3) indirect estimation methods.

Prevost, R. 1999. "Design Alternatives for Building Block Estimates." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). This paper described the prototyping done by the Census Bureau of a Statistical Administrative Records System (StARS) that will combine several major federal administrative records systems such as the IRS individual tax returns and information returns, HCFA Medicare enrollment data, SSA 'Numident' information, HUD Tract Rental Assistance Certification System, Indian Health Service, and Selective Service files. This paper provides background information on StARS and proposes design alternatives for the creation of building block (census block and tract) population and housing estimates after 2000.

Prevost, R. 1996. "Administrative Records and the New Statistical Era." Paper presented at the 1996 Annual meeting of the Population Association of America. New Orleans, LA, May 9th -11th. The author notes that the Census Bureau could reinvent and revolutionize data collection and processing operations in the next millennium by record integration, research, and maximizing the utility of administrative records.

Prevost, R. 1994. "State Housing Unit and Household Estimates: April 1, 1980, to July 1, 1993. *Current Population Reports, Series P-25, No. 1123*. Washington, D: US Government Printing Office. A description of methods, data, procedures, and results for the state level estimates of housing units done the period from 1980 to 1993.

Prevost, R., and C. Leggieri. 1999. "Expansion of Administrative Records Uses at the Census Bureau: A Long-Range Research Plan." Paper presented at the conference of the Federal Committee on Statistical Methodology (available online, <http://www.fcsm.gov/99papers/prevost.pdf>, last accessed, May 2008). The authors present a vision and strategy for the process through which the Census Bureau could reinvent and revolutionize data collection and processing operations in the next

millennium. Their proposed strategy is designed to draw strength from current operations through integration, research, and maximizing the utility of administrative records. The authors argue that this strategy will provide the ability to expand annual inter-censal products, and alternative approaches for statistically representing the United States with cost reductions in 2010. A major component of this strategy is a complete assessment of how effectively the Census Bureau is able to address customers and stakeholder needs. Thus, they include a needs assessment in their long-term strategy, one with three basic goals: (1) Reduced direct data collection cost; (2) Increased data quality; and (3) Reduced respondent burden.

Prevost, R., and D. Swanson. 1986. "A New Technique for Assessing Error in Ratio-correlation Estimates of Population: A Preliminary Note." *Applied Demography* 1(November): 1-4. Among other things, this paper provides a proof of the algebraically equivalency of a series of weighted separate synthetic estimators and the ratio-correlation regression method. The authors find that the coefficients in the ratio-correlation serve as weights, including the intercept term, which serves as a weight for an estimator formed by multiplying the proportion of the population of the area in question (e.g., a county in a given state) at the last census by the current population (estimate) for the aggregated set of areas (e.g., the state).

Price, D. 1955. "Examination of Two Sources of Error in the Estimation of Net Internal Migration." *Journal of the American Statistical Association* 50 (271): 689-700. Relative to using the survival rate method to estimate net migration, the author exams errors stemming from two sources in this method: (1) survival rates; and (2) (net) undercounting of the population. Using data from all (48 at the time) states, he examines the errors found by in using a single set of survival rates and state-specific life tables in ten states and concludes that the median error resulting from survival rates is about 14 percent of the estimate of net migration. Using census survival rates, he estimates about one third of net migration estimates are in error by 25 percent or more due to the effects of (net) under-enumeration.

Pursell, D. 1970. "Improving Population Estimates with the use of Dummy Variables" *Demography* 7: 87-91. In a case study of West Virginia counties, he author finds that the ratio-correlation model of estimating county population can be improved with the use of dummy variables and stratification to represent "type" of county, such as region or rate of development.

Purcell, N. and L. Kish. 1980. "Post-censal Estimates for Local Areas (or Domains)." *International Statistical Review* 48 (1): 3-18. The authors review methods for making small area estimates and present a classification for them, along with an extensive bibliography. They propose adding Iterative Proportional Fitting to these methods and justify both the model and the method within a broad theoretical framework. They provide some empirical results for their model that show improvements over other methods.

Qiu, F., K. Woller, and R. Briggs. 2003. "Modeling Urban Population Growth from Remotely Sensed Imagery and TIGER GIS Road Data." *Photogrammetric Engineering and Remote Sensing* 69: 1031–1042. The authors modeled population growth from 1990 to 2000 in the north Dallas-Fort Worth Metroplex using two different methods: (1) a conventional model based on remote sensing land-use change detection; and (2) a newly devised approach using GIS-derived road development measurements. These methods were applied at both city and census-tract levels and were evaluated against the actual population growth. It was found that accurate population growth estimates are achieved by both methods. At the census-tract level, their models yielded a comparable result with that obtained from a more complex commercial demographics model. At both city and census-tract levels, models using road development were better than those using land-use change detection. In addition to being efficient in cost and time, the authors argue that their models provide direct visualization of the distribution of the actual population growth within cities and census tracts when compared to commercial s demographic model.

Rasmussen, W.N. 1975. "The Use of Driver License Address Change Records for Estimating Interstate and Intercounty Migration." pp. 16-22 in *Inter-censal Estimates for Small Areas and Public Data Files for Research, Small Area Statistics Papers, Series GE-41, No. 1*. U. S. Bureau of the Census, Washington, DC: US Government Printing Office. This paper introduces the Driver License Address Change (DLAC) method, which was developed in the 1970s by the state of California to estimate migration in a component model used to estimate state population. It was subsequently modified to provide estimates for California's counties. In broad outline, the method estimates changes in county population proportion as a function of changes in various data series for three age groups: the population under 18; population, ages 18-64; and the population 65 years and over.

Raymer, J. and A. Rogers. 2007. "Using Age and Spatial Flow Structures in the Indirect Estimation of Migration Streams." *Demography* 44 (2): 199-223. This article outlines a formal model-based approach for inferring interregional age-specific migration streams in settings where such data are incomplete, inadequate, or unavailable. The estimation approach relies heavily on log-linear models, using them to impose some of the regularities exhibited by past age and spatial structures or to combine and borrow information drawn from other sources. The approach is illustrated using data from the 1990 and 2000 U.S. and Mexico censuses.

Raymondo, J. 1992. *Population Estimation and Projection: Methods for Marketing, Demographic, and Planning Personnel*. New York, NY: Quorum Books. The author provides a step-by-step guide for dealing with the issues associated with the methods of producing population estimates and projections. It begins by describing the general nature and differences of population estimates and projections and then covers several methodological issues that provide a foundation for the basic concepts of demographic analysis related to the production of population estimates and projections. Census concepts, including geography, are covered and the book includes a general discussion on major sources of data for the estimation and projection process.

Redfern, P. 1989. "Population Registers: Some Administrative and Statistical Pros and Cons." *Journal of the Royal Statistical Society, Series A* 152: 1-41. The author discusses the advantages and disadvantages of introducing a central population register in the context of the United Kingdom and describes the use of population registers in other European countries. He covers the statistical implications of better population registers, the various population records that do exist in the United Kingdom, and the proposal to introduce identity cards in Australia. A summary of a discussion that took place following presentation of the paper at the Royal Statistical Society is included.

Rees, P. 1994. "Estimating and Projecting the Populations of Urban Communities." *Environment and Planning* 26 (11): 1671-97. The author describes a model for estimating and projecting the populations of communities living in small areas within cities. The model provides a means of updating the demographic inputs needed for projection between censuses and means of developing scenarios of demographic change and housing development. Illustrative projections are discussed and interpreted for the northern English city of Bradford.

Rees, P., and R. Woods 1986. "Demographic Estimation: Problems, Methods, and Examples." pp. 301-343 in R. Woods and P. Rees (Eds). *Population Structures and Models*. London, UK: Allen and Unwin. In this chapter, the authors outline some of the issues the demographic researcher has to confront when investigating populations that vary over space, as well as some of the techniques that may be employed in estimating the data needed for such investigations. The elements considered by the authors include "(a) the concepts used in defining the population stocks and flows; (b) the age-time frameworks adopted; (c) the spatial frameworks used; and (d) the temporal and accounting frameworks employed. These concepts are applied to two examples.

Rees, P., P. Norman, and D. Brown. 2004. "A Framework for Progressively Improving Small Area Population Estimates." *Journal of the Royal Statistical Society, Series A* 167: 5-36. The paper presents a framework for small area population estimation that enables users to select a method that is fit for the purpose. The adjustments to input data that are needed before use are outlined, with emphasis on developing consistent time series of inputs. The authors show how geographical harmonization of small areas, which is crucial to comparisons over time, can be achieved. For two study regions, the East of England and Yorkshire and the Humber, the differences in output and consequences of adopting different methods are illustrated. The paper concludes with a discussion of how data, on stream since 1998, might be included in future small area estimates.

Reese, A. J. 2006. "A Comparison of Housing Unit Estimates to the American Community Survey's Aggregated Master Address File." Paper Presented at the Annual meeting of the Southern Demographic Association, Durham, NC. This report presents a comparison of the estimates of housing units, produced by the Population Division of the U.S. Census Bureau, to the number of valid units in the Master Address File (MAF), at the national, state, and county levels of geography for 2002 through 2005. Geographic patterns based on differences between the two datasets were detected and discussed in an

attempt to gain a deeper level of understanding of the differences between the two sources of data on the housing stock.

Reibel, M., and A. Agrawal, A. 2007. "Areal Interpolation of Population Counts using Pre-classified Land Cover Data." *Population Research and Policy Review* 26(5–6): 619–633. To combine population counts across incompatible tract geographies corresponding to successive census enumerations, the authors propose dasymetric areal interpolation using a pre-classified urban land cover data layer. A test of the interpolation technique using the National Land Cover Dataset (NLCD) shows significant error reduction over area weighted interpolation of the same data. The authors find that the NLCD compares favorably with other common techniques when considered on the basis of accuracy, precision and ease of use.

Reibel, M., and M. Bufalino. 2005. "A Test of Street Weighted Areal Interpolation using Geographic Information Systems." *Environment and Planning A*, 37: 127–139. The authors test a technique of areal interpolation using Geographic Information Systems (GIS) that employs a digital map layer representing streets and roads to derive varying density weights for small areas within aggregation zones. They find that the technique reduces errors in estimation when compared to estimates derived using the commonly applied area weighting technique, with its assumption of uniform density. They argue that the street weighting technique is much easier to use than other interpolation techniques that have also been shown to reduce error when compared to area based weighting.

Rives, N.W., and W. Serow. 1984. *Introduction to Applied Demography: Data Sources and Estimation Techniques*. Beverly Hills, CA: Sage Publications. This was the first book published on applied demography. It identifies kinds and sources of demographic data and then explains how to use this information to determine demographic trends and their consequences.

Rives, N.W., W.J. Serow, A. Lee, H. Goldsmith and P. Voss. 1995. *Basic Methods for Preparing Small-Area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. The chapters in this book largely were compiled from papers given at a workshop on small area population estimation organized for the 1984 meeting of the Southern Demographic Association. Including an afterword, there are eight chapters and an annotated bibliography. Component methods are discussed in the book along with the administrative records method, censal-ratio methods. The housing unit method, and the ratio-correlation method. One chapter provides an assessment of these methods.

Robinson, J.G., P. Das Gupta and B. Ahmed. 1990. "A Case Study in the Investigation of Errors in Estimates of Coverage Based on Demographic Analysis: Black Adults Age 30–64 in 1980." pp. 11–20 in *Proceedings of the Social Statistics Section, American Statistical Association*. Alexandria, VA: American Statistical Association. This paper discusses the possibility of error in some specific components that are used to develop the demographic estimates of population and coverage for U.S Blacks--namely, births, deaths, and base population. The effect of classification error has also been considered. It

has been shown that the net effect of these various sources of error is to overstate the current estimates of percent net undercount for Blacks." The focus is on the 1980 census. Roe, L., J. Carlson and D. Swanson. 1992. "A Variation of the Housing Unit Method for Estimating the Population of Small, Rural Areas: A Case Study of the Local Expert Procedure." *Survey Methodology* 18 (1): 155-163. The authors report on a random sampling study based on an adaptation of the Housing Unit Method and the local expert method to determine the socioeconomic features of three unincorporated rural communities near Yucca Mountain, Nevada. A sample of the study area was selected from a carefully screened frame comprised of electrical utility data. Meter readers from the local utility companies were the local experts and two of them worked together to authenticate the accuracy of recorded data which included number of person in the household as of July 15, 1990 and age and gender of each member. Data accuracy was tested and it was found that the 1990 US Census counts were within the relatively narrow 95% confidence intervals. The mean width was 7.2% of the estimated population, thus the authors conclude that the estimates were meaningful.

Rogers, A. 1975. *Introduction to Multiregional Mathematical Demography*. New York City, NY: Wiley Interscience. This textbook is about the modeling, analysis and projection of populations using concepts from multistate demography. It is focused on migration and regional analysis, particularly in terms of the growth and distribution of multiregional population systems.

Rogers, A. 1995. *Multiregional Demography: Principles, Methods and Extensions*. New York City, NY: John Wiley and Sons. This treatise is primarily designed as reference book on multiregional demography. It combines and updates the author's previous work on this subject and is designed for the readers familiar with the mathematics of uni-regional demographic analysis. Particular attention is paid to the analysis of migration and its contribution to projections of the growth and distribution of multiregional population systems. The concepts are illustrated with observed data from many different countries.

Rogers, A., and L. Castro. 1986. "Migration." pp. 157–210 in A. Rogers and F. Willikens (Eds.). *Migration and Settlement: A Multiregional Comparative Study*. Dordrecht, Netherlands: D. Reidel Publishing Company. In 1976, the International Institute for Applied Systems Analysis initiated a study of migration and population distribution patterns in its seventeen member nations. Much of this study appears in this book. In this chapter, the authors provide a conceptual and methodological overview of the study of migration and catalogue sources of data that can be used in its study, especially sources found in the member nations of IIASA.

Rosenberg, H. 1968. "Improving Current Population Estimates Through Stratification" *Land Economics* 44: 331-338. The author suggests ways in which regions can be stratified, such as level of economic development and how these stratification schemes can be incorporated into standard methods of population, especially regression-based ones such as the ratio-correlation technique.

Rowntree, J. 1990. "Population Estimates and Projections." *Population Trends* 60 (Summer): 33-34. This article describes briefly the different series of official population estimates and projections prepared by the United Kingdom's Office of Population Censuses and Surveys. It also refers to the 'extrapolated estimates' which have recently been introduced.

Sailor, P., and M. Weber. 1998. "The IRS population count: An update." 1998 *Proceedings of the Section on Survey Research Methods*. Alexandria, Va.: American Statistical Association. This is a continuation of the authors' study on the problems involved in using IRS administrative records to prepare estimates of the U.S. population size. Organizationally, this paper is divided into four sections. They demonstrate how administrative records can be used to compute a population estimate and then discuss the reliability of this estimate. Next, they compare estimates from their data base, classified by age, sex, and state, to population data published by the Census Bureau. And finally, they summarize their conclusions and make some recommendations for further research.

Scardamalia, R. 1992. "Estimates Base Adjustment." *Applied Demography* 6 (3): 2-3. This brief paper raises questions about the possible effects of net undercount adjustments on the process of making post-censal population estimates.

Scheuren, F. 1999. "Administrative Records and Census Taking." *Survey Methodology* 25(2): 151-160. The author considers the possible uses of administrative records to enhance and improve population censuses. After reviewing previous uses of administrative records in an international context, he puts forward several proposals for research and development towards increased use of administrative records in the American statistical system.

Schmitt, R. 1956. "Estimating Daytime Populations." *Journal of the American Planning Association* 22 (2): 83-85. The author notes the difficulty in estimating De facto populations because of the paucity of data and makes suggestions on how these shortcomings might be overcome in combination with selected population estimating methods.

Schmitt, R. 1954. "A Method of Projecting the Population of Census Tracts." *Journal of the American Planning Association* 20 (2): 102. Using 1930 and 1940 data, the author constructs a ratio-correlation method for the 84 census tracts comprising the Honolulu SMSA shows how it can be used to project the population of these tracts by substituting 1950 data and 1940 data for the 1930 and 1940 data, respectively.

Schmitt, R. 1954. "An Application of Multiple Correlation to Population Forecasting." *Land Economics* 30 (3): 277-279. This paper is a variation of the paper published by the author in 1954 in the *Journal of the American Planning Association*, although it largely relies on growth rates.

Schmitt, R. 1953. "A New Method of Forecasting City Population." *Journal of the American Planning Association* 19 (1): 40-42. The author presents a regression model with two independent variables, density and prior growth, for estimating/forecasting

population and illustrates its use for Seattle Washington. The model was calibrated using 1930 and 1940 data for thirty-seven (large) cities. He finds that the model performs well for these same cities when applied to 1950 and tested against 1950 census counts.

Schmitt, R. 1952. "Short-Cut Methods of Estimating County Population." *Journal of the American Statistical Association* 47 (258): 232-238. Using preliminary 1950 census data for the 39 counties of Washington as a case study, the author tests the accuracy of a series of 20 short-cut methods of estimate. He includes various weighting methods in this study and finds that properly weighted estimates combined from several methods show promise.

Schmitt, R. 1952. "Estimating Current Populations of Census Tracts." *Sociology and Social Research*, 37, 12-15. The author tests the accuracy of different estimation methods using 1950 census data for the 29 census tracts of Hawai'i.

Schmitt, R., and A. Crosetti. 1954. "Accuracy of the Ratio-correlation Method for Estimating Post-censal Population." *Land Economics* 30: 279-281. This paper introduces the ratio-correlation method and tests it using the 39 counties in Washington State.

Schmitt, R., and J. Grier. 1966. "A Method of Estimating the Population of Minor Civil Divisions." *Rural Sociology* 31: 355-361. The authors introduce the "difference-correlation" regression method using the populations and symptomatic indicators of minor civil divisions in Hawai'i and test its accuracy with 1960 census data. They find that it produced more accurate results than other methods included in the test.

Schoen, R. 1988. *Modeling Multigroup Populations*. New York City, NY: Plenum Press. This three-part book makes contributions to two areas of formal demography and extend their applications: (1) Multistate methods; and (2) the "two-sex" problem. The first part of the book covers life tables and stable population theory. The second part deals with multistate population models and the third part with the two-sex problem.

Schroeder, E., and D. Pittenger. 1983. "Improving the Accuracy of Migration Age Detail in Multiple-Area Population Forecasts." *Demography* 20 (2): 235-248. Population projections are often required for many geographical areas, and must be prepared with maximal computer and minimal analytical effort. At the same time, realistic age detail forecasts require a flexible means of treating age-specific net migration. This report presents a migration projection technique compatible with these constraints. A simplified version of Pittenger's model is used, where future migration patterns are automatically assigned from characteristics of historical patterns. A comparative test of age pattern accuracy for 1970-1980 indicates that this technique is superior to the commonly used plus-minus adjustment to historical rates.

Serow, W., and N. W. Rives. 1995. "Small Area Analysis: Assessing the State of the Art." pp. 1-9 in N. W. Rives, W. Serow, A. Lee, H. Goldsmith, and P. Voss (Eds). *Basic Methods for Preparing Small-Area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. The authors introduce the book they

helped to edit in this chapter and discuss the problem of small-area population estimates in general.

Shahidullah, M. 2003. "Uses, Methods, Input Data, and Evaluation of Population Estimates: Results from a State Survey." *Applied Demography* 16: 5-7. The reports the results of a 1999 survey of the states engaged in the Federal-State Cooperative Program for Population Estimates that was aimed at assessing the uses, methods, input data, and testing and evaluation of population estimates for each state and Puerto Rico. The authors report that 48 states and Puerto Rico returned completed questionnaires.

Shahidullah, M., and M. Flotow. 2005. "Criteria for selecting a suitable method for producing post-2000 county population estimates: A case study of population estimates in Illinois." *Population Research and Policy Review* 24 (3): 215-229. The authors compare 2000 county population estimates for Illinois against 2000 census counts. Administrative records (ADREC) and ratio correlation (Ratio-CORR) methods were used to produce two sets of controlled county estimates for 2000; a third set represented an average of the estimates reached using these methods. Another set using the ADREC method was not controlled to any estimate. ADREC estimates were more accurate than estimates from the Ratio-CORR or Average method in terms of Mean Absolute Percent (MAPE) or weighted MAPE. Undercount adjustment in general improved the accuracy of the estimates for all three methods. A top-down or bottom-up approach worked equally well. As a single method, ADREC performed best.

Shyrock, H. 1959. "Annotated List of Estimates of Net Migration: 1940 to 1950, by the Residual Method." *Population Index* 25 (1): 16-24. This report provides an annotated bibliography of methods for estimating net migration and actual estimates by thematic area and state.

Shryock, H. 1950. "Forecasts of Population in the United States." *Population Studies* 3(4): 406-412. The author describes how the Census Bureau published its first modern forecasts in 1947 as a cooperative venture with the Scripps Foundation and outlines organizational, research, and production plans for the future.

Shryock, H. 1938. "Methods of Estimating Post-censal Population." *American Journal of Public Health* 28: 1042-1047. A review of methods of population estimates, similar to his 1936 publication described in the following citation.

Shryock, H. 1936. "Population Estimates in Post-censal Years." *Annals of the American Academy of Political and Social Science* 188:167-176. The author traces the start population estimates done by the US Census Bureau to its establishment as a permanent organization in 1902 and describes the methods used over the years in estimating national, state and city populations. He describes why methods changed and summarizes the results of then-recent research by the Census Bureau on various methods, including the use of school enrollment data.

Shryock, H. and N. Lawrence. 1949. "The Current Status of State and Local Population Estimates in the Census Bureau." *Journal of the American Statistical Association* 44 (246): 157-173. This paper provides a brief history of population estimates done by the U.S. Census Bureau and a description of the methods being used at the time this paper was written. It compares the accuracy and general efficacy of these methods and discusses their strengths and weaknesses. The methods include Component Method I, Component Method II, arithmetic extrapolation, and apportionment.

Siegel, J. 2002. *Applied Demography: Applications to Business, Government, Law, and Public Policy*. San Diego, CA: Academic Press. This fourteen-chapter book can be used for instruction or reference. It is focused on the U.S. Chapters 9 and 10 cover estimates and projections of the population by age, sex and race, paying particular attention to the sub-national level. Chapter 11 focuses on estimates and projections of households, labor force, school enrolment, educational attainment and health. All three chapters discuss a wide range of methods and include lengthy sections on the evaluation of accuracy and utility. Each chapter comes with an extensive list of suggested readings, which are helpfully classified by section heading.

Siegel, J., and C. H. Hamilton. 1952. "Some Considerations in the use of the Residual Method of Estimating Net Migration." *Journal of the American Statistical Association* 47 (259): 475-599. The authors compare Census net migration data with estimates of net migration obtained by the residual method, representing the difference between total population change and natural change during a period, and discuss some general problems in the use of the residual method. Several residual methods - the vital statistics method and the forward, reverse, and average survival rate methods- are described, compared, and evaluated. On the basis of a symbolic model representing the population in an age group in terms of migration cohorts, the authors show how the various survival rate formulas, unlike the vital statistics method, fail to make an accurate allowance for the net migration of persons who die during the migration period, except under very restricted conditions of migration. They then develop maximum theoretical errors in the use of the various survival rate formulas, resulting from the inability of survival rates to measure deaths occurring in an area exactly, and the theoretical errors under different conditions of timing of migration, and make suggestions on this how the problem may be handled.

Siegel, J., H. Shryock, and B. Greenberg. 1954. "Accuracy of Post-censal Estimates of Population for States and Cities." *American Sociological Review* 19: 440-446. The authors note that census survival rates, which measure inter-censal state and county net migration, by age, color, and sex, have certain technical advantages over other residual methods, specifically the exclusive virtue of a built-in technique which corrects for net census undercount by age, including under-enumeration and misstatements of age. Using three sets of estimated "closed" native populations and reported United States deaths as standards, they evaluate three sets of national census survival rates, but note that the unavailability of appropriate figures make it impossible to determine precisely which is most accurate. They analyze the effects of adjusting census survival rates for national-state mortality differentials in measuring inter-censal net migration and deaths for states.

Next, they examine differences in state net migration and mortality arising from the use of the forward, reverse, and average formulas. They find insignificant differences between adjusted and unadjusted survival rates and among the forward, reverse, and average formulas. Finally, they provide estimates of net interstate migration for native whites, total whites, and nonwhites, by age and sex, for the 1940-50 decade, using census survival rates, and compare the results with the more correct estimates for all ages obtained with vital statistics data. By using the formula that most accurately duplicates "vital statistics" deaths over all ages, they argue that one can obtain the most precise inter-censal state net migration estimates by age.

Simpson, S. 1999. "Population Estimates for Small Areas in the U.K: Performance and Promise." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). This paper reports on "The Estimating with Confidence" project 1993-1996 which evaluated the accuracy of existing methods to produce population estimates for areas with 1,000 -30,000 people. A mid-term enumeration- a local census - was found to be the most accurate, but a number of cheaper desk-top methods employing administrative data gave reasonable results in most areas. The accuracy of these methods has been tabulated and attributed to characteristics of the areas estimated and the estimation strategies employed.

Simpson, S., I. Diamond, P. Tonkin, and R. Tye. 1996. "Updating Small Area Population Estimates in England and Wales." *Journal of the Royal Statistical Society, Series A*, 159 (part 2): 235-247. The authors state by observing that population estimates have important implications for resource allocation within government and commerce, and are often assumed to be without error. They note that currently, central government provides annual population estimates for all of the local and health authority districts in Britain, but estimates are needed for smaller areas, typically for electoral wards and postal sectors. Small area estimates are provided by some local authorities and commercial organizations, using different methods; the accuracy of these estimates is modeled by the authors within a multilevel framework. Certain characteristics of the small area and of the method of estimation are included as explanatory variables. Results show that the method of estimation used is of great importance.

Simpson, S., R. Cossey, and I. Diamond. 1997 "1991 Population Estimates for Areas Smaller than Districts." *Population Trends* 90: 31-39. This article describes the construction of population estimates for mid-1991 for electoral wards in England and Wales and postal sectors in Scotland. It shows how earlier work adjusting 1991 census figures at national and local authority level for undercount and other factors has been extended to smaller areas in a way that produces estimates which are consistent with the estimates for larger areas. Estimates for smaller areas are needed to calculate employment, health and other indices, and as a starting point for population estimates between census years.

Simpson, S., E. Middleton, I. Diamond and D. Lunn. 1997. "Small-area Population Estimates: A Review of Methods used in Britain in the 1990s." *International Journal of Population Geography* 3 (3): 265-280. The authors note that population estimates are usually produced by local government administrations in Britain, for each small area within their authority. Increasing interest has been shown by commerce and by central government. They identify five main methods: apportionment, ratio change, additive change, cohort survival, and local censuses. They also note that estimation strategies also vary according to available data, the detail in which a population is estimated, and the precise combination of elements chosen from one or more of the main methods. They survey the use of methods at the beginning of the 1990s and provide examples. The author conclude by observing that the accuracy of each main method is quantified from empirical data collated by the 'Estimating with Confidence' project and provide a review of likely developments towards the end of the 1990s.

Singh, M., M. Hidirolou, J. Gambino and M. Kovac□ević. 2001. "Estimation Methods and Related Systems at Statistics Canada." *International Statistical Review* 69 (3): 461-485. This paper provides an overview of research in estimation techniques, their application, and the development of generalized estimation systems at Statistics Canada. The paper briefly discusses estimation for longitudinal data and a weighting approach developed for cross-sectional data from these surveys. For cross-sectional household and business surveys, as well as the census of population, appropriate calibration estimators developed for each situation are briefly discussed. In addition, regression composite estimation, a method developed to improve the quality of cross-sectional estimates from rotating panel surveys such as the Canadian Labor Force Survey, is presented. With regard to more detailed cross-sectional estimates at sub-provincial levels, different approaches to small area estimation developed for various programs are also presented. The paper summarizes the various modules developed for the Generalized Estimation System and includes a discussion of new developments within the system such as two-phase estimation as well as the estimation of variance for a number of imputation procedures. The paper concludes with a brief review the status of current estimation research on selected topics and a discussion on the direction of future research.

Sink, L. 2000. "Estimates of the Population of Counties by Age, Sex, Race, and Hispanic Origin: 1990-1999." Unpublished report. Washington, DC. U.S. Census Bureau. (Available online, <http://www.census.gov/popest/archives/methodology/90s-co-meth.txt>, last accessed, May 2008). This is a description of the methods and data used to generate these estimates.

Sink, L. 1996. "Estimates of the Population of Counties by Age, Sex, Race, and Hispanic Origin: 1990-1994." *Release PE-48 (Methodology)*. Washington, DC: U.S. Census Bureau. This is a description of the methods and data used to generate these estimates.

Sirken, M., M. Graubard, and R. La Valley. 1978. "Evaluation of Census Population Coverage by Network Surveys." pp. 239-244 in *Proceedings of the Section on Survey Research Methods*. Alexandria, VA: American Statistical Association. The authors investigate the use of dual system estimators in the context of two Post-enumeration

survey methods, the Post-enumeration survey (PES) and the post-enumeration multiplicity survey (PEMS) that were being tested for use with the 1980 census. They note that except for the counting rule, the design features of both surveys are virtually the same. The PES adopts a De jure residence rule, and the PEMS adopts a multiplicity counting rule. The De jure residence rule specifies that people are eligible to be enumerated only at their usual places of residence. On the other hand, the multiplicity counting rule adopted by PEMS specifies that people are eligible to be enumerated at the households of specified close relatives as well as at their own De jure residences. Dual system estimators are investigated under both approaches with a focus on when PEMS would have a smaller correlation bias than PES.

Sivamurthy, M. 1969. "Errors in the Estimation of Net Migration Rate in the Studies of Internal Migration." *Journal of the American Statistical Association* 64 (328): 1434-1438. The author examines the effect of relaxing the conditions regarding the equality of the mortality rates and of the errors of enumeration between the states and the nation, on the error in the estimation of the net migration rate by the census survival ratio method. He shows that when the national population is closed, what the necessary and sufficient conditions are for this error to become zero. He does this by finding that the relative degree of enumeration for any age x of a given sex in the i^{th} state, as compared with the degree of enumeration in the nation at the first census, bears the same ratio to the relative degree of enumeration for the same cohort at age $(x + n)$ at the second census, as the survival ratio of that cohort from age x to $(x + n)$ in the i^{th} state bears to the corresponding survival ratio in the nation as a whole.

Smith, D. 1992. *Formal Demography*. New York City, NY: Plenum Press. This book is intended as a relatively non-technical introduction to current demographic methods. This book begins with an overview of demographic concepts and measures, including population pyramids and the Lexis diagram, to introduce readers to usual population configurations. Chapter 2 reviews data adjustment techniques that are widely used in demography, and includes elementary formulas for curve fitting, osculatory interpolation, and a selection of parametric distributions which find applications in fertility analysis. The chapter also introduces integral and derivative fittings for polynomial distributions, used in conjunction with the life table. Data adjustment by direct and indirect standardization is treated separately in Chapter 3. Chapters 4-6 focus on life table methodology. The later chapters of the book discuss fertility analysis, population projections and migration, and stable population theory.

Smith, S. K. 1996. "Demography of Disaster: Population Estimates after Hurricane Andrew." *Population Research and Policy Review* 15 (5-6): 459-477. This article describes the estimation problems created by Hurricane Andrew and how those problems were resolved through the use of existing data sources and the collection of new types of data. It concludes with a discussion of several conceptual, methodological and procedural issues that will have to be faced in virtually any attempt to estimate the demographic consequences of natural disasters.

Smith, S. K. 1995. "Housing Unit Method." pp. 89-117 in N. W. Rives Jr., W. J. Serow, A. S. Lee, H. F. Goldsmith, & P. R. Voss (Eds.) *Basic Methods for Preparing Small-area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. This chapter describes the general framework of the Housing Unit Method (HUM) and discusses the strengths and weaknesses of a number of the techniques and data sources that can be used with it. It provides examples and empirical evidence regarding the accuracy of different types of HUM estimates. It concludes with observations on the usefulness of the HUM in making local population estimates.

Smith, S. K. 1994. "Estimating Temporary Populations: The Contributions of Robert C. Schmitt." *Applied Demography* 9 (1): 4-7. This paper reviews the contributions to methods and data sources made by R. Schmitt in estimating temporary (De facto) populations over his career as the Hawaii State Statistician.

Smith, S. K. 1989. "Toward a Methodology for Estimating Temporary Residents." *Journal of the American Statistical Association* 84: 430-436. The author notes that most population statistics for states, counties, and cities refer to permanent residents, or persons who spend most of their time in an area, but that at certain times many states and local areas have large numbers of temporary residents who exert a significant impact on the area's economy, physical environment, and quality of life. He notes that typically, very little is known about the number, timing, and characteristics of these temporary residents. The author discusses the problems of defining and estimating temporary residents, focusing on the strengths and weaknesses of a number of data sources and estimation techniques. He closes with an assessment of the potential usefulness of developing methods to estimate temporary residents

Smith, S. K. 1986. "A Review and Evaluation of the Housing Unit Method of Population Estimation." *Journal of the American Statistical Association* 81:287-96. The author notes that the housing unit (HU) method is used by public and private agencies throughout the United States to make local population estimates. He describes many of the different types of data and techniques that can be used in applying the HU method, and it discusses the strengths and weaknesses of each. Empirical evidence from four different states is provided, comparing the accuracy of HU population estimates with the accuracy of other commonly used estimation techniques. Several conclusions are drawn regarding the usefulness of the HU method for local population estimation.

Smith, S. K., and M. House. 2007. "Temporary Migration: a Case Study of Florida." *Population Research and Policy Review* 26 (4): 437-454. Using several types of survey data, the authors examine the characteristics of non-Floridians who spend part of the year in Florida and Floridians who spend part of the year elsewhere. They develop estimates of the number, timing, and duration of temporary moves and the origins, destinations, characteristics, and motivations of temporary migrants. This study presents the most comprehensive analysis yet of temporary migration in Florida and provides a model that can be used in other places. It also points to a serious shortcoming in the US statistical system, namely, the lack of information on temporary migration streams, which might be addressed via the American Community Survey in the future.

Smith, S. K., and P. Morrison. 2005. "Small-Area and Business Demography." pp. 761-786 in M. Micklin and D. Poston, Jr. (Eds.) *Handbook of Population*. New York City, NY: Kluwer Academic/Plenum. In providing an overview of the subject matter, the authors briefly discuss estimation and forecasting method.

Smith, S. K., and S. Cody. 2004. "An Evaluation of Population Estimates in Florida: April 1, 2000." *Population Research and Policy Review* 23(1): 1-24. The authors investigate the influence of differences in population size and growth rate on estimation errors; compare the accuracy of several alternative techniques for estimating each of the major components of the Housing Unit Method (HUM); compare the accuracy of 2000 estimates with that of estimates produced in 1980 and 1990; compare the accuracy of HUM population estimates with that of estimates derived from other estimation methods; consider the role of professional judgment and the use of averaging in the construction of population estimates; and explore the impact of controlling one set of estimates to another. Their results confirm a number of findings that have been reported before and provide empirical evidence on several issues that have received little attention in the literature. They conclude with several observations regarding future directions in population estimation research.

Smith, S. K., and M. Mandell. 1984. "A Comparison of Population Estimation Methods: Housing Unit versus Component II, Ratio-Correlation, and Administrative Records." *Journal of the American Statistical Association* 79: 282-289. The authors observe that the Housing Unit Method (HUM) is often characterized as inferior to other methods for estimating the population of states and local areas. They challenge this characterization and in this paper evaluate population estimates produced by the housing unit method and by three other commonly used methods: component II, ratio correlation, and administrative records. Basing their analysis on 1980 census data from 67 counties in Florida and testing for precision, bias, and the distribution of errors, the authors find that their application of the HUM performs at least as well as the more highly acclaimed methods of local population estimation.

Smith, S. K., and C. McCarty. 1996. "Demographic Effects of Natural Disasters: A Case Study of Hurricane Andrew." *Demography* 33: 265-275. The authors use information from a sample survey and other sources to evaluate the effects of Hurricane Andrew on the housing stock and population of Dade County, Florida. They estimate that more than half of the homes were damaged and that 330,000 people left their homes, at least temporarily, and that 40,000 left permanently.

Smith, S. K., and J. Nogle. 2004. "An Evaluation of Hispanic Population Estimates," *Social Science Quarterly* 85: 731-745. Using a variety of techniques, the authors develop Hispanic population estimates for counties in Florida and evaluate the accuracy of those estimates by comparing them with 2000 Census counts. They find that Hispanic population estimates have larger errors than estimates of total population; errors vary considerably by population size and growth rate; some techniques perform better than others in places with particular population characteristics; and averages often perform better than individual techniques. They conclude that in many circumstances, symptomatic

data series can provide more accurate estimates of the Hispanic population than more commonly used techniques.

Smith, S. K., and J. Nogle. 1997. "An Experimental Methodology for Estimating Hispanic Residents for States and Counties." *Journal of Social and Economic Measurement* 23 (2) 263 – 275. In this article, the authors describe an experimental methodology for estimating the Hispanic population of states and counties. They use post-censal data on births, deaths, and school enrollment for estimates of the total Hispanic population and data from the two most recent decennial censuses for estimates of the age, sex, and race distribution of that population. They discuss the strengths and weaknesses of this methodology and illustrate its application by making estimates of the Hispanic population for counties in Florida.

Smith, S. K., and S. Cody. 1994. "Evaluating the Housing Unit Method: A Case Study of 1990 Population Estimates in Florida." *Journal of the American Planning Association*. 60: 209-221. The authors observe that the housing unit method (HUM) is the most commonly used approach to making small-area population estimates in the US. They evaluate the accuracy and bias of HUM-based population estimates produced for counties and sub-county areas in Florida for April 1, 1990. They find that population size has a negative effect on estimation errors (disregarding sign) but no effect on bias; growth rates have a U-shaped effect on estimation errors (disregarding sign) and a negative effect on bias; electric customer data provide more accurate household estimates than building permit data; errors in household estimates contribute more to population estimation error than do errors in estimates of average household size or group quarters population; and the application of professional judgment improves the accuracy of purely mechanical techniques. The authors argue the HUM offers a number of advantages over other population estimation methods and provides planners and demographers with a powerful tool for small-area analysis.

Smith, S. K., and M. House. 2007. "Temporary Migration: a Case Study of Florida." *Population Research and Policy Review* 26 (4): 437-454. In this paper, the authors analyze temporary migration streams in Florida, focusing on moves that include an extended stay. Using several types of survey data, they examine the characteristics of non-Floridians who spend part of the year in Florida and Floridians who spend part of the year elsewhere. They develop estimates of the number, timing, and duration of temporary moves and the origins, destinations, characteristics, and motivations of temporary migrants. They argue that this study presents the most comprehensive analysis yet of temporary migration in Florida and provides a model that can be used in other places. They also point to a serious shortcoming in the US statistical system, namely, the lack of information on temporary migration streams. They observe that the American Community Survey provides an opportunity to remedy this problem.

Smith, S. K., and B. Lewis. 1983. "Some New Techniques for Applying the Housing Unit Method of Local Population Estimation: Further Evidence." *Demography* 20: 407-413. The authors note that the housing unit method (HUM) of population estimation is often characterized as being imprecise and having an upward bias. In an earlier paper, the

authors argued that the method itself cannot be properly characterized by a particular level of precision or direction of bias. Only specific techniques of applying the new method can have such characteristics. In that paper, the authors present several new techniques for estimating the number of households and average number of persons per household (PPH). However, the testing of these new techniques was limited by the lack of census results against which the estimates could be compared. Complete census data on population, households, and PPH are available and can be used to test alternate estimation techniques. The tests reported in the earlier paper using 1980 census data for Florida's 67 counties are replicated and the authors argue that this provide further evidence that the new techniques produce more precise, less biased estimates than previously used techniques.

Smith, S. K., and D. Swanson. 1998 "In Defense of the Net Migrant." *Journal of Economic and Social Measurement*. 24: 155-170. This paper discusses the benefits and weaknesses of net migration as a theoretical concept and as a measure of population movement in the United States. It notes that net migration is useful in population estimation, forecasting, and analysis, but that it is faulted for not being as true a measure of population movement as gross migration because net migration is not a process itself, but the difference between two processes. The authors note that this same characterization could apply to the concept of "profit," the difference between gross income and gross expenditures. They go on to note that like profit, net migration is a useful concept even if it is not a "true" measure of population movement.

Smith, S. K., J. Nogle, and S. Cody. 2002. "A Regression Approach to Estimating the Average Number of Persons per Household." *Demography* 39(4): 697-712. The authors develop several regression models in which PPH estimates were based on symptomatic indicators of PPH change. They tested these estimates using county level data in four states and found them to be more precise and less biased than estimates based on more commonly used methods.

Smith, S. K., J. Tayman and D. Swanson. 2001. *State and Local Population Projections: Methodology and Analysis*. New York: Kluwer Academic/Plenum Publishers. This book focuses on the methodology and analysis of state and local population projections. It describes the most commonly used data sources and application techniques within each of three classes of projection methods (cohort-component, trend extrapolation, and structural models) and covers the components of population growth, the formation of assumptions, the development of evaluation criteria, and the determinants of forecast accuracy. It considers the strengths and weaknesses of various projection methods, paying special attention to the unique problems of making projections for small areas, and closes with an examination of technological and methodological changes affecting the production of small-area population projections.

Snow, E.C. 1911. "The application of the method of multiple correlation to the estimation of post-censal populations." *Journal of the Royal Statistical Society* 74 (part 6): 575-620. This paper represents the first published description of the use of multiple correlation (regression) in the estimation of population. It discusses a number of other methods (e.g.,

“The American Method”), pointing out their strengths and weaknesses, then describes the model framework and the data used, and applies the method to districts in the U. K., noting a “false start” from a first attempt and how it was revised.

Spar, M. and J. Martin. 1979. “Refinements to regression-based estimates of post-censal population characteristics.” *Review of Public Data Use* 7: 16-22. The authors find that the ratio-correlation method is more accurate than others in estimating the populations of Virginia counties by race and age.

Spencer, B., and C. Lee. 1980. “Post-censal population estimation methods of the Census Bureau.” pp. 131-187 in *Estimating Population and Income of Small Areas*. Panel on Small-Area Estimates of Population and Income, Committee on National Statistics, National Research Council. Washington, DC: National Academy Press. This paper described the methods used by the U.S. Census Bureau to estimate populations at the national and sub-national levels.

Starsinic, D., and R. Forstall. 1989. “Patterns of Metropolitan Area and County Population Growth: 1980 to 1987.” *Current Population Reports, P-25, No. 1039*. Washington, DC: US Government Printing Office. This report contains population estimates for July 1, 1987, revised estimates for July 1, 1986, and components of population change from 1980 to 1987 for individual metropolitan statistical areas (MSA's) and their component counties....The report also contains census counts for April 1, 1980, annual summary estimates since 1980 for the metropolitan and non-metropolitan population by State, a discussion of trends since 1980, and comparisons with the 1970's and 1960's. It also shows 1986 population estimates for MSA central cities. Summaries for the United States, regions, divisions, and States are presented for the 1987 population inside and outside metropolitan areas and for the 1986 population inside and outside central cities. Selected tables also include data for groupings of metropolitan areas, such as the Northeastern Megalopolis, for cities of 100,000 and over, and for counties.

Starsinic, D., and M. Zitter. 1968. “Accuracy of the Housing Unit Method in Preparing Population Estimates for Cities.” *Demography* 5: 475-484. This paper reports the results of a test of the relative accuracy of the housing unit method in the estimation of the population of cities. Estimates were prepared for 47 cities in excess of 50,000 population in which special censuses were conducted during the years 1964-66. The test points up five features of the housing unit method for the estimation of the population of cities. (1) In general, the method yields estimates on the high side. When building-permit data were used as a basis for estimates, the deviations were positive in about 30 of the 47 cases. Of the cities in which the deviations were negative, about one-half had had substantial annexation after 1960. (2) The use of utility data instead of building-permit data generally reduces the size of errors, although here too there are substantially more positive than negative deviations. (3) Deviations are smaller when the average size of household is extrapolated than when the 1960 values are used. (4) When either building-permit or utility data were used, the average error in the estimate of the number of households was high. (5) The estimate of the number of households is a greater contributor to errors in estimates of population than is the estimate of the average size of household (for this test,

extrapolated from 1950-60 values or assuming no change since 1960). Although the scope of the test was limited, the method made a relatively creditable showing, with average errors of 3.6 to 5.8 percent, excluding areas that are experiencing large annexations.

Starsinic, D., A. Lee, H. Goldsmith, and M. Spar. 1995. "The Census Bureau's Administrative Records Method." pp. 54-69 in N. W. Rives, W. Serow, A. Lee, H. Goldsmith, and P. Voss (Eds). *Basic Methods for Preparing Small-Area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. The authors begin this chapter by noting that the so-called Administrative Records Method (ARM) is similar to Component Method II (CM II) in that it is a component-based method. They note that the two methods differ in their approach to estimating the migration component in that the ARM uses tax returns and CM II uses school enrollment. They describe the details of the ARM and illustrate its use.

Starsinic, M. 2003. "Small Area Modeling for the American Community Survey." Paper presented at the 2003 American Statistical Association Conference, August 3-7. The author investigates whether small area estimation techniques can improve the overall estimates and estimates of specific characteristics for counties and census tracts. He uses EBLUP and hierarchical Bayes estimators and states that by analyzing data from the 2000 American Community Survey Comparison Test, he will be able to compare his estimators against "true" population values from Census 2000.

Statistics Canada. 1987. *Population Estimation Methods, Canada*. Ottawa, Ontario, Canada: Ministry of Supply and Services. The methods used to produce official population estimates for Canada are discussed and evaluated in this monograph. The chapters are organized around three recurring themes: (1) method; (2) data sources, and; (3) quality evaluation so that an attempt is made in each chapter to answer the corresponding questions: (1) how are the estimates produced; (2) what are the data and their sources, and; (3) how reliable are the estimates in light of various validation criteria?" Separate chapters are included on post-censal population estimates for the total population and for the population by sex, age, and marital status, inter-censal estimates, internal migration, emigration, local area population, and family estimates.

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Statistics Finland. 2004. *Use of Registers and Administrative Data Sources for Statistical Purposes.: Best practices of Statistics Finland*. Helsinki, Finland: Statistics Finland. This monograph documents the development, workings, and uses of the Finnish Statistical System, including the generation of population data.

Stone, G. 2008. "Methods for Measuring the Population After a Disaster: Household Population Surveys in Post-Katrina New Orleans, October 2005 – October, 2006." pp. 113-123 in S. Murdock and D. Swanson (Eds.) *Applied Demography in the 21st Century*. Dordrecht, The Netherlands, Springer. The author describes the use of three difference sampling designs to conduct household surveys in Post-Katrina New Orleans. He discusses their limitations, cost and time requirements and the usefulness of the estimates they produced.

Summers, A. and B. Wolfe. 1978. "Estimation of Household Income from Location." *Journal of the American Statistical Association* 73: 288-292. The authors describe a Block Income Estimating Procedure (BIEP) for estimating the average income of the households of a Census block, using block housing information and Census tract distributions relating to housing and household income. They observe that BIEP also can be used to estimate the average income of geographic areas that do not coincide with Census tracts or postal zip code areas, the smallest spatial units for which official data are available. BIEP's efficacy is tested using a special Census tabulation for Philadelphia school feeder areas, and it is compared with its closest rival, a tracts-average procedure. The authors find that BIEP works well relative to the other procedure.

Sutton, G. and G. Danziger. 1989. "Are Accuracy and Quality the Same Thing in Projections of Local Area Populations?" pp. 186-191 in 1989 *Proceedings of the American Statistical Association, Social Statistics Section*. Alexandria, VA: American Statistical Association. This paper offers a method that the authors believe will increase the acceptability of population projections as forecasts by drawing on ecological models of growth and by calling forth theories of age and family life cycle patterns in residential preferences. Sum results from the study of the differences in the shape of age distributions among communities are presented. The method is illustrated with data for Massachusetts from 1970 to 1980.

Swanson, D. 2008. "Measuring Uncertainty in Population Data Generated By the Cohort-Component Method: A Report on Research in Progress." pp. 165- 189 in S. Murdock and D. Swanson (Eds.) *Applied Demography in the 21st Century*. Dordrecht, The Netherlands: Springer. Building on earlier work, the author provides an ex post facto test of a procedure for generating a formal measure of uncertainty for short-term population forecasts made using the cohort-component method using a 1990 forecast launch date and 2000 census data as the benchmark for a small population in a Nevada County. The procedure uses a Mean-Square Error Confidence Interval that is subject to limitations. The author finds that the technique shows promise, but needs more work to be useful.

Swanson, D. 2008. "The Demographic Effects of Hurricane Katrina on the Mississippi Gulf Coast: An Analysis by Zip Code." Presented at the Conference of the Mississippi Academy of Sciences, 20-22 February, Olive Branch, Mississippi. This paper provides an estimate of the effects of Hurricane Katrina on the population of 20 selected zip code areas in Hancock, Harrison and Jackson counties, Mississippi, that were at or near the epicenter of Hurricane Katrina. The effects are examined by using 1990 and 2000 census data, information from a special data collection funded by the National Science Foundation, and special county-level "Katrina impact" 2006 population estimates prepared by the U. S. Census Bureau. The Cohort Change Ratio Method is applied to 1990 and 2000 census data to generate 2007 population estimates in the absence of Katrina. These estimates are then adjusted to take Katrina's effects into account. By comparing the adjusted to the unadjusted estimates an idea of the absolute and relative impact of Katrina is gained. The comparison suggests that Katrina's demographic effects are profound and not only likely to affect the 2010 census counts in these areas, but that

they may persist well beyond. Given the long-lasting demographic effects of such disasters, the author suggests that these methods be used in the future and provide specific recommendations on how this can be accomplished.

Swanson, D. 2004. "Advancing Methodological Knowledge within State and Local Demography: A Case Study." *Population Research and Policy Review* 23 (4): 379-398. This paper examines a regression model developed in Nevada following the 2000 census that led to conflict over its use to estimate the population of Clark County, Nevada in 2002. The discussion reveals statistical and methodological shortcomings in this model that lead to an alternative model not subject to these shortcomings. This example illustrates how this type of analysis and discussion can lead to a wider understanding of methods on the part of practitioners through the corrective process of academic peer review. It also suggests that states in which estimates are used to allocate resources would be well-served by subjecting new methods being considered for use to academic peer review before they are adopted.

Swanson, D. 1989. "Confidence Intervals for Post-censal Population Estimates: A Case Study for Local Areas." *Survey Methodology* 15: 271-280. The author shows how confidence intervals can be developed for population estimates using the ratio-correlation method (and its variants), illustrates the proposed procedure using county data from Washington State and shows that it works well in an ex post facto test using 1980 census data as a benchmark.

Swanson, D. 1986. "Evaluating Population Estimates and Short-Term Forecasts." *Applied Demography* 2 (November): 5-6. The author provides some general guidelines for evaluating population estimates and short-term population forecasts and points out that some of the methods typically used in developing estimates can be used for developing short-term projections and that virtually all of the methods typically used in developing short-term forecasts can be used for estimates.

Swanson, D. 1981. "Allocation Accuracy in Population Estimates: An Overlooked Criterion With Fiscal Implications." pp. 13-21 in *Small Area Population Estimates and Their Accuracy, Series GE-41, No. 7*. U. S. Bureau of the Census. Washington, DC: US Government Printing Office. The author argues that because population estimates are often used to distribute resources in a zero-sum fashion, an important component in measuring the performance of estimation methods is missing, namely allocation error. He proposes using the Index of Dissimilarity to overcome this problem and illustrates its use with Washington State data.

Swanson, D. 1980. "Improving Accuracy in Multiple Regression Estimates of Population Using Principles from Causal Modeling." *Demography* 17: 413-428. This paper reports a mildly restricted procedure for using a theoretical causal ordering and principles from path analysis to provide a basis for modifying regression coefficients in order to improve the estimation accuracy of the ratio-correlation method of population estimation. The modification is intended to take into account temporal changes in the structure of variable relationships, a major element in determining the accuracy of post-censal estimates. The

modification of coefficients is conservative in that it uses rank-ordering as a basis of change. Empirical results are reported for counties in Washington State that demonstrate the increased accuracy obtained using the proposed procedure.

Swanson, D. 1978. "An Evaluation of Ratio and Difference Regression Methods for Estimating Small, Highly Concentrated Populations: The Case of Ethnic Groups." *Review of Public Data Use* 6: 18-27. Using 1970 census data as a benchmark, this paper compares the accuracy of the ratio-correlation and difference-correlations methods for estimating the population by race in Washington State's 39 counties. The models are constructed using 1950 and 1960 data. The difference-correlation model shows much better characteristics (e.g., a higher r^2), but its accuracy is not shown in the test to be any higher than that of the ratio-correlation model. The paper notes that compared to difference-correlation method, the ratio-correlation method cannot deal well with sparse data where zero counts exist because a ratio with a zero in it is undefined while a difference with a zero leads to an actual value. Hence, the poor characteristics of the ratio-correlation model. The paper concludes that this is a case where model characteristics can be misleading since the ratio-correlation model performs as well as the difference-correlation model in the ex post facto test.

Swanson, D., and G. Hough. 2007. "An Evaluation of Persons Per Household (PPH) Data Generated By the American Community Survey: A Demographic Perspective." Paper presented at the Annual Meeting of the Southern Demographic Association. Birmingham, AL. This paper explores the usability of ACS data by examining "Persons Per Household (PPH), a variable of high interest to demographers and others preparing regular post-censal population estimates. The data used in this exploration are taken from 18 of the counties that formed the set of 1999 ACS test sites. The examination proceeds by comparing ACS PPH values to PPH values generated using a geometric model based on PPH change between the 1990 and 2000 census counts. The ACS PPH values represent what could be called the "statistical perspective" because variations in the values of specific variables over time and space are viewed largely by statisticians with an eye toward sample (and non-sample) error. The model-based PPH values represent a "demographic perspective" because PPH values are largely viewed by demographers as varying systematically, an orientation stemming from theory. The results suggest that the ACS PPH values lack sufficient temporal consistency to be used by demographers.

Swanson, D., and A. Al-Jiboury. 1988. "Inter-censal Net Migration Among the Three Major Regions of Iraq: 1957-1977." *Janasamkhya* 6 (December): 93-126. The authors generate total net migration estimates for the Northern, Central, and Southern regions in Iraq between 1957 and 1977. This was accomplished by applying the Reverse Survival Ratio Estimate Method (RSRE). Since the RSRE method has not been used in a nation such as Iraq, which lacks complete census and vital statistics information, it was tested using complete population data from the Mid-Atlantic Division of the United States. The test results indicated a reasonable level of accuracy in determining both the direction and the volume of the total net migration estimates over the 1960-70 period, given the authors' assumptions. The authors conclude that this method of estimation is useful for economic and social development planning in countries with incomplete census data.

Swanson, D., and J. McKibben. 2007. "New Directions in the Development of Population Estimates and Projections." Paper presented at the Satellite Conference on Small Area Statistics, 56th Conference of the International Statistical Institute, Pisa, Italy. The authors argue that a continuously updated Master Address File can be used to develop population estimates and projections if it is properly enhanced (EMAF). The authors describe a set of activities needed to develop EMAF and how EMAF data could be directly assessed for statistical uncertainty and its use as a basis for developing population projections containing a wide range of ascribed (e.g., age and sex) and achieved characteristics (e.g., educational attainment and employment). The authors point out that such a development would bring the US Census Bureau's small area population estimation programs more in line with its European counterparts, but that there are several important challenges that must be surmounted, including issues of public trust, confidentiality, and tradition.

Swanson, D., and L. Pol. 2008. "Applied Demography: Its Business and Public Sector Components." in *Demography* (Ed. Zeng Yi), *Encyclopedia of Life Support Systems (EOLSS)*. Developed under the auspices of UNESCO, EOLSS Publishers, Oxford, UK (available online, <http://www.eolss.net>, last accessed February, 2008). This paper contains a description of the methods and data used for population estimates and projections as well as a bibliography.

Swanson, D., and L. Pol. 2005. "Contemporary Developments in Applied Demography within the United States." *Journal of Applied Sociology* 21 (2): 26-56. In addition to covering contemporary developments in the field of applied demography and some ideas about its future, the paper describes the methods and data used in population estimation and projection.

Swanson, D., and J. Wicks (Eds). 1987. *Issues in Applied Demography: Proceedings of the 1986 National Conference*. Bowling Green, OH: PSRC Press. These are the proceedings of the 1986 Conference on Applied Demography. The focus of the conference was on ways in which demographic data and concepts can be used to produce better and more informed business and public policy decisions. Subject headings include applied demography and government policy; technical issues in business demography; relations between public sector and academic demographers; demography and management issues in business; and linking the demographic information needs of business, state and local governments, and universities.

Swanson, D., and D. Beck. 1994. "A New Short-term County Population Projection Method." *Journal of Economic and Social Measurement* 20: 25-50. This paper proposes a new method for short-term county population projections. It is based on a modification of the ratio-correlation method of population estimation. The modified ratio-correlation method can produce projections with a high potential for accuracy without requiring substantial data and intensive intellectual labor inputs. Tests of accuracy are examined for the modified ratio-correlation method and two currently available alternatives using data

from Washington State. The authors find that the tests suggest that the new method performs well.

Swanson, D., and L. Tedrow. 1984. "Improving the Measurement of Temporal Change in Regression Models used for County Population Estimates." *Demography* 21: 361-372. The ratio-correlation method of population estimation is shown to contain an inconsistent temporal relationship between the model's empirical structure and its actual application. A simple transformation of the model's variables is provided that eliminates the inconsistency. Two tests of the relative accuracy of the original and transformed models show that the transformed model achieves accuracy levels equal to or higher than the original. In one test, all nine years show a higher degree of accuracy, of which four are statistically significant. Several possible reasons are given for the increased accuracy shown by the transformed model. The transformation, termed the "rate-correlation" model, is recommended as a logical starting point in the examination of coefficient stability and spatial autocorrelation as well as a method for estimating small populations.

Swanson, D., T. Burch, and L. Tedrow. 1996. "What is Applied Demography?" *Population Research and Policy Review* 15 (5-6): 403-418. The authors argue that applied demography is intrinsically distinct from basic demography because it exhibits the value-orientation and empirical characteristics of a decision-making science while the latter exhibits the value-orientation and empirical hallmarks of a basic science. Distinguishing characteristics of applied demography are based on the context in which it places precision and explanatory power relative to time and resources as well as the fact [that] its substantive problems are largely exogenously-defined, usually by customers. The substantive problems of basic demography, on the other hand, are largely endogenously-defined, usually by academic demographers. The authors examine this conceptualization of applied demography in terms of the methods and materials that fall within its purview and discuss some important consequences, including research agendas and training programs.

Swanson, D., J. Tayman, and C. Barr. 2000. "A Note on the Measurement of Accuracy for Sub-national Demographic Estimates." *Demography* 37: 193-201. Mean absolute percentage error (MAPE), the measure most often used for evaluating sub-national demographic estimates, is not always valid. The authors describe guidelines for determining when MAPE is valid. Applying them to case data, the authors find that MAPE understates accuracy because it is unduly influenced by outliers. To overcome this problem, the authors calculate a transformed MAPE (MAPE-T) using a modified Box-Cox method. Because MAPE-T is not in the same scale as the untransformed absolute percentage errors, the authors provide a procedure for calculating MAPE-R, a measure in the same scale as the original observations. The authors argue that MAPE-R is a more appropriate summary measure of average absolute percentage error when the guidelines indicate that MAPE is not valid.

Swanson, D., J. Tayman, and D. Beck. 1995 "On the Utility of Lagged Ratio-Correlation as a Short-term County Population Estimation Method: A Case Study of Washington State." *Journal of Economic and Social Measurement* 21:1-16. The utility of a new,

short-term method of projecting future population at the county level is evaluated by the authors and compared with two alternative methods, exponential extrapolation and the cohort-component method, using data for Washington State for 1970, 1980, and 1990. The evaluation suggests that the lagged ratio-correlation method consistently has a high level of utility for all three time points. It achieves reductions in error that are comparable to those achieved by the Cohort-Component Method, yet with much less resource requirements. The exponential extrapolation method is found to have high and moderate utility in two of the three time points.

Swanson, D., G. Hough, J. Rodriguez, and C. Clemans. 1998. "K-12 Enrollment Forecasting: Merging Methods and Judgment." *ERS Spectrum* 16 (4): 24-31 pp. Arlington, Virginia. This article describes an enrollment forecasting process in which technical experts and local community stakeholders in Oregon worked together to produce data that were cost-efficient and yet accurate enough to serve as the basis for sound decisions. The large school district that employed this process gained valuable insights to guide its attendance zone and facilities planning decisions, and also created a group of key communicators to ensure community understanding and support. In an ex post facto evaluation, the authors find that the method produces forecasts sufficiently accurate for the school district to make the right decisions about its capital facility needs.

Swanson, D. J. Carlson, L. Roe, and C. Williams. 1995. "Estimating the Population of Rural Communities by Age and Gender: a Case Study of the Effectiveness of the Local Expert Procedure." *Small Town* 25 (6): 14-21. This article examines the accuracy of a survey-based technique called the Local Expert Procedure for estimating selected demographic characteristics of small, rural areas. The procedure employs local citizens to provide demographic information about households which were randomly selected from a residential sample extracted from utility records. The procedure is used to provide age and sex estimates for the population of three communities near Yucca Mountain, Nevada.

Swanson, D., Morrison, P., Sharkova, I., Tayman, J., and Popoff, C. 1999. *Evaluation of the Washoe County Population Estimation System (WCPEM), and Recommendations for Improving the County's Estimation Program*. Report submitted by S.A.I.C., Inc. to the Washoe County Department of Community Development, Reno, Nevada. The authors evaluated data and human capital resources available to Washoe County, Nevada for purposes of developing annual population estimates and made recommendations on how to use them to accomplish this goal, including the use of assessor parcel records.

Swanson, D., V. Kanhaiya; Y. Riad, B. Barry, and R. Prevost. "Impact of Census Error Adjustments on State Population Projections: the Case of Ohio." *Ohio Journal of Science* 89 (1) : 26-32 National undercount adjustment factors from the 1970 and 1980 U.S. censuses are used to prepare population projections for Ohio, which are in turn compared with unadjusted projections. The findings suggest that decisions concerning adjustment factors have varying effects on short-term, long-term, and strategic forecasting. These effects are particularly salient for selected age-groups and the impact on state government budget decisions typically associated with these age-groups. The authors recommend that

the effects of alternative adjustment possibilities be examined by state demographic centers and budget offices.

Sweet, J. 1984. "Components of Change in the Number of Households: 1970-1980." *Demography* 21 (2): 129-140. This paper decomposes the growth in the number of households during the 1970s into components associated with changing age and marital status composition and changing age by marital status-specific propensities to form households. About one-third of the increase in the number of households was due to increased age by marital status propensity to form households, and two-thirds was due to shifts in the age by marital status distribution and population growth.

Tang, Z. 2008. "A New Approach to Measuring Migration and Local Population." *Canadian Studies in Population* 35 (1): 27-48. The author proposes using IRS data to estimate migration at the sub-county level using a process that consists of two major steps. The author argues that this method can produce timely population estimates by race, sex, and age at the sub-county level in an efficient and economical manner. As well generating estimates at state and county levels using bottom-up method. A comparison between the author's estimates and those produced by the US Bureau of the Census indicates that the historically problematic population underestimation for Massachusetts has been significantly improved through the application of this new methodology.

Taeuber, I. 1949. "Literature on Future Populations, 1943-1948. *Population Index* 15 (91): 2-30. This bibliography begins with a statement by the author that it is intended as a supplement to bibliographies found in "The Future Population of Europe and the Soviet Union: Population Projections, 1940 -1970," by Notestein et al. (1944). The author proceeds to give a general orientation to the field of "future estimation," with specific examples, some discussion on methods (e.g., growth curves), prospects for obtaining data on future populations, carrying capacities, economic and social analyses, "short-time estimates, sub-national projection issues, and the basic research underway on the determinants of population change. The bibliography itself contains 224 entries, organized by thematic (e.g., migration) and geographic (e.g., Germany) areas.

Tarver, J. 1962. "Evaluation of Census Survival Rates in Estimating Inter-censal State Migration." *Journal of the American Statistical Association* 57 (300): 841-862. Census survival rates have certain technical advantages over other residual methods, specifically the exclusive virtue of a built-in technique which corrects for net census undercount by age, including under-numeration and misstatements of age. Using three sets of estimated "closed" native populations and reported United States deaths as standards, this study evaluates three sets of national census survival rates. The study finds insignificant differences between adjusted and unadjusted survival rates and among the forward, reverse, and average formulas. Finally, it estimates net interstate migration for native whites, total whites, and nonwhites, by age and sex, for the 1940-50 decade, using census survival rates, and compares the results with the more correct estimates for all ages obtained with vital statistics data. By using the formula which most accurately duplicates "vital statistics" deaths over all ages, one obtains the most precise inter-censal state net migration estimates by age groups.

Tayman, J. 1999. "Population and Housing estimates for Census Blocks: The San Diego Experience." Paper presented at the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). This paper reports on the integrated system developed by San Diego Association of Governments (SANDAG) for preparing annual population and housing estimates by census block. It also evaluates two sources of address-level information - utility hook-ups and assessors parcel file information - that SANDAG has used to develop these estimates, focusing on their accuracy and their strengths and weaknesses. The paper concludes with some general issues involved in estimating block-level population and housing, including maintaining an up-to-date GIS system, data management, temporal consistency, and controlling.

Tayman, J. 1996. "The Accuracy of Small-area Population Forecasts Based on a Spatial Interaction Land-use Modeling System." *Journal of the American Planning Association* 62 (1): 85-98. The author evaluates census tract forecasts based on a spatial interaction modeling system known as DRAM/EMPAL in a case study of San Diego County, California that focuses on performance measures that provide a broader look at forecast error. Mean absolute and algebraic percent errors are the most commonly used measures of precision and bias, but the author points out that measures based on the average can overstate the typical error because forecast error distributions are often positively skewed. Skewed error distributions, which occur with greater frequency in small areas, often result in different values for the median and the average of the central tendency.

Tayman, J. 1994. "Estimating Population, Housing and Employment for Micro-Geographic Areas." pp. 101-107 in K. V. Rao and J. W. Wicks (Eds.) *Studies in Applied Demography, 1994*. Bowling Green, OH: Population and Society Research Center: Bowling Green State University. This paper described procedures for developing current estimates of population, housing and place-of-work employment for micro-geographic areas in San Diego County, California. It demonstrates that with the proper technology and innovative use of nontraditional data sources, it is possible to estimate these activities for sub-census tract geographic areas. The procedures represent an interdisciplinary approach to the problem, blending the theory and methods from demography and geography. Residential meter and wage and salary employer address-level files allow a reasonably accurate determination of the micro-geographic location of employment and residential activities.

Tayman, J. 1991. "Population and Housing Estimates for Micro-Geographic Areas: A Blend of Demographic and GIS Techniques." Presented at the annual meeting of the Population Association of America. Washington, D.C. This paper describes the tools used to develop population and housing estimates for micro-geographic areas from electric meter residence files, census tract data, and its subdivisions Traffic Analysis Zones (TAZ), gridcells forming the Master Geographic Reference Area (MGRA), and the GBF/DIME file and a GIS procedure called ADMATCH, which maps and matches addresses to a geographic element. The biases occurring from mismatches or missing meters did not cause

a serious problem in estimating. Unique geographic areas can now be created using the procedure POLYGON-to-POLYGON Overlay where MGRA polygon boundaries are fit to the designated polygon boundaries. The procedure in ARC/INFO called NETWORK can generate estimates for an area 10 minutes from a given site. An example is given.

Tayman, J. 1986. "An Integrated System for Subcity Population Estimation." Presented at the annual meeting of the Population Association of America. San Francisco, CA. The author describes the integrated system implemented in the San Diego Region (San Diego County) for preparing census tract level household income estimates. He described the methods, data and procedures used in this system as well as the uses of the estimates generated by the system. He discusses future developments and plans.

Tayman, J., and C. Rynerson. 1997. "An Integrated System for Estimating Subcounty Household Income Distributions. Presented at the annual meeting of the Population Association of America. Washington, DC. The authors described the integrated system implemented in the San Diego Region (San Diego County) for preparing census tract level household income estimates. The estimates were done first for the region, then for 41 groups of census tracts known as sub-regional areas (SRAs), then for the region's 347 census tracts. The modified lognormal curve was employed with a different equation using the parameters of income class, PARM (reflecting constant terms), and EXP (a nonlinear adjustment parameter). To estimate the household income distribution, the parameters of median income, PARM, and EXP were needed. Using 1990 census median incomes and income distributions as inputs, an iterative method was used for 9250 combinations of PARM and EXP to find the parameters that minimize the error between the observed and estimated income distributions. For the investigation of historical trends in the parameters, 1980 census data from eight income ranges were also assembled. Inputs to the model included the base year data, the estimated parameters, control totals from an independent estimate of the number of households for the region, SRAs and census tracts, and adjustment factors calculated from a comparison of the estimated and actual 1990 household income distributions. The integrated household income estimation system was fully implemented by means of finding solutions to the issues of forming households from individual tax returns, residual and adjustment factors, the applicability of the modified lognormal curve, and extrapolating parameters. The internal and external consistency of the estimates was also evaluated.

Tayman, J., and E. Schafer. 1985. "The Impact of Coefficient Drift and Measurement Error on the Accuracy of Ratio-Correlation Population Estimates." *The Review of Regional Studies*. 15(2): 3-10. In this paper, the authors seek to determine the relative impact of 3 sources of error on the accuracy of population estimates produced by the ratio-correlation technique. These sources include coefficient instability, biased estimators and unreliable post-censal symptomatic indicators. The analysis focuses on a comparison of 1980 total population estimates of the counties of Washington developed from 6 specifications of a ratio correlation model. The analysis demonstrated that, at least in this particular situation, unstable regression coefficients contribute very little to overall estimate inaccuracy; the other 2 sources tended to produce estimates with greater inaccuracy. In addition it was found that the 2 sources of measurement error produced inaccuracies in estimates of about equal

level. The findings question O'Hare's conclusion that estimate accuracy using the correlation method cannot be expected to improve unless ways of controlling or adjusting for coefficient drift can be found. From an applications perspective it would seem that greater benefit, i.e., less inaccuracy, can be realized by improving efforts in the area of symptomatic indicator measurement error rather than by modifying the basic ratio correlation model structure. Due to the fact that one is frequently required to produce population estimates from symptomatic data, the authors conclude that the potential impact of improving overall population estimate accuracy appears to be substantial.

Tayman, J., and D. Swanson. 1999. "On the validity of MAPE as a Measure of Population Forecast Accuracy." *Population Research and Policy Review* 18 (4): 299 - 332. The authors note that mean absolute percent error (MAPE) is the summary measure most often used for evaluating the accuracy of population forecasts. While MAPE has many desirable criteria, they argue from both normative and relative standpoints that the widespread practice of exclusively using it for evaluating population forecasts should be changed. Normatively, they argue that MAPE does not meet the criterion of validity because as a summary measure it overstates the error found in a population forecast. They base this argument on logical grounds and support it empirically, using a sample of population forecasts for U.S. counties. From a relative standpoint, they examine two alternatives to MAPE, both sharing with it, the important conceptual feature of using most of the information about error. These alternatives are symmetrical MAPE (SMAPE) and a class of measures known as M-estimators. The empirical evaluation suggests M-estimators do not overstate forecast error as much as either MAPE or SMAPE and are, therefore, more valid measures of accuracy."

Tayman, J., and D. Swanson. 1996. "On the Utility of Population Forecasts." *Demography* 33 (4): 523-528. The authors note that although the forecast evaluation literature is extensive, it is dominated by a focus on accuracy. They go beyond accuracy by examining the concept of forecast utility in an evaluation of a sample of 2,709 [U.S.] counties and census tracts. They find that forecasters provide 'value-added' knowledge for areas experiencing rapid change or areas with relatively large populations. For other areas, reduced value is more common than added value. The authors find that their results suggest that new forecasting strategies and methods such as composite modeling may substantially improve forecast utility.

Tayman, J., E. Schafer, and L. Carter. 1998. "The Role of Population Size in the Determination and Prediction of Population Forecast Errors: An Evaluation Using Confidence Intervals for Subcounty Areas." *Population Research and Policy Review* 17 (1): 1-20. This paper describes a technique for making sub-county population forecasts and for generating confidence intervals around their forecast error. It also develops statistical equations for calculating point estimates and confidence intervals for areas with different population sizes. A non-linear, inverse relationship between population size and forecast accuracy was found and we demonstrate the ability to accurately predict average forecast error and confidence intervals based on this relationship. The data consist of 1980 and 1990 census observations and 1990 population forecasts for San Diego County, California.

Tayman, J., D. Swanson, and C. Barr. 1999. "In Search of the Ideal Measure of Accuracy for Sub-national Demographic Forecasts." *Population Research and Policy Review* 18 (5): 387-409. The authors examine nonlinear transformations of the forecast error distribution in hopes of finding a summary error measure that is not prone to an upward bias and uses most of the information about that error. MAPE, the current standard for measuring error, often overstates the error represented by most of the values because the distribution underlying the MAPE is right skewed and truncated at zero. Using a modification to the Box-Cox family of nonlinear transformations, we transform these skewed forecast error distributions into symmetrical distributions for a wide range of size and growth rate conditions. They verify this symmetry using graphical devices and statistical tests; examine the transformed errors to determine if re-expression to the scale of the untransformed errors is necessary; and develop and implement a procedure for the re-expression. The authors find that MAPE-R developed by this process is lower than the MAPE based on the untransformed errors and is more consistent with a robust estimator of location.

Thomsen, I., and A. Klievie-Holmy. 1998. "Combining Data from surveys and Administrative Record Systems: The Norwegian Experience." *International Statistical Review* 66 (2): 201-222. The authors note that at Statistics Norway administrative data have been extensively used in order to improve the quality of survey data. Various techniques have been used to reduce sampling variance and/or to reduce the effects of non-response. In this paper, the authors discuss some of the most commonly used methods, and based on empirical rather than theoretical evaluations, they provide their conclusions concerning their potentials and limitations.

United Nations. 1969. *Methodology and Evaluation of Population Registers and Similar Systems. Studies in Methods, No. 15.* Sales No. E.69.XVII.15. New York City, NY: United Nations. This manual describes the methods and data commonly found in population registration systems, giving some history. It also describes suggested techniques for evaluating the efficacy of population registers.

United Nations. 1982. *Model Life Tables for Developing Countries.* Sales No. E.81.XIII.7. New York City, NY: United Nations. (Available online, www.un.org/esa/population/publications/Model_Life_Tables/Model_Life_Tables.htm, last accessed May, 2008). This report presents model life tables for developing countries. It gives sets of age-sex patterns of mortality which are based on reliably documented developing country data, thus supplementing the Coale-Demeny model life tables extracted mainly from historical European experience. Both the United Nations model life tables for developing countries and the Coale-Demeny model life tables are also available in the United Nations software package MORTPAK.

United Nations. 1983. *Manual X: Indirect Techniques for Demographic Estimation.* Population Studies, No. 81. Sales No. E.83.XIII.2. New York City, NY: United Nations. (Available online, www.un.org/esa/population/publications/Manual_X/Manual_X.htm, last accessed May, 2008). This manual is designed to assist demographers and population

experts in conducting evaluations and exploitation of data sources, especially those that are incomplete or deficient. Manual X describes a wide range of techniques to make indirect estimates of demographic parameters. Each of the techniques presented is based on a mathematical model and explained in easy-to-follow examples.

United Nations. 1984. *Handbook of Household Surveys. Studies in Methods, Series F*, No. 31. Sales No. E.83.XVIII.13. New York City, NY: United Nations. This is a revised edition of the basic document in a technical series published by the United Nations to assist countries in planning, implementing, and utilizing the results from household surveys. It provides overall technical information and guidance of a relatively general nature to middle- and senior-level personnel who are producers or users of survey statistics. Included in the topics discussed are planning, strategy and technical design; selection of topics and their translation into survey instruments and preparation of the accompanying manuals, instructions and training activities; organization and implementation of field work; processing, compilation, tabulation and dissemination of data; evaluation of the data and the procedures used to collect and process them; and analyses and arrangements for active storage and retrieval of the survey results. Selected issues from survey experience in Africa, Asia, and Latin America are discussed.

United Nations. 1985. *Development and Design of Survey Questionnaires*. National Household Capability Programme. INT-84-014. New York City, NY: United Nations. This manual provides a broad review, with numerous illustrations, of questionnaires and study designs for use in the development and implementation of household surveys.

United Nations. 1993. *Sampling Errors in Household Surveys*. National Household Capability Programme. INT- 92-P80-15E. New York City, NY: United Nations. This manual provides a broad review, with numerous illustrations, of major sources of non-sampling errors in household surveys so as to enhance awareness among survey practitioners of factors which determine the quality of data produced through surveys. The study also provides a practical guide to the measurement and control of non-sampling errors. There are a number of illustrations from a variety of experiences.

United Nations. 1998. *Principles and Recommendations for Population and Housing Censuses, Revision 1*. Sales No. E.98.XVII.8. New York City, NY: United Nations. The structure of the revised Principles and Recommendations closely follows that of the previous recommendations. Modifications are made, in part one, regarding operational aspects of censuses. Part two combines topics for population censuses and those for housing censuses. An entirely new part, part three, has been added to highlight the needs of users. It also contains a section focused on the need to consider the relationship between census topics and specific uses of census data. Formats for selected tabulations for each population and housing topic together with a brief statement for users are shown in annexes. References and an index are shown at the conclusion of the publication.

UNFPA. 1993. *Readings in Population Research Methodology, Volume 5: Population Models, Projections and Estimates*. New York City, NY: UNFPA. One of eight volumes, attempting to put together a complete reference source covering the full range of

population research methodology, Volume 5 examines population models, projections, and estimates.

UNFPA. 1993. *Readings in Population Research Methodology, Volume 6: Advanced Basic Tools*. New York City, NY: UNFPA. One of eight volumes, attempting to put together a complete reference source covering the full range of population research methodology, Volume 6 is about advanced basic tools, including survival and event history methods, multi-state methods, contextual and multi-level methods, and techniques for qualitative analysis.

U. S. Census Bureau, Population Division. 2007. "County Housing Unit Estimates, April 1, 2000 to July 1, 2006." Washington, DC: Population Division, U. S. Census Bureau. (available online, http://www.census.gov/popest/housing/files/HU-EST2006_US.CSV, last accessed January, 2008). This is the data set that was developed using the data, methods, and procedures described in the following citation.

U. S. Census Bureau. 2006. Methodology for County Housing Unit Estimates for Vintage 2006." Washington, DC: Population Division, U.S. Census Bureau (available online, http://www.census.gov/popest/topics/methodology/2006_hu_meth.html, last accessed January 2008). This report describes the methods, data, and procedures to develop sub-county population estimates by a housing unit method that uses housing unit change to distribute county population to sub-county areas. It notes that the state and county housing unit estimates are aggregations of these housing unit estimates and that Housing unit estimates use building permits, mobile home shipments, and estimates of housing unit loss to update housing unit change since the last census. Census counts of housing units are geographically updated each year to reflect legal changes reported in the Boundary and Annexation Survey, Census corrections, and other administrative revisions. The 2006 data can be found via the link in the preceding citation.

U. S. Census Bureau. 2004. "The Census Bureau's Master Address File (MAF): Census 2000 Address List Basics." Washington, DC. Geography Division, U. S. Census Bureau (available online http://www.census.gov/geo/mod/maf_basics.pdf , last accessed January 2008). This report describes the content and procedures used to develop and maintain the MAF.

U. S. Census Bureau. 1990. "State Population and Household Estimates." *Current Population Reports, P25, No. 1058*. Washington, DC: U. S. Government Printing Office. This report contains population and household estimates for U.S. States for July 1, 1989, revised household estimates for July 1, 1988, revised annual estimates for the resident and civilian populations for July 1, 1981-88, and components of population change for the 1980-89 period. The annual estimates of the resident population are further disaggregated by sex and age. The age detail includes 10-year and selected broad age groups.

U. S. Census Bureau. 1987. "State Population and Household Estimates, with Age, Sex, and Components of Change: 1981-86." *Current Population Reports, P25, No. 1010*.

Washington, DC: U. S. Government Printing Office. This report contains provisional estimates for States of the resident and civilian U.S. populations and of households for July 1, 1986, revised annual population and household estimates for July 1, 1981, through 1985, and components of population change for the 1980-86 period.

U. S. Census Bureau. 1986. "State Population and Household Estimates to 1985, With Age and Components of Change." *Current Population Reports, P25, NO. 998*. Washington, DC: U. S. Government Printing Office. This report contains provisional estimates of the resident and civilian populations of U.S. States for July 1, 1985, revised population estimates for July 1, 1981, through 1984, and components of population change and revised household estimates for States for the 1980-85 period. Annual intercensal estimates by age for 1971 to 1979 are also presented. This is the first time that estimates of population and households for States have been included in the same issue of Current Population Reports.

U. S. Census Bureau. 1985. "Estimates of Households for States: 1981 to 1984." *Current Population Reports, P25. No. 974*. Washington, DC: U. S. Government Printing Office. This report presents estimates of the total number of households for U.S. States for July 1, 1981, 1982, and 1983, and provisional estimates for July 1, 1984. In addition to these estimates, census counts of households for 1970 and 1980 are included for comparative purposes.

U. S. Census Bureau. 1979. "Estimates of the Number of Households for States: 1977 and 1978." *Current Population Reports, P25, No. 807*. Washington, DC: U. S. Government Printing Office. This report presents estimates of the total number of households for U.S. States for July 1, 1977 and 1978.

U. S. Department of Commerce. 2002. "A Better Strategy is needed for Managing the Nation's Master Address File." *Inspection Report No. OSE-12065*. Washington, DC: U. S. Department of Commerce. This report found that Census did not establish procedures that would adequately ensure the MAF's accuracy and completeness, and thus used an error-prone database to conduct the decennial census in 2000. Among other problems, the report found that numerous addresses did not link to the correct location in the TIGER file, which hampered the Census Bureau's ability to accurately determine a housing unit's location. Some errors in the file occurred because address verification plans were flawed. In addition, the report finds that when the Census Bureau modified its software for eliminating duplicate addresses in an effort to improve its coverage of multiunit housing such as trailer parks and apartment buildings, the change allowed many suspected duplicate addresses to remain in the address file. The report also notes that maps often contained duplicate and missing streets, and were not always printed in a usable size and format.

U. S. GAO. 2006. *2010 Census: Census Bureau Needs to Take Prompt Actions to Resolve Long-standing and Emerging Address and Mapping Challenges*. GAO-06-272. Washington, D.C. U. S. Government Accountability Office (Note: Effective July 7, 2004, the GAO's legal name became the Government Accountability Office). This report found

that the Census Bureau's address and map modernization efforts have progressed in some areas. The Bureau is researching how to correct addresses that were duplicated, missed, deleted, and incorrectly located on maps. However, some deadlines for completing research are not firm, while other deadlines that had been set continue to slip. Thus, whether research will be completed in enough time to allow the Bureau to develop new procedures to improve the 2010 address file is unknown. Also, the Bureau has not fully addressed emerging issues. For one such issue, the Bureau has acknowledged the compressed time frame for completing address canvassing--an operation where census workers walk every street in the country to verify addresses and maps--but has not reevaluated the associated schedule or staffing workloads. Also, the Bureau has allotted only 6 weeks to conduct address canvassing it completed in 18 weeks in 2000 and expanded the operation from urban areas in 2000 to the entire country in 2010. Whether the Bureau can collect and transmit address and mapping data using the MCD is unknown. The MCD, tested during 2006 address canvassing, was slow and locked up frequently. Bureau officials said the MCD's performance is an issue, but a new MCD to be developed through a contract awarded in March 2006 will be reliable. However, the MCD will not be tested until the 2008 Dress Rehearsal, and if problems emerge, little time will remain to develop, test, and incorporate refinements. If after the Dress Rehearsal the MCD is found unreliable, the Bureau could face the remote but daunting possibility of reverting to the costly paper-based census of 2000. Bureau officials do not believe a specific plan is needed to update the addresses and maps for areas affected by the hurricanes. Securing a count is difficult under normal conditions, and existing procedures may be insufficient to update addresses and maps after the hurricanes' destruction--made even more difficult as streets, housing, and population will be in flux.

Verma, R.B.P. 1992. "Regression-Based Estimates of Total Population for Local Areas: Then and Now." pp. 167-178 in P. Krishnan, C. Tuan, and K. Mahadevan (Eds.) *Readings in Population Research: Policy, Methods and Perspectives*. Delhi, India: B.R. Publishing. This paper provides an overview of the methodological developments in the regression method for estimating local area population and described how the estimation procedure is applied to census divisions in Canada.

Verma, R., K. Basavarajappa, and R. Bender. 1984. "Estimation of Local Area Population: An International Comparison." pp. 324-329 in *1984 Proceedings of the Social Statistics Section*, Alexandria, VA: American Statistical Association. This paper discusses the current status of methodology on local area population estimation in five developed countries, Australia, Canada, England and Wales, New Zealand, and the U.S.A. It notes that the methods employed are compared with respect to the accuracy and the timeliness of estimates and the consistency of procedures and data sources used for different geographic levels.

Verma, R., K. Basavarajappa, and R. Bender. 1983. "The Regression Estimates of Population for sub-provincial Areas in Canada." pp. 512-517 in *1983 Proceedings of the Social Statistics Section*, Alexandria, VA: American Statistical Association. The authors describe two sets of post-censal population estimates that are published yearly by the

government of Canada. The estimates are for census divisions and census metropolitan areas and appear 3 to 4 months and 12 to 15 months following the reference date. "The regression technique uses family allowance recipients as the main symptomatic indicator and where available, additional indicators to derive population change for the current year. The first set is obtained by adding this change to the second set for the previous year produced by the component method, with births and deaths from vital registers, and estimated migration from Revenue Canada taxation files. The two sets were found to be statistically similar, though the first set is more timely, and the second providing more details on the components of population change.

Voss, P., C. Palit, B. Kale, and H. Krebs. 1995. "Censal Ratio Methods." pp. 70-88 in N. W. Rives, W. Serow, A. Lee, H. Goldsmith, and P. Voss (Eds). *Basic Methods for Preparing Small-Area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin. The authors provide a brief history of the development of censal ratio methods, describe its statistical properties, discuss its advantages and disadvantages, and suggest ways in which they can be improved. They also discuss its variations and provide the results of a 1980 test using data from Wisconsin.

Walashek, P., and D. Swanson. 2006. "The Roots of Conflict over U. S. Census Counts in the Late 20th Century and Prospects for the 21st Century." *Journal of Economic and Social Measurement* 31 (3-4): 185-205. Although not originally intended as such, the authors argue that the U. S. census has become a "Commons" in which private benefits are gained at the expense of public costs. The historical development of the census as a Commons first clearly emerged with the release of the 1970 census results, and since that time contentious litigation over census undercount error has become a standard part of the decennial census landscape. Political battles within the federal government have gone hand-in-hand with these litigation activities. They culminated with a Supreme Court decision on the legality of statistically adjusting census 2000 counts for estimated undercount error. As these battles raged, professional interest in providing methodological fixes for net census undercount error increased while public participation in the census generally declined. The authors examine the history behind these legal battles, the legislative acts, and judicial decisions that led to the 16th Amendment and the loss of the careful balance between public costs and private benefits crafted by the Founding Fathers in Article I of the Constitution. They identify the role that historical actions played in making the census into a Commons, thereby setting the stage for modern day census litigation and other forms of conflict. The authors observe that as a Commons, the census is facing a potential collapse that cannot be prevented by methodological developments and conclude by noting that a course of political action may be the best course for preventing such a collapse.

Wang, C. 1999. "Development of National Accounting of Address and Housing Inventory: The Baseline Information for Post-censal Population estimates." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). The paper discusses the use of the Master Address File for a

number of purposes, including the development of data that can be used for population estimates made using the Housing Unit Method.

Warner, S. 1995. "Randomized Response: A Survey Technique for Eliminating Evasive Answer Bias." *Journal of the American Statistical Association* 60: 63-69. For various reasons, the author notes that individuals in a sample survey may prefer not to confide to the interviewer the correct answers to certain questions. In such cases the individuals may elect not to reply at all or to reply with incorrect answers. The resulting evasive answer bias is ordinarily difficult to assess. In this paper, the author argues that such bias is potentially removable through allowing the interviewee to maintain privacy through the device of randomizing his response. A randomized response method for estimating a population proportion is presented as an example. Unbiased maximum likelihood estimates are obtained and their mean square errors of conventional estimates under various assumptions about the underlying population.

Webster, C. 1996. "Population and Dwelling Unit Estimates from Space." *Third World Planning Review* 18 (2): 155-76. This paper reports on attempts to measure the morphological patterns in an urban satellite scene and to use these for image interpretation. The interpretation task addressed is the estimation of residential dwelling units from the patterns discernible in high resolution satellite images of cities. The practical results include dwelling estimates that can be aggregated to any geographical unit of analysis, population estimates for cities and a dwelling density surface that can be categorized into any number of residential land-use classes.

Wetrogan, S. 2007. "Evaluating County Population Estimates Using a Housing Unit Based Approach." Paper presented at the annual meeting of the Southern Demographic Association. Birmingham, AL. The paper compares four alternative 1990-based housing unit estimates for 2000 to Census 2000 population counts and to a separate set of 1990-based county population estimates for 2000 prepared using the administrative records component of change method.

Williams, G. 1999. "The Measurement of Migration Coverage Bias." Paper presented the Estimates Methods Conference, U. S. Bureau of the Census, Suitland, MD. (available online, <http://www.census.gov/population/www/coop/popconf/paper.html>, last accessed June 2007). The author observes that a key variable in the production of county and state estimates under the Census bureau's estimates methodology of the 1990's is IRS migration and notes that there is differential coverage of persons from tax returns, resulting either from no-filers or first time or last time filers, there is likely to be a cumulative bias in the measured amount of migration. He compares migration flows as measured by IRS migration and Alaska Permanent Fund and suggests ways to improve the measurement of migration.

Williams, B., J. Nichols, and M. Conroy. 2002. *Analysis and Management of Animal Populations: Modeling, Estimation, and Decision Making*. San Diego, CA. Academic Press. This book is an all-in-one reference for just about every quantitative technique that could be used in studying animal populations. Topics include sampling, experimental

design, statistical analysis, mark-recapture and other techniques for the estimation of population size and vital rates, population modeling, and decision analysis. The authors have organized these subjects by dividing their book into four sections. The first section provides a framework for the book and includes discussions of the scientific method, the use of models in population ecology, hypothesis testing, sampling and experimental design. The second section deals with mathematical models applied to animal populations and contains, among other things, an overview of classical demographic models, a thorough introduction to stochastic processes, and a discussion of the applied uses of demographic models in management and conservation. The third section covers estimation of abundance and of population vital rates, including survival, movement, and recruitment. Estimation of community attributes, such as species diversity, is also covered. Finally, the fourth section of the book covers decision analysis with a focus on optimal management of populations in the presence of uncertainty. This section ends with a case study focused on management of game birds.

Wilson, T., and P. Rees. 2005. "Recent Developments in Population Projection Methodology: A Review." *Population, Space, and Place* 11 (5): 337-360. In this paper the authors survey five streams of research that have made important contributions to population projection methodology over the last decade. These are: (i) the evaluation of population forecasts; (ii) probabilistic methods; (iii) experiments in the projection of migration; (iv) projecting dimensions additional to age, sex and region; and (v) the use of scenarios for 'what if?' analyses and understanding population dynamics. Key developments in these areas are discussed, and a number of opportunities for further research are identified.

Wolter, K. 1990. "Capture-Recapture Estimation in the Presence of a Known Sex Ratio." *Biometrics* 46 (1): 157-162. The author presents new methods of estimating population size based on capture-recapture data. The methods exploit knowledge of the sex ratio, males per female, and permit "estimability" even when both time of sampling and marking affect the "catchability" of an animal. An example is presented involving *Microtus pennsylvanicus* (meadow vole).

Wolter, K. and B. Causey. 1991. "Evaluation of Procedures for Improving Population Estimates for Small Areas." *Journal of the American Statistical Association* 86 (414): 278-284. The authors provide and illustrate methods for evaluating across-the-board ratio estimation and synthetic estimation, two techniques that might be used for improving population estimates for small areas. The methods emphasize determination of a break-even accuracy of knowledge concerning externally obtained population totals, which marks the point at which improvement occurs.

Woodrow-Lafield, K. 2001 "Implications of Immigration for Apportionment." *Population Research and Policy Review* 20 (4): 267-289. The author observes that around the time of the US decennial censuses, a renewed interest emerges in the method for apportioning the US House of Representatives. Various methods may show slight variations in illustrative apportionments, with biases favoring less populous states, but the general pattern remains. Definition of certain groups as included in the apportionment

counts and coverage levels for selected groups have been debated in the judicial system, legal journals, and government. Unauthorized residents, and, sometimes, lawful immigrants, are often singled out for exclusion. The legal issues are complex, and illustrating the effects of these groups' inclusion is problematic due to poor measures, nationally and geographically. Using approximate distributions, these analyses suggest this next apportionment might differ slightly under various scenarios such as ones excluding either recently entered unauthorized residents or all unauthorized residents. Allowing for net authorized immigration greater than official estimates for the 1990s might have some effect for large states.

Woodrow-Lafield, K. 1995. "An Analysis of Net Immigration in Census Coverage Evaluation." *Population Research and Policy Review* 14 (2): 173-204. The author notes that national surveys monitored growth in the foreign-born population for the 1980s, especially net unauthorized migration's continuing role, but the 1990 census portrayed an even larger foreign-born population than these surveys. Under-coverage in 1990 could have been higher than initially presented because preliminary studies may have insufficiently accounted for decadal net immigration. Assumptions intended to maintain a high unauthorized undercount performed poorly when census counts of foreign-born residents became known. Any point estimate for net unauthorized migration, calculated as a residual, is likely to be biased by assumptions and data gaps for components of calculating net legal immigration, especially in the direction of underestimation. A reasonable statement is that at least 2.1–2.4 million unauthorized residents were enumerated in the 1990 census. The number of un-enumerated unauthorized residents may easily have ranged between 0.5 million and 3.0 million, and a narrower range of 1 million to 2 million is plausible. Despite the importance of unauthorized migration measurement for census evaluation and policy purposes, differences among various unauthorized estimates are more likely to stem from discrepancies in universe, reference dates, or individual judgment, rather than analytic refinement. Better measurement of the foreign born population or its census coverage would aid in setting upper limits on net unauthorized migration.

Word, D., and M. Zitter. 1982. "Further Developments in Inter-censal Population Estimation Using Administrative Records." pp. 260-265 in *1982 Proceedings of the Social Statistics Section*, Alexandria, VA: American Statistical Association. This paper relates to the evaluation of U.S. intercensal population estimates for states and metropolitan areas ongoing at the Census Bureau. The focus of the paper extends the present use of Administrative Records (individual income tax records in this instance) for the purpose of preparing Black population estimates for both States and SMSAs.

Wunsch, G., And M. Termote. 1978. *Introduction to Demographic Analysis: Principles and Methods*. New York City, NY: Plenum Press. This book can serve as a textbook or references book. It provides a unified introduction to the principles and methods essential to conduct analyses of population trends and composition.

Zeng, Y., K. Land, Z. Wang, and D. Gu. 2006. "U. S. family household momentum and dynamics: an extension and application of the ProFamy Method." *Population Research*

and Policy Review 25: 1–41. Unlike the headship-rate method, the ProFamy method uses demographic rates as input and can project detailed household types, sizes, and living arrangements for all members of the population. Tests of projections from 1990 to 2000 using ProFamy and based on observed U.S. demographic rates before 1991 show that discrepancies between ProFamy projections and census observations in 2000 are reasonably small, validating the new method.

Zachariah, K. 1962. “A Note on the Census Survival Ratio Method of Estimating Net Migration.” *Journal of the American Statistical Association* 57 (297): 175-183. In the census survival ratio method, the author observes that one of the common assumptions is that the proportion which the enumerated population in any age-sex group bears to the actual population is the same at each census for each state as for the nation. The significance of this assumption is examined and it is established that such an assumption is not necessary. It is therefore replaced by a less stringent assumption, namely that the ratio of the degree of enumeration in a state (i.e. the proportion which the enumerated population in any age-sex group bears to the true population) to that of the nation is the same for the same cohort. In the light of the change in assumption, it is shown that much of the criticism of the method made by Daniel O. Price is untenable. Though his main conclusion (i.e. small relative differences in estimates of net migration should be interpreted with extreme caution) is correct, the errors in migration rates estimated by the census survival ratio method are probably much smaller than his analysis suggests.

Zaslavsky, A. 1993. “Combining Census, Dual-System, and Evaluation Study Data to Estimate Population Shares.” *Journal of the American Statistical Association* 88 (423): 1092-105. This article addresses methods for combining the census, the Dual Systems Estimates (DSE), and bias estimates obtained from the evaluation programs to produce accurate estimates of population shares, as measured by weighted squared- or absolute-error loss functions applied to estimated population shares of domains. Several procedures are reviewed that choose between the census and the DSE using the bias evaluation data or that average the two with weights that are constant across domains. A multivariate hierarchical Bayes model is proposed for the joint distribution of the undercount rates and the biases of the DSE in the various domains. The specification of the model is sufficiently flexible to incorporate prior information on factors likely to be associated with undercount and bias. When combined with data on undercount and bias estimates, the model yields posterior distributions for the true population shares of each domain. The performance of the estimators was compared through an extensive series of simulations. The hierarchical Bayes procedures are shown to outperform the other estimators over a wide range of conditions and to be robust against misspecification of the models. The various composite estimators, applied to preliminary data from the 1990 Census and evaluation programs, yield similar results that are closer to the DSE than to the census. Analysis of a revised data set yields qualitatively similar estimates but shows that the revised post-stratification improves on the original one.

Zitter, M., and H. Shryock. 1964. “Accuracy of Methods of Preparing Post-censal Population Estimates for States and Local Areas.” *Demography* 1(1): 227–241. A general assessment of methods that are and can be used for developing post-censal population

estimates at the sub-national level in the United States. The authors discuss strengths and weaknesses of these methods.

BIBLIOGRAPHY III. Estimating the Foreign-Born: Residual and Related Methods

Ahmed, B. and J.G. Robinson. 1994. "Estimates of Emigration of the Foreign-born Population: 1980-1990." Population Division Working Paper No. 9, U. S. Census Bureau. Washington, DC. (available online, <http://www.census.gov/population/www/techpap.html>, last accessed March, 2008). This paper attempts to develop estimates of emigration of the foreign-born population at the national level based on the numbers of foreign-born persons enumerated in the 1980 and 1990 censuses. The methodology employed here is a residual technique in which the counted population is subtracted from the expected population to obtain the amount of emigration and emigration rates. The total amount of emigration of the foreign-born population was about 195,000 per year during 1980-1990. The new estimate, which is about 47 percent higher than the current level of 133,000 per year, is consistent with the recent increase in immigration. Of the 1980 foreign-born stock, the highest emigration rate was for the cohort of 1970-1979 (19 percent), followed by the 1960-1969 (9 percent) and the before 1960 cohorts (7 percent). The age pattern of emigration shows a declining trend by age for both males and females. The pattern is similar for all races. The emigration rates for non-Hispanic Whites and the Asian and Pacific Islander population hovered around 10 to 11 percent. The emigration rates for Blacks and Hispanics were 14 percent and 7 percent, respectively. The low emigration rate for Hispanics was probably because of the same reasons for which Hispanic immigration is high (e.g., relative difference in economic and social conditions at origin and destination countries). The high rate for Blacks was because of high rate for the 1970-1979 cohort and relatively larger proportion of Blacks who came recently.

Bean, F., R. Corona, R. Tuiran, K. Woodrow-Lafield, and J. Van Hook. 2001. "Circular, Invisible, and Ambiguous Migrants: Components of Difference in Estimates of the Number of Unauthorized Mexican Migrants in the United States." *Demography* 38(3): 411-422. Working from an equation that can be used with available data and that provides a basis for facilitating decomposition analyses, the authors estimate that about 2.54 million total (as opposed to enumerated) unauthorized Mexicans resided in the United States in 1996. Comparing this figure with an estimate of about 2.70 million released by the U.S. Immigration and Naturalization Service (INS) during the 1990s, we find that the two estimates involve different assumptions about circular, invisible, and ambiguous migrants. Such differences not only can have important policy implications; they can also be sizable and can operate in opposite directions, as illustrated by findings from a components-of-difference analysis. The results are also extrapolated to 2000, and implications for 2000 census counts are discussed.

The authors note that in 1957, the Immigration and Naturalization Service (INS) stopped collection of data on emigration, disposing of the only direct way in which to estimate the number of foreign-born emigrants and since that time, indirect methods have been used to estimate emigration. Employing a residual method, the authors produce

contemporary emigration estimates and rates. Using Census 2000, the 2005 and 2006 American Community Survey (ACS), and National Center for Health Statistics life tables, this paper produces emigration rates for the foreign-born population and then utilizes these rates to estimate annual emigration from 2000 to 2006. Also, this paper evaluates the assumptions of the residual technique and assesses the estimates and rates produced by comparing them to past research.

Bean, F., R. Corona, R. Tuiran, and K. Woodrow-Lafield. 1998. "Quantification of Migration Between Mexico and the United States." pp. 1-90 in *Migration Between Mexico and the United States: Binational Study, Volume I, Thematic Chapters, Mexico-United States Binational Migration Study*, Mexican Ministry of Foreign Affairs and U. S. Commission on Immigration Reform (Available online, <http://www.utexas.edu/lbj/uscir/binpapers/v1-1bean.pdf>, last accessed April 2008). This report focuses on the question of the quantity of migration. How large is the flow and what are the sizes of the populations in the U.S and Mexico that result from it? The authors note that as of 1980, stock and flow estimates of the unauthorized migrant population tended to be unreliable due in part to lack of methodologies for correcting for biases in the available data sources and that early analytic estimates tended to be inconsistent in their assumptions, methodologies, and consequently, in the populations they describe. They describe changes that took place in the methods since 1980 and note that these changes have narrowed considerably the range of plausible estimates.

Clark, R., J. Passel, W. Zimmerman, M. Fix, T. Mann, and R. Berkowitz. 1994. *Fiscal Impacts of Unauthorized Aliens: Selected Estimates for Seven States*. Project Report. Washington, DC: The Urban Institute. This report is concerned with the fiscal impacts of unauthorized aliens in the United States. It estimates the cost of supplying three types of services and assesses the revenues generated by three types of taxes in the seven states with the largest numbers of unauthorized aliens. The services considered are prisons, schools, and emergency medical care, and the taxes are state income tax, state sales tax, and state and local property tax. The lack of suitable data for studies of this nature is noted and recommendations are made for improving the situation.

Costanzo, J., C. Davis, C. Irazi, D. Goodkind, and R. Ramirez. 2001. "Evaluating Components of International Migration: The Residual Foreign-Born," *Population Division Working Paper 61*. Washington, DC: U. S. Census Bureau. This report focuses on the evaluation of the U.S. Census Bureau's estimated residual foreign-born population (including both unauthorized and quasi-legal migrants) in 1990 and 2000. The estimates shown here were calculated in conjunction with estimates of other components of international migration: legal permanent migration and legal temporary migration. These components of international migration, along with assumed deaths and emigrants, are subtracted from a total foreign-born population yielding a residual count. The authors note that this residual foreign-born population is not an estimate of the number of unauthorized migrants. This estimate also includes people who are here legally but are not yet included in the official estimates of legal migrants and refugees. It also includes people in "quasi-legal" status who are awaiting action on their legal migration requests. Because the estimate was derived from a residual methodology, any limitations in the

methods or in the measurement of other migration components are reflected in the residual number. In addition, our assumptions include a great deal of uncertainty, especially for small migration components. Therefore, the residual may be quite different from the actual number of unauthorized migrants. According to their calculations, the estimated residual foreign-born population was 3,765,906 in 1990 and 8,705,419 in 2000. The residual foreign born were less likely to be male (48.4 percent) in 1990 than in 2000 (54.2 percent).

Duleep, H. 1994. "Social Security and the Emigration of Immigrants." *Social Security Bulletin* 57(1): 37–51. This article describes the general assumptions related to emigration [from the United States] that underlie projections of Social Security's financial status and examines how closely these assumptions fit research findings." She concludes that as a greater percentage of recent immigrants come from developing rather than developed countries, the rate of emigration of immigrants is likely to decline.

Fernandez, E. 1995. "Using Analytical Techniques to Evaluate the 1990 Census Coverage of Young Hispanics." *Population Division Technical Working Paper No. 11*. Washington, DC: U.S. Census Bureau. The author uses data from the 1980 U.S. census and immigration data for the decade 1980-1990 to estimate the size of the Hispanic population in 1990. The completeness of census coverage for this population group is then examined by calculating the difference between this estimate and the actual census count.

Fortuny, K., R. Capps, and J. Passel. 2007. *The Characteristics of Unauthorized Immigrants in California, Los Angeles County, and the United States*. Washington DC: The Urban Institute (Available online, http://www.urban.org/UploadedPDF/411425_Characteristics_Immigrants.pdf , last accessed April, 2008). This report seeks to fill some of the knowledge gaps in the current immigration debate by describing the unauthorized population nationally and in California and Los Angeles—the state and urban area with the largest numbers of these immigrants. Unauthorized immigrants numbered 2.45 million in California in 2004, representing almost one-quarter (24 percent) of the nation's total (10.3 million). There are about 1 million unauthorized immigrants in the Los Angeles metropolitan area, almost twice the number of any other metro area; the unauthorized are one-tenth of the area's population (10 million). The report presents findings about these populations, including their socio-economic characteristics, such as national origin, education, employment, and poverty.

Gibbs J., G. Harper, M. Rubin, and H. Shin. 2003. "Evaluating Components of International Migration: Native-Born Emigrants." Population Division Working Paper No. 63. (Available online, <http://www.census.gov/population/www/techpap.html> , last accessed March 2008). This report focuses on the evaluation of the assumptions about emigration of the native population used by the Census Bureau. From the 1970s through the 1980s, the Census Bureau estimated annual emigration of the native population at a constant level of 27,000. For the 1990-2000 inter-censal decade, the Census Bureau estimated annual emigration of the native population at a constant level of 48,000. The

evaluation attempted - unsuccessfully - to replicate the approach taken to arrive at the 48,000 figure. Working with published data from population censuses and statistical reports of other countries, the authors were able to calculate a rough estimate of the net effect of the native emigrant flow on the 2000 national resident population estimate. They compared the available data for dates as close to 1990 and 2000 as possible for 16 countries for which data were available. These 16 countries represented 58 percent of the American population abroad as measured by 2000 State Department data. They then applied 1990 U.S. survival rates to survive the populations of the 11 countries for which age distribution data were available. The authors note that the limitations on the available data make the estimate of the native emigrant population questionable, but that their research indicates that the magnitude of this population is small and likely to fluctuate over time. Their best estimate of the annual emigration of the native born is 18,000, or 180,00 for the 1990-2000 inter-censal decade. Based on this estimate, they believe that the estimate of 480,000 native emigrants for the 1990-2000 decade that was used in the 2000 national population estimate is too high by approximately 300,000.

Goldberg, H. 1974. "Estimates of Emigration from Mexico and Illegal Entry into the United States, 1969-1970, by the Residual Method." Unpublished Manuscript, Center for Population Research, Georgetown University. In this paper, the author uses data on the number of legally admitted aliens and counts of the entire population to estimate the number of illegal aliens. His calculations involve the subtraction of the expected number of people (those who reside legally in the United States) from the actual number of people (those who have been found to be in the United States). Thus, the unauthorized foreign born who entered legally will be overlooked in this procedure, because they are included in the expected number of people.

Heer, D. 1979. "What is the Annual Flow of Unauthorized Mexican Immigrants to the United States?" *Demography* 16: 417-424. In this paper, seven estimates are made concerning the net flow of unauthorized Mexican immigrants to the United States in the period 1970-1975. These estimates are based on the growth of the population of Mexican origin according to the Current Population Survey. According to these estimates the annual net flow ranged from 82,300 to 232,400 persons.

Hill, K. 2006. "Estimates of Legal and Unauthorized Foreign-Born Population for the United States Bases on Census 2000." Presented at the U. S. Census Bureau Conference: Immigration Statistics: Methodology and Data Quality, February 13-14. . Alexandria, VA. The author presents estimates using a residual method.

Hill, K. 1987. "New Approaches to the Estimation of Migration Flows from Census and Administrative Data." *International Migration Review* 21 (4): 1279-1303. The author presents two methods for estimating migration flows from census data and illustrates them by applications to recent U.S. data. The first method is a simplification of existing intercensal projection methods, and will be affected by changes in census coverage. The second method incorporates independent information on the age pattern of intercensal migration and estimates consistent adjustment factors for census coverage and the scale of the migration schedule. Interpretation of the results of the two methods is discussed.

Hill, K. 1985. "Indirect Approaches to Assessing Stocks and Flows of Migrants." pp. 205-224 in D. Levine, K. Hill, and R. Warren (Eds.) *Immigration Statistics: A Story of Neglect*. Washington, DC: National Academy Press. The author assesses methods to estimate the flows and stock of migrants, and focuses on residual techniques.

Hoefler, M., N. Rytina, and C. Campbell. 2007. *Estimates of the Unauthorized Immigrant Population Residing in the United States: January 2006*. Washington, DC: U. S. Department of Homeland Security, Office of Immigration Statistics. This report provides estimates of the number of unauthorized immigrants residing in the United States as of January 2006 by period of entry, region and country of origin, and state of residence. The estimates were obtained using the same "residual" methodology employed for estimates of the unauthorized population in 2005. The authors estimate there were 11.6 million unauthorized immigrants living in the United States as of January 2006. Nearly 4.2 million had entered in 2000 or later. An estimated 6.6 million were from Mexico.

Hoefler, M., N. Rytina, and C. Campbell. 2006. *Estimates of the Unauthorized Immigrant Population Residing in the United State: January 2005*. Washington, DC: U. S. Department of Homeland Security, Office of Immigration Statistics. This report provides estimates of the number of unauthorized immigrants residing in the United States in January 2005 by period of entry, country of origin, and state of residence. These estimates were calculated using a "residual method," whereby estimates of the legally resident foreign-born population as of January 1, 2005 were subtracted from the total foreign-born population at the same point in time. Estimates of the legally resident foreign-born were based primarily on administrative data of the Department of Homeland Security (DHS), while estimates of the total foreign-born population were obtained from the American Community Survey (ACS) of the U.S. Census Bureau. The starting point for the estimates was 1980, as persons who entered the United States earlier were assumed to be legally resident. Revised estimates of the unauthorized immigrant population living in the United States in 2000 are also presented in this report. These revised estimates are also based on the "residual method" and do not include as legally resident those persons who had applied for but not yet been granted asylum or legal permanent resident (LPR) status as well as Temporary Protected Status (TPS) applicants and beneficiaries. The authors estimate that there were an estimated 10.5 million unauthorized immigrants residing in the United States in January 2005 compared to 8.5 million in January 2000. During the 2000-2004 period, the unauthorized resident population grew at an annual average of 408,000. Assuming this same rate of growth, the unauthorized immigrant population would have reached nearly 11 million by January 2006.

Jasso, G., and M. Rosenzweig. 1982. "Estimating the Emigration Rates of Legal Immigrants Using Administrative and Survey Data: The 1971 Cohort of Immigrants to the United States." *Demography* 19(3): 279-290. Based on administrative and survey data as well as data-based assumptions about the bounds on alien address reporting, this study provides estimates of the lower and upper bounds for the cumulative net emigration rates, by country and area of origin, of the FY1971 cohort of legal immigrants to the United

States as of January 1979. The merged data indicate that the cumulative net emigration rate for the entire cohort could have been as high as 50 percent.

Luther, N., K. Gaminiratner, S. de Silva, and R. Retherford. 1987. "Consistent Correction of International Migration Data for Sri Lanka, 1971-81." *International Migration Review* 21 (4): 1335-1369. A new methodology is used by the authors to estimate net international emigration by age and sex from Sri Lanka between 1971 and 1981. The procedure starts with a set of preliminary estimates of census populations in 1971 and 1981 and inter-censal births, deaths, and migrants. These preliminary estimates are corrected in such a way as to be consistent with a set of inter-censal demographic balancing equations. The methodology, which is formulated in terms of finite-dimensional vector spaces and which involves an optimizing criterion, includes a weighting procedure by which the brunt of the corrections can be made to fall on the least reliable quantities, in this case migrants. The procedure also yields corrected estimates of population, births, deaths, and derived life tables.

Madrian, B., and L. Lefgren. 1999. "An Approach to Longitudinally Matching the Current Population Survey." NBER Technical Working Paper No. 247. National Bureau of Economic Research. November. (Available online, <http://papers.nber.org/papers/T0247> , last accessed January 2008). In this paper, the authors propose an approach for evaluating the trade-offs inherent in different approaches used to match Current Population Survey (CPS) respondents across various CPS surveys. Because there is some measurement error in both the variables used to identify individuals over time and in the characteristics of individuals at any point in time, any procedure used to match CPS respondents has the possibility of both generating incorrect matches and failing to generate potentially valid matches. They propose using the information contained in the variable on whether an individual lived in the same house on March 1 of the previous year as a way to gauge these trade-offs. They find that as measured by reported residence one year ago, increasing the fraction of 'invalid' merges that are rejected usually comes at a cost of decreasing the fraction of 'valid' merges that are retained. However, they acknowledge that there are clearly some approaches that are superior to others in the sense that they result in both a higher fraction of 'invalid' merges being rejected and a higher fraction of 'valid' merges being retained.

Mulder, T., B. Guzmán, and A. Brittingham. 2002. "Evaluating Components of International Migration: Foreign-Born Emigrants." Demographic Analysis-Population Estimates (DAPE) Research Project, Population Division Working Paper No. 62. U. S. Bureau of the Census. Washington, DC. April (Available online, <http://www.census.gov/population/www/documentation/twps0062.html> , last accessed April 2008). This report focuses on the evaluation of the U.S. Census Bureau's estimate of foreign-born emigration from the United States between 1980 and 1990. Estimates produced by Ahmed and Robinson (1994) and Oosse (1998) were recreated and evaluated by age, sex, race, and Hispanic origin to determine if the estimated flows were realistic. In addition, an attempt was made to create new foreign-born emigration estimates for the 1990 and 2000 decade using the preliminary results from Census 2000. Based on recreation and evaluation efforts, Ahmed and Robinson and Oosse estimates

appear sound and represent the most recent and most reliable data on foreign-born emigration available. Future research is needed to evaluate the application of a residual method to estimate foreign-born emigration. In addition, efforts will focus on creating new estimates using alternative methodologies and data sources.

Passel, J. 2007. *Unauthorized Migrants in the United States: Estimates, Methods, and Characteristics*. Working Paper no. 57, Organization for Economic Cooperation and Development. Paris, France: Organization for Economic Cooperation and Development. (Available online, <http://www.oecd.org/dataoecd/41/25/39264671.pdf> , last accessed, May 2008). This report discusses methods of measuring unauthorized migration to the United States. The “residual method” involves comparing an analytic estimate of the legal foreign-born population with a survey-based measure of the total foreign-born population. The difference between the two population figures is a measure of the unauthorized migrant population in the survey; it can then be corrected for omissions to provide a measure of the total unauthorized population. The report includes a detailed description of the residual methods and the underlying data and assumptions as it has been applied to recent data from the Current Population Survey (CPS) and decennial censuses. The paper presents new results of estimates derived from the march 2006 CPS which show that the unauthorized population in the U.S. has reached 11.5 million; of these, 6.5 million or 57% are from Mexico. The report also presents derived data on a range of social and economic characteristics of the unauthorized population developed with an extension of the residual estimates. Finally, historical data on trends in unauthorized migration and several alternative estimation methods are presented and discussed.

Passel, J. 2006. *The Size and Characteristics of the Unauthorized Migrant Population in the U.S.: Estimates Based on the March 2005 Current Population Survey*. Washington, DC: Pew Hispanic Center. The author estimates that there were 11.1 million unauthorized migrants in the United States a year before the report was issued. Based on analysis of other data sources that offer indications of the pace of growth in the foreign-born population, he developed an estimate of 11.5 to 12 million for the unauthorized population as of March 2006. The estimate of unauthorized workers is derived by using a variant of a basic “residual” method. That is, the unauthorized population consists of persons and groups not included in the authorized population. To reach that number, the first step is to develop an estimate for the legal, foreign-born population. That estimate is based on admissions into the country provided by the Department of Homeland Security (DHS) and its predecessor, the Immigration and Naturalization Service (INS), as well on the number of refugees admitted and the number of asylum applications granted.

Passel, J. 2005. *Estimates of the Size and Characteristics of the Unauthorized Population*. Washington, DC: Pew Hispanic Center, Washington. Using data from the March 2004 Current Population Survey, the author applies the residual method and finds that the unauthorized residents reached an estimated 10.3 million in March 2004 with unauthorized Mexicans numbering 5.9 million or 57 percent of the total.

Passel, J., and K. Woodrow. 1984. "Geographic distribution of unauthorized immigrants: estimates of unauthorized aliens counted in the 1980 census by state", *International Migration Review* 18: 642-671. This article presents estimates of the number of unauthorized aliens counted in the 1980 census for each state and the District of Columbia. The estimates, which indicate that 2.06 million unauthorized aliens were counted in the 1980 census, are not based on individual records, but are aggregate estimates derived by a residual technique. The census count of aliens (modified somewhat to account for deficiencies in the data) is compared with estimates of the legally resident alien population based on data collected by the Immigration and Naturalization Service in January 1980. The final estimates represent extensions to the state level of national estimates developed by Warren and Passel (1984). Estimates are developed for each of the states for selected countries of birth and for age, sex, and period of entry categories. The article describes the origins of the unauthorized alien population, as well as some of their demographic characteristics. Some of the implications of the numbers and distribution of unauthorized aliens are also discussed.

Passel, J., and K. Woodrow. 1987. "Change in the Unauthorized Alien Population in the United States, 1979-1983." *International Migration Review* 21(4): 1304-1334. This article presents estimates of the number of unauthorized aliens included in the April 1983 Current Population Survey (CPS) derived by subtracting an estimate of the legally resident foreign born population from the survey estimate of all foreign born residents. The methodology is similar to that used by Warren and Passel (1987) with the 1980 census. Also presented are similar estimates for the November 1979 CPS – re-estimates following the work of Warren (1982). Estimates are presented by period of entry for Mexico and other groups of countries. Comparison of the April 1983 estimate with the census-based estimate and the November 1979 survey-based estimate provide an indication of growth in the unauthorized alien population for 1980-83. For this recent period, the implied annual growth in the unauthorized alien population is in the range of 100,000 to 300,000 - a range lower than has usually been offered in speculative assessments.

Passel, J., J. Van Hook, and F. Bean. 2004. "Estimates of the Legal and Unauthorized Foreign-Born Population for the United States and Selected States, Based on Census 2000." Arlington, VA: Immigration White Papers, Sabre Systems. (available online, http://www.sabresystems.com/sd_whitepapers_immigration.asp, last accessed December 2007). Based on analyses drawing on data from Census 2000 and myriad other sources, this report presents initial, direct estimates of the unauthorized foreign-born population of the United States and six states in the year 2000. The estimates are presented by age, sex, and period of entry for broad country of origin groups and for 29 individual countries of origin. The authors believe that the estimates are the first using Census 2000 data incorporating improved methods for identifying and adjusting directly on the basis of microdata for the presence of legal non-immigrants (or legal temporary migrants²) among the enumerated foreign-born in census data.

Robinson, J. G., B. Ahmed, P. Das Gupta, and K. Woodrow. 1993. "A. Estimation of Population Coverage in the 1990 United States Census Based on Demographic Analysis."

Journal of the American Statistical Association 88 (423): 1,061-1079. This article presents estimates of net coverage of the national population in the 1990 U.S. census, based on the method of demographic analysis. The general techniques of demographic analysis as an analytic tool for coverage measurement are discussed, including use of the demographic accounting equation, data components, and strengths and limitations of the method. Patterns of coverage displayed by the 1990 estimates are described, along with similarities or differences from comparable demographic estimates for previous censuses. The article concludes with the results of the first statistical assessment of the uncertainty in the demographic coverage estimates for 1990.

Warren, R. 1995. *Estimates of the Unauthorized Immigrant Population Residing in the United States by Country of Origin and State of Residence: October, 1992*. Washington, DC: U.S. Department of Justice, Immigration and Naturalization Service. The author constructs estimates by combining detailed statistics, by year of entry, for each component of change that contributes to the unauthorized resident immigrant population and finds 5 million unauthorized immigrants were residing in the United States in October 1996, with a range of about 4.6 to 5.4 million. He estimates that this population was estimated to be growing by about 275,000 each year, which is about 25,000 lower than the annual level of growth estimated by the INS in 1994.

Warren, R. 1982. "Estimation of the Size of the Illegal Alien Population in the United States." Paper presented at the Annual Meeting of the Population Association of America, San Diego, CA. The author compared estimates of foreign born respondents to the November 1979 Current Population Survey who reported they had immigrated since 1970 with two INS population counts: (1) the number of legal immigrants and refugees since 1970; and (2) the number of aliens reporting addresses in 1980.

Warren, R., and J. Passel. 1987. "A Count of the Uncountable: Estimates of Unauthorized Aliens Counted in the 1980 United States Census." *Demography*. 24 (3): 375-93. This paper presents estimates showing that 2 million unauthorized aliens were included in the 1980 census; of these, 1.1 million were born in Mexico. The estimates are developed by comparing estimates of aliens counted in the 1980 census with estimates of the legally resident alien population, based principally on data collected by the Immigration and Naturalization Service in January 1980. Estimates are presented by age, sex, and period of entry for all aliens residing in the United States and for selected countries of origin, including Mexico. The authors provide a framework for assessing the total number of unauthorized aliens in the country.

Woodrow-Lafield, K. 1998. "Unauthorized Residents in the United States in 1990: Issues of Uncertainty in Quantification." *International Migration Review* 32(1): 145-174. The author presents possible upper and lower boundaries on components for estimating legal migration in 1980-1989 and on the foreign-born population in 1990. Positing ranges for net unauthorized immigration; between 2 million and 4 million unauthorized residents may have been counted in the 1990 census. The total number of unauthorized residents may have been as high as 6 million.

Woodrow-Lafield, K. 1998. "Estimating Authorized Immigration," pp. 619-682 in *Migration Between Mexico and the United States: Binational Study, Volume 2, Research Reports and Background Materials, Mexico-United States Binational Migration Study*, Mexican Ministry of Foreign Affairs and U. S. Commission on Immigration Reform. (Available online, <http://www.utexas.edu/lbj/uscir/binpapers/v2a-5woodrow.pdf>, last accessed December 2007). This study provides a conceptual framework for analyzing migration by legal status and an operational framework with review of data on legal migration, statistical data systems, and official statistics. It explicates the discontinuities in measuring legal migration to the United States that derive in part from the fragmentation of statistical functions within the federal government. After explicitly referring to the criteria for measuring legal migration, prior estimates of legal migration are reviewed and discussed as to methodological strength. At that point, an assessment of legal migration from all countries and from Mexico is made based on existing data, alternative assumptions, and carefully explained logic. Two major concerns are raised and the author concludes with suggestions for research priorities for the U.S. and Mexican governments on the measurement of migration between the two countries by legal status.

Woodrow-Lafield, K. 1995. "An Analysis of Net Immigration in Census Coverage Evaluation," *Population Research and Policy Review* 14(2): 173-204. The author notes that national surveys monitored growth in the foreign-born population for the 1980s, especially net unauthorized migration's continuing role, but the 1990 census portrayed an even larger foreign-born population than these surveys. She suggests that under-coverage in 1990 could have been higher than initially presented and observes that assumptions intended to maintain a high unauthorized undercount performed poorly when census counts of foreign-born residents became known. She argues that any point estimate for net unauthorized migration, calculated as a residual, is likely to be biased by assumptions and data gaps for components of calculating net legal immigration, especially in the direction of underestimation and suggests that a reasonable statement is that at least 2.1–2.4 million unauthorized residents were enumerated in the 1990 census while the number of un-enumerated unauthorized residents may easily have ranged between 0.5 million and 3.0 million, and a narrower range of 1 million to 2 million is plausible. Despite the importance of unauthorized migration measurement for census evaluation and policy purposes, the author believes that differences among various unauthorized estimates are more likely to stem from discrepancies in universe, reference dates, or individual judgment, rather than analytic refinement. She concludes that better measurement of the foreign born population or its census coverage would aid in setting upper limits on net unauthorized migration.

Woodrow, K. 1992. "A Consideration of the Effect of Immigration Reform on the Number of Unauthorized Residents in the United States." *Population Research and Policy Review* 11: 117-144. This analysis presents national survey data on the foreign-born population in November 1989 for comparison with an independently derived estimate of the legally resident foreign-born population at the same date. Precise measurement of the size of this population is complicated by the uncertainties surrounding the population of approximately one million Special Agricultural Workers admitted under IRCA. The author argues that unauthorized migration, especially across

the southern border, appears to have occurred at consistent levels throughout the past fifteen years.

Woodrow, K. 1990. "Using Census and Survey Data to Measure Unauthorized Immigration and Emigration from the United States," *Statistical Journal of the United Nations Economic Commission for Europe* 7: 241-251. The estimation of emigration and unauthorized immigration rates for the United States is discussed. A residual methodology compares census or survey data on the resident foreign-born population with an independently derived estimate of the legally resident foreign-born population. The difference is the estimated unauthorized population which may be compared for alternative dates to derive measures of change. In 1988, this difference was 1.9 million, similar to the 1980 estimate of 2.1 million. Measurement of emigration...has recently relied on resident reports of immediate relatives who have emigrated. Controlling for multiple reporting of the same emigrants, the direct estimate of the emigrant population from the United States is about 1.2 million. Allowing for under-coverage of the emigrant population due to nonresident relatives, there could be 2.0 million or more emigrants.

Woodrow, K. 1990. "Unauthorized Immigrants Living in the United States." pp. 77-82 in *1990 Proceedings of the American Statistical Association. Social Statistics Section*. Alexandria, VA: American Statistical Association. This research focuses on the population of unauthorized immigrants living in the United States. The first two sections of this paper discuss this implicit unauthorized population and estimation of the legally resident foreign-born population...The third part...is an analysis of Current Population Survey (CPS) data and immigration data to develop an estimate of the number of unauthorized immigrants living in the United States in November 1989.

Woodrow, K., and J. Passel. 1990. "Post-IRCA Unauthorized Immigration to the United States: An Assessment Based on the June 1988 CPS." pp 33-75 in F. Bean, B. Edmonston and J. Passel (Eds.) *Unauthorized Migration to the United States: IRCA and the Experience of the 1980s*. Washington, DC: The Urban Institute. The authors note that although IRCA reduced the unauthorized resident population by nearly 1.7 million residents and an unknown number of the agricultural legalizations, a significant number of unauthorized immigrants, at least 2.0 million, remained as of 1988. Some were long term residents, but others appear to have arrived since IRCA's implementation. IRCA's legalization program led to changes in the composition of the unauthorized population, specifically, a female majority and a non-Mexican majority.

Woodrow, K., J. Passel, and R. Warren. 1987. "Preliminary Estimates of Unauthorized Immigration to the United States, 1980-1986: Analysis of the June 1986 Current Population Survey," pp. 256-261 in *1987 Proceedings of the American Statistical Association, Social Statistics Section*. Alexandria, VA: American Statistical Association. This paper draws on data from the June 1986 U.S. Current Population Survey to reassess post-1980 growth in the foreign-born population with the residual methodology previously used in Warren and Passel...and Passel and Woodrow. The unauthorized population included in the CPS is estimated as the difference between the CPS estimate of the foreign-born population and an independent estimate of the legally resident

foreign-born population in the country. This figure is compared with the previous estimates of the unauthorized population as of November 1979 and April 1980 to derive estimates of annual change in the size of the unauthorized population in the United States.

BIBLIOGRAPHY IV. Estimating the Foreign-Born: Administrative Records Methods

Cassidy, R. 2005. "Involuntary and Voluntary Migrant Estimates." Paper presented at the Census Bureau Conference on Immigration Statistics: Methodology and Data Quality. Alexandria, VA. (available online, <http://www.copafs.org/> , last accessed March 2008). This paper presents estimates of involuntary and voluntary migrants in the U.S. in Census 2000 and describes the methodology used to identify these two groups within the foreign-born population. These are the first migrant groups to be estimated for this project, and they are a reasonable starting point for two main reasons. First, all foreign-born people can be classified as either involuntary or voluntary migrants, and the criteria used to identify these two groups are relatively simple, so these estimates easily provide at least some more detailed information about the foreign-born population than is currently available from administrative or survey data. This information could help provide a better understanding of international migration, by approaching it from a different perspective than usual. Second, sorting out the foreign-born population into involuntary and voluntary migrants should make it easier to classify it into more detailed migrant status groups with future algorithms.

Elbel, F. 2007. "How Many Illegal Aliens Are in the U.S.? - An Alternative Methodology for Discovering the Numbers." *The Social Contract* (4): 242-254. (Available online http://www.thesocialcontract.com/artman2/publish/tsc_17_4/index.shtml , last accessed April 2008). The author states that the Department of Homeland Security estimated that between 8 million to 12 million unauthorized people resided in the United States as of December 2008 and 700,000 new unauthorized people enter and stay each year. These official estimates are somewhat suspect and may represent significant undercounts, as they are produced by the very entity responsible for the tidal wave of illegal aliens entering our nation—the United States Government. An alternative methodology is used here to estimate a range of numbers of unauthorized people that is likely more realistic.

Ericksen, E., and J. Kadane. 1986. "Using Administrative Lists to Estimate Census Omissions." *Journal of Official Statistics* 2: 397–414. The authors present a method for estimating omission rates from censuses. Their method is based on the merger of administrative lists, sampling from these lists, and matching against census rolls. They describe the method, present the results of a test in New York City...in 1980, and evaluate the results and compare the proposed method to other procedures for estimating omission rates.

Espenshade, T. and D. Acevedo. 1995. "Migrant Cohort Size, Enforcement Effort, and the Apprehension of Unauthorized Aliens." *Population Research and Policy Review* 14: 145-172. This article examines macro-structural conditions that affect time trends in aggregate probabilities of unauthorized alien apprehension along the Mexico-U.S. border. It shows that the number of migrants attempting to cross the border illegally in a given period and the level of effort expended by the INS to apprehend unauthorized migrants

are principal determinants of apprehension probabilities. These findings differ from those in earlier work by Donato, Durand, and Massey who argue that individual, household, and community factors are not significant predictors of apprehension probabilities and conclude that escaping INS detection at the border is essentially a random process unrelated to personal traits or to enforcement provisions of the 1986 Immigration Reform and Control Act. The paper concludes that it is worth modeling the effects of individuals' characteristics on apprehension probabilities by including as predictors an estimate of the flow of unauthorized migrants and measures of INS border enforcement effort.

Fernandez, E. 1995. "Estimation of the Annual Emigration of U. S. Born Persons by using Foreign Censuses and Selected Administrative Data: Circa 1980." Population Division Technical Working Paper No. 10. U. S. Census Bureau: Washington, DC. (Available online, <http://www.census.gov/population/www/techpap.html> , last accessed December 2007). In this study, the cohort survival method of analytical demography is supplemented by State Department U.S. citizen registration-data to estimate the annual rate of U.S. born emigration. The author claims that the estimates generated, by age, sex, and race are not unreasonable reaching: 48,000 U.S. native born emigrants annually. This estimate is certainly no less credible than the current estimate of native-born emigration being used in our national estimation and projection programs.

Grieco, E. 2004. *Estimates of the Non-immigrant Population in the United States: 2004*. Washington, DC: Department of Homeland Security, Office of Immigration Statistics. This report presents estimates of the non-immigrant population in the United States in 2004. The estimates were based primarily on data from the Department of Homeland Security's Non-immigrant Information System (NIIS). Stock estimates for the total non-immigrant population by category of admission and country of citizenship were generated using this administrative flow data and a "person year" methodology. The results of this analysis suggest that, on a typical day in 2004, there were an estimated 3.8 million non-immigrants in the United States, including 2.3 million tourists, business travelers, and other short-term visitors, 704,000 temporary workers, 640,000 students and exchange visitors, and 68,000 diplomats and other representatives.

Lancaster, C., and F. Scheuren. 1978. "Counting the Uncountable Illegals: Some Initial Statistical Speculations Employing Capture-recapture Techniques." pp. 530-535 in *Proceedings of the Social Statistics Section, 1977: Part I.*, Alexandria, VA: American Statistical Association. This paper provides some initial statistical speculations on the number of illegal aliens residing in the United States. The results come from the 1973 CPS-IRS-SSA Exact Match Study which was conducted by the Census Bureau and the Social Security Administration, assisted by the Internal Revenue Service. Direct estimates are presented only for the age group 18 to 44 years old as of April 1973; however, there are some discussions of ways, using other sources, that one can extend these figures to all age groups and project them forward in time.

Rosenthal-Urey, I. 1984. "Church Records as a Source of Data on Mexican Migrant Networks: A Methodological Note." *International Migration Review* 18 (3): 767-781. This article discusses the methodological issues in the study of Mexican migration

initiated by Cornelius and others in a recent issue of this journal (1982). It addresses two problems: the need to locate strategic regions in Mexico before field-work is begun; and the need to develop techniques for longitudinal studies of migration networks.

Rytina, N. 2007. *Estimates of the Legal Permanent Resident Population in 2006*. Washington, DC: Department of Homeland Security, Office of Immigration Statistics. This report presents estimates of the legal permanent resident (LPR) population living in the United States on January 1, 2006. The LPR population includes persons granted lawful permanent residence, e.g. "green card" recipients, but not those who had become U.S. citizens. The estimates are shown for the total LPR population and the LPR population eligible to apply to naturalize by country of birth, state of residence, and the year LPR status was obtained. Data for the estimates were obtained primarily from administrative records of U.S. Citizenship and Immigration Services (USCIS) of the Department of Homeland Security (DHS). The methodology used for the 2006 estimates is similar to that used in previous DHS estimates. Minor changes in assumptions, made to be consistent with DHS estimates of the unauthorized population, had little effect on the estimates. In summary, an estimated 12.1 million LPRs lived in the United States on January 1, 2006. The LPR population remained relatively stable between 2004 and 2006.

Rytina, N. 2006. *Estimates of the Legal Permanent Resident Population and Population Eligible to Naturalize in 2004*. Washington, DC: Department of Homeland Security, Office of Immigration Statistics. This paper presents estimates of the legal permanent resident (LPR) population living in the United States and of the population eligible to naturalize updated to September 2004 by the year LPR status was obtained, country of birth, and state of residence. The estimates are based primarily on a database created by the Office of Immigration Statistics (OIS) from administrative records of U.S. Citizenship and Immigration Services (USCIS) of the Department of Homeland Security. The methodology used for the 2004 estimates is essentially the same as that used for the 2002 and 2003 estimates.

Rytina, N. 2005. *Estimates of the Legal Permanent Resident Population and Population Eligible to Naturalize in 2003*. Washington, DC: Department of Homeland Security, Office of Immigration Statistics. This paper presents estimates of the legal permanent resident (LPR) population living in the United States and of the population eligible to naturalize updated to 2003 by year of admission for permanent residence, country of birth, and state of residence. The estimates are based primarily on a database created by the Office of Immigration Statistics (OIS) from administrative records of U.S. Citizenship and Immigration Services (USCIS) of the Department of Homeland Security. (Both OIS and USCIS were part of the former Immigration and Naturalization Service (INS).) The methodology used for the 2002 estimates was also used for the 2003 estimates.

Rytina, N. 2004. *Estimates of the Legal Permanent Resident Population and Population Eligible to Naturalize in 2002*. Washington, DC: Department of Homeland Security, Office of Immigration Statistics. This paper presents estimates of the legal permanent

resident (LPR) population living in the United States and of the population eligible to naturalize in 2002 by year of admission for permanent residence, country of origin, and state of residence. The methodology used for the estimates relies primarily on a database created by the Office of Immigration Statistics (OIS) from administrative records of the former Immigration and Naturalization Service (INS) on LPRs admitted for permanent residence between 1973 and 2002. The results are found to be consistent with estimates derived by other researchers.

U. S. GAO. 2004. *Illegal Alien Schoolchildren: Issues in Estimating State-by-State Costs*. GAO-04-733. Washington, DC: United States Government Accountability Office. To address the potential for estimating the costs of educating illegal alien schoolchildren, this report (1) identifies major government sources of relevant data, (2) describes a Census Bureau plan for developing new information, and (3) outlines cost estimation approaches.

U. S. GAO. 2001. *Record Linkage and Privacy: Issues in Creating New Federal Research and Statistical Information*. GAO-01-126SP. Washington, DC: United States Government Accountability Office. The study was motivated by the need to address increased confidentiality and privacy concerns that arise with the use of the Internet, while realizing the benefits of data sharing. In this study, the GAO develops a research issues framework based on a survey of existing literature. The framework is used to identify OR/MS research opportunities in disclosure prevention, record-linkage, and in the assessment of the impact of data sharing. Addressing these issues could enable organizations to securely share data.

Van Hook, J., W. Zhang, F. Bean, and J. Passel. 2006. "Foreign-Born Emigration: A New Approach and Estimates Based on Matched CPS Files." *Demography* 43 (2): 361-382. The authors introduce a new method for estimating foreign-born emigration that takes advantage of the sample design of the Current Population Survey (CPS): repeated interviews of persons in the same housing units over a period of 16 months. Individuals appearing in a first March Supplement to the CPS but not the next include those who died in the intervening year, those who moved within the country, and those who emigrated. They use statistical methods to estimate the proportion of emigrants among those not present in the follow-up interview. Our method produces emigration estimates that are comparable to those from residual methods in the case of longer-term residents (immigrants who arrived more than 10 years ago), but yields higher--and what appear to be more accurate--estimates for recent arrivals. Although somewhat constrained by sample size, they also generate estimates by age, sex, region of birth, and duration of residence in the United States.

Woodrow-Lafield, K. 1998. "Estimating Authorized Immigration," pp. 619-682 in *Migration Between Mexico and the United States: Binational Study, Volume 2, Research Reports and Background Materials, Mexico-United States Binational Migration Study*. Mexican Ministry of Foreign Affairs and U. S. Commission on Immigration Reform. (Available online, <http://www.utexas.edu/lbj/uscir/binpapers/v2a-5woodrow.pdf>, last accessed March 2008). This study focuses on estimating net authorized immigration from

all countries and from Mexico and presents 30 alternative series on the basis of varying assumptions as to emigration levels (95,000 to 195,000), agricultural legalization beneficiaries as residents (300,000 to 850,000), and other nonspecific authorized or ambiguous immigration (0 to 1,000,000). Net authorized immigration for 1960-1996 may have resulted in 16.1 to 19.4 million residents of foreign birth. Net authorized immigration from Mexico in 1996 may easily have ranged between 3.7 and 5.5 million at mid-decade. These amounts are increased over the 1960-1990 amounts of 13.1 to 15.9 million overall and 3.8 to 4.0 million for Mexico. This measurement is an essential step for quantifying net unauthorized or unauthorized immigration requiring further exercise of expert judgment.

Woodrow-Lafield, K. 1998. "Unauthorized Residents in the United States in 1990: Issues of Uncertainty in Quantification." *International Migration Review* 32 (1): 145-174. The author presents possible upper and lower boundaries on components for estimating legal migration in 1980-1989 and on the foreign-born population in 1990. Positing ranges for net unauthorized immigration; between 2 million and 4 million unauthorized residents may have been counted in the 1990 census. The total number of unauthorized residents may have been as high as 6 million.

Woodrow-Lafield, K. 1995. "An Analysis of Net Immigration in Census Coverage Evaluation." *Population Research and Policy Review* 14 (2): 173-204. The author notes that national surveys monitored growth in the foreign-born population for the 1980s, especially net unauthorized migration's continuing role, but the 1990 census portrayed an even larger foreign-born population than these surveys. Under-coverage in 1990 could have been higher than initially presented because preliminary studies may have insufficiently accounted for decadal net immigration. Assumptions intended to maintain a high unauthorized undercount performed poorly when census counts of foreign-born residents became known. Any point estimate for net unauthorized migration, calculated as a residual, is likely to be biased by assumptions and data gaps for components of calculating net legal immigration, especially in the direction of underestimation. A reasonable statement is that at least 2.1–2.4 million unauthorized residents were enumerated in the 1990 census. The number of un-enumerated unauthorized residents may easily have ranged between 0.5 million and 3.0 million, and a narrower range of 1 million to 2 million is plausible. Despite the importance of unauthorized migration measurement for census evaluation and policy purposes, differences among various unauthorized estimates are more likely to stem from discrepancies in universe, reference dates, or individual judgment, rather than analytic refinement. Better measurement of the foreign born population or its census coverage would aid in setting upper limits on net unauthorized migration.

Woodrow, K. 1991. "DA Evaluation Project D2: Preliminary Estimates of Unauthorized Residents in 1990." *Preliminary Research and Evaluation Memorandum No. 75*. Washington, DC: U. S. Bureau of the Census. Demographic analysis to evaluate census coverage requires an estimate of the unauthorized population residing in the United States on April 1, 1990. There are no administrative or survey data sources on the population without documents of legal residence. The preliminary estimate for the

number of unauthorized residents on April 1, 1990 is 3.3 million, based on two approaches. The first approach increased the direct estimate of unauthorized immigrants in the November 1989 Current Population Survey (CPS) to allow for CPS and census under-coverage. The second approach employs implicit estimates from carrying forward the alternative estimates for unauthorized residents in 1980 with alternative estimates of change for periods of 1979-1986, 1979-1988, 1979-1989, 1986-1988, and 1986-1989. Allowing for CPS under-coverage, the range is 1.8 to 3.2 million with a "point" estimate of 2.5 million. Considering plausible levels for census under-coverage (20 to 30 percent) yields a range of 1.9 to 4.5 million. Without recent legalization of about 1.7 million long-term residents, the "point" estimate might have been 5.0 million, or between 4.5 and 5.5 million. The "point" estimate for unauthorized residents in 1990 is 3.3 million with a likely range of 1.9 million to 4.5 million. To account for more sources of uncertainty, the true number of unauthorized residents in 1990 is assumed as between 1.7 and 5.5 million. Census planning in the decade led to this empirically based estimate for the number of unauthorized residents as of Census Day, 1990. In 1982, preliminary evaluation of 1980 census coverage was made without any empirical estimates for the number of unauthorized residents, and those estimates were not completed until 1983-84, delaying final coverage estimates until 1985.

Woodrow, K. 1990. "Unauthorized Immigrants Living in the United States," pp. 77-82 in *1990 Proceedings of the American Statistical Association, Social Statistics Section*. Alexandria VA, American Statistical Association. This research focuses on the population of unauthorized immigrants living in the United States. The first two sections of this paper discuss this implicit unauthorized population and estimation of the legally resident foreign-born population. The third part is an analysis of Current Population Survey (CPS) data and immigration data to develop an estimate of the number of unauthorized immigrants.

BIBLIOGRAPHY V. Estimating the Foreign-Born: Survey-Based Methods

DaVanzo, J., J. Hawes-Dawson, R. B. Valdez, G. Vernez, C. Andrews, B. Levitan, J. Peterson, and R. Schoeni. 1994. *Surveying Immigrant Communities: Policy Imperatives and Technical Challenges*. Santa Monica, CA: RAND. To assess the feasibility of a large-scale survey of immigrants, the authors conducted a pilot study, the Los Angeles Community Survey of Salvadorans and Filipinos, in 1991. The results are encouraging: The survey was able to obtain useful information from eleven-year-old census data to target high-concentration sample areas; it successfully recruited and trained bilingual staff; it enlisted respondents' cooperation at acceptable rates; and it elicited responses to sensitive questions, including immigration status, that are critical for developing and assessing policy. The authors conclude that costs for a similar survey conducted in selected sites across the country, though substantial, would be low compared with the potential costs that immigration may impose, or even with the costs of programs intended to address immigration issues. Appendixes contain the survey materials.

Droitcour, J., and E. Larson. 2002. "An Innovative Technique for Asking Sensitive Questions: The Three-Card Method." *Bulletin de Méthodologie Sociologique*. 75: 5-23. The authors report that the United States Government Accountability Office (GAO) designed a grouped answers approach to estimating irregular migration in a survey in the United States, which has universal applicability for estimating such migration in other countries. The method directly estimates the number of persons in various "regular" or legal immigration status groups, indirectly estimates the number in sensitive irregular groups, while providing privacy protection. GAO created this methodology because of a lack of data; without information on immigration status, "policy researchers cannot track trends in employment or other important outcomes (such as subsequent educational attainment, income/poverty status, or family formation experience) for legal immigrants, illegal aliens, or persons of other immigration statuses.

Droitcour, J., E. Larson and F. Scheuren. 2001. "The Three-Card Method: Estimating Sensitive Survey Items--With Permanent Anonymity of Response." *Proceedings of the Survey Research methods Section, American Statistical Association*. Alexandria, VA: American Statistical Association (Available online, <http://www.amstat.org/sections/srms/Proceedings/y2001/y2001.html> , last accessed April 2008). This paper discusses the three card method in terms of: (1) basic logic; (2) special features; (3) preliminary testing and results; and (4) variance costs and ways to reduce them. A final section shows how an immigration group that is currently of special concern—"visa overstays"—might be estimated using a version of the method.

Droitcour, J., R. Caspar, T. Ezzati, M. Hubbard, T. Parsley, and W. Visscher. 1991 "The Item Count Technique as a Method of Indirect Questioning: A Review of its Development and a Case Study Application." pp. 85-210 in P. Biemer, R. Groves, L. Lyberg, N. Mathiowetz, and S. Sudman (Eds.) *Measurement Errors in Surveys*. New York City, NY: John Wiley & Sons. Unlike randomized response, which uses two

questions, one sensitive and one not, the authors report that in the “item count method” respondents are given lists of behaviors in which the sensitive behavior is imbedded among a list of non-sensitive behaviors. Respondents indicate the number of the behaviors that apply to them rather than answering questions on the actual behaviors. Random parts of the sample receive lists with and without the sensitive behavior. Like Randomized response, the item count method allows the researcher to use statistical methods to estimate the total number of people who engaged in the sensitive behavior; However, neither randomized response nor the item count method allow one to determine if a particular person engaged in the sensitive behavior. Because of this feature, both randomized response and the item count method preclude disclosure to the general public and sponsor as well as to the interviewer and other persons who may be nearby.

Fairchild, S. and N. Simpson. 2004. “Mexican Migration to the United States Pacific Northwest.” *Population Research and Policy Review* 23: 219-234. Using data supplied by the Mexican Migration Project, the authors compare the characteristics of Mexican migrants to the Pacific Northwest with characteristics of Mexicans who migrate to other parts of the U.S. The data reveal significant differences between the two groups: Mexican migrants to the PNW earn lower U.S. wages, are less likely to migrate illegally, and more commonly work in agriculture. They also are more transitory in nature, making more frequent, shorter trips to the U.S.

Fawcett, J. and F. Arnold. 1987. “The Role of Surveys in the Study of International Migration: An Appraisal.” *International Migration Review* 21 (4): 1523-1540. The authors point out that surveys provide an effective method for studies of the complex processes that underlie spatial mobility. They identify and discuss eight advantages of surveys that are related to research design and seven advantages that are related to research content. Deficiencies and disadvantages of surveys are also reviewed. Suggestions are made for improving surveys of international migration through better samples and attention to different points in a migration system.

Flores, E. 1984. “Research on Unauthorized Immigrants and Public Policy: A Study of the Texas School Case.” *International Migration Review* 18 (3): Special Issue: 505-523. This article reviews and evaluates the ‘Texas School’ case and social, political and educational issues pertinent to it. It further provides social and demographic data from a sample of parents of unauthorized children while analyzing the international ramifications of the case.

Golden, S. K. 2008. *Immigration and Construction: An Analysis of the Impact of Immigration on Construction Project Costs*. Unpublished Ph.D. Dissertation., Department of Civil and Environmental Engineering, University of Maryland.

The main objectives of this dissertation are to (1) to analyze the current makeup of construction industry workforces, native-born versus immigrant and legal versus illegal immigrant in the Washington, D.C. metropolitan region, (2) to predict possible effects of

immigration and immigration reform legislation on worker wages, and (3) to assess the likely wage. It is a case study of the Washington, D.C. metropolitan region and uses a

Heer, D. 1997. "The legal status of the children of unauthorized Mexican immigrants in Los Angeles County" pp. 355-360 in 1997 proceedings of the section on government statistics and section on social statistics. Alexandria, VA: American Statistical Association. The author presents estimates of the legal status of the children of unauthorized Mexican immigrants in Los Angeles County, California. The data for this paper come from a household survey conducted in the fall of 1994 jointly by the University of Southern California and El Colegio de la Frontera Norte (COLEF), an academic institution located in Tijuana, Mexico.

Heer, D. 1990. *Unauthorized Mexicans in the United States*. Arnold and Caroline Rose Monograph Series of the American Sociological Association. New York City, NY: Cambridge University Press. In this book, the author analyzes the results of a unique survey conducted in Los Angeles County, where an estimated 44 percent of the unauthorized Mexican population lives. The survey allows the author to make explicit comparisons among the groups of unauthorized and legal Mexican immigrants and to study the effects of legal status on their living conditions. The author also examines the findings of a number of other social scientists, providing a comprehensive summary of the present data on unauthorized Mexicans in the United States. In his conclusion, he turns to an evaluation of policy options for incorporating this group into the U.S. population and for controlling the future flow of such immigrants.

Heer, D. and J. Passel. 1987. "Comparison of Two Methods for Estimating the Number of Unauthorized Mexican Adults in Los Angeles County." *International Migration Review* 21(4): 1446-1473. This article compares two different methods for estimating the number of unauthorized Mexican adults in Los Angeles County (i.e., the Los Angeles Primary Metropolitan Statistical Area or PMSA). The first method, called the survey-based method, uses a combination of 1980 census data and the results of a survey conducted in Los Angeles County in 1980 and 1981. A sample was selected from babies born in Los Angeles County who had a mother or father of Mexican origin. The survey included questions about the legal status of the baby's parents and certain other relatives. The resulting estimates of unauthorized Mexican immigrants are for males aged 18 to 44 years and females aged 18 to 39 years. The second method, called the residual method, is the method used by Warren and Passel (1987) and Passel and Woodrow (1984) to estimate the number of unauthorized aliens counted in the 1980 census for the United States and each state, respectively. The method involves comparison of census figures for aliens counted with estimates of legally-resident aliens developed principally with data from the Immigration and Naturalization Service (INS). For this study, estimates by age, sex, and period of entry were produced for persons born in Mexico and living in Los Angeles County.

Hempstead, K. 2003. "Immigration and Native Migration in New York City, 1985–1990." *Population Research and Policy Review* 22: 333-349. In this paper, the 1990 Public Use Micro Sample is used to analyze the relationship between immigration and

outmigration of the native born in New York City. The study population is limited to native born males who lived in the five boroughs in 1985. The relationship between immigration and the probability of various kinds of moves is assessed using logistic regression. Results suggest that immigration has an insignificant effect on migratory behavior, with the exception of inter-borough migration. Unlike prior work, this study examines a single metro area, and does not limit itself to inter-state migration. These results are consistent with more recent work (Card 2001; Kritz et al. 2001), which has failed to find a positive labor market level effect of immigration on native migratory behavior. The inter-borough finding is consistent with the occurrence of voluntary residential segregation within the city, in which the native born move away from areas of immigrant concentration but do not leave the labor market, yet there is no direct evidence that this process occurred.

Larson, E. 2007. "Estimating Irregular Migration in a Survey: The Two Card Follow-up Method." Sixth Coordination Meeting on International Migration. New York, NY: Population Division, Department of Economic and Social Affairs, United Nations. UN/POP/MIG-6CM/2007/01. We term the most recent method based on this approach, the "Two-Card Follow-Up" method, because two different cards list different groups of immigration statuses and follow-up questions. Five key points of the method are: (1) The categories must be mutually exclusive and exhaustive; (2) No respondent is ever asked whether he, she, or anyone else is in a specific sensitive category (for example, illegal immigrant or "irregular migrant"); in this example, currently "unauthorized;" (3) Follow-up questions are asked of respondents; (4) Two pieces of information are separately provided by two sub-samples of respondents (completely different people — no one is shown both immigration status cards); (5) taking the two pieces of information together — like two pieces of a puzzle — allows indirect estimation of the unauthorized population, but no individual respondent (and no piece of data on an individual respondent) is ever categorized as unauthorized.

Larson, E. and T. Sullivan. 1987. "Conventional Numbers" in Immigration Research: The Case of the Missing Dominicans." *International Migration Review* 21 (4): 1474-1497. It is first noted in this paper that most estimates of Dominicans living abroad converge on 500,000. However, both 1980 U.S. and 1981 Dominican census counts suggest that the real total of Dominican emigrants is under 200,000. "This article examines the 500,000 estimate and concludes that its empirical basis is overestimated, possibly because of the difficulty of estimation, the tendency to repeat unsubstantiated estimates, and the incorrect interpretation of missing values.

Marcelli, E., and D. Heer. 1998. "The unauthorized Mexican immigrant population and welfare in Los Angeles County: a comparative statistical analysis." *Sociological Perspectives* 41 (2): 279-302. Using a unique 1994 Los Angeles County Household Survey of foreign-born Mexicans and the March 1994 and 1995 Current Population Surveys, the authors estimate the number of unauthorized Mexican immigrants (UMIs) residing in Los Angeles County, and compare their use of seven welfare programs with that of other non-U.S. citizens and U.S. citizens. Non-U.S. citizens were found to be no more likely than U.S. citizens to have used welfare, and UMIs were 11% (14%) less

likely than other non-citizens (U.S.-born citizens). They demonstrate how results differ depending on the unit of analysis employed, and on which programs constitute 'welfare'.

Massey, D. 1987. "The Ethnosurvey in Theory and Practice." *International Migration Review* 21: 1498-522. This article describes a research approach designed to overcome the limitations of federal immigration statistics and to illuminate the social processes underlying aggregate patterns of migration. The principal weaknesses of existing data sources are that they under-enumerate and imperfectly measure unauthorized migration; they do not reflect the widespread circularity of modern international movements; they omit variables central to the immigration process; and their cross-sectional collection and tabulation precludes the analysis of immigration as a dynamic process. The ethnosurvey is a research design that ameliorates these problems through five specific design features: multi-method data collection, representative multi-site sampling, multilevel data compilation, life history collection, and parallel sampling. These design features are described, justified, and tied to the broader methodological literature in social science. The ethnosurvey design is illustrated by its recent application to study Mexican migration to the United States, and empirical evidence is presented to show how it corrects the limitations of federal data on immigration.

Massey, D. 1999. "When Surveys Fail: An Alternative Approach to Studying Illegal Migration." pp. 145-160 in Arthur A. Stone et al. (eds.), *The Science of the Self-Report: Implications for Research and Practice*. New York City, NY: Erlbaum Press. This article evaluates the validity of the ethnosurvey as a method of demographic data collection by analyzing the representativeness of the Mexican Migration Project (MMP) as a source of information on Mexico-U.S. migration. After briefly delineating the philosophy, structure, and organization of the MMP's ethnosurvey design, we describe MMP's public use dataset as well as Mexico's Encuesta Nacional de la Dinamica Demografica (ENADID) as a benchmark for its systematic evaluation. Although the MMP over-represents migrants in the western states and mid-sized communities, it yields a relatively accurate and valid profile of migrants to the United States. A comparison of multivariate models estimated using MMP and ENADID data suggests that whereas the former's sampling errors are small and yield biases that are substantively unimportant, the latter's potential for specification error and selection bias may seriously compromise results. Our comparison thus validates the ethnosurvey as an accurate and reliable method of data collection and the MMP as a good source of reasonably representative data on authorized and unauthorized migration to the United States.

Massey, D., and A. Singer. 1995. "New Estimates of Unauthorized Mexican Migration and the Probability of Apprehension." *Demography* 32 (2) : 203-11. Using a new source of data, we estimate the probability of apprehension among Mexican migrants attempting to cross into the United States without documents. Over the period 1965-1989 we found an average apprehension probability of .35, confirming earlier estimates. We then applied annual probabilities to estimate the gross volume of unauthorized Mexican migration and adjusted these figures to derive estimates of the net unauthorized inflow.

Massey, D., and R. Zenteno. 1998. "The dynamics of mass migration." *Proceedings of the National Academies of Sciences* 96 (April): 5328–5335. The authors specify a set of equations defining a dynamic model of international migration and estimate its parameters by using data specially collected in Mexico. The authors then used it to project a hypothetical Mexican community population forward in time. Beginning with a stable population of 10,000 people, the authors project ahead 50 years under three different assumptions: no international migration; constant probabilities of in- and out-migration, and dynamic schedules of out- and in-migration that change as migratory experience accumulates. This exercise represents an attempt to model the self-feeding character of international migration noted by prior observers and theorists. The authors' model quantifies the mechanisms of cumulative causation predicted by social capital theory and illustrates the shortcomings of standard projection methodologies. The failure to model dynamically changing migration schedules yields a 5% overstatement of the projected size of the Mexican population after 50 years, an 11% understatement of the total number of US migrants, a 15% understatement of the prevalence of US migratory experience in the Mexican population, and an 85% understatement of the size of the Mexican population living in the U. S.

McQuiston, C., E. Parrado, A. Martinez, and L. Uribe. 2005. "Community-Based Participatory Research with Latino Community Members: Horizonte Latino." *Journal of Professional Nursing*. 21 (4) 210-215. This article demonstrates how experiential learning of community members as research participants provided culturally grounded insights used in grant writing. The experiences and involvement of the community researchers shaped the research questions and provided the major conceptual basis in response to a National Institutes of Health Request for Applications.

North, D., and M. Houston. 1976. *The Characteristics and Role of Illegal Aliens in the U. S. Labor Market: An Exploratory Study*. Washington, DC: Linton. The authors present data on the characteristics and experiences of illegal aliens in the U.S. labor market. Current and past U.S. immigration policy is reviewed, and causes of immigration, areas of origin of illegal immigrants, socioeconomic disparities between sending and receiving nations are analyzed. Migrants are described according to individual characteristics, family obligations, and ties with the United States and the country of origin. Data on migrant's employment history, occupation, wages, and participation in public programs are presented, and manpower policy implications are analyzed. Data are from a 1975 study of 793 apprehended illegal aliens who had work experience in the United States

Paradies, Y. and T. Barnes. 2005. "A New Variant of Dual-record Population Estimation with an Application in Remote Indigenous Communities." *Journal of Population Research* 22 (2): 119-139. The authors note that dual-record system methods are commonly used as a basis for population estimation and that a basic assumption is that the units sampled are drawn only from the population to be estimated. Because this assumption cannot be met for remote Indigenous communities in Australia, the authors present a new variant of dual-record population estimation is presented, which relies on the availability of specific additional information to relax the assumption of perfect frame specification. This variant is applied to two remote Indigenous communities in the

Northern Territory of Australia, using locally available data sources. Further theoretical exploration of this method is presented along with possible applications in estimating area-enumerated populations and census coverage.

Passel, J. and K. Woodrow. 1987. "Change in the Unauthorized Alien Population in the United States, 1979-1983." *International Migration Review* 21(4): 1304-1334. This article presents estimates of the number of unauthorized aliens included in the April 1983 Current Population Survey (CPS) derived by subtracting an estimate of the legally resident foreign-born population from the survey estimate of all foreign born residents. The methodology is similar to that used by Warren and Passel (1987) with the 1980 census. Also presented are similar estimates for the November 1979 CPS, that is, re-estimates following the work of Warren (1982). Estimates are presented by period of entry for Mexico and other groups of countries. Comparison of the April 1983 estimate with the census-based estimate and the November 1979 survey-based estimate provide an indication of growth in the unauthorized alien population for 1980-83. For this recent period, the implied annual growth in the unauthorized alien population is in the range of 100,000 to 300,000—a range lower than has usually been offered in speculative assessments.

Reagan, P., and R. Olsen. 2000. "Immigration to the United States and Return Flows - You Can Go Home Again: Evidence From Longitudinal Data." *Demography* 37 (3): 339-350. In this paper, the authors analyze the economic and demographic factors that influence return migration, focusing on generation 1.5 immigrants. Using longitudinal data from the 1979 youth cohort of the National Longitudinal Surveys (NLSY79), we track residential histories of young immigrants to the United States and analyze the covariates associated with return migration to their home country. Overall, return migration appears to respond to economic incentives, as well as to cultural and linguistic ties to the United States and the home country. They find no role for welfare magnets in the decision to return, but we learn that welfare participation leads to lower probability of return migration. Finally, They see no evidence of a skill bias in return migration, where skill is measured by performance on the Armed Forces Qualifying Test.

Reyes, B. 2004. "Changes in Trip Duration for Mexican Immigrants to the United States." *Population Research and Policy Review* 23: 235-257. Using the Mexican Migration Project sample, this paper explores the patterns of trip duration for Mexican immigrants to the United States and the reasons for the patterns observed. I found that the most important factors leading to changes in trip duration are US immigration policy, the conditions of the Mexican economy, and the development of social networks. It appears that the legalization of many immigrants after passage of the Immigration Reform and Control Act encouraged short-term migration, but the build-up at the US-Mexico border may have changed this pattern leading to longer duration in the United States. An expansion of networks and resources for immigrants in the United States leads to longer duration in the United States.

Schmidley, A. D., and J. G. Robinson. 2003. "Measuring the Foreign-Born Population in the United States with the Current Population Survey: 1994-2002." *Population Division*

Working Paper No. 73. Washington DC: U. S. Census Bureau. In this paper, the authors evaluate CPS nativity data collected between January 1994 and December 2002. Where feasible, they compare these data with data from other sources. They incorporate a limited amount of the information found in "How Well Does the Current Population Survey Measure the Foreign-Born Population in the United States?" which evaluated the March Annual Social and Economic Supplement (ASEC) nativity data 1994 to 1997.¹² The current paper extends the period to 2002 and includes information about the monthly or basic survey.

Skeldon, R. 1987. "Migration and the Population Census in Asia and the Pacific: Issues, Questions and Debate." *International Migration Review* 21 (4): 1074-1100. The author notes that the main issues to be resolved when designing questions and strategies to collect migration-related data are discussed here. The strengths and weaknesses of the various approaches are assessed in the light of the data collected by countries in the Asia-Pacific region during the 1980 round of censuses. In the context of the developing countries of the region, the author argues that higher quality and more useful migration data can be captured through questions on last place of previous residence and duration of residence in De facto-based censuses. Variations of, and amplifications to, this approach are considered.

U. S. GAO. 2006. *Estimating the Unauthorized Population: A "Grouped Answers" Approach to Surveying Foreign-born Respondents.* GAO-06-775. Washington, DC: United States General Accountability Office. This report reviews the ongoing development of a potential method for obtaining such information: the "grouped answers" approach. In 1998, GAO devised the approach and recommended further study. In response, the Census Bureau tested respondent acceptance and recently reported results. GAO answers four questions: (1) Is the grouped answers approach acceptable for use in a national survey of the foreign-born; (2) What further research may be needed; (3) How large a survey is needed; (4) Are any ongoing surveys appropriate for inserting a grouped answers question series (to avoid the cost of a new survey)? For this study, GAO consulted an independent statistician and other experts, performed test calculations, obtained documents, and interviewed officials and staff at federal agencies. The Census Bureau and DHS agreed with the main findings of this report. DHHS agreed that the National Survey of Drug Use and Health is not an appropriate survey for inserting a grouped answers question. GAO finds that the grouped answers approach is acceptable to many experts and immigrant advocates, with certain conditions, such as (for some advocates) private sector data collection.

U. S. GAO. 1999. *Survey Methodology: An Innovative Technique for Estimating Sensitive Survey Items.* GAO/GGD-00-30. Washington, DC: United States General Accountability Office. This study discusses an innovative technique for collecting data on sensitive policy-relevant topics. The "three card method" is designed to collect sensitive information in large-scale surveys. It is intended

to allow estimation of the needed statistics while maximizing response privacy and reducing "question threat." If successful, this technique might eventually fill in key data gaps and improve statistics that would be helpful in making public policy decisions. GAO's main goal is to spur interest in--and, where appropriate, encourage more development and testing of -- this promising, albeit not yet fully validated, technique.

Van Hook, J., W. Zhang, F. Bean, and J. Passel. 2006. "Foreign-Born Emigration: A New Approach and Estimates Based on Matched CPS Files." *Demography* 43 (2): 361-382. The authors introduce a new method for estimating foreign-born emigration that takes advantage of the sample design of the Current Population Survey (CPS): repeated interviews of persons in the same housing units over a period of 16 months. Individuals appearing in a first March Supplement to the CPS but not the next include those who died in the intervening year, those who moved within the country, and those who emigrated. They use statistical methods to estimate the proportion of emigrants among those not present in the follow-up interview. Our method produces emigration estimates that are comparable to those from residual methods in the case of longer-term residents (immigrants who arrived more than 10 years ago), but yields higher--and what appear to be more accurate--estimates for recent arrivals. Although somewhat constrained by sample size, they also generate estimates by age, sex, region of birth, and duration of residence in the United States.

Woodrow-Lafield, K. 1996. "Emigration from the United States: Multiplicity Survey Evidence." *Population Research and Policy Review* 15(2): 171-199. During the 1980s, the Census Bureau conducted special national surveys to measure the number of emigrants from the US. Using a multiplicity sampling approach, the survey obtained information from resident relatives about their immediate relatives (parents, siblings, and children) who are living outside the US (an who at 1 time lived here). The June 1988 Current Population Survey (CPS) yielded an estimate of at least 1 million emigrants. This survey-based estimate does not include emigrants who do not have a resident immediate relative. Adjusting for such omission error, the number of emigrants surviving is likely to exceed 2 million. Of this potential population, about 1.2 had departed during the 1980-88 period. This amount implies annual levels of emigration during the 1980s that are similar to those found for the 1960s and 1970s in inter-censal research and analyses of the legally registered alien population.

Woodrow, K. 1992. "A Consideration of the Effect of Immigration Reform on the Number of Unauthorized Residents in the United States." *Population Research and Policy Review* 11 (2): 117-144. This analysis presents national [U.S.] survey data on the foreign-born population in November 1989 for comparison with an independently derived estimate of the legally resident foreign-born population at the same date. The demonstration of a measurable unauthorized population residing in the United States is very helpful in evaluating the success of the Immigration Reform and Control Act of 1986. Despite the legalization of 1.7 million aliens who provided evidence of unauthorized residence since before 1982, and economic sanctions against employers found to hire unauthorized workers, an unauthorized population persists in the United

States that appears to be largely composed of aliens from Latin American countries. Precise measurement of the size of this population is complicated by the uncertainties surrounding the population of approximately one million Special Agricultural Workers admitted under IRCA.

Woodrow, K. 1991. "DA Evaluation Project D2: Preliminary Estimates of Unauthorized Residents in 1990." *Preliminary Research and Evaluation Memorandum No. 75*. Washington, DC: U. S. Bureau of the Census. The author uses Demographic analysis to evaluate census coverage requires an estimate of the unauthorized population residing in the United States on April 1, 1990. She produces a preliminary estimate for the number of unauthorized residents on April 1, 1990 is 3.3 million, based on two approaches. The first approach increased the direct estimate of unauthorized immigrants in the November 1989 Current Population Survey (CPS) to allow for CPS and census under-coverage. The second approach employs implicit estimates from carrying forward the alternative estimates for unauthorized residents in 1980 with alternative estimates of change for periods of 1979-1986, 1979-1988, 1979-1989, 1986-1988, and 1986-1989. Allowing for CPS under-coverage, the range is 1.8 to 3.2 million with a "point" estimate of 2.5 million. Considering plausible levels for census under-coverage (20 to 30 percent) yields a range of 1.9 to 4.5 million. Without recent legalization of about 1.7 million long-term residents, the "point" estimate might have been 5.0 million, or between 4.5 and 5.5 million. The "point" estimate for unauthorized residents in 1990 is 3.3 million with a likely range of 1.9 million to 4.5 million. To account for more sources of uncertainty, the true number of unauthorized residents in 1990 is assumed as between 1.7 and 5.5 million. Census planning in the decade led to this empirically based estimate for the number of unauthorized residents as of Census Day, 1990. In 1982, preliminary evaluation of 1980 census coverage was made without any empirical estimates for the number of unauthorized residents, and those estimates were not completed until 1983-84, delaying final coverage estimates until 1985.

Woodrow, K. and J. Passel. 1990. "Post-IRCA Unauthorized Immigration to the United States: An Assessment Based on the June 1998 CPS. pp 33-75 in F. Bean, B. Edmonston and J. Passel (Eds.) *Unauthorized Migration to the United States: IRCA and the Experience of the 1980s*. Washington, DC: The Urban Institute. Although IRCA reduced the unauthorized resident population by nearly 1.7 million residents and an unknown number of the agricultural legalizations, the authors note that a significant number of unauthorized immigrants, at least 2.0 million, remained as of 1988. Some were long term residents, but others appear to have arrived since IRCA's implementation. IRCA's legalization program led to changes in the composition of the unauthorized population, specifically, a female majority and a non-Mexican majority. Measurement of the size of the resident unauthorized population are crucial for evaluating immigration policies.

BIBLIOGRAPHY VI. Estimating the Foreign-Born: Other Methods

Bean, F., A. King, and J. Passel. 1983. "The Number of Illegal Migrants of Mexican Origin in the United States: Sex-ratio Based Estimates of 1980." *Demography* 20: 99-109. This article reports the results of applying a sex ratio-based method to estimate the number of unauthorized Mexicans residing in the United States in 1980. The approach centers on a comparison between the hypothetical sex ratio one would expect to find in Mexico in the absence of emigration to the United States and the sex ratio that is in fact reported in preliminary results from the 1980 Mexican Census. The procedure involves, inter alia, assuming a range of values for the sex ratio at birth and for census coverage differentials by sex in Mexico. Even the combinations of these values most likely to result in large estimates suggest that no more than 4 million illegal migrants of Mexican origin were residing in the United States in 1980.

Massey, D., and R. Zenteno. 1998. "The dynamics of mass migration." *Proceedings of the National Academies of Sciences* 96 (April): 5328–5335. The authors specify a set of equations defining a dynamic model of international migration and estimate its parameters by using data specially collected in Mexico. The authors then used it to project a hypothetical Mexican community population forward in time. Beginning with a stable population of 10,000 people, the authors project ahead 50 years under three different assumptions: no international migration; constant probabilities of in- and out-migration, and dynamic schedules of out- and in-migration that change as migratory experience accumulates. This exercise represents an attempt to model the self-feeding character of international migration noted by prior observers and theorists. The authors' model quantifies the mechanisms of cumulative causation predicted by social capital theory and illustrates the shortcomings of standard projection methodologies. The failure to model dynamically changing migration schedules yields a 5% overstatement of the projected size of the Mexican population after 50 years, an 11% understatement of the total number of US migrants, a 15% understatement of the prevalence of US migratory experience in the Mexican population, and an 85% understatement of the size of the Mexican population living in the U. S.

Wolter, K. 1990. "Capture-Recapture Estimation in the Presence of a Known Sex Ratio." *Biometrics* 46 (1): 157-162. The author presents new methods of estimating population size based on capture-recapture data. The methods exploit knowledge of the sex ratio, males per female, and permit "estimability" even when both time of sampling and marking affect the "catchability" of an animal. An example is presented involving *Microtus pennsylvanicus* (meadow vole).

Wolter, K. and B. Causey. 1991. "Evaluation of Procedures for Improving Population Estimates for Small Areas." *Journal of the American Statistical Association* 86 (414): 278-284. The authors provide and illustrate methods for evaluating across-the-board ratio estimation and synthetic estimation, two techniques that might be used for improving population estimates for small areas. The methods emphasize determination of a break-

even accuracy of knowledge concerning externally obtained population totals, which marks the point at which improvement occurs.

BIBLIOGRAPHY VII. Estimating the Foreign-Born: Evaluations of Methods

Bean, F., R. Corona, F. Tuiran, K. Woodrow-Lafield, and J. Van Hook. 2001. "Circular, Invisible, and Ambiguous Migrants: Components of Difference in Estimates of the Number of Unauthorized Mexican Migrants in the United States." *Demography* 38 (3): 411-422. Working from an equation that can be used with available data and that provides a basis for facilitating decomposition analyses, the authors estimate that about 2.54 million total (as opposed to enumerated) unauthorized Mexicans resided in the United States in 1996. Comparing this figure with an estimate of about 2.70 million released by the U.S. Immigration and Naturalization Service (INS) during the 1990s, we find that the two estimates involve different assumptions about circular, invisible, and ambiguous migrants. Such differences not only can have important policy implications; they can also be sizable and can operate in opposite directions, as illustrated by findings from a components-of-difference analysis. The results are also extrapolated to 2000, and implications for 2000 census counts are discussed.

Bolton, N. 2007. "The Challenge of Accurately Estimating the Population of Illegal Immigrants." *The Social Contract* (4): 224-229. (Available online, http://www.thesocialcontract.com/artman2/publish/tsc_17_4/index.shtml , last accessed April 2008). The author observes that estimates of the size of the illegal alien population currently living in the U.S. range from about 12 million to over 20 million. The lower number is based on Census Bureau estimates of the foreign-born population in various Census Bureau surveys. The larger number is based on methodology that is not reliant on a respondent's candor. While the Census Bureau makes a Herculean effort to get a complete count, it is virtually impossible to get an accurate count of populations who are resistant to being identified. This article contrasts Census Bureau estimates with alternative estimates.

Borjas, G., R. Freeman, and K. Lang. 1991. "Unauthorized Mexican-born workers in the United States: How many, how permanent?" pp. 77-100, in: M. Abowd and R. Freeman (eds.) *Immigration, trade, and the labor market*. Chicago, IL: University of Chicago Press. The authors analyze three government data sets and a small survey of illegal aliens in the San Diego, California area in order to evaluate conflicting claims about the size of the Mexican-born migrant population.

Bos. E. 1984. "Estimates of the Number of Illegal Aliens: An Analysis of the Sources of Disagreement." *Population Research and Policy Review* 3: 239-254. This article analyzes differences in estimates of the number of illegal aliens in the United States. Although smaller than differences among estimates made by some of the earlier studies, estimates

constructed in the past decade often differ by several million. An examination of the problems involved in making these estimates produced four likely sources of the discrepancies. The four 'sources of disagreement' are discussed, followed by suggestions for improving the reliability of the estimates. Some consequences for immigration law reform are also addressed.

Briggs, V. 1984. "Methods of Analysis of Illegal Immigration into the United States." *International Migration Review* 18 (3): 623-641. The author notes that a major barrier to the discussion of the scope and impact of illegal immigration on the American economy has been the inadequacy of existing data. Although data problems are not unique to this topic, the limited availability of macro-data on the size of the annual flows and of the accumulated stock of individuals as well as of micro-data on their influences on selected labor markets has been effectively used to forestall policy reform efforts.

Bustamante, J. 1977. "Unauthorized Immigration from Mexico: Research Report." *International Migration Review* 11: 149-177. This paper focuses on three aspects of the unauthorized immigration from Mexico to the United States. First is presented, a statement on the state of the art regarding the empirical research on this phenomenon; second is, a review of what we know on some of the characteristics of this migration and the presentation of preliminary findings of a survey conducted by the author in nine Mexican border cities, based on interviews with Mexican unauthorized emigrants recently deported from the United States; and third is, a discussion on past attempts to solve the problems and some suggestions on how it might be solved.

Camarota, S. and J. Cappizzano. 2005. "Evaluation of Sub-national ACS Foreign-Born Data – Benchmarking Report 1." Paper presented at the Census Bureau Conference On Immigration Statistics: Methodology and Data Quality. Alexandria, VA. (available online, <http://www.copafs.org/> , last accessed March 2008). This paper discusses the challenges and tradeoffs from the researcher's perspective of the different techniques that may be used in calculating unbiased standard errors of ACS estimates. It begins by discussing both the publicly available and internal U.S. Census Bureau methods for calculating the standard error of ACS estimates. These include two methods under the "generalized variance" approach (design factors and parameters) and the replication method. It then discusses the strengths and weaknesses of each approach from the perspective of a researcher outside of the U.S. Census Bureau. The paper concludes by making recommendations concerning ways the U.S. Census Bureau can make it easier for an external researcher to calculate unbiased standard errors of ACS estimates, particularly those that can be used in significance testing.

Camarota, S. and J. Cappizzano. 2005. "Assessing the Quality of Data Collected on the Foreign Born: An Evaluation of the American Community Survey (ACS)." Paper presented at the Census Bureau Conference On Immigration Statistics: Methodology and Data Quality. Alexandria, VA. (available online, <http://www.copafs.org/> , last accessed March 2008). This study presents findings from an evaluation of the foreign-born data collected during 1999 in Harris and Fort Bend Counties, Texas, and an evaluation of the foreign-born data from the 2000 ACS national sample, known as the Census 2000

Supplementary Survey (C2SS).[4] This study was designed to review ACS data collection procedures and to assess the quality of ACS foreign-born data collected both in a sampling area with a high concentration of foreign born and in the nationally representative ACS sample.

Camarota, S., and J. Capizzano. 2004. *Assessing the Quality of Data Collected on the Foreign Born: An Evaluation of the American Community Survey (ACS), Pilot and Full Study Findings*. Unpublished Report. Sabre Systems, Inc. (available online, http://www.sabresystems.com/whitepapers/CIS_whitepaper.pdf, last accessed January, 2008). This study presents findings from an evaluation of the foreign-born data collected during 1999 in Harris and Fort Bend Counties, Texas, and an evaluation of the foreign-born data from the 2000 ACS national sample, known as the Census 2000 Supplementary Survey (C2SS). This study was designed to review ACS data collection procedures and to assess the quality of ACS foreign-born data collected both in a sampling area with a high concentration of foreign born and in the nationally representative ACS sample.

Cassidy, R. and L. Pearson. 2001. "Evaluating Components of International Migration: Temporary (Legal) Migrants." *Population Division Working Paper No. 60*. Washington DC: U. S. Census Bureau.

Costanzo, J., C. Davis, C. Irazi, D. Goodkind, and R. Ramirez. 2001. "Evaluating Components of International Migration: The Residual Foreign-Born," *Population Division Working Paper 61*. Washington, DC: U. S. Census Bureau. This report focuses on the evaluation of the U.S. Census Bureau's estimated residual foreign-born population (including both unauthorized and quasi-legal migrants) in 1990 and 2000. The estimates shown here were calculated in conjunction with estimates of other components of international migration: legal permanent migration and legal temporary migration. These components of international migration, along with assumed deaths and emigrants, are subtracted from a total foreign-born population yielding a residual count. The authors note that this residual foreign-born population is not an estimate of the number of unauthorized migrants. This estimate also includes people who are here legally but are not yet included in the official estimates of legal migrants and refugees. It also includes people in "quasi-legal" status who are awaiting action on their legal migration requests. Because the estimate was derived from a residual methodology, any limitations in the methods or in the measurement of other migration components are reflected in the residual number. In addition, our assumptions include a great deal of uncertainty, especially for small migration components. Therefore, the residual may be quite different from the actual number of unauthorized migrants. According to their calculations, the estimated residual foreign-born population was 3,765,906 in 1990 and 8,705,419 in 2000. The residual foreign born were less likely to be male (48.4 percent) in 1990 than in 2000 (54.2 percent).

Cresce, A., R. Ramirez, and G. Spencer. 2001. "Evaluating Components of International Migration: Migration Between Puerto Rico and the United States." *Population Division Working Paper No. 42*. Washington DC: U. S. Census Bureau. This report addresses the question: "How do edit and imputation procedures affect the consistency of foreign-born

and Hispanic populations?” Comparisons were made between the edit and imputation specifications for the 1990 census and Census 2000 for the questions on place of birth and Hispanic origin to determine what impact, if any, such differences might have had on comparisons of numbers between the censuses. There were few significant differences in the specifications for the question on place of birth. The most significant difference - “hot deck” imputation of specific countries of birth in Census 2000 but not in 1990 - did not affect the overall total of foreign-born people. Regarding the specifications for the Hispanic question, several important differences were noted, the most important of which was the use of surname assisted “hot decks” in assigning an origin. Overall, the Census 2000 edit and imputation procedures seemed to be more accurate than the 1990 procedures in assigning an origin. The improvement in assigning an origin was assisted by a substantial decline between 1990 and 2000 in the level of non-response to the question on Hispanic origin.

Deardorff, K., and L. Blumerman. 2001. “Evaluating Components of International Migration: Estimates of the Foreign-Born by Migrant Status in 2000.” *Population Division Working Paper No. 58*. Washington DC: U. S. Census Bureau. This report focuses on the evaluation of the U.S. Census Bureau's estimates of the foreign-born population by migrant status in 2000. In particular, we assess the assumptions used to estimate the various types of international migrants (legal immigrants, temporary migrants, unauthorized migrants, and emigrants) and the effect of alternative assumptions in estimating the size of the foreign-born population. By reviewing alternative assumptions about the types of international migrants, the authors assess the completeness of coverage of the foreign-born population in Census 2000, and the reasonableness of the resulting Demographic Analysis (DA) estimate.

Durand, J., and D. Massey. 1992. “Mexican Migration to the United States: a Critical Review.” *Latin American Research Review* 27 (2): 3-42. The authors attempt a critical review and synthesis of research carried out in Mexico and the United States on migration between the two countries. They begin by examining two issues: (1) the number of Mexican migrants to the United States; and (2) the quantity of their monetary remittances to Mexico, and then suggest that once rhetoric is separated from fact and analysis from opinion, the various estimates are actually relatively consistent." They also undertake a review of studies on communities sending migrants to the United States. Their review suggests that only a few community factors account for the diversity of conclusions in different case studies: the age of the migration stream; the degree to which productive resources are equitably distributed; the quality of local resources, especially land; the niche in the U.S. industrial structure where the community's migrants first became established; and the geographic, political, and economic position of the community within Mexico.

Edmonston, B., and M. Michalowski. 2004. “International Migration” pp. 455-492 in J. Siegel and D. Swanson (Eds). *The Methods and Materials of Demography, 2nd Edition*. Amsterdam, The Netherlands, Elsevier Academic Press. This chapter presents an overview of the materials and method used in studying international migration. It illustrates these methods with examples.

Espenshade, T., and D. Acevedo. 1995. "Migrant cohort size, enforcement effort, and the apprehension of unauthorized aliens." *Population Research and Policy Review* 14: 145-172. This article examines macro-structural conditions that affect time trends in aggregate probabilities of unauthorized alien apprehension along the Mexico-US border. We show that the number of migrants attempting to cross the border illegally in a given period and the level of effort expended by the INS to apprehend unauthorized migrants are principal determinants of apprehension probabilities. Our findings differ from those in earlier work by Donato, Durand, and Massey who argue that individual, household, and community factors are not significant predictors of apprehension probabilities and conclude that escaping INS detection at the border is essentially a random process unrelated to personal traits or to enforcement provisions of the 1986 Immigration Reform and Control Act. Although Donato et al. recognize that apprehension probabilities are affected by the size of the US Border Patrol budget and the number of personnel, they omit these larger structural factors from consideration. Instead, they introduce annual dummy variables to control for macro-structural forces. This approach is unsatisfactory because it confounds the effects of numerous explanatory factors. We conclude that one implication for future research is that it is worth modeling the effects of individuals' characteristics on apprehension probabilities by including as predictors an estimate of the flow of unauthorized migrants and measures of INS border enforcement effort. Controlling explicitly for three macrostructural conditions may disclose the importance of some individual-level factors that would otherwise be obscured.

Heer, D. 1979. "What is the Annual Net Flow of Unauthorized Mexican Immigrants to the United States?" *Demography* 16: 417-424. In this paper, seven estimates are made concerning the net flow of unauthorized Mexican immigrants to the United States in the period 1970-1975. These estimates are based on the growth of the population of Mexican origin according to the Current Population Survey. According to these estimates the annual net flow ranged from 82,300 to 232,400 persons.

Heer, D., and J. Passel. 1987. "Comparison of two methods for estimating the number of unauthorized Mexican adults in Los Angeles County." *International Migration Review* 21 (4): 446-473. This article compares two different methods for estimating the number of unauthorized Mexican adults in Los Angeles County. The first method, called the survey-based method, uses a combination of 1980 U.S. census data and the results of a survey conducted in Los Angeles County in 1980 and 1981. The second method, called the residual method...involves comparison of census figures for aliens counted with estimates of legally-resident aliens developed principally with data from the Immigration and Naturalization Service (INS). For this study, estimates by age, sex, and period of entry were produced for persons born in Mexico and living in Los Angeles County.

Gibbs, J., G. Harper, M. Rubin, and H. Shin. 2001. "Evaluating Components of International Migration: Native Emigrants." *Population Division Working Paper No. 63*. Washington DC: U. S. Census Bureau. This report focuses on the evaluation of the assumptions about emigration of the native population used by the Census Bureau. From the 1970s through the 1980s, the Census Bureau estimated annual emigration of the

native population at a constant level of 27,000. For the 1990-2000 inter-censal decade, the Census Bureau estimated annual emigration of the native population at a constant level of 48,000. The evaluation attempted - unsuccessfully - to replicate the approach taken to arrive at the 48,000 figure.

Jasso, G., and M. Rosenzweig. 1987. "Using National Recording Systems for the Measurement and Analysis of Immigration to the United States." *International Migration Review* 21 (4): 1212-1244. This article considers the kinds of data required to increase scientific knowledge about U.S. immigration and, in light of those requirements, assesses the principal currently available data sets (the U.S. decennial Censuses and the administrative records of the Immigration and Naturalization Service) and makes recommendations for improving the data environment.

Judson, D. 2006. "Memorandum for E. Lamas (21 September): Subject: Preliminary Results and Evaluation of Experimental Estimates of the Foreign-Born Population by Legal Status." US. Census Bureau. (Available online, http://wikileaks.org/wiki/US_Census_Bureau_Estimates_of_Unauthorized_Persons, last accessed March 2008). This memo documents preliminary results and an evaluation of experimental estimates of the foreign-born population by legal status. It represents an evaluation of the work done in the first phase of this initiative: To develop annual estimates of the foreign born population by legal status (totals) at the national level. Under this phase, ISS is comparing the utility of different methods and datasets for estimates by legal status. Potential methods include residual methods, statistical modeling, and algorithmic assignment.

Malone, M. 2001. "Evaluating Components of International Migration: Consistency of 2000 Nativity Data." *Population Division Working Paper No. 66*. Washington DC: U. S. Census Bureau. This report focuses on the consistency of the data sources related to the foreign-born population. Specifically, the analysis examines the comparability and consistency of data from three different data sources collected in 2000: the March 2000 Current Population Survey (original and re-weighted); the Census 2000 Supplementary Survey; and a provisional Census 2000 nativity data file. We examine differences in estimates among survey/census items specific to the foreign-born population - citizenship, place of birth and year of entry - as well as by general population characteristics, such as age, sex, race and Hispanic origin.

Massey, D., and C. Capoferro. 2004. "Measuring Unauthorized Migration." *International Migration Review* 38 (3): 1075-1102. This article reviews standard sources of demographic data-censuses, inter-censal surveys, registration systems, and specialized surveys and describes their inability to provide accurate data on immigrants, particularly those without documents. The authors discern a need for data that can identify unauthorized migrants and their characteristics, measure trends over time, support longitudinal research, compare the characteristics of migrants before and after they enter, provide sufficient sample sizes for detailed analyses, study transitions between different legal statuses and movements back and forth, and monitor the effects of policy changes on a timely basis. They suggest that the ethnosurvey design satisfies these criteria and

describe the theory, structure, and organization of the ethnosurvey, and its application in the Mexican Migration Project. They then highlight its application in other locations around the world and outline an agenda for future comparative research.

Menendez, J. 2007. "Comparison of ACS and ASEC Data on Citizenship, Year of Entry, and region of Birth: 2004." Washington, DC: Population Division, U.S. Census Bureau (Available online, http://www.census.gov/acs/www/Downloads/ACS_ASEC_Report_FINAL_08_06_07.pdf, last accessed April 2008). This report is one in a series that compares data from the American Community Survey (ACS) with data from the Annual Social and Economic Supplement (ASEC) to the Current Population Survey (CPS). The report focuses on comparisons of national distributions of citizenship status, year of entry, and place of birth between the 2004 ACS and the 2004 ASEC. It suggests possible explanations for those differences that are both statistically and substantively different. The population living in group quarters is excluded from the analysis.

Mulder, T., B. Guzmán, and A. Brittingham. 2001. "Evaluating Components of International Migration: Foreign-Born Emigrants." *Population Division Working Paper No. 62*. Washington DC: U. S. Census Bureau. This report focuses on the evaluation of the U.S. Census Bureau's estimate of foreign-born emigration from the United States between 1980 and 1990. Estimates produced by Ahmed and Robinson (1994) and Oosse (1998) were recreated and evaluated by age, sex, race, and Hispanic origin to determine if the estimated flows were realistic. In addition, an attempt was made to create new foreign-born emigration estimates for the 1990 and 2000 decade using the preliminary results from Census 2000. Based on recreation and evaluation efforts, Ahmed and Robinson and Oosse estimates appear sound and represent the most recent and most reliable data on foreign-born emigration available. Future research is needed to evaluate the application of a residual method to estimate foreign-born emigration. In addition, efforts will focus on creating new estimates using alternative methodologies and data sources.

Murdock, S. 2006. "The Potential Effects of Legal and Unauthorized International Migration on the Census and other Data sources in the United States: Methodological and Policy Issues in 2010 and Beyond." *Journal of Economic and Social Measurement* 31 (3-4): 207-220. This article considers the accurate measurement of international migration to and from the United States, both legal and unauthorized, and how these measurement characteristics might affect the accuracy and utility of the 2010 census and other data sources. It provides a brief overview of the recent magnitude and impacts of US immigration. It delineates the role of immigration in determining an accurate census and discusses specific parameters that must be accurately measured in order to adequately assess immigration, both legal and unauthorized. It makes specific recommendations for addressing the effects of such factors.

Perry, M., B. Van der Vate, L. Auman, and K. Morris. 2001. "Evaluating Components of International Migration: Legal Migrants." *Population Division Working Paper No. 59*. Washington DC: U. S. Census Bureau. This report focuses on the evaluation of the U.S. Census Bureau's estimate of legal immigration to the United States between 1980-1990

and 1990-2000. Specifically, the review process validated the estimates of the numbers of people who obtained legal permanent residency in the United States, either as a new arrival or by adjusting their residency status. To produce the estimate of legal immigrants, the Census Bureau reviewed data files from the Immigration and Naturalization Service (INS). The evaluation resulted in legal immigration estimates of 5.373 million for 1980 to 1990, and 7.543 million for 1990 to 2000. For both time periods, legal immigrants included more women than men, were likely to be non-Hispanic, and the largest numbers were between the ages of 30 and 49.

Pitken, J. 2008. "U.S. Immigration in the Rear View Mirror." Paper presented at the annual meeting of the Population Association of America, New Orleans, LA. This paper uses reverse survival for estimating annual immigration prior to 2000 on a basis that is consistent with 2000 census counts. This new method is based on responses to the census question on Year of Entry that was asked of foreign-born persons in 2000. Although a similar question had been asked in earlier (1980, 1990, 2000) censuses, the 2000 census questionnaire for the first time asked for a response in terms of an exact year rather than a period of years. The advantage of this method is that it is, by definition, consistent with 2000 population counts.

Poros, M., and A. Orum. 2005. "Report on Cognitive Testing of Proposed International Migration Questions for the American Community Survey." Paper Presented at the Census Bureau Conference on Immigration Statistics: Methodology and Data Quality. Alexandria, VA. (available online, <http://www.copafs.org/>, last accessed March 2008). The authors report on cognitive interviews as a follow up to cognitive testing conducted by Westat. Specifically, the place of birth question includes detail on respondent's place of birth, including city, town or village of birth. The U.S. citizenship status question asks for the respondent's year of naturalization. Finally, the year of entry question asks for respondents to indicate if they have come to the U.S. only once or more than once and to include their dates of arrival to the U.S. The authors recruited 16 foreign-born respondents in the Chicago metropolitan area in order to conduct cognitive testing of proposed international migration questions for the American Community Survey. The authors tested four main aspects of cognition: (1) comprehension of the question; (2) retrieval from memory of the relevant information to answer the question; (3) the decision process used to answer the question; and (4) the response process used to answer the question. The results suggest that, on the whole, respondents were able to understand the meaning, intent, and terminology used in the questions on place of birth and citizenship. Based on these results, the authors make the following recommendations: (1) Test the city/town/village terminology to obtain information on detailed place of birth of foreign-born respondents; (2) Test the year of naturalization and "No, not a U.S." the response options on the U.S. citizenship status question; and (3) Test the two-part year of entry question.

Pryor, E., and J. Long. 1987. "The Canada-United States Joint Immigration Study: Issues in Data Comparability." *International Migration Review* 21 (4) 1038-1066. The authors note that the Canada-United States immigration project is an attempt to assess carefully the flows, trends, and characteristics of immigrants between the two countries. The

primary focus for data is the census information derived from the 1980 U.S. and 1981 Canadian censuses. Comparable data were a primary preoccupation of the project. They report on the highlights of the various comparability issues experienced and the means used to address these.

Raymer, J. and A. Rogers. 2007. "Using Age and Spatial Flow Structures in the Indirect Estimation of Migration Streams." *Demography* 44 (2): 199-223. This article outlines a formal model-based approach for inferring interregional age-specific migration streams in settings where such data are incomplete, inadequate, or unavailable. The estimation approach relies heavily on log-linear models, using them to impose some of the regularities exhibited by past age and spatial structures or to combine and borrow information drawn from other sources. The approach is illustrated using data from the 1990 and 2000 U.S. and Mexico censuses.

Redstone, I. and D. Massey. 2004. "Coming to Stay: An Analysis of the U. S. Census Question on Immigrants' Year of Arrival." *Demography* 41 (4): 721-738. Using the New Immigrant Survey Pilot, the authors compare answers to the census question on year of arrival in the United States with answers to questions about the dates and durations of earlier U.S. trips. We show that the year identified by the census does not correspond to the year of either the first or the last U.S. trip. Because many immigrants enter and leave the United States several times before becoming legal immigrants, the census question produces estimates of U.S. experience that are quite different from those produced by direct questions about trip durations.

Robinson, J.G. 2001. "ESCAP II: Demographic Analysis Results." *Report No. 1, Executive Steering Committee for Accuracy and Coverage Evaluation Policy II*. Washington, DC: U.S. Census Bureau (available online, <http://www.census.gov/dmd/www/pdf/Report1.PDF>, last accessed, May 2008). The report is part of a larger effort to address the differences in the net undercount estimate of the 2000 census that resulted from Demographic Analysis (DA) and the Accuracy and Coverage efforts (ACE). It begins by noting that the DA implies a net undercount of +0.12 percent and then describes the data, methods, and assumptions used in DA.

Robinson, J. G., B. Ahmed, and K. Woodrow. 1991. "DA Evaluation Project D7: Uncertainty Measures for Other Components," *Preliminary Research and Evaluation Memorandum No. 80*. Washington, DC: U. S. Bureau of the Census. This evaluation addressed uncertainty associated with components of net international migration other than unauthorized residents and emigrants. In particular, the report discussed the lack of information about the quantity of temporary residents with appropriate documentation and refugees and asylees other than those captured in population estimates programs.

Robinson, J. G., B. Ahmed, and K. Woodrow. 1991. "DA Evaluation Project D7: Uncertainty Measures for Other Components," *Preliminary Research and Evaluation Memorandum No. 80*. Washington, DC: U. S. Bureau of the Census. This evaluation addressed uncertainty associated with components of net international migration other than unauthorized residents and emigrants. In particular, the report discussed the lack of

information about the quantity of temporary residents with appropriate documentation and refugees and asylees other than those captured in population estimates programs.

Schmidley, A. D. 2001. "Profile of the Foreign-Born Population in the United States: 2000." *Current Populations Reports, Special Studies, P23-206*. Washington DC: U.S. Census Bureau. (available online, <http://www.census.gov/prod/2002pubs/p23-206.pdf> , last accessed April 2008). This report presents data on a wide range of geographic, demographic, social, economic, and housing characteristics for the foreign-born population of the United States. Data for the native population are included for comparison. The data in this report for 2000 are from the March 2000 Current Population Survey (CPS) and do not include information from Census 2000 or the Census 2000 Supplementary Survey. Data for 1990 and earlier years, which are included for historical comparison, are from the decennial censuses of population.

Schmidley, A. D., and J.G. Robinson. 1998. "How Well Does The Current Population Survey Measure The Foreign Born Population In The United States?" *Population Division Working Paper No. 22*. Washington, DC: U.S. Census Bureau. (available online, <http://www.census.gov/population/www/documentation/twps0022/twps0022.html>, last accessed April 2008). In this paper, the authors describe our recent efforts to review and evaluate these data from the CPS. They begin with an overview of the CPS, highlighting aspects of the data collection and development process that affect the nativity data. They then discuss the nativity and citizenship questions introduced in the 1994 CPS. Data comparability issues are the focus of the third section of this paper. Throughout the paper, where relevant, they make limited comparisons of the CPS nativity and citizenship data with 1990 census data.

Schmidley, A. D., and J. G. Robinson. 2003. "Measuring the Foreign-Born Population in the United States with the Current Population Survey: 1994-2002." *Population Division Working Paper No. 73*. Washington DC: U. S. Census Bureau. In this paper, the authors evaluate CPS nativity data collected between January 1994 and December 2002. Where feasible, they compare these data with data from other sources. We have incorporated a limited amount of the information found in "How Well Does the Current Population Survey Measure the Foreign-Born Population in the United States?" which evaluated the March Annual Social and Economic Supplement (ASEC) nativity data 1994 to 1997.¹² The current paper extends the period to 2002 and includes information about the monthly or basic survey.

Stottard, E. 1976. "Illegal Mexican Labor in the Borderlands: Institutional Support of an Unlawful Practice." *Pacific Sociological Review* 19: 175-210. The upsurge in numbers of illegal Mexican aliens (IMAs) entering the United States is traditionally explained in legalistic terms, placing the onus for the problem on the aliens themselves. This study presents the view that IMAs are a natural, functional phenomenon in the U.S.-Mexico Borderlands, overtly and covertly supported by political, economic, social, religious, and cultural Borderlands institutions.

U. S. GAO. 2004. *Overstay Tracking: A Key Component of Homeland Security and Layered Defense*. GAO-04-82. Washington, DC: United States General Accounting Office. In this report, GAO: (1) describes available data on the extent of overstaying, (2) reports on weaknesses in the Department of Homeland Security's long-standing overstay tracking system, and (3) provides some observations on the impact that tracking system weaknesses and significant levels of overstaying may have on domestic security.

U. S. GAO. 1998. *Immigration Statistics: Information Gaps, Quality Issues Limit Utility of Federal Data to Policymakers*. GAO/GGD-98-164. Washington, DC: United States General Accounting Office. Because of deficiencies identified in DHS and Census bureau information systems, GAO attempted to identify existing strategies or develop new ones to improve immigration statistics. In particular, GAO devised a new method for collecting survey data on the legal status of foreign-born respondents. The "three-card method" asks questions that are less sensitive than a direct question about legal statistics. This report outlines this proposal.

U. S. GAO. 1993. *Illegal Aliens: Despite Data Limitations, Current Methods Provide Better Population Estimates*. GAO/PEMD-93-25. Washington, DC: United States General Accounting Office. In this report, GAO identifies five national-level illegal alien estimation methods: three for estimating the size of the population and two for the flow. The report finds that estimates of the illegal alien population have narrowed since GAO'S earlier work found that the range of estimates of the illegal alien population-1 million to 12 million-was too broad for policy purposes. GAO reports here that more recently published estimates are in a much narrower range and that a likely maximum is about 3.4 million. Further confidence could come through improving the quality of information used to make estimates. Currently, data limitations include lack of information on: (1) the legal status of members of the foreign-born population, (2) the geographic distribution of illegal aliens, (3) the size of the illegal alien population uncounted by the Census Bureau, (4) the birth and death rates of the foreign-born population, (5) whether the special agricultural worker applicants under IRCA are being counted by the Census Bureau, (6) the exact emigration of legally resident aliens, and (7) the inconsistencies between the decennial census and the Current Population Survey.

U. S. GAO. 1982. *Problems and Options in Estimating the Size of the Illegal Alien Population*. GAO-IPE-82-9. Washington, DC: United States General Accounting Office. In response to a congressional request, GAO reviewed methodologies used in measuring hidden populations for their potential in improving estimates of illegal aliens, described the problems attending the use of alternative estimation methods, and presented options for acquiring improved policymaking information in the illegal alien area. GAO notes that acquiring population statistics on illegal aliens is important, not only because of their illegal status, but also because illegal aliens are considered to be aggravating employment and community resource problems. However, available estimates of the size and growth of the illegal alien population are not satisfactory for policymaking. Accurate estimates of population size for other hidden populations have been made, but the prospects of using any of these methods to estimate the size of the illegal alien population are poor because knowledge is limited. Current estimates stem from incomplete or questionable databases

or untested or demonstrably incorrect assumptions or are restricted to a subgroup of the illegal alien population. Producing reliable estimates from available methods would require an extensive, expensive, and time-consuming research program, although estimates of changes in both the size of the illegal alien population and its flow into the country may be sufficient for some policymaking purposes. GAO discussed another method that could yield accurate estimates of various subgroups of the illegal alien population. The usefulness and accuracy of such information depend upon the specific subgroup in question and have to be assessed carefully case by case. Estimating the illegal alien population as a whole requires more specific information than presently exists. GAO recommends that Congress should weigh the extent of its concern for such information against the significant expenditures that would be necessary for its acquisition.

U. S. GAO. 1980. *Controls over Non-immigrant Aliens Remain Ineffective*. GAO/GGD-80-87. Washington, DC: United States General Accounting Office. In this report, GAO reviews certain activities of the Immigration and Naturalization Service (INS), which is responsible for admitting aliens, monitoring their status, and apprehending those who violate the conditions of their entry. INS has made little progress toward implementing recommended evaluation programs, developing better guidelines, or improving the criteria used by schools and INS adjudicators to approve foreign students' applications. Inadequate recordkeeping procedures continue to limit INS ability to provide complete, accessible information. Proposed legislation to waive the visa requirement for temporary business visitors and tourists from certain low-risk countries may also affect INS control of non-immigrants. INS cannot realistically implement control mechanisms which provide the degree of precision required by the legislation. In addition, GAO finds that the INS Non-immigrant Document Control system cannot be used to account for non-immigrants or as an enforcement tool. The information provided by the system is neither timely nor reliable. INS is trying to improve its information systems by: (1) identifying inadequacies of the current Non-immigrant Document Control system; and (2) automating district offices. However, these efforts have been hindered by the inability to specify study objectives and by the absence of a long-range automatic data processing plan to guide automation efforts.

Van Hook, J., and F. Bean. 1998. *Estimating Unauthorized Mexican Migration to the United States: Issues and Results*. U. S Commission on Immigration Reform, Binational Research Papers. (available online, <http://www.utexas.edu/lbj/uscir/binpap-v.html>, last accessed January 2008). This report attempts to provide an overview of the best analytical approaches and estimates of the stock and flow of the unauthorized Mexican migrant population from the late 1970s to the present. In doing so, the authors describe the prevailing methods used for estimating the unauthorized migrant population, including the unauthorized Mexican migrant population, during the late 1970s, 1980s, and 1990s. they describe how the methodology and data used for making estimates of the stock and flow of the unauthorized migrant population in the United States in general and the unauthorized Mexican migrant population in particular have changed over the past two decades. They highlight how these changes have led to improvements and, in some cases, to increased inaccuracy associated with estimates of particular

components of the unauthorized population. The report is divided into five sections: (1) a discussion of the concepts and terms that influence both the selection of approaches to estimation and the interpretation of results that have emerged from various estimating procedures; (2) a review the approaches to estimation of the stock of unauthorized Mexican migrants that have been used since the late 1970s; (3) an assessment for estimates of flows; (4) a discussion of several issues whose lack of satisfactory resolution has plagued the conclusiveness and interpretation of the results of almost all estimation approaches; and (5) a summary of the results of the estimates and a presentation of what the authors believe are the most satisfactory estimates are of the size of the unauthorized Mexican population in the U.S. as of the mid-1996, based on the most recent data available.

Wasem, R. 2007. "Unauthorized Aliens in the United States: Estimates Since 19876. *CRS Report for Congress, Order Code RS21938*. Washington, DC: Congressional Research Service. (available online, <http://www.ilw.com/immigdaily/news/2007,0315-crs.pdf>, last accessed May, 2008). The author reports that estimates derived from the March Supplement of the U.S. Census Bureau's Current Population Survey indicate that the unauthorized resident alien population (commonly referred to as illegal aliens) has risen from 3.2 million in 1986 to 10.3 million in 2004, noting that the estimated number of unauthorized aliens had dropped to 1.9 million in 1988 following passage of a law that legalized many unauthorized aliens. She reports that research suggests that a constellation of factors has contributed to the increase in unauthorized resident aliens, including the "push-pull" of a prosperous economy, the inadvertent consequence of border enforcement policies that have curbed the fluid movement of migrant workers, and the backlogs in processing immigrant petitions. Some observers also assert that resources for enforcement of immigration laws in the interior of the country are inadequate.

Woodrow-Lafield, K. 1999. "Labor Migration, Family Integration, and the New America During the Twentieth Century," pp. 13-26 in D. Haines and K. Rosenblum (Eds.) *Illegal Immigration in America: A Reference Handbook*. Westport, CT: Greenwood Press. This chapter deals with four issues surrounding the twin topics of authorized and unauthorized immigration: (1) the recent debate about immigration and its impacts is paired with rather unconvincing data; (2) current general theories of immigration revolve in part about typologies of immigrants framed according to the immigration system; (3) an unauthorized resident population persists despite immigration policies; and (4) the magnitude and momentum of current immigration, which is affected by the interplay of net unauthorized immigration, legalization, naturalization, and net authorized immigration. She argues that Post-1960 net authorized immigration as of 1996 is likely to range from 18.2 to more than 19 million, having increased by 20 to 40 percent since 1990 with increasing lawful immigration and the amnesty programs. For Mexico, net authorized immigration is likely to range from 4.7 to 4.9 million and may be as much as 5.5 million, considerably more than in 1990 (3.8 to 4.0 million) or in 1980 (1.4 million). With greater uncertainty about net authorized immigration, uncertainty about net unauthorized immigration is also greater.

Woodrow-Lafield, K. 1998. "Unauthorized Residents in the United States in 1990: Issues of Uncertainty in Quantification." *International Migration Review* 32 (1): 145-174. The author analyzes the uncertainty in measurement of net unauthorized migration by using possible upper and lower boundaries on legal migration components and on the foreign-born population in 1990. Between two and four million unauthorized residents may have been counted in the 1990 census. The total number of unauthorized residents may have been as high as six million. The most important component in increasing the unauthorized estimate is the size of the foreign-born population, counted and uncounted. She finds that the most influential components in decreasing the unauthorized estimate are the number of legal aliens in 1980, the number of post-1980 lawful immigrants, and the number of agricultural legalization beneficiaries resident Census Day 1990.

Woodrow-Lafield, K. 1995. "An Analysis of Net Immigration in Census Coverage Evaluation." *Population Research and Policy Review* 14 (2):173-204. The author notes that the 1990 census portrayed a larger foreign-born population than shown in national surveys in the 1980s. Yet the assessment of population coverage may have insufficiently accounted for decadal net immigration. With an allowance of one million for presence of foreign-born persons having authorization for temporary residence and certain ambiguous categories, 1990 census coverage could have easily been lower than initially presented. Without adequate accounting for net authorized immigration, these evaluations cannot deal with allocating a sufficient amount for uncounted unauthorized immigrants. At least 2.1 to 2.4 million unauthorized residents were included in the 1990 census, with a point estimate of 2.3 million. Based on acceptable assumptions of under-coverage of the foreign-born population, the number of un-enumerated unauthorized residents may easily have ranged between .5 and 3.0 million, and a range of 1 to 2 million is plausible. Better measurement of census coverage of the foreign-born population would aid in setting upper limits on net unauthorized immigration as of the census. She argues that the PES measure of net undercount cannot include much of the undercount of unauthorized immigrants.

Woodrow, K. 1993. "Coverage Evaluation and Growth of the Foreign-born Population," pp. 457-478 in *Proceedings of the Research Conference on Undercounted Ethnic Populations*. Washington, DC: U. S. Bureau of the Census. The author notes that Demographic Analysis of census coverage carries implications as to coverage of the foreign-born population. Estimates of census under-coverage of the unauthorized should be developed in conjunction with a realistic estimate of under-coverage of the total foreign-born population. Any error in estimating the lawfully resident population can be captured as coverage error within the coverage error of the total foreign-born population. Preliminary estimates of 1990 coverage might not have allowed sufficiently for under-enumeration of foreign-born persons so that under-coverage might have been greater than two percent. Based on past trends of net unauthorized immigration, the size of the unauthorized population in 2000 might be 4 to 6 or 7 million. She observes that simulations of estimated under-coverage for the 2000 census suggested these guidelines as more important for evaluating the 2000 census.

Woodrow, K. 1991. "DA Evaluation Project D2: Preliminary Estimates of Unauthorized Residents in 1990," *Preliminary Research and Evaluation Memorandum No. 75*. Washington, DC: U.S. Bureau of the Census. The author uses Demographic Analysis to evaluate census coverage requires an estimate of the unauthorized population residing in the United States on April 1, 1990. She notes that there are no administrative or survey data sources on the population without documents of legal residence. The preliminary estimate for the number of unauthorized residents on April 1, 1990 is 3.3 million, based on two approaches. The first approach increased the direct estimate of unauthorized immigrants in the November 1989 Current Population Survey (CPS) to allow for CPS and census under-coverage. The second approach employs implicit estimates from carrying forward the alternative estimates for unauthorized residents in 1980 with alternative estimates of change for periods of 1979-1986, 1979-1988, 1979-1989, 1986-1988, and 1986-1989. Allowing for CPS undercoverage, the range is 1.8 to 3.2 million with a "point" estimate of 2.5 million. Considering plausible levels for census under-coverage (20 to 30 percent) yields a range of 1.9 to 4.5 million. Without recent legalization of about 1.7 million long-term residents, the "point" estimate might have been 5.0 million, or between 4.5 and 5.5 million. The "point" estimate for unauthorized residents in 1990 is 3.3 million with a likely range of 1.9 million to 4.5 million. To account for more sources of uncertainty, the true number of unauthorized residents in 1990 is assumed as between 1.7 and 5.5 million. Census planning in the decade led to this empirically based estimate for the number of unauthorized residents as of Census Day, 1990. In 1982, preliminary evaluation of 1980 census coverage was made without any empirical estimates for the number of unauthorized residents, and those estimates were not completed until 1983-84, delaying final coverage estimates until 1985.

Woodrow, K., and J. Passel (with the assistance of J. G. Robinson). 1989. "Estimates of Emigration Based on Sample Survey Data from Resident Relatives." Prepared for the Office of Management and Budget, Office of Information and Regulatory Affairs, U. S. Census Bureau. (Abstract available online, <http://home.comcast.net/~karenwoodrowlafield/kwljsp1989abs.html>, last accessed April 2008). The report discusses several reasons why the multiplicity estimates of emigration are low. However, it note that the administrative data provide a confident assessment of under-coverage in the CPS for Americans living overseas that can be used as a basis for adjusting the estimates of overall emigration.

Zaba, B. 1987. "The Indirect Estimation of Migration: A Critical Review." *International Migration Review* 21 (4): 1395-1445. This paper seeks to summarize the methodology used in indirect estimation techniques for measuring migration, and to examine some recent theoretical developments. In particular, an assessment is presented of possible biases in the estimates of migration obtained by indirect methods.

GLOSSARY⁶

ADJUSTED RATE. (See **STANDARDIZATION**).

ADMINISTRATIVE RECORDS. Data collected by government agencies and sometimes private organizations for taxation, registration, fee collection, and other administrative purposes that indirectly provide demographic information. These data are used by demographers for analyses, estimates, projections, and the evaluation of data specifically collected for demographic purposes (See also **ADMINISTRATIVE RECORDS METHOD**).

ADMINISTRATIVE RECORDS METHOD. In the United States, a member of the family of component methods for estimating population that relies on a past census, vital statistics data, and migration data derived from tax returns (See also **POPULATION ESTIMATE**).

AGGREGATION. The process of assembling individual elements into summary form for purposes of presentation or analysis. For example, to assemble census records for individuals in a given area into a summary for the area as a whole.

AGGREGATION BIAS. A type of distortion that can result by attributing relationships found among summaries to the individual elements from which the summaries were obtained.

ALIEN. (See **FOREIGNER**).

ALLOCATION. The assignment of values to cases for which “item non-response” is found in a sample survey or census. Many allocation methods are available, including automated algorithms (See also **IMPUTATION** and **SUBSTITUTION**).

AMERICAN COMMUNITY SURVEY (ACS). In the United States, an on-going household survey conducted by the Census Bureau on a “rolling” geographic basis that is designed to provide demographic characteristics for counties, places, and other small areas. It may replace the long-form in the 2010 census (See also **AMERICAN COMMUNITY SURVEY-DEFINED RESIDENT** and **CENSUS**).

AMERICAN COMMUNITY SURVEY-DEFINED RESIDENT. The American Community Survey residency rule is more consistent with the De facto approach to residency than with the De jure approach used by the Decennial Census. It uses a two month residency rule, whereas the Census Residency Rule is based on self-reporting of one’s usual place of residence (See also **CENSUS DEFINED RESIDENT** and **RESIDENCY RULES**)

ANNEXATION. In the United States, the legal act of adding territory to a governmental unit, usually an incorporated place, through the passage of an ordinance, court order, or other legal action.

AREA ANALYSIS. Measurements collected on a number of variables for each of many administrative/ statistical areas that are usually analyzed using multivariate techniques.

ASYLEES. Persons already in the United States who apply for and are granted legal status for the same type of humanitarian reasons as refugees. Asylees generally do not remain in asylee status for more than one or two years. Rather, they generally “adjust their status” and become lawful permanent resident aliens (See also **LAWFUL PERMANENT RESIDENT ALIENS** and **REFUGEES**).

AT-RISK POPULATION. The persons to whom an event can potentially occur. In the form of the population at the middle of a given period, such as a year, it is used as an approximation of “Person-years lived”(See also **EXPOSURE**, **PERSON-YEARS LIVED**, and **PROBABILITY**).

AUTHORIZED LEGAL IMMIGRANTS. There are two types: (1) immigrants who have obtained citizenship; and (2) immigrants who have applied for Legal Permanent Resident (LPR) status and have been formally admitted. (See also **AUTHORIZED LEGAL TEMPORARY RESIDENT**, **CITIZEN**, **IMMIGRANT**, and **LEGAL PERMANENT RESIDENT**).

AUTHORIZED LEGAL TEMPORARY RESIDENTS. Those residing in the United States who are not immigrants. Persons for whom lawful temporary applications have been accepted and for whom have neither terms of admission been violated nor either naturalized or Legal Permanent Resident status been granted, even if applications exist. (See also **AUTHORIZED LEGAL IMMIGRANT**, **CITIZEN**, **IMMIGRANT**, **LEGAL PERMANENT RESIDENT** and **SPECIAL AGRICULTURAL WORKER**).

AVERAGE FAMILY SIZE. The mean number of living children of an individual or couple.

BALANCING EQUATION. A term attributed to A. Jaffe that describes the basic population relation: $P_t = P_0 + I - O$, where P_t equals a given population at time = 0 + t, P_0 = the given population at time =0, I = the number of persons entering the population through birth and immigration between time=0 and time = 0+t, and O = the number of persons exiting the population through death and emigration between time=0 and time=0+t (See also **COHORT-COMPONENT METHOD**, **COMPONENT METHOD**, **ERROR OF CLOSURE**, **INTER-CENSAL COMPONENT METHOD**, and **RESIDUAL METHOD**).

BASE PERIOD. In a population projection, this is the period between the initial year for which data are used to generate the projection and the last year, which is known as the launch year. (See also LAUNCH YEAR, PROJECTION HORIZON, and TARGET YEAR; and POPULATION PROJECTION).

BIAS. The deviation of an estimate or set of estimates from the correct value(s) in one direction (i.e., above or below the correct value(s)).

BLOCK. In the United States, the lowest level of geography for which census data are compiled. It is typically a city block, but specifically is a small area bounded on all sides by identifiable features (e.g., roads, rivers, and city limits) that does not cross the boundaries of a given census tract. Each block is numbered uniquely within census tracts (See also BLOCK GROUP, BLOCK NUMBERING AREA, CENSUS TRACT, and CENSUS GEOGRAPHY).

BLOCK GROUP. In the United States, a cluster of blocks within a census tract that have the same first digit in their identifying numbers (See also BLOCK, BLOCK NUMBERING AREA, CENSUS TRACT and CENSUS GEOGRAPHY).

BLOCK NUMBERING AREA. In the United States, these were used in the 1990 census as the framework for grouping and numbering blocks in counties that did not have census tracts and provided coverage only for the block-numbered portion of a county. Starting with the 2000 Decennial census all U. S. counties have census tracts. (See also BLOCK, BLOCK GROUP, CENSUS TRACT, and CENSUS GEOGRAPHY).

CAPTURE-RECAPTURE METHOD. A technique initially developed to estimate the size of a given wildlife population in which two samples are taken. In the first sample, individuals are uniquely marked, counted, and released. After a period of time to allow the marked individuals to redistribute themselves among the unmarked population, a second sample is taken. From the distribution of marked and unmarked individuals in the second sample, an estimate of population size can be obtained using certain assumptions (i.e., the population is closed and the two samples are independent) as follows: $N = (n_1 * n_2) / n_{12}$, where N is the number estimated for the total population, n_1 = the number marked in the first sample, n_2 is the number marked in the second sample and n_{12} is the number marked in both samples. This formula is an algebraic re-arrangement of the formula used to determine expected cell size in a 2x2 table for purposes of the Chi-squared test. In a human setting, two sets of administrative records usually take the place of the two samples (See also DUAL- SYSTEMS ESTIMATION and MATCHING).

CENSAL-RATIO METHOD. A set of population estimation techniques found within the “Change in Stock Method” family that uses crude rates (e.g., birth and death) as measured at the most recent census date(s) and post-censal administrative records. For example, a population estimate for 2002 can be obtained by dividing reported deaths for 2002 by the crude death rate measured in 2000 or by a crude death rate projected from 2000 to 2002. Often a series of Censal-Ratio estimates are averaged together. D. Swanson and R. Prevost showed in 1985 that the Ratio-Correlation Method is algebraically equivalent to a weighted average of censal-ratio estimates in which regression slope coefficients serve as weights (See also **CHANGE IN STOCK METHOD**, **POPULATION ESTIMATE**, **RATIO-CORRELATION METHOD**, and **WEIGHTED AVERAGE**).

CENSORED. A condition affecting time-ordered data because the time frame for which data are collected does not cover the entire time span over which an event of interest may occur (e.g., a pregnancy at future point beyond the time frame in which data were collected). “Left-Censored” is used to describe the period preceding the data collection time frame and “right-censored,” the subsequent period.

CENSUS. The count of a given population (or other phenomena of interest) and record its characteristics, done at a specific point in time and usually at regular intervals by a governmental entity for the geographic area or subareas under its domain (See also **AMERICAN COMMUNITY SURVEY**, **CENSUS COVERAGE**, **CENSUS DEFINED RESIDENT**, **POPULATION**, **POPULATION ESTIMATE**, and **SAMPLE**).

CENSUS COVERAGE. An estimate of how complete a census was of a given population (See also **COVERAGE ERROR**, **NET CENSUS UNDERCOUNT ERROR** and **TRUE POPULATION**).

CENSUS COVERAGE ERROR. (See **COVERAGE ERROR**).

CENSUS COUNTY DIVISION. In the United States, a statistical subdivision of counties in states established cooperatively by the Census Bureau and local groups in which minor civil divisions (e.g., townships) are not suitable for presenting census data (See also **CENSUS GEOGRAPHY**).

CENSUS DEFINED RESIDENT. The concept of defining persons counted in a census in order to count each and every person once and only once. One of two counting bases is used: (1) De jure, which attempts to locate persons at their usual residence; and (2) De facto, which counts people where they are found. The U. S. Decennial Census is based on the De jure method. There is a difference between the definition of residency used in the Decennial Census and its related products and the definition of residency used in the American Community Survey. (See also **AMERICAN COMMUNITY SURVEY-DEFINED RESIDENT**, **CENSUS**, **DE FACTO POPULATION**, **DE JURE POPULATION**, **DOMICLE**, **RESIDENCE**, **RESIDENCY RULES**, and **USUAL RESIDENCE**).

CENSUS DESIGNATED PLACE (CDP). In the United States, a concentration of population enumerated during the decennial census in an area lacking legal boundaries, but recognized by the residents (and others) as a distinctive area with a name. A CDP is defined cooperatively by local officials and the Census Bureau. CDPs have been used since the 1980 census; from 1940 to 1970, they were called Unincorporated Places. (See also CENSUS GEOGRAPHY).

CENSUS ERROR (See COVERAGE ERROR).

CENSUS GEOGRAPHY. In the United States, this refers to the hierarchical system of geographic areas that is used in conjunction with each decennial census. It consists of two major components: (1) areas defined by political or administrative boundaries (e.g., states, counties, townships, and cities.); and (2) areas defined by “statistical” boundaries (e.g., block, census designated place, census tract). The areas so defined are used for analytical, political, and administrative purposes. Any country conducting a census uses some type of census geography. (See also BLOCK, CENSUS COUNTY DIVISION, CENSUS DESIGNATED PLACE, CENSUS TRACT, CITY, COUNTY, METROPOLITAN AREA).

CENSUS TRACT. In the United States, this is the lowest level of “statistical geography” found in the decennial census designed to be homogenous with respect to population and economic characteristics (note that blocks and block groups, while at a lower level, are not designed with respect to population or economic homogeneity). Once established it is designed to be consistent in its boundaries for a long period of time. Starting with the 2000 census, all areas in the United States are tracted. (See also BLOCK, BLOCK GROUP, BLOCK NUMBERING AREA; and CENSUS GEOGRAPHY).

CENTRAL CITY. Within the U. S. Census Bureau’s geography system, the core area in a metropolitan area. However, in other contexts, it is usually viewed as the concentrated inner area of a city consisting of business districts and urban housing.

CENTRAL RATE. An event-exposure ratio where the numerator is the number of events in a given period to the estimated number of people exposed to the event as of the mid-point of the period.

CHANGE IN STOCK METHOD. A family of techniques for estimating population that is based on the measuring the total change in population since the last census rather than the components of change. Examples include the censal-ratio method, housing unit method, and the ratio-correlation method (See also COMPONENT METHOD, CENSAL-RATIO METHOD, HOUSING UNIT METHOD, and POPULATION ESTIMATE).

CHILD-WOMAN RATIO. A measure formed by dividing the number of children (aged 0-4) by the number of women of child-bearing age (aged either 15-49 or 15-44). (See also EFFECTIVE FERTILITY).

CITIZEN. A legal national of a given country. Citizenship may be acquired either by birth or naturalization (see also **AUTHORIZED LEGAL TEMPORARY RESIDENT**, **CITIZEN**, **IMMIGRANT**, and **LEGAL PERMANENT RESIDENT**).

CITY. In the United States, a type of incorporated place (See also **CENSUS GEOGRAPHY**).

CIVILIAN NON-INSTITUTIONAL POPULATION. In the United States, persons 16 years and over who are not inmates of institutions and who are not on active duty in the armed forces (See also **CURRENT POPULATION SURVEY**).

CIVILIAN POPULATION. Persons who are not members of the armed forces. This may, however, include persons who are dependents of members of the armed forces.

CLOSED POPULATION. A population for which in and out migration is minimal, if at all. For example, the population of the world as a whole is “closed,” whereas the population of New York City is not.

COHORT. A group of people who experience the same demographic event during a particular period of time such as their year of marriage, birth, or death. Cohorts are typically defined on the basis of a initiating signal event (e.g., birth), but they also can be defined on the basis of a terminating signal event (e.g., death). (See also **COHORT ANALYSIS**, **COHORT EFFECT**, **COHORT MEASURE**, and **PERIOD**).

COHORT ANALYSIS. An analysis that traces the demographic history of a cohort as it progresses through time (See also **AGE-PERIOD-COHORT EFFECT**, **COHORT**, **LEXIS DIAGRAM**, and **PERIOD ANALYSIS**).

COHORT CHANGE RATIO (see **HAMILTON-PERRY METHOD**).

COHORT-COMPONENT METHOD. A projection technique that takes into account the components of population change, births, deaths, and migration, and a population’s age and sex composition, (See also **BALANCING EQUATION**, **COMPONENT METHOD**, and **POPULATION PROJECTION**).

COMPONENT METHOD. In general, this refers to any technique for estimating population that incorporates births, deaths, and migration. Also known as a “Flow Method” (See also **BALANCING EQUATION**, **CHANGE IN STOCK METHOD**, **COMPONENT METHOD I**, **COMPONENT METHOD II**, and **POPULATION ESTIMATE**).

COMPONENT METHOD I. A component method of estimating population that uses the relationship between local and national school enrollment data to estimate the net migration component. (See also **COMPONENT METHOD**, **COMPONENT METHOD II**, and **POPULATION ESTIMATE**).

COMPONENT METHOD II. A component method of estimating population that uses the relationship between expected (survived) and actual local school enrollment data to estimate the net migration component. (See also COMPONENT METHOD, COMPONENT METHOD I, and POPULATION ESTIMATE).

COMPONENTS OF CHANGE. There are four basic components of population change: births, deaths, in-migration, and out-migration. The excess of births over deaths results in natural increase, while the excess of deaths over births results in natural decrease. The difference between in- and out-migration is net migration. In an analysis of special characteristics or groups, the number of components is broadened to include relevant additional factors (e.g., aging, marriages, divorces, annexations, and retirements), depending on the group (See also BALANCING EQUATION).

COMPOSITE METHOD. A technique for estimating total population that is based upon independent estimates of age or age-sex groups that are summed to obtain the total population (See also POPULATION ESTIMATE).

CONSOLIDATED METROPOLITAN STATISTICAL AREA. (See METROPOLITAN AREA).

CONTROLLING. The act of adjusting a distribution to an independently derived total value (See also CONTROLS).

CONTROLS. Independently derived estimates of a “total value” to which distributions are adjusted for purposes of improving accuracy, reducing variance and bias, or maintaining consistency. Controls can be univariate (one-dimensional) or multivariate (n-dimensional). Many methods may be used, including those that take account of whether the distributions have only positive values or both positive and negative values. (See also CONTROLLING, ITERATIVE PROPORTIONAL FITTING and PLUS-MINUS METHOD).

COVERAGE ERROR. In principle, this refers to the difference between the “true population” and the number reported in a set of data such as a census, survey, or set of administrative records. In practice, it is the difference between an estimate of the true number and the number reported in a set of data such as a census, survey, or set of administrative records (See also CENSUS, NET CENSUS UNDERCOUNT ERROR, TOTAL ERROR, and TRUE POPULATION).

COUNTY. In the United States, a type of governmental unit that is the primary administrative subdivision of every state except Alaska and Louisiana (See also CENSUS GEOGRAPHY).

COUNTY EQUIVALENT. In the United States, a geographic entity that is not legally recognized as a county but referred to by the Census Bureau as the equivalent of a county for purposes of data presentation. Boroughs and certain statistically defined areas are county equivalents in Alaska and parishes are county equivalents in Louisiana (See also COUNTY and CENSUS GEOGRAPHY).

CROSS SECTIONAL ANALYSIS. Studies that focus on phenomena that occur during a precise time interval (such as a calendar year) among several cohorts (See also COHORT ANALYSIS and PERIOD ANALYSIS).

CURRENT POPULATION SURVEY(CPS). In the United States, a sample survey conducted monthly by the Census Bureau designed to represent the civilian non-institutional population that obtains a wide range of socio-economic-demographic data (See also CIVILIAN NON-INSTITUTIONAL POPULATION).

CURVE. A mathematical function, usually continuous and otherwise “well-behaved” that can be used as a model for a demographic process such as the change in the size of a population over time. Examples include the Exponential, Geometric, Gompertz, Linear, Logistic, and Polynomial.

CURVE-FITTING. The process of finding a mathematical function that serves as a model for a given demographic process.

DATA LINKAGE. (see MATCHING).

DECREMENT. The exit of an individual or set of individuals from a “population” of interest, where the population is often defined by a model. In the case of a model such as the standard life table, such an exit would be due to death (See also INCREMENT and INCREMENT-DECREMENT LIFE TABLE).

DE FACTO POPULATION. A census concept that defines an enumerated person on the basis of his or her actual location at the time of the census (See also AMERICAN COMMUNITY SURVEY- DEFINED RESIDENT, CENSUS DEFINED RESIDENT, DE JURE POPULATION, and RESIDENCY RULE)

DE JURE POPULATION. A census concept that defines an enumerated person on a basis other than his or her actual location at the time of the census. The most common basis is the person’s usual place of residence at the time of a census. (See also AMERICAN COMMUNITY SURVEY-DEFINED RESIDENT, CENSUS DEFINED RESIDENT, DE FACTO POPULATION, and RESIDENCY RULE).

DEMOGRAPHIC ACCOUNTING. The process of analyzing the change in a population using “stocks” (e.g., conditions such as the number of people in a given age-sex group) and “flows” (e.g., events such as births and deaths by age and sex) to show how the flows affect stocks over time. Ideally the stocks and flows should be measured without error and form mutually exclusive and exhaustive categories.

DEMOGRAPHIC ANALYSIS. Generally, this refers to the methods of examination, assessment, and interpretation of the components and processes of population change, especially births, deaths, and migration. In the United States, it also refers to a specific method of estimating net census undercount using the components and process of population change.

DEMOGRAPHICS. A popular term for demography also used to represent demographic data and the application of demographic data, methods, and perspectives to activities undertaken by non-profit organizations, businesses, and governments (See also **DEMOGRAPHY**).

DEMOGRAPHY. The study of population, typically focused on five aspects: (1) size; (2) geographic distribution; (3) composition; (4) the components of change (births, deaths, migration); and (5) the determinants and consequences of population change. This term is usually used to refer to human populations, but it also is used to refer to non-human, particularly wildlife, populations. (See also **DEMOGRAPHICS**, **FAMILY DEMOGRAPHY**, **HOUSEHOLD DEMOGRAPHY**, **ORGANIZATIONAL DEMOGRAPHY**, and **POPULATION**).

DENSITY. The number of people per unit area (e.g., persons per square kilometer).

DIFFERENCE-CORRELATION METHOD. (See **RATIO-CORRELATION METHOD**).

DIRECT ESTIMATION. The measurement of demographic phenomena using data that directly represent the phenomena of interest. (See also **INDIRECT ESTIMATION**).

DIRECT STANDARDIZATION. The adjustment of a summary rate (e.g., the crude death rate) for a population in question found by computing a weighted average of group-specific rates (e.g., age specific death rates) for the population in question, where the weights consist of specific groups (e.g., the proportion in each age group) found in a “standard” population. This procedure is designed to produce a summary rate that controls for the effects of population composition (e.g., age) and is usually used for purposes of comparison with directly standardized rates for other populations computed using the same standard population. To standardize a crude death rate by the direct method, multiply the age-specific death rates for the population in question by the age-specific proportions in a standard population and sum the products. (See also **INDIRECT STANDARDIZATION**, **STANDARD POPULATION**, and **STANDARDIZATION**).

DIURNAL FLUCTUATION. For a given area, the change in its De facto population over the course of a day (i.e., a 24 hour period) (See also **DE FACTO POPULATION**).

DOMESTIC MIGRATION. The movement of people within a given country across political or administrative boundaries. People leaving an area are out-migrants and those entering an area are in-migrants. It is a synonym for internal migration. (See also FOREIGN MIGRATION and MIGRATION)

DOMICILE. A person's fixed, permanent, and principal home for legal purposes (See also HOUSEHOLD, HOUSING UNIT, RESIDENCE and USUAL RESIDENCE).

DUAL RESIDENCE. The state of having two usual places of residence over a given period of time, which must be resolved in a De jure census through the use of a set of procedures designed to count persons once and only once.

DUAL-SYSTEMS ESTIMATION. Estimation of the true number of events or persons by matching the individual records in two data collections systems (See also CAPTURE-RECAPTURE METHOD and MATCHING).

EMIGRANT. A resident of a given country who departs to take up residence in another country (See also DOMESTIC MIGRATION, FOREIGN MIGRATION, and MIGRATION).

EMIGRATION. (see FOREIGN MIGRATION).

EMIGRATION RATE. An out-migration rate for a country as a whole (See also FOREIGN MIGRATION and OUT-MIGRATION RATE).

ENTRANTS WITHOUT INSPECTION (EWI) A designation used by the former INS for individuals who sneaked into the United States across unprotected borders or entered the United States through ports of entry, but with fraudulent documents.

ENUMERATION. The act of counting the members of a population in a census.

ENUMERATION DISTRICT. The area assigned to an enumerator during a census or survey of a given area.

ERGODICITY. A process whereby a closed population subject to fixed or nearly fixed fertility and mortality schedules eventually acquires a constant or nearly constant age composition that is independent of its starting age composition (See also STABLE POPULATION).

ERROR OF CLOSURE. The difference between the change in population implied by census counts at two different dates and the change implied by an estimate not dependent on both census counts. This also can refer to a term added to the demographic balancing equation to account for errors in the components of change that cause them not to exactly match the change in measured independently for the population to which they apply. (See also BALANCING EQUATION and RESIDUAL METHOD).

ESTIMATE. (See POPULATION ESTIMATE).

EXPOSURE. The condition of a population being at risk of having an event occur to it during a specified period (See also AT-RISK POPULATION).

EXTENDED FAMILY. A group within a specified degree of consanguinity or marriage who tend to collaborate in support activity for one another.

EXTINCT GENERATIONS. A technique introduced by P. Vincent in the early 1950s that is designed to estimate the number of extremely old persons in a population at a given date by cumulating deaths (to include, as needed, reported, estimated, and projected deaths) to given cohorts to the point where all members of the given cohorts have expired.

EXTRAPOLATION. The process of determining (estimating or projecting) values that go beyond the last known data point in a series (e.g., the most recent census or estimate). It is typically accomplished by using a mathematical formula, a graphic procedure, or a combination of the two. (See also INTERPOLATION).

FAMILY. Those members of a household who are related through blood, adoption, or marriage (See also HOUSEHOLD and NON-FAMILY HOUSEHOLD).

FAMILY DEMOGRAPHY. The study of the size, distribution, and composition of families, along with their components of change, and the determinants and consequences of family change (See also DEMOGRAPHY and HOUSEHOLD DEMOGRAPHY).

FAMILY LIFE CYCLE. An approach to the study of the family that considers its evolution through various stages (e.g., marriage, birth of first child, birth of last child, divorce, widowhood).

FAMILY SIZE . Number of living children of an individual or couple.

FERTILITY. The reproductive performance of a woman, man, couple, or group. Also a general term for the incidence of births in a population or group. One of the components of population change (See also COMPONENTS OF CHANGE and FECUNDITY).

FIPS CODE. In the United States, one of a series of codes issued by the National Institute of Standards and Technology for the identification of geographic entities. FIPS stands for "Federal Information Processing Standards"

FLOW METHOD. (See COMPONENT METHOD).

FORECAST. (See POPULATION FORECAST).

FOREIGN-BORN. People born outside of the country of interest. This usually omits citizens born outside the country of interest (e.g., children of diplomats).

FOREIGN MIGRATION. The movement of residents across national boundaries. Residents of a given country leaving it to take up permanent residence in another country are called emigrants and residents of a given country entering another country in order to take up permanent residence are called immigrants (See also DOMESTIC MIGRATION and MIGRATION).

FOREIGNER. A person in a given country who is not a citizen.

FORMAL DEMOGRAPHY (See MATHEMATICAL DEMOGRAPHY).

FORWARD SURVIVAL RATE. A type of rate that expresses survival of a population group from a younger age to an older age. Where a survival rate is not further labeled, forward survival is to be assumed (See also REVERSE SURVIVAL RATE and SURVIVAL).

FORWARD-REVERSE SURVIVAL METHOD. A technique used in both estimating inter-censal populations and net migration between two censuses in which an “average” is taken between the results of using forward and reverse survival rates to age and “young” a given population, respectively, over the period between the two censuses (See also FORWARD SURVIVAL RATE, REVERSE SURVIVAL RATE, and SURVIVAL).

GENERAL RATE. A rate that relates a demographic event to a set of people in a given population generally thought to be exposed to the event of interest, but one for which no distinction is made regarding different exposure levels to the event. A GENERAL RATE is distinguished from a CRUDE RATE because of the former’s attempt to limit the population at risk to those actually exposed to the event in question, typically on the basis of age. Examples include the General Activity Rate, General Divorce Rate, General Enrollment Rate, and the General Fertility Rate. (See also AGE-SPECIFIC RATE, CRUDE RATE and RATE)

GEOCODING. The assignment of geographic or spatial information to data, such as coordinates. It is the most fundamental operation in the development of a “GIS” - Geographic Information System (See also GEOGRAPHIC INFORMATION SYSTEM).

GEOGRAPHIC INFORMATION SYSTEM (GIS). A chain of operations involving the collection, storage, manipulation, and display of data referenced by geographic or spatial coordinates (e.g., coded by latitude and longitude).

GIS. (See GEOGRAPHIC INFORMATION SYSTEM).

GRADUATION. (See SMOOTHING).

GRAVITY MODEL. A model (borrowed from classical physics) based on the hypothesis that movement (migration, commuting, retail purchasing, etc.) between two areas is directly related to the population size of each area and inversely related to the distance between the two areas.

GROSS MIGRATION. The sum of in-migration and out-migration for a given area (See also **MIGRATION**, and **NET MIGRATION**).

GROUP QUARTERS. In the United States, a term used by the Census Bureau for places in which people reside that are not considered as “housing units.” Such places include prisons, long-term care hospitals, military barracks, and school and college dormitories. (See also **HOUSING UNIT** and **HOUSEHOLD POPULATION**).

GROUPED ANSWERS METHOD. (See **TWO CARD METHOD**).

GROWTH RATE. Often used as a general expression to describe the rate of change in a given population, even one that is declining (See also **RATE** and **RATE OF CHANGE**).

HAMILTON-PERRY METHOD. A technique developed by H. Hamilton and J. Perry used in population projections that refers to a type of survival rate calculated for a cohort from two censuses. It includes not only the effects of mortality, but also the effects of net migration and relative census enumeration error (See also **SURVIVAL RATE**).

HAZARD FUNCTION. One of three algebraically related functions used in survival analysis, the other two being the “Death Density Function” and the “Survivorship Function.” The hazard function is found by dividing the death density function by the survivorship function (See also **DEATH DENSITY FUNCTION**, **HAZARD RATE**, and **SURVIVORSHIP FUNCTION**).

HAZARD RATE. The probability that an event occurs within a given time interval, no matter how small the interval, given that the event has not occurred to the subject of interest prior to the start of the interval. Typically, the event of interest is a “decrement” such as death (See also **DECREMENT**, **FORCE OF MORTALITY**, and **HAZARD FUNCTION**).

HEAD OF HOUSEHOLD. A “marker” for a household, its type and structure. It is usually defined as the principal wage-earner or provider for a multi-person household, or, alternatively, is a person in whose name the housing unit is rented or owned. Persons living alone also are designated as heads of households. In principle, the number of households is equal to the number of household heads (See also **HEADSHIP RATE** and **HOUSEHOLD**).

HEADSHIP RATE. Usually defined as the proportion of the (household) population who are “heads” of households. (i.e., divide the number of households by the household population), often by age. It is often used in conjunction with population projections to obtain household projections (See also **HEAD OF HOUSEHOLD**, **HOUSEHOLD** and **POPULATION PROJECTION**).

HETEROGENEITY. The presence of variation among the members of a population with respect to a given characteristic of interest (See also **HOMOGENEITY**).

HOMELESS PERSON. Member of a population without a home or an official address usually found in shelters, on the streets, in vacant lots or vacant buildings not intended for residence (See also **DOMICLE**, **GROUP QUARTERS**, **HOUSING UNIT**, and **HOUSEHOLD**).

HOMOGENEITY. Lack of variation among the members of a population with respect to a given characteristic of interest (See also **HETEROGENEITY**).

HORIZON. (See **PROJECTION HORIZON**).

HOT DECK IMPUTATION. (See **IMPUTATION**).

HOUSEHOLD. Either a single person or a group of people making provision for food and other essentials of living, occupying the whole, part of, or more than one housing unit or other provision for shelter. (See also **DOMICLE**, **FAMILY**, **GROUP QUARTERS**, **HEAD OF HOUSEHOLD**, **HOMELESS PERSON**, **HOUSEHOLD POPULATION**, **HOUSING UNIT**, **RESIDENCY RULE**, and **VACANT HOUSING UNIT**).

HOUSEHOLD DEMOGRAPHY. The study of the size, distribution, and composition of households, along with their components of change and the determinants and consequences of household change. Sometimes called **HOUSING DEMOGRAPHY** (See also **DEMOGRAPHY**, **FAMILY DEMOGRAPHY**, and **HOUSEHOLD**).

HOUSEHOLD POPULATION. Members of a population living in households, (as opposed to those who are homeless or living in group quarters - e.g., prisons, long-term care hospitals, military barracks, and school and college dormitories) (See also **GROUP QUARTERS**, **HOMELESS PERSONS**, **HOUSEHOLD**, **HOUSING UNIT**, and **RESIDENCY RULE**).

HOUSEHOLDER (See **HEAD OF HOUSEHOLD**).

HOUSING DEMOGRAPHY. (See **HOUSEHOLD DEMOGRAPHY**).

HOUSING UNIT. Generally a shelter intended for “separate use” by its occupants, such that there is independent access to the outside and the shelter is not a group quarters. A housing unit may be occupied or vacant. (See also **DOMICLE**, **FAMILY**, **GROUP QUARTERS**, **HOMELESS PERSONS**, and **HOUSEHOLD**).

HOUSING UNIT METHOD. A population estimation technique found within the “Change in Stock Method” family that uses current housing unit counts, vacancy estimates, and estimates of the number of persons per household to estimate the total household population, to which can be added an estimate of the group quarters population to obtain an estimate of the total population (See also **CHANGE IN STOCK METHOD**, **HOUSEHOLD**, **HOUSING UNIT**, **GROUP QUARTERS**, and **OCCUPANCY RATE POPULATION ESTIMATE**, and **VACANCY RATE**).

ILLEGAL ALIENS. (See **UNAUTHORIZED MIGRANTS**)

ILLEGAL MIGRANTS (See **UNAUTHORIZED MIGRANTS**).

IMMIGRANT. Residents of a given country entering another country in order to take up permanent residence (See also **DOMESTIC MIGRATION**, **FOREIGN MIGRATION**, and **MIGRATION**).

IMMIGRATION. (see **FOREIGN MIGRATION**).

IMPUTATION. In a sample survey or census, a general term used to describe the assignment of values to cases for which one or more variables have missing values due to “non-response.” Four common methods are: (1) deductive imputation, which is based on other information available from the case in question; (2) hot-deck imputation, which is based on information from “closest-matching” cases; (3) mean-value imputation, which uses means of variables as the source of assignment; and (4) regression-based imputation, in which models are constructed using cases with no missing values and a dependent variable is the one whose missing values will be imputed and the independent variables are those that yield acceptable regression equations (See also **ALLOCATION** and **SUBSTITUTION**).

INCIDENCE RATE. The frequency with which an event, such as a new case of illness, occurs in a population at risk to the event over a given period of time

INCREMENT. The entry of an individual or set of individuals into a population of interest, where the population of interest is often defined by a model. In the case of a model of nuptiality, such an entry would be marriage (See also **DECREMENT** and **INCREMENT-DECREMENT LIFE TABLE**).

INCREMENT-DECREMENT LIFE TABLE. A life table in which there are both entries and exits to the population of interest. It is often used in reference to multiple increments and multiple decrements. That is, when there is more than one way to enter and exit a population of interest (e.g., enter via marriage and in-migration and exit via divorce, death, and out-migration). In such a life table it is potentially possible to exit and re-enter the population of interest (See also **DECREMENT**, **INCREMENT**, **LIFE TABLE**, and **MULTI-STATE LIFE TABLE**).

INDIRECT ESTIMATION. The measurement of demographic phenomena using data that do not directly represent the phenomena of interest.(See also DIRECT ESTIMATION).

INDIRECT STANDARDIZATION. The adjustment of a summary rate (e.g., the crude death rate) for a population in question found in part by computing a weighted average of group-specific rates (e.g., age-specific death rates) of a “reference” population, where the weights are the specific groups (e.g., proportion in each age group) of the population in question. This procedure is designed to produce a summary rate that controls for the effects of population composition (e.g., age) and is usually used for purposes of comparison with indirectly standardized rates for other populations computed using the same reference population. To standardize a crude (death) rate by the indirect method, first multiply the age-specific-(death) rates in the reference population by the population in the corresponding age groups of the population in question and sum the products to get the “expected” total (deaths) for the population in question. Then divide the expected total (deaths) into the total reported (deaths) for the population in question and multiply this ratio by the crude (death) rate of the reference population (See also DIRECT STANDARDIZATION and STANDARDIZATION).

INFLATION-DEFLATION METHOD. A technique that compensates for census coverage error by adjusting the demographic composition of the population of interest, but not its total number. It is sometimes used in conjunction with the cohort-component method of population projection, with the population in the launch year subject to “inflation” and the subsequent projection(s) subject to a compensating “deflation.” It also is employed in the preparation of the official estimates of the population of the United States by age, sex, race, and ethnicity (Hispanic and non-Hispanic) (See also COVERAGE ERROR, COHORT-COMPONENT METHOD, LAUNCH YEAR, and POPULATION ESTIMATE).

IN-MIGRANT. A person who takes up residence within a “migration-defined” receiving area (the destination) after leaving a residence at a location outside of the receiving area (the origin), but one within the same country. For most countries, the destination and origin must be in different areas as defined by a political, administrative, or statistically-defined boundary. In the U.S., the destination must be in a different county than the origin for a person to be classified as an in-migrant by the Census Bureau (See also DESTINATION, IMMIGRANT, IN-MIGRATION RATE, MIGRANT, MIGRATION, MOVER, NET MIGRATION, NON-MIGRANT, ORIGIN, and OUT-MIGRANT).

IN-MIGRATION. (See IN-MIGRANT).

IN-MIGRATION RATE. The ratio of the number of in-migrants to a receiving area (the destination) over a given period to any one of a number of measures of the population of the receiving area, including the population at the end of the period, the population at the beginning of the period, and so on. Sometimes the denominator is formed by using an approximation of the population at risk of migrating, e.g., the national population outside of the destination (See also DESTINATION, IN-MIGRANT, MIGRATION, NET MIGRATION RATE, and OUT-MIGRATION RATE).

INTERNAL MIGRATION. (See DOMESTIC MIGRATION).

ITEM NON-RESPONSE. (See NON-RESPONSE).

INTER-CENSAL. The period between two successive censuses.

INTER-CENSAL COHORT-COMPONENT METHOD. A “residual” method that uses a sophisticated version of the balancing equation, namely the cohort-component method. (See also BALANCING EQUATION, COHORT-COMPONENT METHOD, INTER-CENSAL COMPONENT METHOD FOR THE TOTAL POPULATION, and RESIDUAL METHOD).

INERCENSAL COMPONENT METHOD FOR THE TOTAL POPULATION. A residual method that uses the Balancing Equation. (See also BALANCING EQUATION, INTER-CENSAL COHORT-COMPONENT METHOD, INTER-CENSAL COMPONENT METHOD FOR THE FOREIGN-BORN POPULATION, and RESIDUAL METHOD)

INERCENSAL COMPONENT METHOD FOR THE FOREIGN-BORN POPULATION. A residual method that estimates the foreign-born population by..... (See also BALANCING EQUATION, INTER-CENSAL COMPONENT METHOD, INTER-CENSAL COMPONENT METHOD FOR THE TOTAL POPULATION, and RESIDUAL METHOD)

INTERNATIONAL MIGRATION. The movement across an international boundary for the purpose of establishing a new permanent residence (See also DOMESTIC MIGRATION).

INTERPOLATION. The calculation of intermediate values for a given series of numbers. It is typically accomplished by using a mathematical formula, a graphic procedure, or a combination of the two. It typically imparts or even imposes a regularity to data and can, therefore, be used for smoothing, whether or not the imposed regularity is realistic (See also EXTRAPOLATION and SMOOTHING).

INTRINSIC RATE. A rate that would eventually be reached if a given population were subject to fixed mortality and fertility schedules, such that it became a “stable population” in the formal demographic sense. Intrinsic rates include the intrinsic birth rate, intrinsic death rate, and the intrinsic rate of increase. (See also BIRTH RATE, DEATH RATE, and RATE OF NATURAL INCREASE).

INVOLUNTARY MIGRANTS. Foreign-born people who have emigrated because they have been displaced from their home country, have an established or well-founded fear of persecution, or have been moved by deception or coercion (See also VOLUNTARY MIGRANTS).

ITERATIVE PROPORTIONAL FITTING. A method for adjusting a multi-way distribution to a set of independently derived total values that approximates a least-squares approach. (See also CONTROLLING, CONTROLS and PLUS-MINUS METHOD).

JUMP-OFF YEAR. (See LAUNCH YEAR).

KARUP-KING METHOD. A technique used to interpolate between given points or to subdivide groups. It is based on a polynomial osculatory formula (See also INTERPOLATION).

KINSHIP NETWORK. Family support system that operates both within and outside of a household.

LAUNCH YEAR. The year in which a population projection is launched, typically the year of the most recent census. Sometimes referred to as the “Jump-Off” year, it is the starting point of the projection horizon (See also BASE PERIOD, PROJECTION HORIZON, TARGET YEAR; and POPULATION PROJECTION).

LAWFUL PERMANENT RESIDENT ALIENS (LPR). These are immigrants who are admitted as legal immigrants or “green card” holders to the United States. LPR aliens are the only immigrants who are eligible to become U. S. citizens (See also ASYLEES and REFUGEES).

LEFT-CENSORED. (See CENSORED).

LEGAL TEMPORARY MIGRANTS. A category used by Passel et al. (2006). These are individuals admitted on temporary visas who are allowed to live and, in some cases, work in the United States for specified periods and for specified purposes. The largest group of legal temporary migrants is comprised of persons with student visas.

LESLIE MATRIX. An approach to population projection developed by P.H. Leslie in the late 1940s. It represents the calculations for cohort-component projections of the age distribution of the population in terms of a square matrix incorporating age-specific birth rates and survival rates and a vector containing the initial age composition of the population.

LEXIS DIAGRAM. A graphic technique developed apparently independently by several people, but largely attributed to Wilhelm Lexis (hence, the name “Lexis Diagram”), that is designed to reveal the relationship between age, time and population change, with particular applications to cohort analysis, life table construction, and population estimation (See also COHORT ANALYSIS and LIFE TABLE).

LIFE CYCLE. A sequence of significant periods through which an individual, group (e.g., family, household), or culture passes over time.

LIFE EXPECTANCY. The average number of years of life remaining to a person or group of persons who reached a given age, as calculated from a life table. (See also LIFE TABLE and SURVIVAL RATE).

LIFE TABLE. A statistical model comprised of a combination of age-specific mortality rates for a given population. A period life table (Also known as a cross-sectional life table) is constructed using mortality and age data from a single point in time; a generation life table (also known as a cohort life table) is based on the mortality of an actual birth cohort followed over time (to its extinction). A complete life table contains mortality information for single years of age, while an abridged table contains information by age group (See also INCREMENT-DECREMENT LIFE TABLE, PERIOD LIFE TABLE, LIFE EXPECTANCY and SURVIVAL RATE).

LIFE TABLE FUNCTIONS. The fundamental elements of a life table, to include the number surviving to a given age, the number of deaths to those surviving to a given birthday before they reach a subsequent birthday, the probability of dying before reaching a subsequent birthday for those who survived to a given birthday, the number alive between two birthdays, and the years of life remaining for those who survive to a given birthday (including birth). Life table functions can be interpreted in two ways: (1) as a depiction of the lifetime mortality experience of a cohort of newborns; and (2) as a stationary population that would result from a fixed mortality schedule and a constant number of annual births equal to the constant number of annual deaths resulting from the fixed mortality schedule (See also LIFE TABLE).

LIFE TABLE SURVIVAL RATE. (see SURVIVAL RATE)

LIFETIME MIGRATION. Migration that has occurred between birth and a given point in which a census or survey is conducted.

LOGISTIC CURVE. A mathematical model that depicts an “S-Shaped” curve indicative of three stages of population change: (1) an initial period of slow growth; (2) a subsequent period of rapid growth; and (3) a final period in which growth slows and comes to a halt (See also **DEMOGRAPHIC TRANSITION**).

LOGIT: A mathematical transformation, often used in event history analysis. For a number between 0 and 1, its logit is usually defined as the natural logarithm of the number divided by one minus the same number: $\text{logit}(n) = \ln[n/(1-n)]$, where $0 < n < 1$. Sometimes it is defined as $\text{logit}(n) = (.5)\{\ln[n/(1-n)]\}$. (See also **EVENT HISTORY ANALYSIS**, **ODDS RATIO**, and **PROBIT**).

LOGIT TRANSFORM. (See **LOGIT**).

LOGIT LIFE TABLE SYSTEM. A system of model life tables initially developed by William Brass that relies on forming logits of the proportion of deaths to those who survived to a given birthday before reaching a subsequent birthday (See also **LOGIT**).

LONG FORM. In the United States, the decennial census form given on a sample basis (approximately 1 in 6 households) that is designed to collect a wide range of population and housing data. The data collected go well beyond the basic information collected in the short form, which is given to the remaining households. Note, however, that the questions on the short form are contained in the long form (See also **SHORT FORM**).

LONGEVITY. (See **LIFE SPAN**).

LORENZ CURVE. Named after M. Lorenz, who introduced it in 1905, it is used to measure the distributional equality of two variables (e.g., the distribution of income across a population; the geographic distribution of the Hispanic population relative to the distribution of the non-Hispanic population over the same geography). To plot the curve, units in both variables are aggregated and the cumulative proportion of one variable is plotted against the corresponding cumulative proportion of the other, e.g., x percent of the people have y percent of all income. (See also **GINI INDEX**, **INDEX OF DISSIMILARITY**, and **SEGREGATION INDEX**).

MAJOR CIVIL DIVISION. A “primary” sub-national political area established by law or a related process. (See also **CENSUS GEOGRAPHY** and **MINOR CIVIL DIVISION**).

MALTHUSIAN GROWTH. The hypothesis that unless negative checks (i.e., T. Malthus’s idea of “moral restraint”) are introduced, a population increases geometrically until some type of positive check is imposed (i.e., famine, war, pestilence).

MARKOV PROCESS (also known as a **MARKOV CHAIN**). A systems model named after A. A. Markov that is specified by transition probabilities between the different states of the system, where the transition probabilities are dependent solely on the present distribution of the population in these states (See also **MULTI-STATE LIFE TABLE**).

MARRIAGE. The social institution involving legal and/or religious sanction whereby men and women are joined together for the purpose of founding a family unit. In some countries, marriage includes couples joined for purposes other than founding a family unit (See also **DIVORCE**, **SINGLE**, and **WIDOWED**).

MASTER ADDRESS FILE (MAF). In the United States, the set of records maintained by the Census Bureau for purposes of conducting the decennial census. It is intended to represent the geographic location of every housing unit.

MATCHED GROUPS. A group constructed on a case-by-case basis through matching of sets of records according to a limited number of characteristics.

MATCHING (of Records). Assembly of data in a common format from different sources but pertaining to the same unit of observation, (e.g., a person, household, or an event such as death). Also known as Record Matching and Data Linkage (See also **CAPTURE-RECAPTURE** and **DUAL-SYSTEMS ESTIMATION**).

MATHEMATICAL DEMOGRAPHY. The field of demography that applies mathematics to the interpretation, analysis, and solution of issues in demography, particularly with regard to population structure and population dynamics. This is a branch of applied mathematics.

MEAN POPULATION AGE. The average age of all members of a population.

MEDIAN POPULATION AGE. The age at which a population is divided into two equally-sized groups.

METROPOLITAN AREA. In the United States, this refers to a family of specific census geographies intended to represent a large population nucleus and aggregations thereof. Specific types of include “Primary Metropolitan Statistical Area” and “Standard Consolidated Statistical Area.” (See also **CENSUS GEOGRAPHY**, **PRIMARY METROPOLITAN STATISTICAL AREA**, and **STANDARD CONSOLIDATED STATISTICAL AREA**).

MIGRANT. A person who makes a relatively permanent change of residence from one country, or region within a country (an origin), to another (the destination) during a specified (migration) period. For most countries, the change must be across a political, administrative, or statistically-defined boundary for a person to be classified as a migrant. In the U.S., the origin and destination must be in different counties for a person to be classified as a migrant (See also **DESTINATION**, **EMIGRANT**, **IMMIGRANT**, **IN-MIGRANT**, **MIGRATION**, **MOVER**, **NON-MIGRANT**, **ORIGIN**, and **OUT-MIGRANT**).

MIGRATION. A general term for the incidence of movement by individuals, groups or populations seeking to make relatively permanent changes of residence. One of the components of population change (See also ASYLEE, COMMUTING, COMPONENTS OF CHANGE, DESTINATION, DOMESTIC MIGRATION, EMIGRANT, FOREIGN-BORN, GROSS MIGRATION, IMMIGRANT, IN-MIGRANT, INTERNALLY DISPLACED PERSONS, INTERNATIONAL MIGRATION, MIGRANT, MOBILITY, MOVER, NATIVE, NET MIGRATION, NON-MIGRANT, ORIGIN, OUT-MIGRANT, and REFUGEE).

MIGRATION HISTORY. Information obtained in a census or a sample survey that provides lifetime migration data (See also LIFETIME MIGRATION).

MIGRATION PREFERENCE INDEX. As defined by R. Bachi in 1957, the ratio of the actual to the expected number of migrants to a given area, where the expected number is directly proportional to both the population at the origin and the destination.

MIGRATION STATUS. (See MOBILITY STATUS).

MIGRATION STREAM. A group of migrants with a common origin and destination over a given period. (See also COUNTERSTREAM).

MILITARY POPULATION. Persons who are members of the armed forces.

MILITARY DEPENDENT POPULATION. Persons who are dependents of members of the armed forces.

MINOR CIVIL DIVISION. A “secondary” sub-national political area established by law or a related process (See also CENSUS GEOGRAPHY and MAJOR CIVIL DIVISION).

MOBILITY, GEOGRAPHIC. Any move resulting in a change of residence (See also DOMESTIC MIGRATION and MIGRATION).

MOBILITY RATE. The ratio of the number of movers over a given time period to the population at risk of moving over the same period (See also IN-MIGRATION RATE, MIGRATION, and OUT-MIGRATION RATE).

MOBILITY STATUS. A Classification of people based on their residential locations at the beginning and end of a given time period.

MODEL. A generalized representation of a demographic process, set of demographic relationships, pattern of mortality, fertility, migration, or marriage, or method of population estimation or projection.

MODEL LIFE TABLE. A life table based on the generalization of empirical relationships derived from a group of observed life tables.

MOMENTUM OF POPULATION GROWTH. The tendency of a population to increase for as many as 70 years after reaching replacement level fertility. It may be measured as the projected percent increase in the population between the current level and the level when it is projected to become stationary in the absence of migration (See also **STATIONARY POPULATION**).

MORTALITY. A general term for the incidence of deaths in a population or group. One of the components of population change (See also **COMPONENTS OF CHANGE**).

MOVER. A person who reports in a census or survey that he or she lived at a different address at an earlier date (e.g., five years before the census or survey). In the U.S., a mover is classified by the Census Bureau as a person who changed residence, but within the same county (See also **MIGRATION**).

MULTIPLE DECREMENT TABLE. (See **MULTI-STATE LIFE TABLE**).

MULTIPLE INCREMENT TABLE. (See **MULTI-STATE LIFE TABLE**).

MULTIPLE INCREMENT-DECREMENT TABLE. (See **MULTI-STATE LIFE TABLE**).

MULTIPLE INCREMENT-DECREMENT LIFE TABLE. (See **MULTI-STATE LIFE TABLE**).

MULTI-REGIONAL ANALYSIS. An analysis of multi-regional systems in which spatial and demographic factors are linked.

MULTI-STATE LIFE TABLE. An extension of the standard life table in which multiple transitions between states are possible and the transitions are expressed in terms of transition probabilities between states (See also **DECREMENT**, **INCREMENT**, **INCREMENT-DECREMENT LIFE TABLE**, and **MARKOV PROCESS**).

NATIVE. Persons born in a particular country or region as distinguished from foreign-born.

NATIVITY. (See **NATIVE**)

NATURALIZED CITIZENS. Persons who were born as citizens of other countries but acquired U. S. citizenship through administrative processes of the Immigration and Naturalization Service (INS) or, more recently, the Department of Homeland Security (DHS). Eligible adults can attain citizenship by taking a test, demonstrating competency in English, and swearing allegiance to the United States. Non-citizen children (under 16) can acquire “derivative citizenship” upon the naturalization of their parents. Finally, under recent legislation, orphans adopted by U. S. citizen parents acquire citizenship immediately upon arrival in the United States.

NATURAL DECREASE. (See NATURAL INCREASE).

NATURAL FERTILITY. The level of fertility in a population in which deliberate control of childbearing (e.g., contraception, abstinence) is not practiced.

NATURAL INCREASE. The excess of births over deaths in a population is defined as natural increase; an excess of deaths over births is defined as natural decrease.

NATURAL VACANCY RATE. A concept that represents the average vacancy rate for a rental property market that would result if supply and demand were in balance, often a judgmental benchmark against which observed vacancy rates in a given market can be compared (See also VACANCY RATE).

NET CENSUS UNDERCOUNT ERROR. The estimated level of coverage error in a census computed by algebraically adding estimated overcounts and estimated undercounts for population groups (e.g., age-sex-race) and summing them. (See also COVERAGE ERROR, NON-RANDOM ERROR and TRUE POPULATION)

NET MIGRATION. The difference between the number of in-migrants and the number of out-migrants for a given area (e.g., a county) over a given period of time: $\text{Net} = \text{In} - \text{Out}$ (See also GROSS MIGRATION, IN-MIGRANT, MIGRATION, NET MIGRATION RATE, and OUT-MIGRANT).

NET MIGRATION RATE. The ratio of net migration for a given area (e.g., a county) over a given period to any one of a number of measures of the population of the area, including the population at the end of the period, the population at the beginning of the period, and so on. Sometimes the denominator is formed by using a population outside of the area (e.g., the national population outside of the county) (See also IN-MIGRATION RATE, MIGRATION, NET MIGRATION, and OUT-MIGRATION RATE).

NET NUMBER OF MIGRANTS (See NET MIGRATION).

NON-FAMILY HOUSEHOLD. One or more persons living together in a housing unit that are not related by blood or marriage (See also FAMILY and HOUSEHOLD)

NON-IMMIGRANTS (NONPERMANENT RESIDENTS/TEMPORARY RESIDENTS)
NON-IMMIGRANT ALIENS

NON-METROPOLITAN POPULATION. The number of people living outside large urban settlements. In the U.S., this represents the population outside Metropolitan Statistical Areas (See also CENSUS GEOGRAPHY).

NON-MIGRANT. In a census or survey, an individual who resided in an area both at the beginning and end of the designated migration period. Alternatively, an individual who has neither migrated into nor migrated out of his or her area of residence. (See also IN-MIGRANT, MIGRATION, MOVER, NET MIGRATION and OUT-MIGRANT).

NON-RANDOM ERROR. All errors not due to the effects of random sample selection (i.e., random error). It can occur both in a sample survey and in a population census. Examples include non-response, incorrect answers by a valid respondent, answers given by a non-valid respondent, as well as coding and other processing errors. Statistical inference can only be used to estimate random error, not non-random error (See also NET CENSUS UNDERCOUNT ERROR, NON-RESPONSE, POPULATION, RANDOM ERROR, SAMPLE, and TOTAL ERROR).

NON-RESPONSE. Missing data on a form used in a survey or census due to a number of reasons, including the refusal of a respondent to answer, the inability to locate a potential respondent, the inability of a respondent (or informant) to answer questions, or the omission of answers due to a clerical or some other form of error. Total non-response refers to a case (i.e., an observation) in which all variables have missing values and item non-response refers to a case in which fewer than all variables have one or more missing values. Imputation is often used to estimate values for cases in which they are missing (See also IMPUTATION, NON-RANDOM ERROR, NON-RESPONDENT, and RANDOMIZED RESPONSE)

NON-RESPONSE ERROR. (See NON-RESPONSE).

NON-RESPONDENT. In a sample survey or census, a respondent who refuses to be interviewed, or is otherwise unable to take part (See also NON-RESPONSE)

OCCUPIED HOUSING UNIT. A Housing unit that is not vacant. In principle, a household. (See also, HOUSEHOLD, OCCUPANCY RATE, RESIDENCY RULE, and VACANT HOUSING UNIT).

OCCUPANCY RATE. The ratio of occupied housing units to the total number of housing units, usually multiplied by 100 so that this ratio is expressed as a percent. (See also HOUSING UNIT, OCCUPIED HOUSING UNIT, and VACANCY RATE).

OCCURRENCE-EXPOSURE RATIO. The ratio of the number of events occurring during a given period to the population at risk during the same period. The population at risk may be measured in different ways.

ODDS RATIO. As defined for a dichotomous variable, the ratio of the proportion of the population having a characteristic of interest to the proportion not having the characteristic. For example, the percent of the population to the percent not in poverty. The logarithm of the odds ratio is termed a logit. (See also LOGIT).

OPEN-ENDED INTERVAL. A class interval in a distribution of grouped data that is not bounded on one end. For example, in a distribution of data on income, the highest income class may be given as \$100,000 or more; in a life table the last age interval may be given as 85 years and over. In a longitudinal analysis, the period between the most recent occurrence of an event of interest (e.g., a live birth) and a subsequent time point. For example, in a survey of birth histories, the period between the second birth and the survey would constitute an open-ended interval for a woman reporting two births, whereas the periods between her first and second birth would be a closed interval.

OPEN INTERVAL. (See OPEN-ENDED INTERVAL).

OPEN LIVE-BIRTH INTERVAL. The time elapsed since the most recent birth, typically measured as an average for a group of women; an index that directly reflects the effect of increased spacing between births.

ORIGIN. The place of residence that a migrant left at the start of a given (migration) period (See also DESTINATION, MIGRANT, and MIGRATION).

ORPHANHOOD METHODS. A set of survey and census-based techniques for estimating adult mortality in a population that lacks reliable mortality data. It is based on identifying the proportion of respondents with living mothers and fathers. (See also SIBLING METHODS).

OSCULATORY INTERPOLATION. An interpolation method that involves combining higher-order polynomial formulas into one equation, designed to provide a smooth junction between two adjacent groups of data (e.g., age group 5-9 and age group 10-14). (See also INTERPOLATION).

OUT-MIGRANT. A person who leaves his or her residence in a “migration-defined” sending area (the origin) to take up residence at a location outside of the sending area (the destination), but one within the same country. For most countries, the origin and destination must be in different areas as defined by a political, administrative, or statistically-defined boundary. In the U.S., the origin must be in a different county than the destination for a person to be classified as an out-migrant by the Census Bureau (See also DESTINATION, EMIGRANT, IN-MIGRANT, MIGRANT, MIGRATION, MOVER, NET MIGRATION, NON-MIGRANT, ORIGIN, and OUT-MIGRATION RATE)

OUT-MIGRATION.(See INTERNAL MIGRATION).

OUT-MIGRATION RATE. The ratio of the number of out-migrants from a sending area (the origin) over a given period to some measure of the population of the sending area, including the population at the beginning of the period, the population at the end of the period, and so on. (See also ORIGIN, OUT-MIGRANT, IN-MIGRATION RATE, MIGRATION, and NET MIGRATION RATE)

OVERCOUNT. In a census, this can be due to counting some people more than once, counting people in a census who are not members of the population in question, or a combination of both (See also **NET CENSUS UNDERCOUNT ERROR** and **UNDERCOUNT**).

OWN-CHILD METHOD. A census or survey-based method for measuring fertility that uses counts of children living with their mothers.

PARTIAL MIGRATION RATE. The number of in-migrants from a particular origin to a given destination relative to the population of either the origin or destination.

PARTICIPATION RATE. The proportion of a population or segment of a population with a certain characteristic, usually social or economic, e.g., the proportion aged 10-14 who are enrolled in school.

PARITY SPECIFIC BIRTH RATE. Live births to women of specific parities.

PERCENT. (See **PROPORTION**).

PERIOD ANALYSIS. The analysis of demographic data observed during a brief period of time (usually one year), such as death registrations, or a single date, such as census data on marital status, and sometimes at several points of time. The data are typically comprised of more than one cohort (See also **AGE-PERIOD-COHORT EFFECT**, **COHORT ANALYSIS**, **PERIOD EFFECT**, and **PERIOD MEASURE**).

PERIOD EFFECT. An analytical perspective that attempts to determine the effect of a period event (e.g., a war, famine, or natural disaster) on a variable of interest (See also **AGE EFFECT**, **AGE-PERIOD-COHORT EFFECT**, **COHORT EFFECT**, and **PERIOD ANALYSIS**).

PERIOD MEASURE. A summary measure of data collected during a brief period of time (usually one year) that typically represent more than one cohort (See also **COHORT MEASURE** and **PERIOD ANALYSIS**).

PERIOD LIFE TABLE. A life table based on mortality data collected at a given point in time (a year) or a short period (two or three years) for a given population (See also **GENERATION LIFE TABLE** and **LIFE TABLE**).

PERSON-YEARS LIVED. The total number of years (and fractions thereof) lived by a given population or population segment during a given period of time. It is approximated by computing the product of: (1) the number of persons in the population or population segment; and (2) the amount of time in years (and fractions thereof) lived by these same persons during the time in question (See also **AT-RISK POPULATION** and **LIFE TABLE**).

PERSONS PER HOUSEHOLD. The ratio of the total number of persons living in households to the total number of households, often referred to as the average number of persons per household. (See also **HOUSEHOLD** and **HOUSING UNIT METHOD**).

PLACE OF RESIDENCE. (See **USUAL RESIDENCE**)

PLUS-MINUS METHOD. A “controlling” technique that attempts to compensate for both increasing and decreasing subsets of a population of interest by using two separate adjustment factors. For example, one might use the plus-minus method in adjusting post censal population estimates of census tracts to an estimate of the county containing the tracts, if some tracts show growth since the last census and others show decline (See also **CONTROLLING**, **CONTROLS**, and **ITERATIVE PROPORTIONAL FITTING**).

POPULATION. In the demographic sense, the “inhabitants” of a given area at a given time, where inhabitants could be defined either on the De facto or De jure basis (but not a mixture of both). Note that the concept of “area” can be generalized beyond the geographical sense to include, for example, formal organizations. In the statistical sense, the term “population” refers to the entire set of persons (or phenomenon) of interest in a particular study, as compared to a sample, which refers to a subset of the whole (See also **CENSUS**, **DE FACTO POPULATION**, **DE JURE POPULATION**, **DEMOGRAPHY**, **SAMPLE**, and **SPECIAL POPULATION**)

POPULATION AT RISK. (See **AT-RISK POPULATION**).

POPULATION COMPOSITION. The classification of members of a population by one or more characteristics such as age, sex, race, and ethnicity. It can be presented in either absolute or relative numbers. “Population distribution” and “population structure” are often used as synonyms (See also **POPULATION DISTRIBUTION**).

POPULATION DECREASE. Reduction in the number of inhabitants in an area.

POPULATION DENSITY. Number of persons per unit of land area.

POPULATION DISTRIBUTION. Usually used to refer to the location of a population over space at a given time, but sometimes used as a synonym for population composition (See also **POPULATION COMPOSITION**)

POPULATION DYNAMICS. Changes in population size and structure due to fertility, mortality, and migration, or the analysis of population size and structure in these terms.

POPULATION ESTIMATE. An approximation of a current or past population of a given area at a given time, or its distribution and composition, in the absence of a complete enumeration, ideally done in accordance with one of two standards for defining a population, De facto or De jure. In the United States, most population estimates are done using data that represent the set of Census defined residents, although some may be done that represent the De facto population and modifications of it (See also ADMINISTRATIVE RECORDS METHOD, CENSAL-RATIO METHOD, CENSUS, CENSUS DEFINED RESIDENT, CHANGE IN STOCK METHOD, COMPONENT METHOD, COMPOSITE METHOD, DE FACTO POPULATION, DE JURE POPULATION, HOUSING UNIT METHOD, POPULATION PROJECTION, RATIO-CORRELATION METHOD, RATIO ESTIMATION, RESIDENCY RULES, SYNTHETIC METHOD, and VITAL RATES METHOD).

POPULATION FORECAST. An approximation of the future size of the population for a given area, often including its composition and distribution. A forecast usually is one of a set of projections selected as the most likely representation of the future (See also POPULATION ESTIMATE and POPULATION PROJECTION).

POPULATION MOMENTUM. (See MOMENTUM OF POPULATION GROWTH).

POPULATION PROJECTION. The numerical outcome of a particular set of implicit and explicit assumptions regarding future values of the components of population change for a given area in combination with an algorithm. Strictly speaking, it is a conditional statement about the size of a future population (often along with its composition and distribution), ideally made in accordance with one of the two standards used in defining a population, De facto or De jure (See also BASE PERIOD, CENSUS, CENSUS DEFINED RESIDENT, COHORT-COMPONENT METHOD, DE FACTO POPULATION, DE JURE POPULATION, LAUNCH YEAR, POPULATION FORECAST, POPULATION ESTIMATE, PROJECTION HORIZON, and TARGET YEAR).

POPULATION PYRAMID. A graphic device that shows the age-sex composition of a given population and possibly other characteristics as well. It is in pyramidal form, ranging from an equilateral triangle to a near-rectangle, with the shape determined by the effects of the components of population change on a prior age-sex composition.

POPULATION REGISTER. An administrative record system used by many countries (e.g., China, Finland, Japan, and Germany) that requires residents to register their place of residence, usually at a local police station. By itself, such a system provides limited demographic information (e.g., total population), but where it can be matched to other administrative record systems (e.g., tax, social and health care services), the result is often a system that provides a wide range of longitudinal and cross-sectional demographic information.

POPULATION REPLACEMENT. In general, the process of renewal by which a population replaces losses from deaths by means of births. In stable population theory, it refers to the extent to which women in the population are being replaced over the course of a generation or a year. It is measured by the net reproduction rate for a generation and by the intrinsic rate of increase on an annual basis. These measures allow for both the level of fertility and the level of mortality through the childbearing ages. Exact replacement requires a net reproduction rate of 1.00.

POPULATION SIZE. The number of persons inhabiting a given area at a given time. (See also CENSUS and POPULATION).

POPULATION STATISTICS. These are generally comprised of vital statistics, migration statistics, and census and survey data, but they vary by country in that not all countries collect all types of data. They also may include administrative record data, including population register data,

POPULATION STRUCTURE. (See POPULATION COMPOSITION).

PREVALENCE. The number of persons who have a given characteristic (e.g., disease, contraceptive use, impairment, labor force participation) in a given population at a designated time or who had the characteristic at any time during a designated period, such as a year (See also PREVALENCE RATE).

PREVALENCE RATE. The proportion of persons in a population who have a particular disease or attribute at a specified time (point prevalence) or at any time during a designated period, such as a year (period prevalence). (See also PREVALENCE).

PRIMARY METROPOLITAN STATISTICAL AREA. In the United States, a census-based piece of geography defined by the Office of Management and Budget that is comprised of a central city and county and adjoining counties linked to the central city by social and economic interactions that meet prescribed standards. (See also CENSUS GEOGRAPHY, METROPOLITAN AREA, and STANDARD CONSOLIDATED AREA).

PROBABILITY. A ratio in which the numerator consists of those in a population experiencing an event of interest (e.g., death) over a specified period of time, while the denominator consists of the at-risk population. (See also AT-RISK POPULATION, PROPORTION, RATE, and RATIO).

PROBIT. A mathematical transformation, often used in event history analysis, for “linearizing” the cumulative normal distribution of a variable of interest. The probit unit is $y = 5 + Z(p)$, where p = the prevalence of response at each dose level and $Z(p)$ = the corresponding value of the standard cumulative normal distribution (See also EVENT HISTORY ANALYSIS and LOGIT).

PROJECTION. (See POPULATION PROJECTION).

PROJECTION HORIZON. In a population projection, the period between the launch year and the target year (See also Base Period, Launch Year, and Target Year; and POPULATION PROJECTION).

PROPORTION. A ratio used to describe the status of a population with respect to some characteristic (e.g., married), where the numerator is part of the denominator. When multiplied by 100, a proportion is known as a “percent.” (See also PROBABILITY, RATE, and RATIO).

PROPORTIONAL HAZARDS. The examination of “exogenous” explanatory variables in the analysis of survival time and related data (See also PROPORTIONAL HAZARDS MODEL and SURVIVAL)

PROPORTIONAL HAZARDS MODEL. A regression-based approach to the analysis of survival or duration data designed to examine survival time, failure time, or other duration data in terms of the effect of exogenous explanatory variables (See also PROPORTIONAL HAZARDS)

PUBLIC USE MICRODATA SAMPLE (PUMS). In the United States and elsewhere this usually refers to a hierarchically-structured data set that contains individual, family, and household information in a given record and for which confidentiality is maintained by deleting identifying information. It is typically obtained by sampling from census records.

QUASI-LEGAL STATUS. A term applied to unauthorized migrants who have legal statuses that entitle them to live, and sometimes work, in the United States. Some, such as those with Temporary Protected Status (TPS), have papers that allow them to be in the United States, but their status will expire or is expected to expire without the migrant attaining full legal status. Others, such as migrants who have been approved for asylum but have not been granted asylee status or persons approved for green cards or with K- or V-visas, are expected to acquire full Legal permanent Resident status once their cases have been processed. These migrants are often referred to as “quasi-legal” migrants. Whether they are included as legal migrants or in the unauthorized may depend on the availability of data and/or on the purpose of the estimates

QUASI-STABLE POPULATION. A population not affected by migration with constant fertility and gradually changing mortality. It also is used to refer specifically to a formerly stable population in which fertility remains constant but mortality is gradually changing (See also STABLE POPULATION).

RADIX (OF A LIFE TABLE). A hypothetical cohort of newborns used as the starting point of a life table, typically 100,000.

RAKING. (See CONTROLLING).

RANDOM ERROR. The difference between a statistic of interest (e.g., mean age) found in a sample unaffected by non-random error and its corresponding parameter (e.g., mean age) found in the population from which the sample was drawn. Random error can only occur in a sample, never in a population. It is often referred to as sample error or sampling error (See also NON-RANDOM ERROR, POPULATION, SAMPLE, and TOTAL ERROR).

RANDOMIZED RESPONSE. A technique designed to reduce non-response error in regard to sensitive issues by preserving respondent confidentiality through randomization. As an example, respondents could be asked to toss a coin and then answer “yes,” if either your coin came up “heads” or if you are an “unauthorized migrant,” otherwise answer “no.” With a sample size of 100, we would expect 50 “yes” replies if none of the respondents was an unauthorized migrant; additional “yes” responses would suggest that some respondents whose coins came up “tails” also replied “yes,” and the proportion who were unauthorized migrants could be estimated from the results without identifying the individuals concerned. The technique was proposed by Stanley L. Warner in an article titled “Randomized response: a survey technique for eliminating evasive answer bias,” which was published in pages 63 to 69 in volume 60 of the *Journal of the American Statistical Association* in 1965. (See also NON RESPONSE, TWO CARD METHOD and UNAUTHORIZED MIGRANT).

RATE. Technically, this type of ratio is the same as a probability. However, the term is often applied to the type of ratio known as a proportion, as in the case of “vacancy rate,” which is the ratio of unoccupied housing units to all housing units. It is also applied to other types of ratios in which the denominators are not precisely the “at-risk populations,” as is the case of the crude birth rate (See also AT-RISK POPULATION, PROBABILITY, PROPORTION, and RATIO).

RATE-CORRELATION METHOD. (See RATIO-CORRELATION METHOD).

RATE OF CHANGE . The change of population during a given period express as a rate. The rate may relate to the entire period, in which case the denominator is usually the initial population. Alternatively, it may be an average annual rate, in which case the rate may assume annual compounding, continuous compounding, or some other function (See also POPULATION CHANGE)

RATE OF NATURAL INCREASE. The result of subtracting the crude death rate from the crude birth rate. For a population closed to migration it provides the rate of increase (or the rate of decrease if the crude death rate exceeds the crude birth rate) (See also CRUDE BIRTH RATE, CRUDE DEATH RATE, and INTRINSIC RATE).

RATIO. A single number that expresses the relative size of two other numbers - i.e., a quotient, which is the result of dividing one number by another. (See also PROBABILITY, PROPORTION, and RATE).

RATIO-CORRELATION METHOD. A regression-based sub-national population estimation technique found within the “Change in Stock Method” family. Introduced by R. Schmitt and A. Crosetti in the early 1950s: (1) the dependent variable consists of the ratio formed by dividing the most recent population proportion for a set of sub-areas (e.g., proportion of a state population in each of its counties at the most recent census) by the population proportion for the same subareas at an earlier time (i.e., the previous census); and (2) the independent variables consist of corresponding ratios of proportions for symptomatic indicators of population (e.g., school enrollment, automobile registrations, births, deaths) available from administrative records. Variations of the Ratio-Correlation Method include the Difference-Correlation Method introduced by R. Schmitt and J. Gier in 1966 and the Rate-Correlation Method introduced by D. Swanson and L. Tedrow in the 1984 (See also CENSAL-RATIO METHOD, CHANGE IN STOCK METHOD, POPULATION ESTIMATE, and WEIGHTED AVERAGE).

RATIO ESTIMATION. A set of techniques used to estimate population based on ratios across geographic areas, variables, or both. (See also POPULATION ESTIMATE).

RECORD LINKAGE. (See MATCHING).

RECORD MATCHING. (See MATCHING).

REFERENCE POPULATION. (See STANRARD POPULATION).

REFUGEES. The Foreign-born who are admitted to the United States for humanitarian reasons, e.g., they are fleeing persecution because of their religion, race, ethnicity, or political beliefs. Refugees are governed by different policies because they are admitted outside the regular immigration admission regime. For example, refugees are immediately eligible for various kinds of government assistance whereas “regular” immigrants are not. Once refugees are admitted and resident, they are referred to as Asylees and generally they do not remain in asylee status for more than one or two years. Rather, they generally “adjust their status” and become lawful permanent resident aliens (See also ASYLEES and LAWFUL PERMANENT RESIDENT ALIEN)

RESIDENCE. The place where a person lives. Defined differently in different censuses, but often interpreted as “usual residence,” which is the case in the U. S. decennial census based on the De jure method (See also AMERICAN COMMUNITY SURVEY, AMERICAN COMMUNITY SURVEY-DEFINED RESIDENT, CENSUS, CENSUS-DEFINED RESIDENT, DE FACTO POPULATION , DE JURE POPULATION, DOMICILE, HOMELESS PERSON, HOUSEHOLD, GROUP QUARTERS, RESIDENCY RULES, and USUAL RESIDENCE).

RESIDENCY RULES. A set of criteria used directly in an enumeration such that everybody is counted once, and only once. The criteria are used indirectly for purposes of estimation. In principle, the Decennial Census is based on the De jure concept, which translates as a person's place of usual residency, which adds "in the right place" to the objective that everybody should be counted once and only once. The American Community Survey is based on a modification of the De facto concept that accepts a person as a resident if that person has lived in a given location for two months. As such, it tends to ignore the "in the right place" feature found in the Decennial Census (See also AMERICAN COMMUNITY SURVEY- DEFINED RESIDENT, CENSUS DEFINED RESIDENT, DE FACTO POPULATION, DE JURE POPULATION, HOUSEHOLD, and POPULATION).

RESIDENTIAL MOBILITY. A change of residence, either in the same city or town, or between cities, states, countries, or communities.

RESIDUAL METHOD. In the general demographic sense, this is a technique that estimates inter-censal net migration for a given area by subtracting from the most recent census count, the algebraic sum of inter-censal births and deaths added to the population counted at the preceding census. Resulting estimates are confounded by differences in net census undercount error. This method is also used to estimate the foreign-born population and to estimate the number of unauthorized migrants. (See also BALANCING EQUATION, ERROR OF CLOSURE, FOREIGN-BORN, INTER-CENSAL COMPONENT METHOD FOR THE FOREIGN-BORN, NET MIGRATION, RESIDUAL METHOD FOR UNAUTHORIZED MIGRANTS and UNAUTHORIZED MIGRANTS).

RESIDUAL METHOD FOR UNAUTHORIZED MIGRANTS. This is a "Stock Method" that is estimated as the difference between the non-citizen population enumerated in a census or a survey (i.e., the Current Population Survey or the American Community Survey) and the legally resident alien population, where enumerated unauthorized resident migrants = enumerated non-citizens - legally resident aliens. This computation can be done by national origin, period of entry, age, sex, and depending on the level of detail available in estimates of the legal population, by state and metropolitan area. According to Van Hook and Bean (1998), this method was not employed with data collected to 1980 because the 1980 census was the first decennial census in which a sizable enumerated migrant population could be detected through demographic analysis. Van Hook and Bean (1998) identify three different residual methods that have been developed.

RETURN MIGRATION. A move back to point of origin, whether domestic or foreign (See also MIGRATION).

REVERSE RECORD CHECK. A technique used to estimate census coverage error that attempts to match a sample drawn from a reliable source of records independent of the census with data collected in the census. For example, a reverse record check may attempt to match a sample of births over a 10-year period with children under 10 in the census, or a sample of enrollees under Medicare with the elderly population in the census (See also CENSUS and COVERAGE ERROR).

REVERSE STREAM. (See COUNTERSTREAM)

REVERSE SURVIVAL METHOD. Any method of estimating population involving backward “survival” of a population to an earlier date (See also SURVIVAL RATE).

RIGHT-CENSORED. (See CENSORED).

RISK ASSESSMENT. The qualitative or quantitative estimation of the likelihood of adverse effects attributable to exposure to specified health hazards or medical procedures or treatments, such as contraceptives.

RURAL POPULATION. Usually defined as the residual population after the urban population has been identified (See also URBAN POPULATION).

RURAL-URBAN MIGRATION. The migration from rural to urban areas, both internal and international.

SAMPLE. A subset of a population (in the statistical sense) for which data are typically collected in a “survey,” which is a way of providing respondents with questions to be answered (e.g., through personal interviews, telephone interviews, mail-out/mail-back questionnaires). Samples may also be selected from administrative and other records such that interviews are not needed because data are taken directly from the records themselves (e.g., from Medicare files). Samples may be defined in a number of ways, but if statistical inference is to be used, a sample’s elements should have a known probability of selection, or at least a reasonable approximation thereof, so that “random error” can be estimated (See also CENSUS, NON-RANDOM ERROR, POPULATION, and RANDOM ERROR).

SAMPLE ERROR. (See RANDOM ERROR).

SCHOOL-AGE POPULATION. Children of school age, usually defined by the ages for which school attendance is compulsory, which varies from country to country and sometimes with a given country.

SEASONAL ADJUSTMENT. A statistical modification to a data series to reduce the effect of seasonal variation (See also SEASONAL VARIATION).

SEASONAL VARIATION. Seasonal differences in the occurrence of data collected over time and reported at least quarterly (See also SEASONAL ADJUSTMENT).

SEGREGATION. There are many different interpretations of the term “segregation” and at least five dimensions of segregation have been identified: (1) centralization; (2) concentration; (3) clustering; (4) evenness; and (5) exposure. In demography, segregation usually refers to the spatial separation or isolation of a race, ethnic, or socioeconomic group by residence (See also SEGREGATION INDEX)

SEGREGATION INDEX. There are at least 20 indices that have been developed to measure the different dimensions of segregation, many of which are algebraically related to one another. Those typically used in demography are concerned with residential segregation, with the most common being the Index of Dissimilarity (See also GINI INDEX, INDEX OF DISSIMILARITY, LORENZ CURVE, and SEGREGATION).

SELF-ENUMERATION. A method of conducting a census or sample survey in which respondents fill out questionnaire themselves, usually in connection with a mail-out/mail-back design for distributing and retrieving the questionnaires.

SEPARATION FACTORS. The proportions used to assign deaths at each age in each calendar year to birth cohorts in connection with the calculation of probabilities of dying, especially for constructing life tables. Special separation factors are applied to infant deaths because of the tendency for deaths to be concentrated in the earliest days, weeks, and months of infancy (See also LIFE TABLE FUNCTIONS).

SETTLEMENT AND RESETTLEMENT. The relocation of refugees and other displaced persons in a new place. (See also ASYLEES, INTERNALLY DISPLACED PERSONS, and REFUGEES).

SEX COMPOSITION. (See POPULATION COMPOSITION).

SEX DISTRIBUTION. (See SEX COMPOSITION)

SEX RATIO. The ratio of males to the number of females in a population, usually computed for age groups and expressed per 100 females.

SEX STRUCTURE. (See POPULATION COMPOSITION).

SHORT FORM. In the United States, the decennial census form asking a limited range of basic population and housing questions and distributed to about five-sixths of the households, with the so-called “long form” being distributed to the remaining households. Note, however, that the questions on the short form are contained in the long form, so in effect all households receive the short form (See also LONG FORM).

SIBLING METHOD. A set of survey and census-based techniques for measuring mortality in a population that lacks otherwise reliable mortality data. It is based on asking respondents for dates of birth and ages at death (if applicable) of brothers and sisters with living mothers and fathers. (See also ORPHANHOOD METHODS).

SINGLE. A general term for a person not currently married. It could be applied to a person who has never been married or a person who is divorced or widowed and not yet re-married (See also **MARRIAGE**).

SMALL AREA. The subdivisions of the primary political subdivisions of a country. In the United States, counties and their subdivisions are usually considered small areas, although some limit the term to subcounty areas such as census tracts, block groups, and blocks and the areas that can be aggregated from them (See also **CENSUS GEOGRAPHY**).

SMOOTHING. The adjustment of data to eliminate or reduce irregularities and other anomalies assumed to result from measurement and other errors. A common application of smoothing procedures is in connection with single-year-of-age data that appear to be affected by age heaping (See also **AGE-HEAPING** and **INTERPOLATION**).

SPECIAL AGRICULTURAL WORKERS. (SAWs) Persons for whom lawful temporary applications have been accepted for purposes of agricultural work and for whom have neither terms of admission been violated nor either naturalized or Legal Permanent Resident status been granted, even if applications exist. (See also **AUTHORIZED LEGAL IMMIGRANT, AUTHORIZED TEMPORARY LEGAL RESIDENTS, CITIZEN, IMMIGRANT, LEGAL PERMANENT RESIDENT** and **SPECIAL AGRICULTURAL WORKER**).

SPECIAL POPULATION. Population groups identified separately for purposes of a census and or sample survey because of their distinctive living arrangements, such as college students, prison inmates, residents of nursing homes, and military personnel and their dependents. Special populations usually are characterized by components of change very different from the broader populations in which they are found, sometimes because of laws or regulations governing them. (See also **COMPONENTS OF CHANGE** and **POPULATION**).

STABLE POPULATION. A population with an unchanging relative age composition and a constant rate of change in its total size, resulting from conditions of constant fertility and mortality rates over an extended period, about 70 years (See also **QUASI-STABLE POPULATION, POPULATION COMPOSITION, STABLE POPULATION METHOD,** and **STATIONARY POPULATION**).

STABLE POPULATION METHOD. The use of a “reference” stable population and its parameters approximating the conditions of an observed population to evaluate and estimate the composition and the fertility and mortality levels of an observed population of interest (See also **STABLE POPULATION**).

STANDARD CONSOLIDATED AREA. In the United States, a combination of Primary Metropolitan Statistical Areas, with a total population of at least 1,000,000, established by the Office of Management and Budget. (See also CENSUS GEOGRAPHY, METROPOLITAN AREA, and PRIMARY METROPOLITAN STATISTICAL AREA).

STANDARD LIFE TABLE. A life table against which values from another life table are compared, or from which a life table for a population of interest is constructed. The term also is used to refer to the conventional life table, representing the diminution of a cohort of births through age-specific death rates of a particular year or short group of years without additional decrements or any increments (See also LIFE TABLE).

STANDARD METROPOLITAN STATISTICAL AREA. (See PRIMARY METROPOLITAN AREA).

STANDARD POPULATION. A “reference” population used for purposes of analyzing a population of interest. Also, specifically, a population whose age distribution is employed in the calculation of standardized rates by the direct method. (See also DIRECT STANDARDIZATION and STANDARDIZATION)

STANDARDIZATION. The adjustment of a summary rate (e.g., the crude death rate) to remove the effects of population composition (e.g., age), usually done to compare rates across populations with different compositions. There are two general types of standardization, direct and indirect. The type selected is dependent on the data available for the population(s) of interest (See also DIRECT STANDARDIZATION, INDIRECT STANDARDIZATION, POPULATION COMPOSITION, STANDARD POPULATION, and STANDARDIZED RATE).

STANDARDIZED RATE. A rate that has been subjected to standardization. (See also STANDARDIZATION).

STATIONARY POPULATION. A stable population in which the rate of increase is zero and the total size and both the absolute and relative age composition are constant (See also MOMENTUM OF POPULATION GROWTH and STABLE POPULATION).

STATIONARITY. The condition where a population is stationary. (See also STATIONARY POPULATION)

SUBSTITUTION. In a sample survey or census, the process of assigning values for a case in which there is “total non-response.” Many substitution methods are available, including automated algorithms (See also ALLOCATION and IMPUTATION).

SUBURBAN. A popular term referring to the residential area surrounding a central city. Such an area may follow the transportation lines and be dependent on the central city both economically and culturally but, increasingly, such areas are becoming the equivalent of central cities to suburbs of their own. (See also URBAN FRINGE)

SUBURBANIZATION. The spatial diffusion of population growth affecting areas adjoining a city.

SURVEY. (See **SAMPLE**).

SURVIVAL. Primarily a condition where an individual or group remains alive after a specified interval, and secondarily a condition where an individual or group maintains membership in the group of interest, such as a school enrollment cohort, marriage cohort, or the non-poor population. (See also **SURVIVAL RATE**).

SURVIVAL CURVE. A graph depicting a survivorship function (See also **SURVIVORSHIP FUNCTION**)

SURVIVAL RATE. A rate expressing the probability of survival of a population group, usually an age group, from one date to another and from one age to another. A survival rate can be based on life tables or two censuses. When based on two censuses, the rate includes not only the effects of mortality, but also the effects of net migration and relative census enumeration error. (See also **FORWARD SURVIVAL RATE**, **HAMILTON-PERRY METHOD**, **LIFE TABLE**, **SURVIVAL**, and **SURVIVORSHIP FUNCTION**).

SURVIVORSHIP. (See **SURVIVAL**).

SURVIVORSHIP FUNCTION. The probability that an individual survives to at least time = t before an event of interest (e.g., death) occurs. It is one of three algebraically related functions used in survival analysis, the other two being the “death density function” and the “hazard function.” The survivorship function is found by dividing the death density function by the hazard function (See also **DEATH DENSITY FUNCTION**, **HAZARD FUNCTION**, and **SURVIVAL RATE**).

SURVIVORSHIP RATIO. (See **SURVIVAL RATE**).

SYNTHETIC METHOD. A member of the family of ratio estimation methods that is used to estimate characteristics of a population in a subarea (e.g., a county) by reweighting ratios (e.g., prevalence rates or incidence rates) obtained from survey or other data available at a higher level of geography (e.g., a state) that includes the subarea in question. (See also **POPULATION ESTIMATE**, **RATIO ESTIMATION** and **WEIGHTED AVERAGE**).

TARGET YEAR. In a population projection, the final year for which a population is projected, the end point of the projection horizon (See also **BASE PERIOD**, **LAUNCH YEAR**, and **PROJECTION HORIZON**; and **POPULATION PROJECTION**).

TEMPORARY MIGRATION. A type of migration, both internal and international, in which the duration of stay is temporary. Data for temporary migration are not normally included in the official data on internal or international migration and are usually obtained from a special sample survey.

THREE CARD METHOD (See TWO CARD METHOD).

TIGER. (See TOPOLOGICALLY INTEGRATED GEOGRAPHIC ENCODING AND REFERENCING SYSTEM).

TOPOLOGICALLY INTEGRATED GEOGRAPHIC ENCODING AND REFERENCING SYSTEM. (TIGER). A digital database of geographic features (e.g., roads, rivers, political boundaries, census statistical boundaries, etc.) covering the entire United States. It was developed by the U. S. Census Bureau to facilitate computerized mapping and areal data analysis. (See also GEOGRAPHIC INFORMATION SYSTEM).

TOTAL ERROR. In a sample, the theoretical sum of random error and non-random error, which in practice can at best only be roughly approximated because of the difficulty of estimating non-random error. Also known as Total Sample Error. In a census, total error is comprised solely of non-random error (see also NON-RANDOM ERROR, RANDOM ERROR, and TRUE POPULATION).

TREND EXTRAPOLATION: (See EXTRAPOLATION).

TRUE POPULATION. In theory, the population that would be counted if there were no errors in a census. In practice, it is a value representing the theoretical actual number for the population at a given date, which cannot be precisely measured, but which can be roughly approximated by adjusting a census for net census undercount error (See also CENSUS and NET CENSUS UNDERCOUNT ERROR)

TRUNCATION BIAS. Distortion of results due to the systematic omission from an analysis of values that fall below or above a given range.

TURNOVER. A term sometimes employed to refer to the sum of the components of change during a period, i.e., births plus deaths plus immigrants/in-migrants plus emigrants/out-migrants.

TWO CARD METHOD. A method of eliciting information, which is typically of a sensitive nature, from a respondent. In this approach to estimating the number of foreign-born who are "unauthorized migrants," a random half of respondents are shown one card, which results in estimates of the percentage of the foreign-born population who are in each box of that card. The other half of the respondents are shown a second card, resulting in corresponding estimates for slightly different boxes. (No one sees both cards.) The percentage of "unauthorized migrants" is estimated by subtraction: The percentage of the foreign-born who are in Box B of one card minus the percentage who are in Box A of the other card. This replaced the "Three Card method." (See also RANDOMIZED RESPONSE and UNAUTHORIZED MIGRANTS)

UNAUTHORIZED MIGRANTS. Foreign-born residents who do not have “green cards,” are not refugees or asylees, and are not legal temporary migrants. A large majority of unauthorized migrants are not entitled by law to live or work in the United States. They may have entered with valid temporary visas and stayed beyond the expiration date of the visa or otherwise violated the terms of their admission; this group is known as “visa overstayers.” A larger group, however, consists of migrants who snuck into the United States across unprotected borders; this group was designated as “entrants without inspection” or EWIs by the former INS and is also known as clandestine entrants. Individuals entering the United States through ports of entry, but with fraudulent documents are customarily grouped with EWIs. (see also **AUTHORIZED LEGAL IMMIGRANTS**, **AUTHORIZED LEGAL EMPORARY RESIDENTS**, **IMMIGRANTS**, **LEGAL PERMANENT RESIDENTS** and **SPECIAL AGRICULTURAL WORKERS**).

UNDERCOUNT. In a census, the omission of valid members of the population in question (See also **NET CENSUS UNDERCOUNT ERROR** and **OVERCOUNT**).

UNDER-ENUMERATION. (See **UNDERCOUNT**).

UNDER-REGISTRATION. The omission of persons or events from a registration system or other administrative record system.

UNAUTHORIZED ALIENS (See **UNAUTHORIZED MIGRANTS**)

UNINCORPORATED PLACE. (See **CENSUS DESIGNATED PLACE**)

URBAN FRINGE. The densely settled area surrounding the core city of an urbanized area. Sometimes population referred to as the suburban area (See also **SUBURBAN**).

URBAN POPULATION. Usually defined as a large population in a densely-packed area that meets criteria derived from geographic, social, and economic factors, which, in turn, may vary by country (See also **RURAL POPULATION**).

URBANIZATION. Growth in the proportion of persons living in urban areas; the process whereby a society changes from a rural to an urban way of life.

USUAL RESIDENCE. The place where one usually eats and sleeps, a concept associated with a De jure census (See also **CENSUS**, **CENSUS-DEFINED RESIDENT**, **DE JURE**, **DOMICILE**, and **RESIDENCE**).

VACANCY RATE. The ratio of vacant housing units to the total number of housing units, usually multiplied by 100 so that this ratio is expressed as a percent. (See also **HOUSING UNIT**, **NATURAL VACANCY RATE**, and **OCCUPANCY RATE**)

VACANT HOUSING UNIT. A vacant housing unit is one that is not occupied, but intended for occupancy. For vacant units, the criteria of separateness and direct access are applied to the intended occupants whenever possible (See also HOUSING UNIT, HOUSEHOLD, and VACANCY RATE)

VISA OVERSTAYERS. Unauthorized Migrants who may have entered with valid temporary visas and stayed beyond the expiration date of their visas or otherwise violated the terms of their admission (See also UNAUTHORIZED MIGRANT).

VITAL EVENTS. Births, deaths, fetal losses, abortions, marriages, annulments, divorces-any of the events relating to mortality, fertility, marriage, and divorce recorded in registration systems (See also VITAL STATISTICS).

VITAL RATES METHOD. A censal-ratio method of population estimation introduced by D. Bogue in the 1950s that uses crude birth and crude death rates (See also CENSAL-RATIO METHOD and POPULATION ESTIMATE)).

VITAL RECORDS. (See VITAL STATISTICS).

VITAL STATISTICS. Data on births, deaths, fetal losses, abortions, marriages, and divorces usually compiled through registration systems or other administrative record systems (See also VITAL EVENTS).

VOLUNTARY MIGRANTS. International migrants who have moved as a result of their own desires and motivations (See also INVOLUNTARY MIGRANTS).

WEIGHTED AVERAGE. Usually an arithmetic mean of an array of specific rates or ratios, with variable weights applied to them representing the relative distribution of the populations on which the rates or ratios are based. More generally, a summary measure of a set of numbers (absolute numbers or ratios), computed as the cumulative product of the numbers and a set of weights representing their relative importance in the population. An unweighted average is one in which each number in the set has the same weight (e.g., 1 or $1/n$, where n is the total set of numbers) (See also CENSAL RATIO METHOD and SYNTHETIC METHOD).

ZIP CODE. Administrative areas set up by the U. S. Postal Service as postal delivery areas and used for marketing and related purposes in the United States. They have fluid boundaries that do not correspond to any established political area or statistical area of the decennial census but may approximate some small areas defined by the census (See also CENSUS GEOGRAPHY).

ENDNOTES

1. Material in this section is adapted from several sources, including Deardorff and Blumerman, (2001); Edmonston and Michalowski (2004), Judson (2006), and Malone, Beluja, Costanzo, and Davis (2003).
2. Material in this section is adapted from Swanson and Pol (2005).
- 3, Material in this section is adapted from several sources, including Deardorff and Blumerman (2001), Judson (2006); and Passel, Van Hook, and Bean (2004).
- 4, Some of the material in this section is adapted from Golden(2007).
5. The annotated bibliography contains materials adapted from many sources, including *Popline*, *Population Index*, and bibliographies compiled by:
 - (a) R. B. Valdez, K. McCarthy, and C. Moreno for the bibliography they compiled in 1987, “An Annotated Bibliography of Sources on Mexican Immigration,” RAND (available online, <http://www.rand.org/pubs/notes/2007/N2392.pdf>, Last accessed, April, 2008).
 - (b) Lucky Tedrow and David Swanson (1987), which appears in “Appendix C, Bibliography,” pp. 41-52 in E. Byerly in “State and Local Agencies Preparing Population Estimates.” *Current Population Reports, P-25, No. 1063*. U. S. Census Bureau, September, 1990;
 - (c) Anne Lee (1995), which is found on pp. 148- 161 in Rives, N.W., W. J. Serow, A. Lee, H. Goldsmith and P. Voss. 1995. *Basic Methods for Preparing Small-Area Population Estimates*. Madison, WI: Applied Population Laboratory, University of Wisconsin;
 - (d) the Population Association of America (2003), *A Bibliography of Population Estimates* (available online, http://www.popassoc.org/files/public/Pop_Estimates.pdf, Last accessed, March, 2008);
 - (e) Tommy Wright and Joyce Farmer (2000), “A Bibliography of Selected Statistical methods and Development Related to Census 2000,” *Statistical Research Report Series, No. No. RR 2000/02*, Washington, DC: U. S. Census Bureau (available online, <http://www.census.gov/srd/papers/pdf/rr2000-02.pdf>, Last accessed May, 2008); and
 - (f) Henry S. Shryock (1959). “Annotated List of Estimates of Net Migration, 1940 to 1950, by the Residual Method.” *Population Index* 25 (1): 16-24.

6. The Glossary is largely adopted from:

(a) D. Swanson and G. Stephen. 2004. "Glossary" pp. 751-778 in J. Siegel and D. Swanson (Eds.). *The Methods and Materials of Demography*. New York City, NY: Elsevier Academic Press. It excludes many of the entries in the original and includes some entries not found there.

Additional material is from:

(b) J. Passel, J. Van Hook, and F. Bean. 2006. "Narrative Profile with Adjoining Tables of Unauthorized Migrants and other Immigrants, Based on Census 2000: Characteristics and Methods." Sabre Systems White Paper (available online, http://www.sabresystems.com/sd_whitepapers_immigration.asp , Last accessed December 2007); and