Vintage 2013 State and County Age-Sex Projection Methodology: Some Salient Points

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Introduction

Beginning with the first release of long-range projections in 1969, Wisconsin's Demographic Services Center, and its predecessors, has consistently used the cohort-component method to develop its state and county age-sex population projections. In its most basic formulation, this method takes the initial population of a geographic area by age and sex and progresses it forward in equal intervals (usually five years), with modifications to fertility, mortality and migration rates, to produce predictions of the future population.

Over the years, the projections have varied in terms of the time horizon and ultimate age group projected. The 1969 vintage carried the projected population only to 1980, and the ultimate age group was 65 and over. As programmatic needs of other state and local agencies required greater specificity—and with improvements in methodology and computational capacity—the time horizon has expanded to 30 years into the future, and the ultimate age group has been extended to 100 and over for the state, and 90 and over for the counties.

While there is certainly great interest, no attempt has been made yet to develop Wisconsin or county projections by race and Hispanic/Latino origin. The Census Bureau, as the nation's primary demographic statistical agency, has now maintained a consistent framework for enumerating racial and ethnic categories from the 2000 Census forward. (Whether or not individual respondents maintain this consistency is another question.) However, the other critical base components—births and deaths—still are unreliable in race and ethnicity recording. A number of theoretical models have been constructed, and various bridging techniques and reclassification schemes have been developed, in academia and federal agencies to overcome these shortcomings. Nonetheless, particularly in Wisconsin's case, the relatively small numbers and proportions of non-white residents make the process of calculating valid base and projected rates an undependable exercise.

The balance of this document outlines the procedure for computing the state's and counties' base and projected rates in fertility, mortality and migration in the vintage 2013 population projections (so named because the calculations were completed in 2013). Detailed algorithms and formulas are available in the documents listed in the "Citations" section at the end, or by contacting the author.[1]

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Initial Age-Sex Population

The 2013 vintage of state and county age-sex projections used the Census 2000 and 2010 results, with adjustments, as its base population sets.

Following the publication of the past two decennial Censuses, the Census Bureau has provided a Count Question Resolution Program, or CQR, in which local governments may challenge the official enumeration. Thus, revised Census figures may be released up to three years after the Census. Some local communities that identify errors take advantage of the program, others do not pursue it.

For the preliminary state projections, produced and released in 2012, no adjustments were made to the original Census 2010 results, as the summation of any error corrections, CQR-approved and not, would have only minimal impact on the age-sex distribution of the state's population and the calculation of base survival and migration rates. The Census 2000 published figures were modified only to accommodate the minor change between the initial state total and the post-CQR total, which amounted to a net gain of 40 residents.

For the county and final state projections, base populations were revised for a number of sizeable group quarters errors that went uncorrected through the CQR process. In effect, the adjustments for these errors were made because of their outsized effect on age-sex specific net migration rates. The residents of most group quarters tend to be focused in a limited number of age groups (e.g., college residence halls, correctional institutions, nursing homes). Demographic Services Center, having produced annual population estimates for more than 40 years, has an extensive historical time series for larger group quarters in the state that provides an excellent guide for comparing published Census results to the "on-the-ground" reality. In 2000, one substantial over-count occurred at a state correctional facility; in 2010, 11 group quarters' mis-counts, including several boarding middle and high schools that were enumerated but should not have been, required modification before computing the base survival and net migration rates.[2]

In addition, five good-sized group quarters, all state correctional facilities, opened in the 2000 - 2010 decade. The increases that these institutional populations created for their host counties were also controlled for.

The 2010 Census values as they appear in the projections' publications match the CQR-corrected results. These Census figures are considered immutable, in spite of the mis-enumerations. Adjusting the survival and net migration rates ameliorates some of the effect that enumeration problems create.

[2] According to Census guidance, students below the college level who reside in school-provided housing are supposed to be counted at their parental home, not at the school. In addition, the CQR program's structure prevents the Census Bureau from making adjustments for group quarters that they missed at the Census.

State and County Age-Sex Survival Rates: Base

To establish base survival rates at both the state and county levels, the resident deaths by birth cohort (in five-year groupings) and sex in the exact intercensal period of April 1, 2000 through March 31, 2010 were used in combination with the age-sex population of the decade's beginning and ending Censuses. Thus, initial 10-year survival rates, centered on 2005, were computed.

Through the use of life table formulas, these 10-year rates were converted to five-year rates; in turn, these quinquennial values were further summarized to life expectancy at birth (e_0), a one-number synthesized estimate (for men and women separately) that allows for comparison across time and to other geographies, such as the nation.

At the state level, both male and female life expectancy showed improvement from the 1990s to the 2000s, as it had from the 1980s to 1990s, but with slightly larger numeric increases. In addition, male life expectancy in Wisconsin is increasing more rapidly than that for females. This gradual narrowing of the male/female gap—about 1 year per decade since the 1980s—correlates with calculations that have been made for the United States. Furthermore, Wisconsin's expectancies have been higher than those for the nation and have maintained rather constant differentials across recent decades.

The tables below summarize Demographic Services Center's calculations of life expectancy at birth for the past three decades, with comparisons between sexes and across time, and the state's life expectancies compared to corresponding national values for decadal mid-point years.[3]

Life Expectancy at Birth , State of Wisconsin, 1980s – 2000s

"Center" Year	Male e_0	Female e_0	Fem e_0 - Male e_0	Change, Male e_0	Change, Female e_0
1985	72.94	79.67	6.73	--	--
1995	74.51	80.35	5.84	1.57	0.68
2005	76.58	81.44	4.86	2.07	1.09

Life Expectancy at Birth , State of Wisconsin and United States

"Center" Year	WI Male e_0	US Male e_0	Difference, WI - US	WI Female e_0	US Female e_0	Difference, WI - US
1985	72.94	71.20	1.74	79.67	78.18	1.49
1995	74.51	72.54	1.97	80.35	78.95	1.40
2005	76.58	74.86	1.72	81.44	79.94	1.50

At the county level, some counties showed declines in life expectancy from the 1990s to the 2000s: women's life expectancy fell in 20 of the 72 counties, men's in 10 counties. While this finding might seem surprising, academic research has discovered that life expectancies are

[3] The federal values, prepared by the National Center for Health Statistics (NCHS), are calculated using only one calendar year of deaths and mid-year population estimates. Hence, the bases for the DSC and NCHS life expectancies summarized here are different; the comparison is offered mainly for illustrative purposes, but does influence assumptions made as projected survival rates are developed.

declining for certain subgroups of the American population; in a study of all counties in the United States, the UW-Madison Population Health Institute determined that mortality rates worsened for women in 43% of the nation's counties from the early 1990s to the early 2000s.

The figures cited above are derived from the initial survival rates that are based on the actual data of the 2000-2010 decade; that is, the size of the population cohorts as they aged from *x* at 2000 to *x+10* at 2010, and the deaths occurring during the intercensal period within each cohort. For the purposes of projections, smoothing techniques are applied to the initial results to produce base survival rates that will maintain certain qualities as calculations progress through the projections period. For example, base and projected female rates in each 5-year age group should be higher than the corresponding male rates; within each sex, starting with age 10-14, survival rates should decline, with the decrease accelerating through the life course. In addition to these goals, it is important to maintain reasonable proximity to broader indicators such as life expectancy at birth.

This smoothing of state survival rates is relatively simple, generally involving interpolation between adjacent values to replace anomalous ones. Using this interpolative method, the base life expectancies shifted only +0.04 years for men and -0.07 years for women. However, counties proved to be much more problematic. The presence of small quantities—not only the number of deaths, but the beginning and ending populations—in some counties can cause tremendous variability. After a number of tests, model life tables were constructed that had the desired male/female and within-sex relationships as described above; counties were assigned to each model based on the proximity of their initial life expectancies to those of the models.

State and County Age-Sex Survival Rates: Projected

For projecting state-level age-sex survival rates, the principle of "As goes the nation, so goes the state" was assumed. As noted above, the numeric differential in life expectancy at birth between Wisconsin and the U.S. has been relatively constant for the past three decades. It is reasonable to assume that this pattern will continue into the future.

At the time that the state age-sex projections were computed initially (in 2012), the Census Bureau had last produced national population projections in 2008. The Bureau's projections are more detailed than Wisconsin's: single year of age by sex, and advancing by single calendar years with a time horizon of 2050. Employing the Bureau's underlying projections of deaths, abridged life tables for the base year of 2005 and target years (2010, 2015, etc. through 2040) were constructed.

The formula for calculating survival rates in the future held constant the Wisconsin/U.S. ratios at the base year, multiplied by future U.S. survival rates, to produce projected Wisconsin rates. Formulaically, this process for each age-sex group is represented as:

$$\frac{Sx_{WI,2005}}{Sx_{US,2005}} \times Sx_{US,i} = Sx_{WI,i}$$

where *i* equals the five-year interval values from 2010 to 2040.

The projected Wisconsin rates were reviewed for consistency between the sexes and across age groups. A modest adjustment was applied to projected female survival rates at age 15-19, which initially were lower than the age 20-24 rates, and for males at age 100 & over.

Converting these projected survival values to the summary measure of life expectancies at birth, the projected male and female rates produced relatively constant, increasing change across the 30-year projection horizon, and maintained a reasonable differential between the sexes and in comparison to corresponding results at the national level.

Life Expectancy at Birth, 2005-2040, at Five-Year Intervals—Final								
	2005	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Wisconsin Males	76.62	77.34	78.05	78.76	79.45	80.14	80.82	81.48
Change from Prior		*0.72*	*0.71*	*0.71*	*0.70*	*0.69*	*0.68*	*0.67*
Wisconsin Females	81.37	82.00	82.63	83.25	83.87	84.48	85.07	85.66
Change from Prior		*0.62*	*0.63*	*0.63*	*0.62*	*0.61*	*0.60*	*0.59*
Female-Male Differential	4.75	4.65	4.58	4.50	4.42	4.34	4.26	4.18
Life Expectancy at Birth, 2005-2040, at Five-Year Intervals *Source: Census Bureau National Projections, vintage 2008*								
	2005	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
United States Males	75.31	75.99	76.66	77.33	77.99	78.64	79.28	79.91
Change from Prior		*0.69*	*0.67*	*0.67*	*0.66*	*0.65*	*0.64*	*0.63*
United States Females	80.42	81.02	81.61	82.20	82.78	83.34	83.90	84.45
Change from Prior		*0.60*	*0.60*	*0.59*	*0.58*	*0.57*	*0.56*	*0.55*
Female-Male Differential	5.11	5.03	4.95	4.87	4.79	4.71	4.63	4.54
Difference in Life Expectancy at Birth, Wisconsin and U.S. Projections								
Males	1.32	1.35	1.39	1.43	1.46	1.50	1.54	1.58
Females	0.96	0.98	1.02	1.05	1.09	1.13	1.17	1.21

For projecting county-level age-sex survival rates, the same principle of a larger geographic area guiding the predicted values for smaller areas—in essence, “as goes the state, so go the counties”—was maintained. As noted in the section on the setting of base county survival rates, the state’s counties were divided into ten groups according to base life expectancy proximity. Using the formula reproduced above, these starting rates were projected forward. Converting these projected survival values to the summary measure of life expectancies at birth, the patterns of change in life expectancy—between the sexes and among the ten county groupings—appeared reasonable. As with the state-level projected rates, some minor smoothing was applied.

Because survival rates at the state level were projected to rise for all age-sex categories, the county rates, and corresponding life expectancies, also rose across time. This result might seem counter-intuitive to the finding that, from 1995 to 2005, women’s life expectancies fell in 20 counties and men’s fell in 10 counties. However, in projections mode, how would “winners” and “losers” be determined? The modeling technique actually increased the “spread” in life expectancies across the projections period. For example, those counties with the lowest base male life expectancies improved about 2.9 years through 2040, those with the highest base expectancies increased 3.5 years.

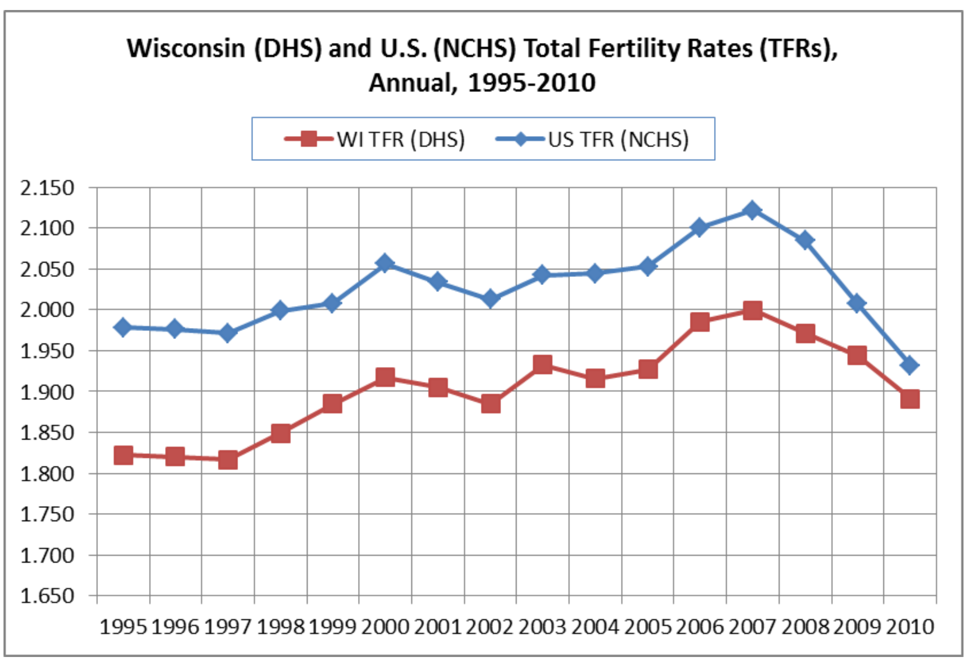
Finally, a maximum limit of projected age-sex specific survival rates of 0.9995 was established. This upper bound affected younger age cohorts. Allowing projected survival rates to rise unfettered sometimes results in no predicted deaths an age-sex group across 30 years. While somewhat arbitrary, this imposed limit would lead to the calculation of one death per 2,000 persons in an age-sex category in a five-year period. In a majority of cases in Wisconsin's counties, the age-sex population falls below this threshold.

State and County Fertility Rates: Base

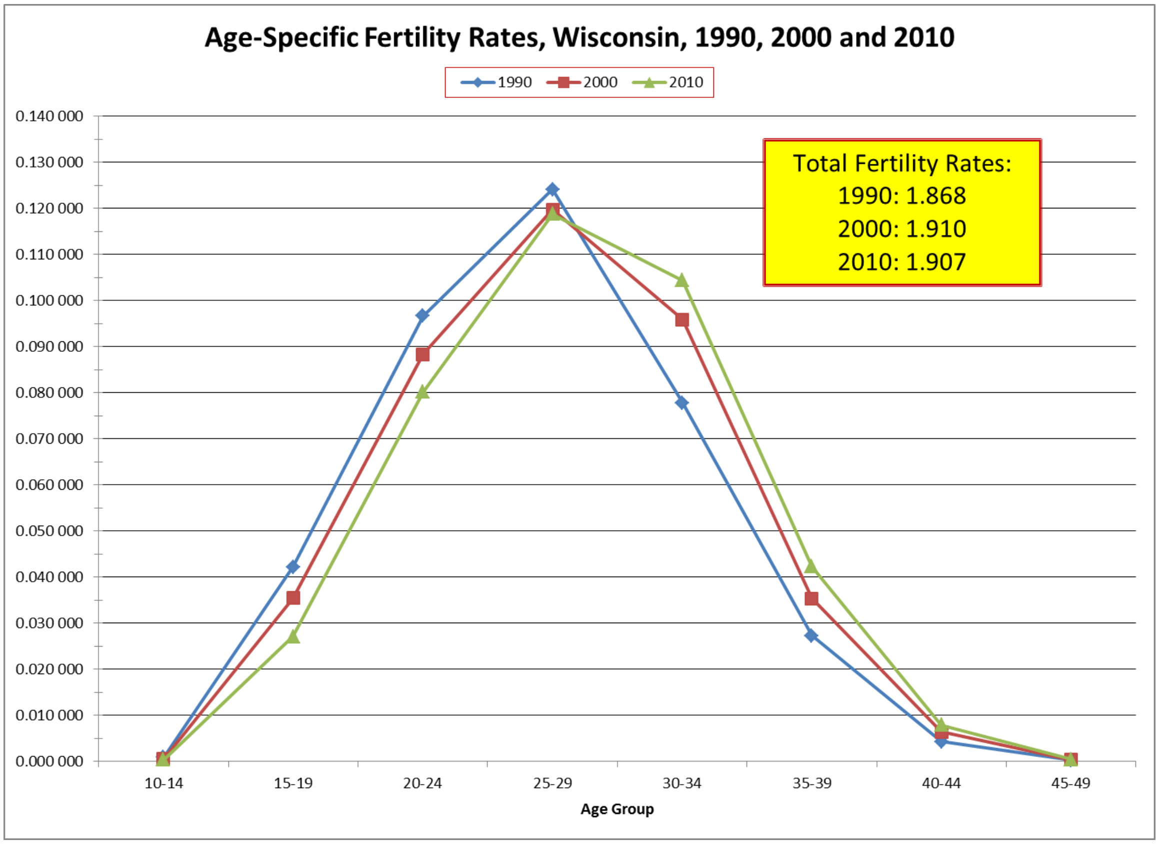
At the state level, the age-specific fertility rates (ASFRs) are used to determine base rates and also in projecting births in each five-year interval of the 30-year projection horizon.

As had been done in recent projection vintages, the base state ASFRs were calculated using 12 months of Wisconsin resident births, centered on April 1, 2010. In short, the numerators are the sum of one-fourth of the calendar year 2009 and three-fourths of the calendar year 2010 births, by age of mother in five-year categories from ages 10-14 through 45-49; the denominators are the count of women in these five-year groups at Census 2010.

In turn, the ASFRs sum to the total fertility rate (TFR), a synthesized, one-number estimate of the number of births an average woman would have, if the current age-specific birth rates applied to her throughout her reproductive years. The 2010 TFR was 1.907, slightly less than the value calculated in the same manner at 2000 (1.910). However, based on the Department of Health Services' estimation of TFRs in the intervening decade, the TFR had been much higher; the decline, also seen at the national level (see graph below), was related to the 2007-2009 recession.



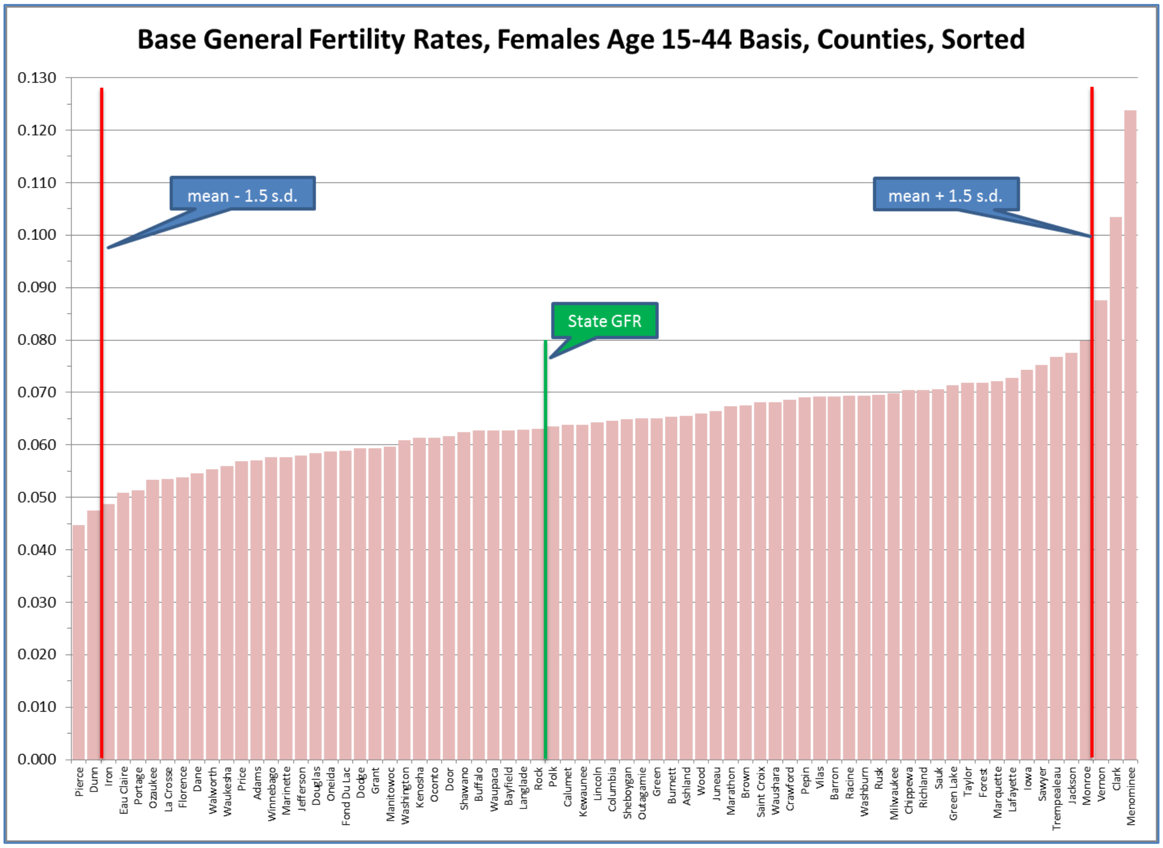
While the total fertility rates were falling from 2007 through 2010, a notable pattern across the past three decades in Wisconsin has been that age-specific rates for younger women have been declining, while those for older women have been increasing.



At the county level, because of smaller quantities of births and women in the fertile age range, base general fertility rates (GFRs) are calculated as the starting point for the projections. A broader period of resident births—30 months, or 2½ years—centered on the 2010 Census date is used. The age range of women in the denominator were those aged 15-44.[4]

The following graph illustrates the county-specific GFRs for 2010, with vertical lines added to delineate those counties in which GFRs were greater or less than the mean ± 1.5 standard deviations, and the state GFR for comparison. Counties that have outlying rates are treated slightly differently in projections mode, which is described in the next section.

[4] The county computations of GFRs need not necessarily match the time frame of births and age range of women that were used for state-level ASFR calculations. In projections mode, the GFRs provide a comparative basis among counties, and the total projected births are controlled to the state projected totals.



Unlike the TFR, the state's GFR increased slightly from 2000 (0.059) to 2010 (0.063). The general fertility rate is very dependent on the age distribution of women within the selected fertile age range. In 2000, the age 15-44 group was dominated by age 35-44 year-olds (the tail end of the Baby Boom generation) who, as the graph of ASFRs displays, have lower age-specific rates. By 2010 this group had aged out of the fertile cohort.

State and County Fertility Rates: Projected

In order to project age-specific fertility rates at the state level, it is reasonable to assume that Wisconsin's rates will change in a similar pattern as is expected for a larger geographic area, such as the United States. Indeed, there is historical evidence to this effect; the time series graph of comparative total fertility rates in the previous section illustrated this similarity.

When the state preliminary projections were prepared in 2012, the "depressed" level of the state's ASFRs and TFR at the starting year of 2010 was a concern. Most research indicated that the lower fertility rates that began with the 2007-09 recession would rebound as the national economy recovered. In addition, it would be reasonable to assume that the Wisconsin's fertility patterns will rise gradually over time, as predicted by national-level projections models that were prepared prior to the Great Recession.

Furthermore, it also seems plausible that—building upon Wisconsin's pattern of the past twenty years—the ASFRs for younger-aged women (particularly ages 15-19 and 20-24) will continue to decline, while those for older women (particularly ages 30-34 through 40-44) will continue to increase.

In short, the projected birth rates needed to capture both an increasing TFR, with a bit of an accelerated "bump" in the early years of the projections period, and a mixture of declining and rising ASFRs for particular age categories.

First, the state's ASFRs for 1990, 2000 and 2010, which generally fit a straight trend line quite well, were projected using simple linear regression. This step produced a smooth series of ASFRs extending through the 30-year projections period, with the desired downward tilt for younger women and upward slant for older cohorts. However, the effective TFRs of these projected age-specific rates were relatively flat. In order to "lift" these rates across time to project an increase in the total fertility rate, the rates prepared for the vintage 2008 Demographic Services projections were instructive. Combining both Wisconsin's historic pattern and the rise in the national TFR predicted by the Census, the model did an excellent job of projecting births for the 2005-2010 period: the projection was only 0.2% different from the actual births. Thus, as a second step, the rates from the vintage 2008 projections were substituted for the projection years 2015 through 2035; a linear extrapolation carried these ASFRs to 2040. Finally, an inordinate rise in the projected ASFRs for women ages 30-34 was smoothed to create a more reasonable, modest increase across time. The finished series of projected total fertility rates, after starting at 1.907 in 2010, rose to 1.980 in 2015 (an increase of .073), then rose in a linear fashion through 2040 to 2.040.

As part of the calculation of projected births in each five-year cycle, the beginning and ending ASFRs are interpolated to the midpoint, then multiplied by the midpoint projection of women in each age group to generate projected births by age group.

In order to project general fertility rates at the county level, the first assumption is that the GFRs centered on 4/1/2010 are adequate as a midpoint projection for the first five-year cycle, given that the time difference is minimal. Beyond that, a second assumption is that the fertility rates of individual counties will tend toward a projected state rate at some distant point in time, or a "point of conjunction." For most counties—those having base GFRs within 1.5 standard deviations of the mean for all counties—a target point of conjunction is set at 50 years from the launch year of 2010. However, for the five statistically outlying counties (Pierce, Dunn, Vernon, Clark and Menominee), their relative distance from the mean indicates that it may take them longer to rise or fall to a future state GFR. It is anticipated that the GFRs for these outliers will tend toward the state's rate at a slower pace, placing the point of conjunction at 75 years.

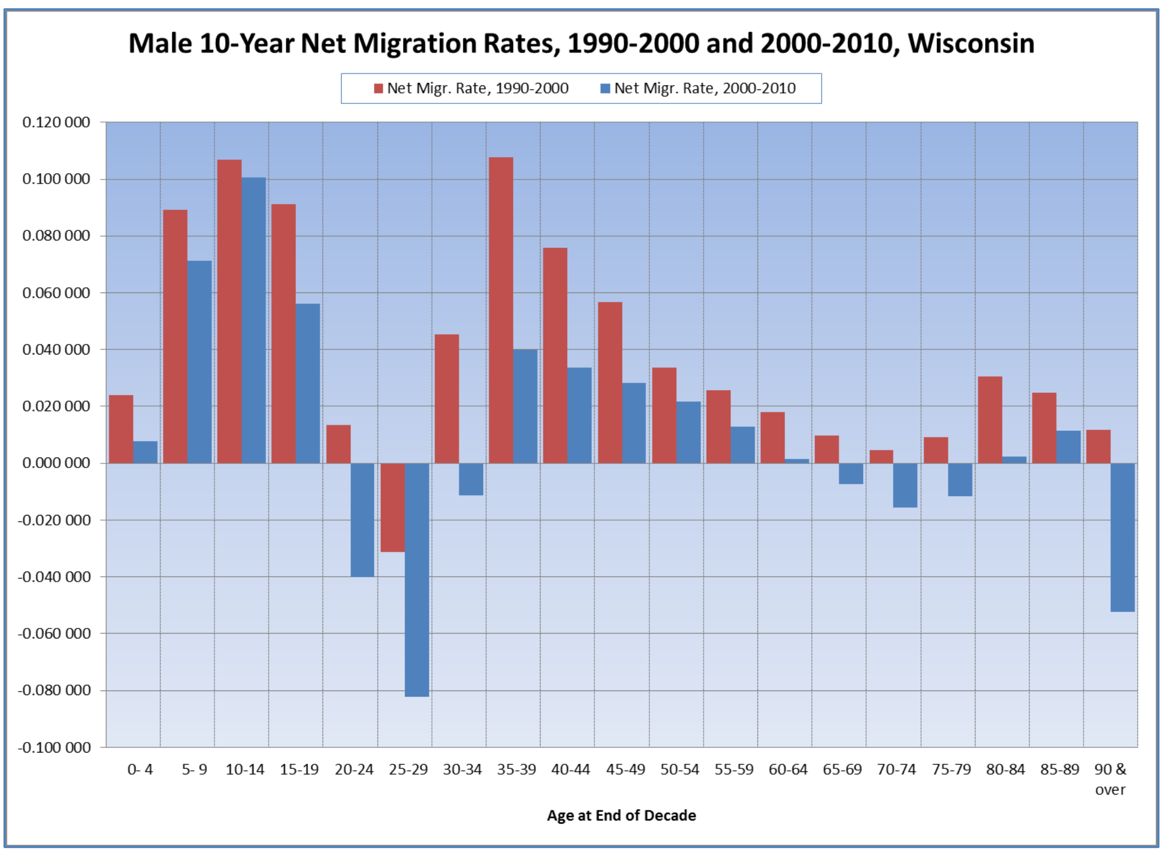
After preliminary projected births for each five-year interval are calculated for each county, the sum is controlled proportionally to the state projected births to create the final county projected births.

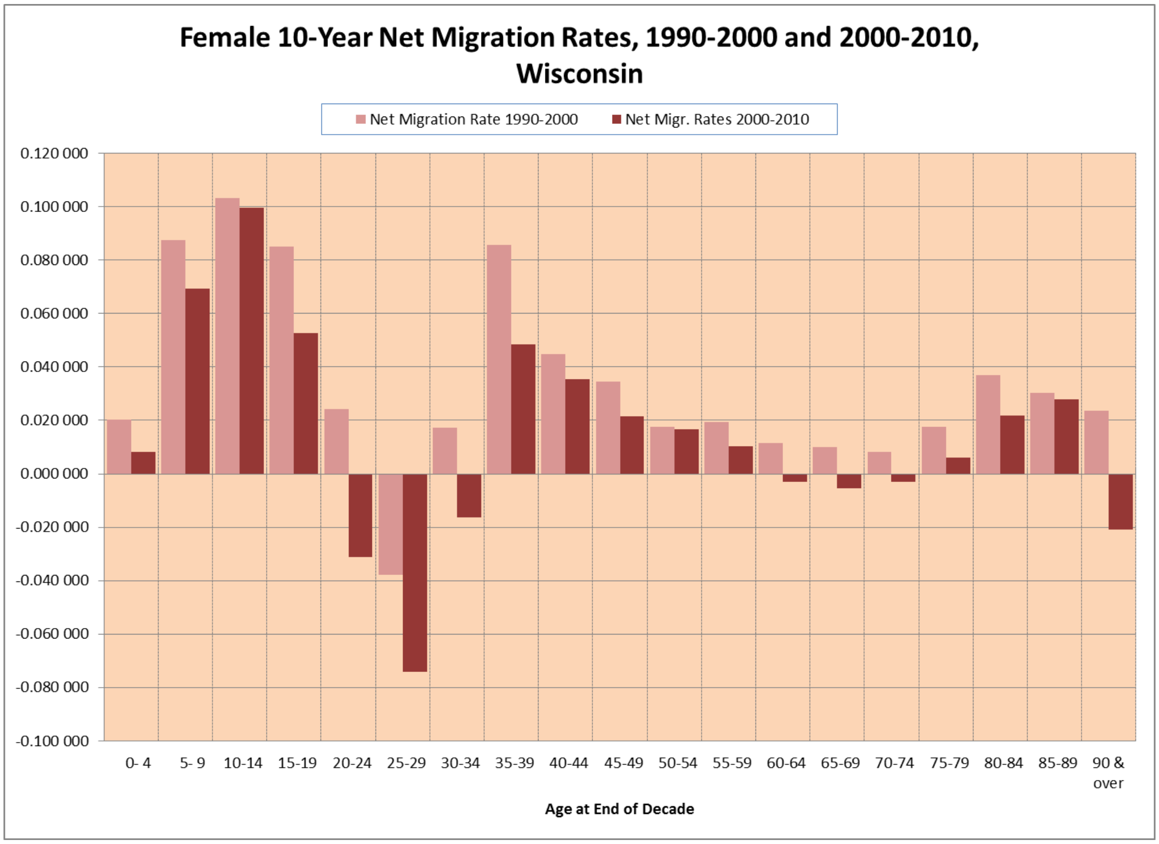
State and County Age-Sex Migration Rates: Base

As with base survival rates at both the state and county levels, the calculation of base net migration rates makes use of the resident deaths by birth cohort (in five-year groupings) and sex in the exact intercensal period of April 1, 2000 through March 31, 2010. The decadal net migrants are the residual of the ending population minus the expected population; the initial 10-year rates, centered on 2005, are simply the net migrants divided by the expected population.

As described earlier in the "State and County Age-Sex Survival Rates: Base" section, for the county projections, base populations were adjusted for a number of sizeable group quarters errors that went uncorrected through the CQR process and for the opening of five state correctional facilities during the decade.

During the 2000s, at the state level, net migration was substantially lower than the 1990s. The calculated net migrants numbered approximately 79,900, far below the 1990 – 2000 result of 224,000. This decrease in net migrants is reflected in the contrast between age-sex specific net migration rates (NMRs) for the past two decades, illustrated in the following two graphs. Note that, for both sexes, the NMRs for ages 20-24 and 30-34 both "flipped" from positive to negative, the NMRs for ages 25-29 became more negative, and other age categories, while mostly positive, were less so in the 2000s than the 1990s.





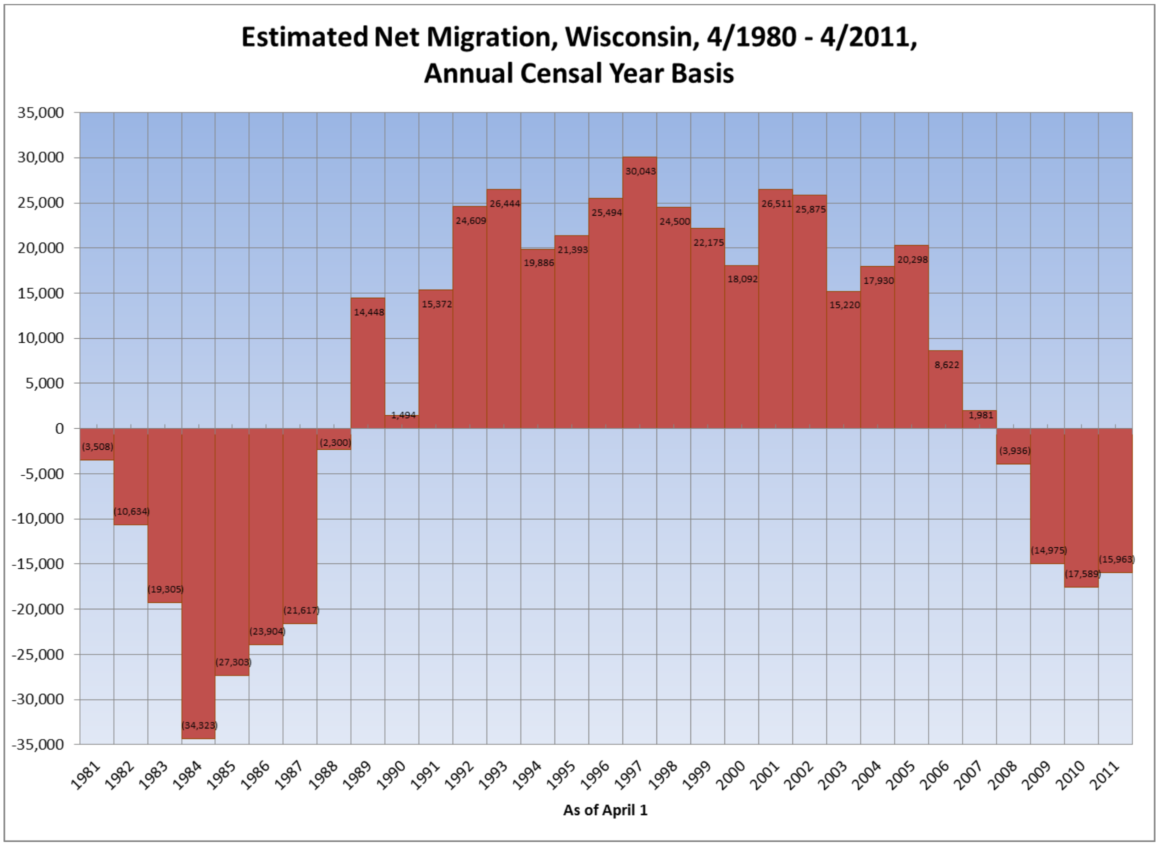
In a similar vein, at the county level, the total net migration was positive for 68 counties in the 1990s but for only 49 counties in the 2000s.

The 10-year net migration rates were converted to five-year rates using an adjacent-cohort technique, with modifications that have been developed by Demographic Services Center in prior vintages of projections.

State and County Age-Sex Migration Rates, Projected

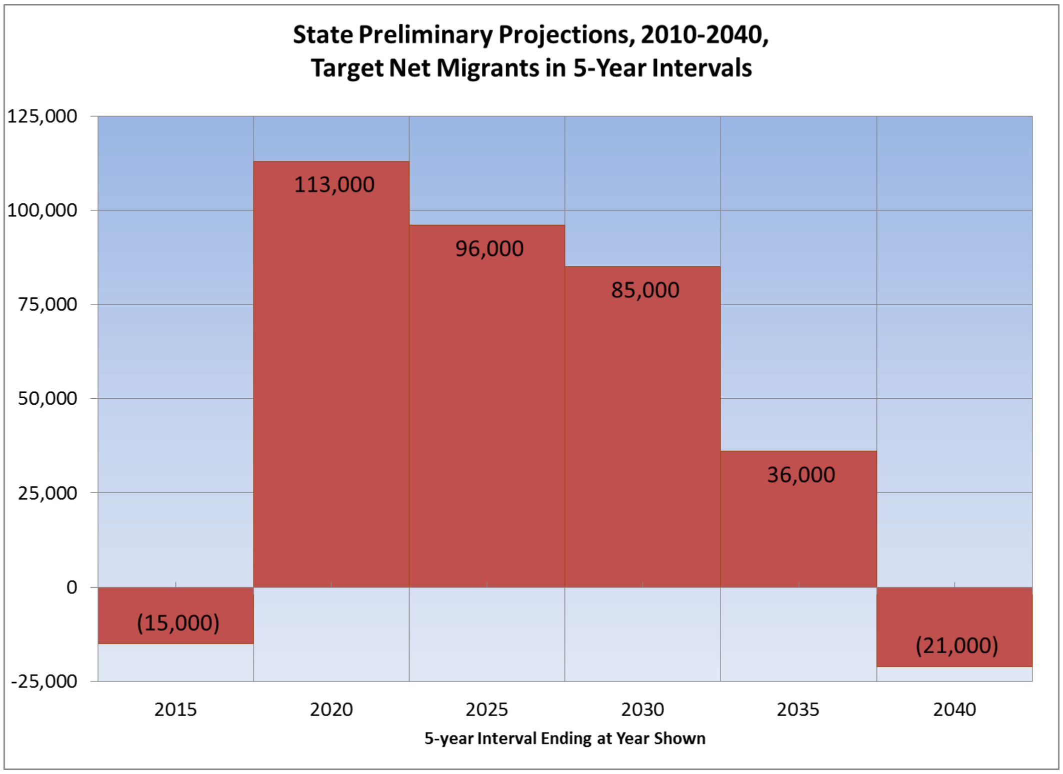
The first step in setting projected state net migration rates is to set numeric net migrant targets for each 5-year interval going forward. In recent vintages, Demographic Services has predicted total net migration by using the historical experience of the prior three decades in a weighted averaging technique, allotting more heft to recent decade(s) as compared to earlier ones. The initial result of this method assigned approximately 49,000 target net migrants to each quin-quennial period.

Assigning equal values to the six five-year intervals in the projection series is, in effect, a way of "hedging one's bets." In reality, migration is far more variable (consequently, making it the most difficult of population component changes to predict). In order to introduce variability, the time series of Demographic Services Center's annual population estimates was studied. With nearly 40 years of history, Demographic Services' estimates indicated the following pattern, on a year-to-year basis, of net migration.



Clearly, three periods of migratory experience are apparent: out-migration during the “Rust Belt Recession” of the early 1980s; recovery and solid in-migration during the 1988 -2006 period of relatively strong economic growth in the state; and a tail-off into negative migration associated with the 2007-09 Great Recession and its aftermath.

This cyclical pattern can be applied to the projections period, maintaining the target net migrants for the entire 30 years at 294,000 (49,000 × 6), but allocating their distribution to accommodate likely peaks and valleys in migration activity. The graph below demonstrates the final allocation of migration targets for each five-year interval.



With the targets set, projected age-sex net migration rates were then calculated, employing the "two-K" adjustment factor technique that was developed in Kale *et al.* (2005).

At the county level, the process of setting target net migrants was broken into four parts:

1) For the initial five-year period of 2010-2015, the estimated net migrants of 2005-2010—in aggregate, about -25,900—were proportionally controlled to the target of -15,000.
2) The predicted restoration of strong positive migration in the 2015-2020 period is very similar to the state's pattern in the 1990s. As noted earlier, the state gained approximately 224,000 migrants from 1990 to 2000; the target of 113,000 for 2015-2020 is almost exactly one-half that. Thus, the net migrant results of that earlier decade were used to proportionally assign the counties' migrant targets. Some minor adjustments for values that appeared to be anomalies were also made.
3) For the following three five-year cycles, the counties' target net migrants were reduced proportionally.
4) For the final five-year period, the net migrant targets of the 2010-2015 period were replicated initially. Then, counties with negative targets were held constant; counties with positive targets were proportionally reduced so that the aggregation of all counties totaled -21,000.

Having established male and female county migrant targets, K factors were computed and age-sex migration rates were projected within each cycle.[5]

[5] The "one K" method was used for the counties, even though the two-K factor technique was employed at the state level. Trying to replicate the two-K method at the county level is extraordinarily difficult. Nonetheless, because net migrants are controlled to the state age-sex specific totals, the two-K method was utilized indirectly.

Citations

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