

Population Projections: Reasons for Uncertainty

by

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Demographic Axiom

No wise demographer should ever make a population projection for any period of time that he or she does not expect to exceed his or her lifetime

Component Methods

Uses three components of Population Change:

$$P_{t_2} = P_{t_1} + B_{t_1-t_2} - D_{t_1-t_2} + NM_{t_1-t_2}$$

Where:

P_{t_2} = population for estimate period

P_{t_1} = population for base period

$B_{t_1-t_2}$ = births between P_{t_1} and P_{t_2}

$D_{t_1-t_2}$ = deaths between P_{t_1} and P_{t_2}

$NM_{t_1-t_2}$ = net migration between P_{t_1} and P_{t_2}

Basic Method of Population Projection

Steps in Making Projections Using Component Methods

1. Determine the base population (usually from recent population counts).
2. Determine baseline fertility, mortality and migration rates
3. Determine future fertility, mortality and migration rates

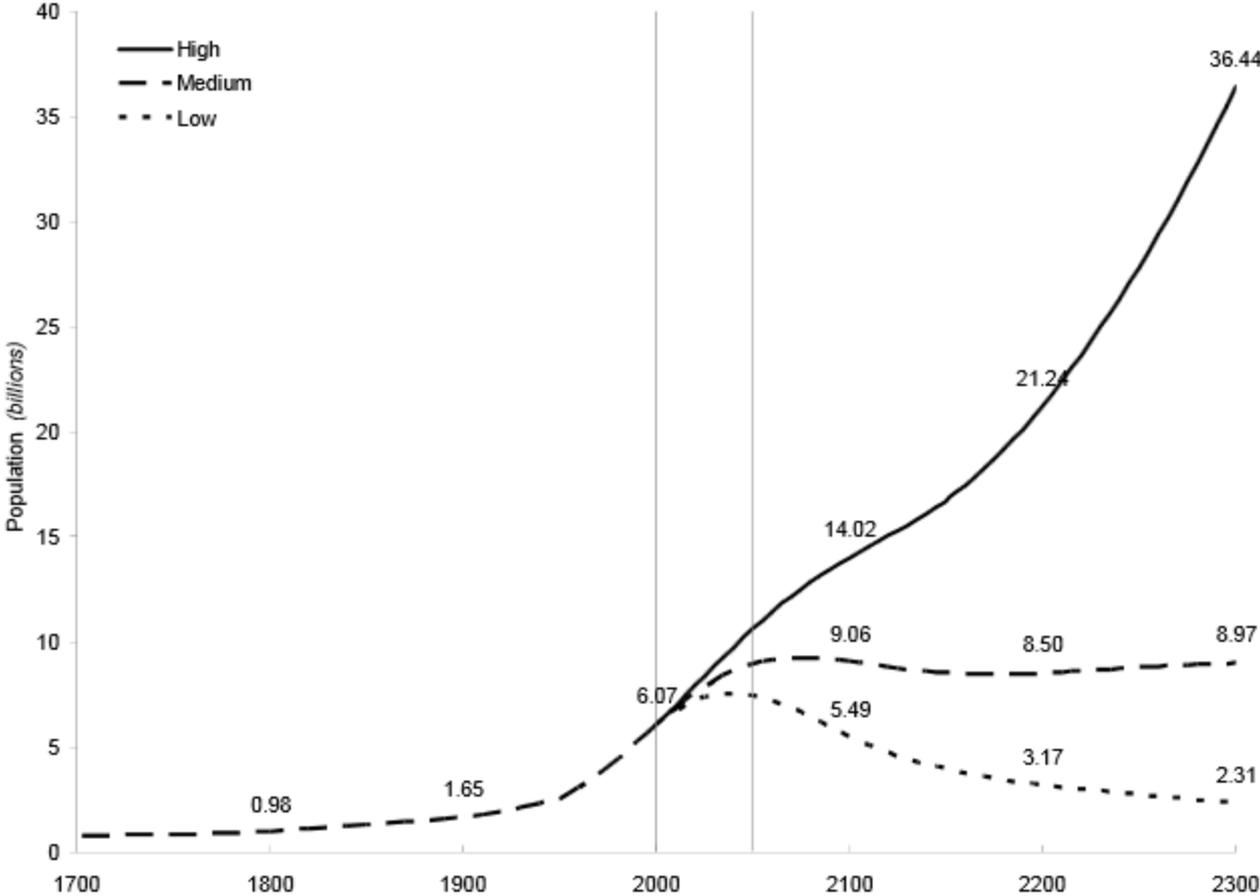
Major Agencies Completing World Population Projections

- United Nations--First Set produced in 1958
- United States Census Bureau--Since the 1940s
- The World Bank--Since 1978

Other Entities Producing Projections

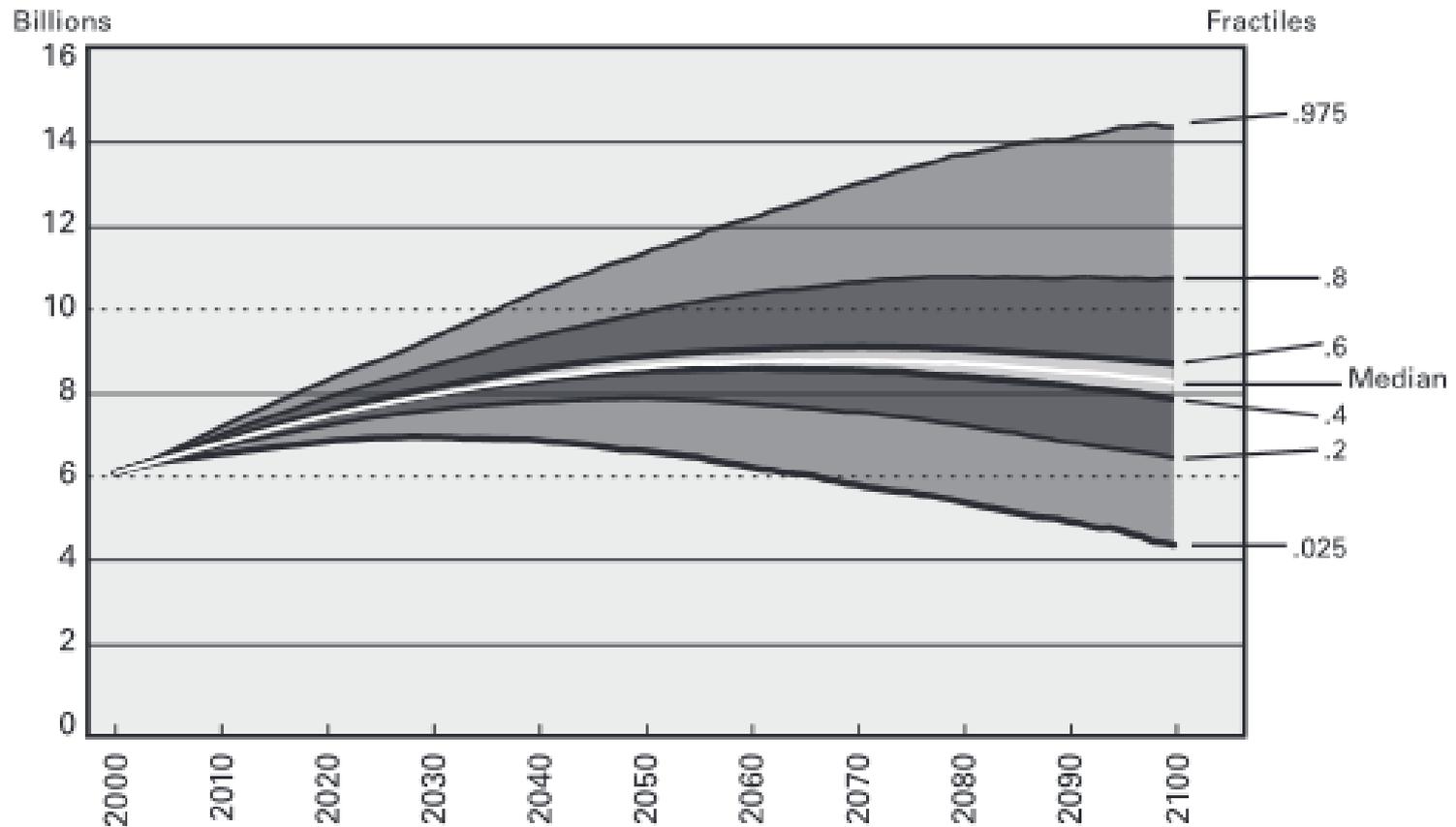
- Population Reference Bureau (since the 1970s)
- International Institute for Applied Systems Analysis (Since the 1990s)
- Several entities periodically but not continuously

Figure 54. World population, estimates and three scenarios: 1700-2300



Source: United Nations Department of Economic and Social Affairs/Population Division (2004) *World Population to 2300*.

Total World Population



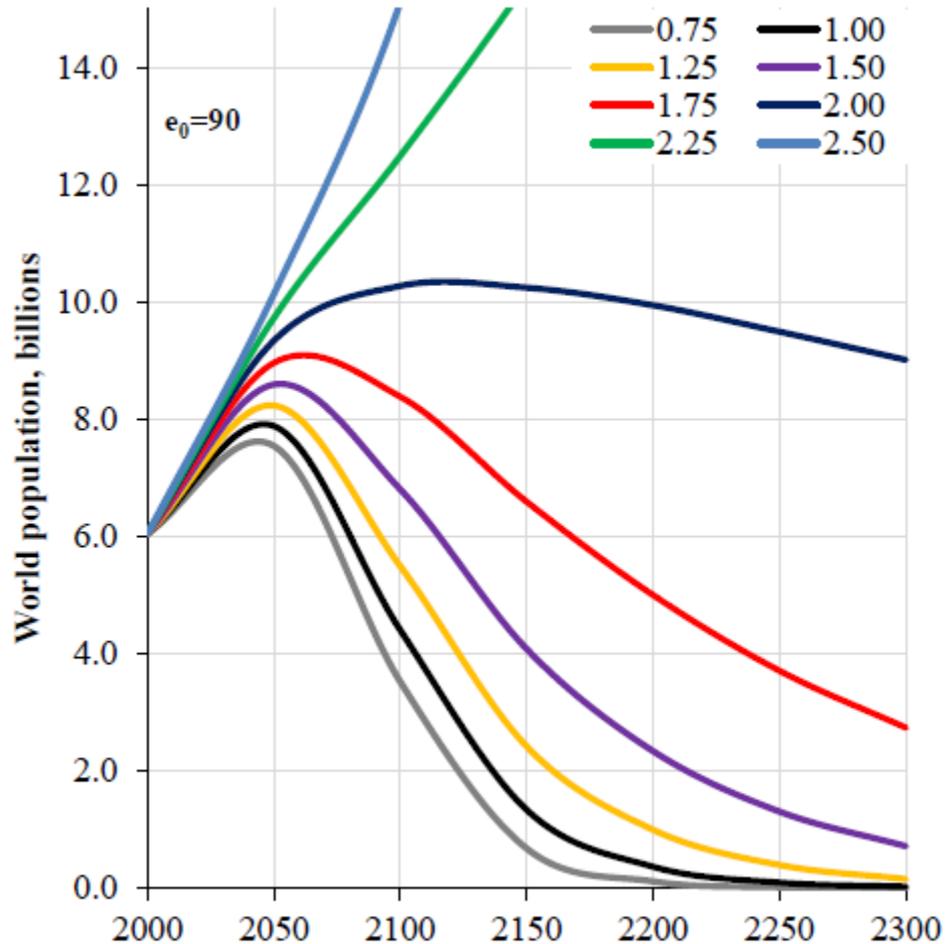
Source: Lutz, Wolfgang (2001) World Population in 2050: Assessing the Projections. Discussion. Paper presented at the Federal Reserve Bank of Boston Conference “Seismic Shifts: The Economic Impact of Demographic Change.”

Lutz Synopsis of Projections

- “The results show about an 85 percent probability that world population will reach a maximum (over 14 billion) over the course of this century and then start to decline. There is about a 60 percent probability that world population will not reach 10 billion before 2100, and around a 15 percent probability that in 100 years, world population will be even lower than today.”

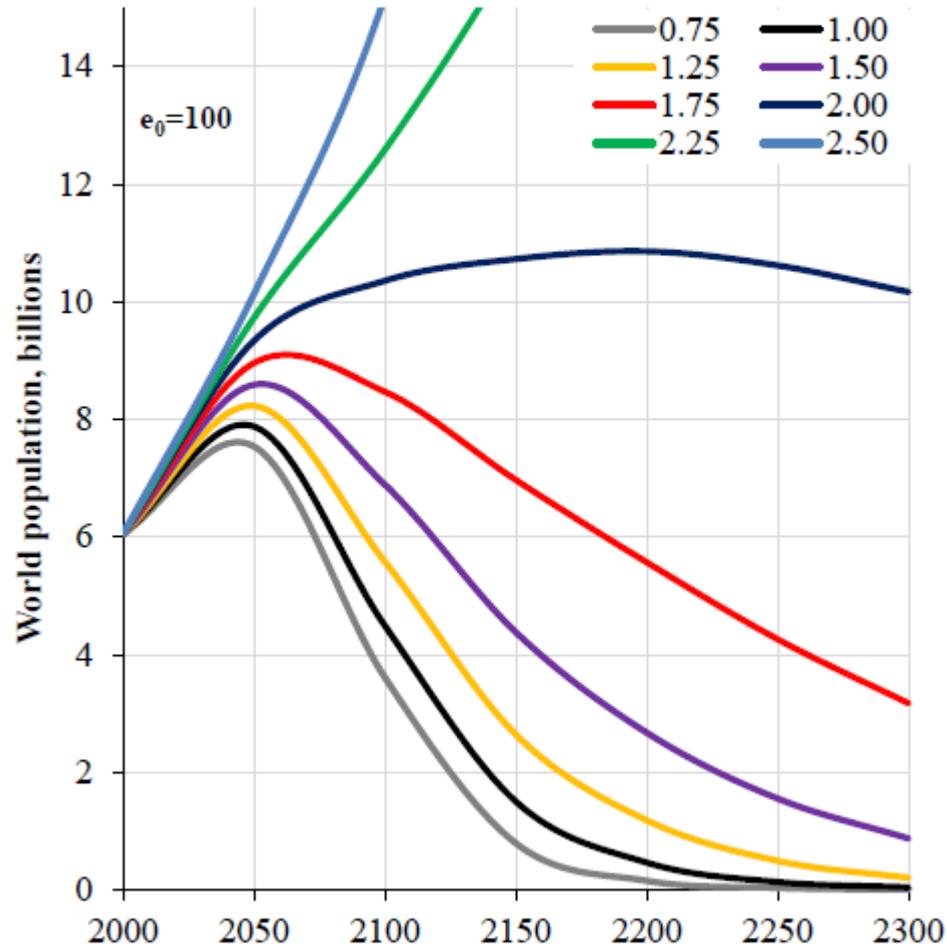
Source: Lutz, Wolfgang (2001) World Population in 2050: Assessing the Projections. Discussion. Paper presented at the Federal Reserve Bank of Boston Conference “Seismic Shifts: The Economic Impact of Demographic Change.

Global Population Size from 2000 to 2300 Resulting from Alternative Global Fertility Levels as Indicated (TFR to be Reached by 2030-2050 and Kept Constant) Combined with a Maximum Life Expectancy of 90.



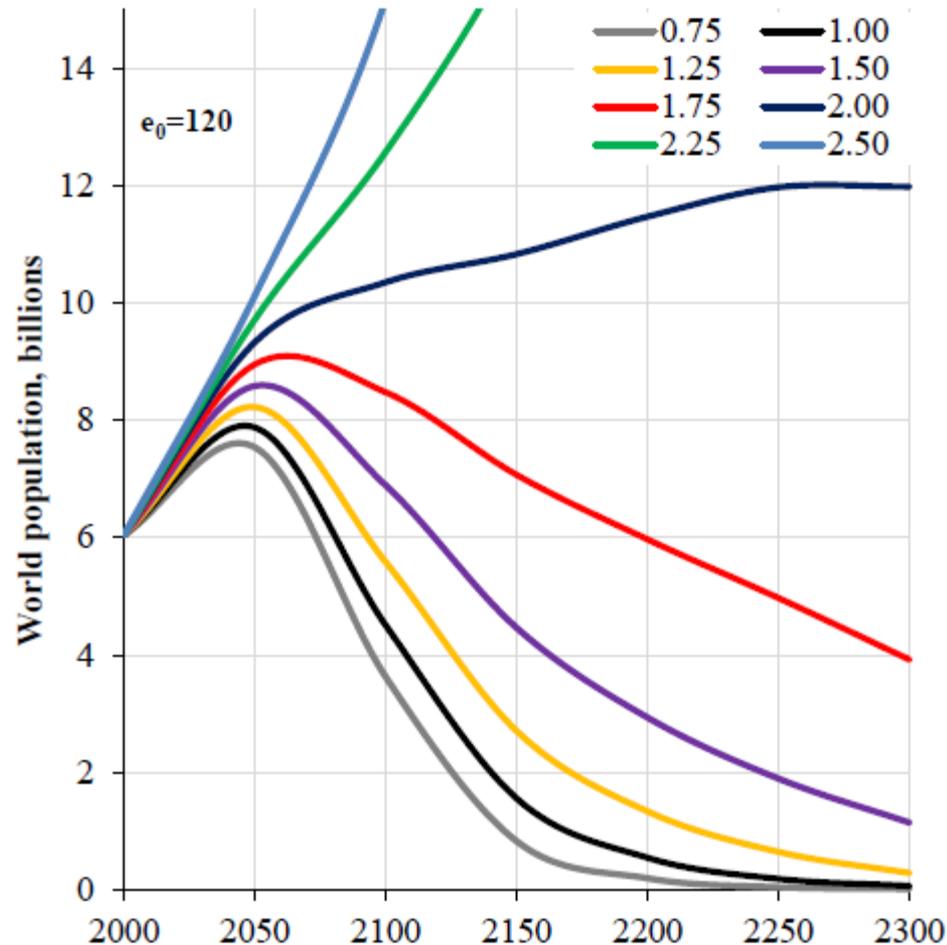
Source: Basten, Stuart, Wolfgang Lutz, and Sergei Scherbov (2013). Very Long Range Global Population Scenarios to 2300 and the Implications of Sustained Low Fertility,” Demographic Research. Vol. 28(39), pgs. 1145-1166.

Global Population Size from 2000 to 2300 Resulting from Alternative Global Fertility Levels as Indicated (TFR to be Reached by 2030-2050 and Kept Constant) Combined with a Maximum Life Expectancy of 100.



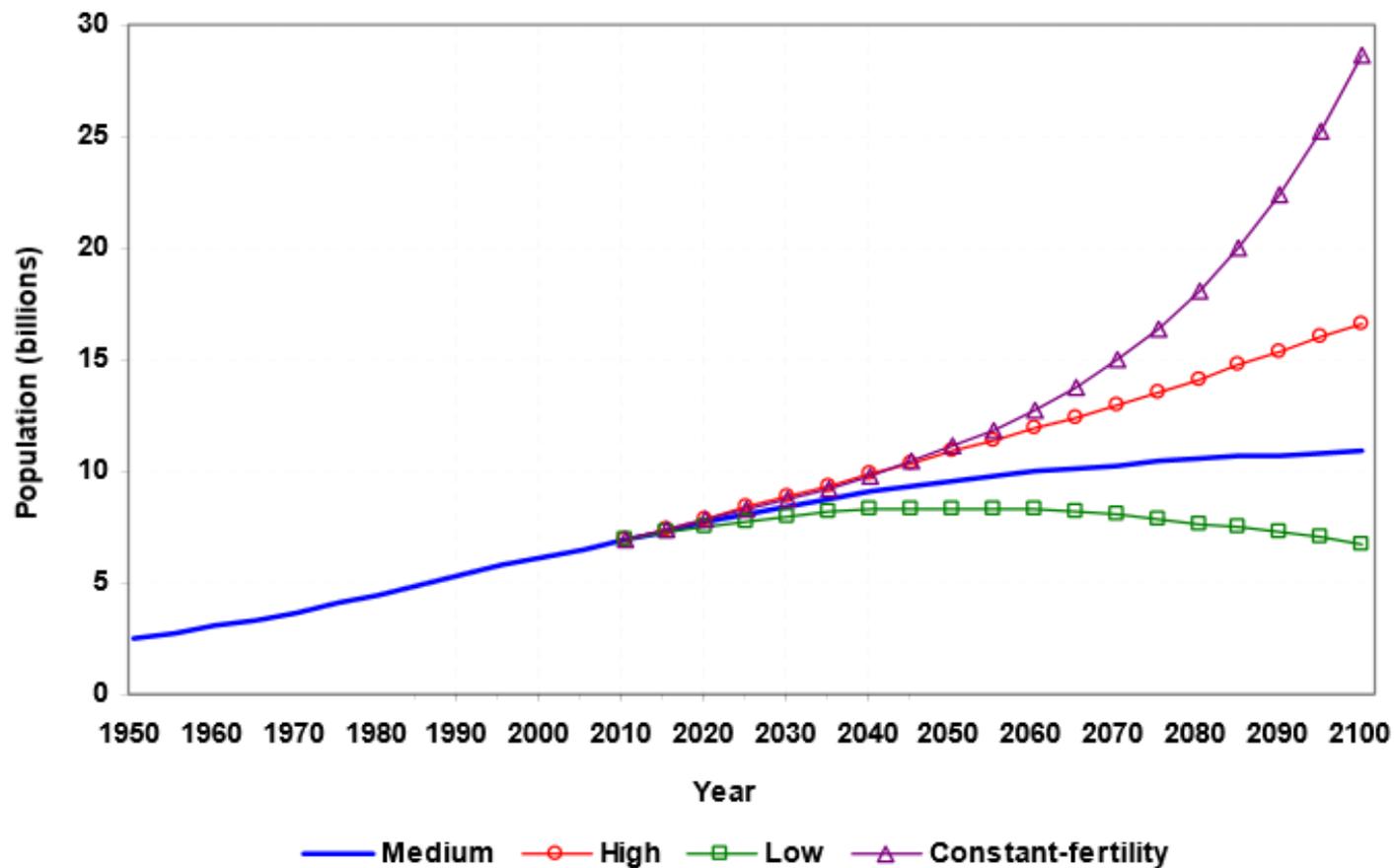
Source: Basten, Stuart, Wolfgang Lutz, and Sergei Scherbov (2013). Very Long Range Global Population Scenarios to 2300 and the Implications of Sustained Low Fertility,” Demographic Research. Vol. 28(39), pgs. 1145-1166.

Global Population Size from 2000 to 2300 Resulting from Alternative Global Fertility Levels as Indicated (TFR to be Reached by 2030-2050 and Kept Constant) Combined with a Maximum Life Expectancy of 120.



Source: Basten, Stuart, Wolfgang Lutz, and Sergei Scherbov (2013). Very Long Range Global Population Scenarios to 2300 and the Implications of Sustained Low Fertility,” Demographic Research. Vol. 28(39), pgs. 1145-1166.

Figure 1. Population of the world, 1950-2100, according to different projections and variants



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013). *World Population Prospects: The 2012 Revision*. New York: United Nations.

United States Projections

- Assessment of the accuracy of components of long-term population projections
- Assessment of the accuracy of components of short-term population projections

Table 3. Percent Error for the Total U.S. National Population Forecasted
Annual Growth Rates: 1947 to 1999

[In percents. Resident population]

Base Year	Percent Error (%) of Forecast Period				
	1st	5th	10th	15th	20th
1947	(12.69)	(48.62)			
1949	5.02	(35.80)	(47.27)		
1953	(6.23)	(15.41)	(14.25)	16.77	10.42
1955	(15.05)	(9.20)	8.30	14.08	37.13
1957	0.82	2.79	47.76	64.34	83.74
1963	(2.83)	29.16	50.66	46.20	69.88
1966	6.41	4.66	56.71	61.34	66.69
1969	(16.66)	20.30	10.99	47.59	27.44
1970	(16.83)	27.47	23.66	52.31	10.83
1972	(8.51)	3.09	20.72	21.04	(15.75)
1974	(26.49)	(18.09)	14.58	(5.08)	(26.08)
1976	(25.06)	(6.01)	2.23	(24.00)	(29.87)
1982	2.25	3.39	(24.95)	(31.25)	
1986	3.21	(22.31)	(27.44)		
1991	0.01	3.11			
1992	4.94	1.94			
1994	1.37	(4.35)			

Note: Negative values are denoted in parenthesis.

Source: Population Projections Program, Population Division, US Census Bureau: May 2000

Internet Release Date: November 6, 2002

Table 4. Error Statistics for the Forecasted Number of Births for the Total US Resident Population: 1963 to 1999.

[Resident population]

Forecast Period	Individual Series (By Base Year)												Multiple Series
	1963	1966	1969	1970	1972	1974	1976	1982	1986	1991	1992	1994	
Five years													
MPE (%)	12.47	15.11	14.61	29.04	17.60	6.37	0.56	2.42	(8.34)	0.19	2.58	0.08	11.97
MAPE (%)	12.47	15.11	15.80	29.04	17.60	6.37	1.76	2.42	8.34	0.49	2.58	0.92	13.85
MdAPE (%)	14.18	14.18	17.60	33.09	19.28	5.91	1.16	2.62	10.24	0.50	2.59	0.95	9.42
RMSE	514,994	575,225	600,227	995,674	582,069	228,178	85,171	92,489	357,445	22,365	102,095	36,616	627,065
RMSE Naïve	465,722	84,820	351,984	513,028	100,353	184,380	337,574	78,290	261,370	162,579	147,085	49,386	346,936
Ten years													
MPE (%)	23.89	34.06	23.84	37.13	20.32	8.83	3.71	(1.47)	(9.32)				24.26
MAPE (%)	23.89	34.06	24.43	37.13	20.32	8.83	4.32	3.89	9.32				28.33
MdAPE (%)	20.76	32.50	29.89	42.78	21.90	8.99	4.75	3.04	10.11				23.39
RMSE	961,809	1,265,388	879,576	1,290,937	709,716	336,487	191,381	184,829	381,507				1,152,530
RMSE Naïve	603,597	338,116	356,029	453,081	235,066	368,031	447,665	278,243	204,582				495,138
Fifteen years													
MPE (%)	37.32	42.07	27.06	39.39	21.31	8.50	2.37	(3.46)					26.20
MAPE (%)	37.32	42.07	27.46	39.39	21.31	8.50	4.08	5.08					29.39
MdAPE (%)	30.94	53.59	31.75	43.50	22.42	9.32	4.32	6.88					28.19
RMSE	1,431,970	1,558,015	1,008,076	1,406,844	766,643	332,862	180,409	226,634					1,324,306
RMSE Naïve	724,396	301,200	291,210	372,706	333,660	505,362	610,939	268,718					577,229
Twenty years													
MPE (%)	42.94	46.22	28.26		18.48	5.86	0.76						24.58
MAPE (%)	42.94	46.22	28.56		18.48	6.89	4.07						26.79
MdAPE (%)	57.53	57.13	31.99		21.23	7.27	4.24						17.05
RMSE	1,644,427	1,731,781	1,067,397		696,644	291,309	175,922						1,360,758
RMSE Naïve	681,917	263,650	281,452		494,633	627,910	662,275						610,736

Note: Negative values are denoted in parenthesis.

Source: Population Projections Program, Population Division, US Census Bureau: May 2000

Internet Release Date: November 6, 2002

Table 6. Percent Error for the Fertility Forecasts of the US: 1963 to 1999

[In percents. Resident population]

Base Year	Percent Error (%) of Forecast Period				
	1st	5th	10th	15th	20th
Births					
1963	0.80	20.76	56.93	65.88	61.80
1966	8.73	24.68	62.03	57.22	58.24
1969	(2.96)	28.10	31.68	36.41	26.25
1970	8.62	42.99	42.56	41.10	
1972	10.70	21.08	23.39	19.97	7.84
1974	2.78	8.53	13.26	1.80	(1.99)
1976	(2.98)	4.32	6.81	(4.25)	(4.64)
1982	2.83	1.67	(7.21)	(8.50)	
1986	(3.88)	(10.31)	(11.13)		
1991	(0.66)	0.50			
1992	2.14	2.32			
1994	1.06	(0.95)			
Crude Birth Rate					
1963	0.87	19.99	53.63	57.87	50.21
1966	8.44	23.80	57.40	48.75	44.96
1969	(2.88)	27.71	30.71	33.23	21.29
1970	9.14	41.93	39.75	35.03	
1972	11.37	21.78	23.65	18.83	7.01
1974	3.69	10.88	15.49	3.63	1.06
1976	(1.39)	7.00	9.35	(1.46)	(0.47)
1982	3.02	1.34	(6.38)	(6.76)	
1986	(4.11)	(10.15)	(9.52)		
1991	(0.73)	0.29			
1992	1.95	2.22			
1994	1.20	(0.77)			

Note: Negative values are denoted in parenthesis.

Table 9. Percent Error for the Mortality Forecasts of the US: 1963 to 1999

[In percents. Resident population]

Base Year	Percent Error (%) of Forecast Period				
	1st	5th	10th	15th	20th
DEATHS					
1963	2.35	(0.21)	5.32	14.19	14.50
1966	3.08	4.94	12.74	14.59	12.96
1969	1.32	6.81	14.79	13.54	13.34
1970	5.35	11.89	12.95	13.23	
1972	1.15	11.41	13.97	11.50	13.87
1974	8.21	12.17	10.96	10.65	9.80
1976	3.61	5.86	6.35	9.66	8.58
1982	(0.34)	(1.12)	1.38	(0.41)	
1986	(1.26)	1.98	(0.10)		
1991	1.59	0.15			
1992	(5.14)	(1.91)			
1994	(0.31)	2.17			
CRUDE DEATH RATE					
1963	2.10	(0.85)	3.25	8.38	6.29
1966	2.48	3.98	8.80	8.42	3.48
1969	1.19	7.23	13.81	10.89	8.88
1970	5.64	11.00	10.72	8.36	
1972	1.92	12.37	14.21	10.45	13.00
1974	9.11	14.47	13.15	12.64	13.22
1976	5.61	8.58	8.88	12.86	13.33
1982	(0.24)	(1.68)	2.12	1.92	
1986	(1.69)	2.12	1.92		
1991	1.58	0.06			
1992	(5.20)	(2.28)			
1994	(0.31)	2.30			

Note: Negative values are denoted in parenthesis.

Table 10. Percent Error for Net Immigration Forecasts of the US: 1963 to 1999

[In percents]

Base Year	Percent Error (%) of Forecast Period				
	1st	5th	10th	15th	20th
IMMIGRANTS (net of emigration)					
1963	(5.36)	(24.62)	(26.29)	(48.63)	(49.34)
1966	(3.38)	(13.61)	(6.76)	(42.00)	(39.51)
1969	(22.18)	2.04	(35.06)	(32.11)	(43.82)
1970	(13.61)	(23.81)	(52.66)	(38.32)	
1972	(1.72)	(14.89)	(32.77)	(39.92)	(60.28)
1974	(23.81)	(35.06)	(32.11)	(43.82)	(50.66)
1976	(14.89)	(42.00)	(39.51)	(58.34)	(57.32)
1982	(24.01)	(32.41)	(55.31)	(53.94)	
1986	(10.11)	(44.89)	(48.31)		
1991	(12.62)	(6.09)			
1992	(0.29)	(9.92)			
1994	(4.42)	(4.22)			
NET IMMIGRATION RATE					
1963	(8.02)	(25.79)	(27.83)	(51.01)	(52.97)
1966	(4.35)	(14.31)	(9.57)	(45.12)	(44.59)
1969	(22.23)	1.94	(35.63)	(33.69)	(46.03)
1970	(13.28)	(24.13)	(53.60)	(40.97)	
1972	(1.11)	(14.40)	(32.63)	(40.48)	(60.59)
1974	(21.81)	(34.21)	(31.81)	(44.42)	(48.56)
1976	(15.62)	(39.98)	(38.13)	(57.90)	(54.67)
1982	(24.82)	(30.71)	(54.35)	(53.36)	
1986	(11.16)	(44.20)	(47.87)		
1991	(11.23)	(6.50)			
1992	(0.56)	(9.46)			
1994	(4.94)	(4.36)			

Note: Negative values are denoted in parenthesis.

Table 1. Population Projections and 2010 Census Counts by Hispanic Origin for the United States: 2010

Numbers in thousands

2010 Census Counts and Population Projections	Total population		Hispanic		Non-Hispanic	
	Number	Difference from 2010 Census	Number	Difference from 2010 Census	Number	Difference from 2010 Census
2010 Census	308,746	(X)	50,478	(X)	258,268	(X)
2008 National Projections	310,233	1,487	49,726	-752	260,507	2,239
2009 National Projections						
High Net International Migration Series	312,504	3,758	50,918	440	261,586	3,318
Low Net International Migration Series	308,282	-464	48,702	-1,776	259,580	1,312
Constant Net International Migration Series	307,907	-839	48,531	-1,947	259,375	1,107

X Not applicable

Note: The 2010 Census counts represent the U.S. resident population on April 1, 2010. The projections data represent the projected U.S. resident population on July 1, 2010. Since the data measure points in time that are three months apart, small differences are expected when comparing Census counts with projections data.

Source: U.S. Census Bureau, 2008-2010

Table 2. Population Projections and 2010 Census Counts by Race and Hispanic Origin for the United States: 2010

Numbers in thousands

Race and Hispanic Origin ^{1,2}	2010 Census	2008 National Projections	2009 Net International Migration Series		
			High	Low	Constant
White	241,937	246,630	248,137	245,336	245,300
Black	40,251	39,909	40,105	39,741	39,735
American Indian or Alaska Native	3,740	3,188	3,206	3,172	3,169
Asian	15,160	14,415	14,922	13,979	13,658
Native Hawaiian and Other Pacific Islander	675	592	601	584	581
Two or More Races	6,984	5,499	5,534	5,470	5,465
Hispanic	50,478	49,726	50,918	48,702	48,531
Non-Hispanic White	197,319	200,853	201,235	200,524	200,639
Difference from 2010 Census (Number in thousands)					
White	(X)	4,693	6,200	3,399	3,363
Black	(X)	-342	-146	-510	-516
American Indian or Alaska Native	(X)	-552	-534	-568	-571
Asian	(X)	-745	-238	-1,181	-1,502
Native Hawaiian and Other Pacific Islander	(X)	-83	-74	-91	-94
Two or More Races	(X)	-1,485	-1,450	-1,514	-1,519
Hispanic	(X)	-752	440	-1,776	-1,947
Non-Hispanic White	(X)	3,534	3,916	3,205	3,320
Difference from 2010 Census (Percent)					
White	(X)	1.94	2.56	1.40	1.39
Black	(X)	-0.85	-0.36	-1.27	-1.28
American Indian or Alaska Native	(X)	-14.76	-14.28	-15.19	-15.27
Asian	(X)	-4.91	-1.57	-7.79	-9.91
Native Hawaiian and Other Pacific Islander	(X)	-12.30	-10.96	-13.48	-13.93
Two or More Races	(X)	-21.26	-20.76	-21.68	-21.75
Hispanic	(X)	-1.49	0.87	-3.52	-3.86
Non-Hispanic White	(X)	1.79	1.98	1.62	1.68

¹ Race refers to each of the race groups alone and the Two or More Races category represents the population

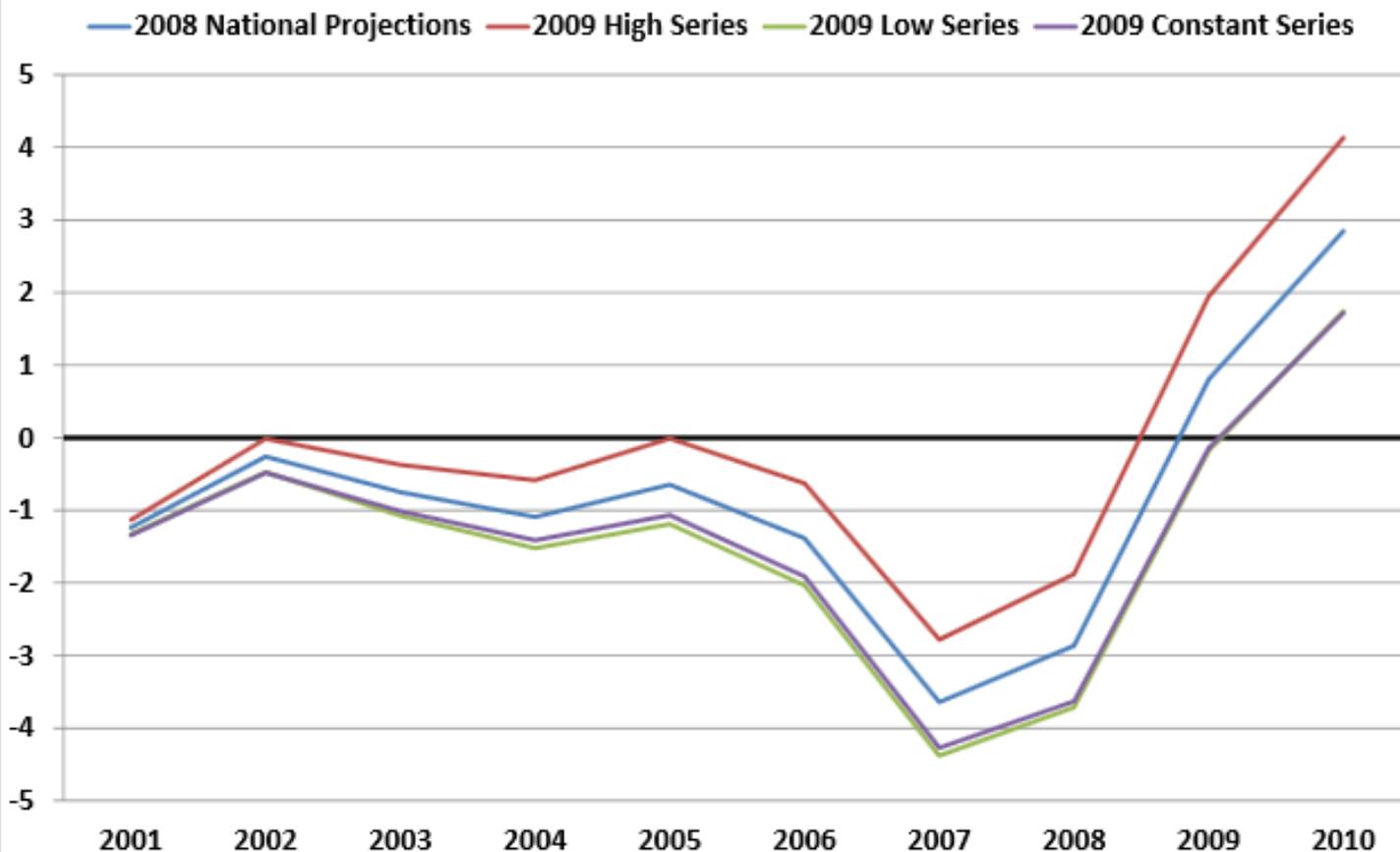
² Hispanics may be of any race.

Notes:

The original race data from Census 2010 are modified to eliminate the "some other race" category. This modification is used for all Census Bureau projections products and is explained in the document entitled "Modified Race Data Summary File Technical Documentation and ASCII Layout" that can be found on the Census Bureau website at <http://www.census.gov/popest/archives/files/MRSF-01-US1.html>.

The 2010 Census counts represent the U.S. resident population on April 1, 2010. The projections data represent the projected U.S. resident population on July 1, 2010. Since the data measure points in time that are three months apart, small differences are expected when comparing Census counts with projections data.

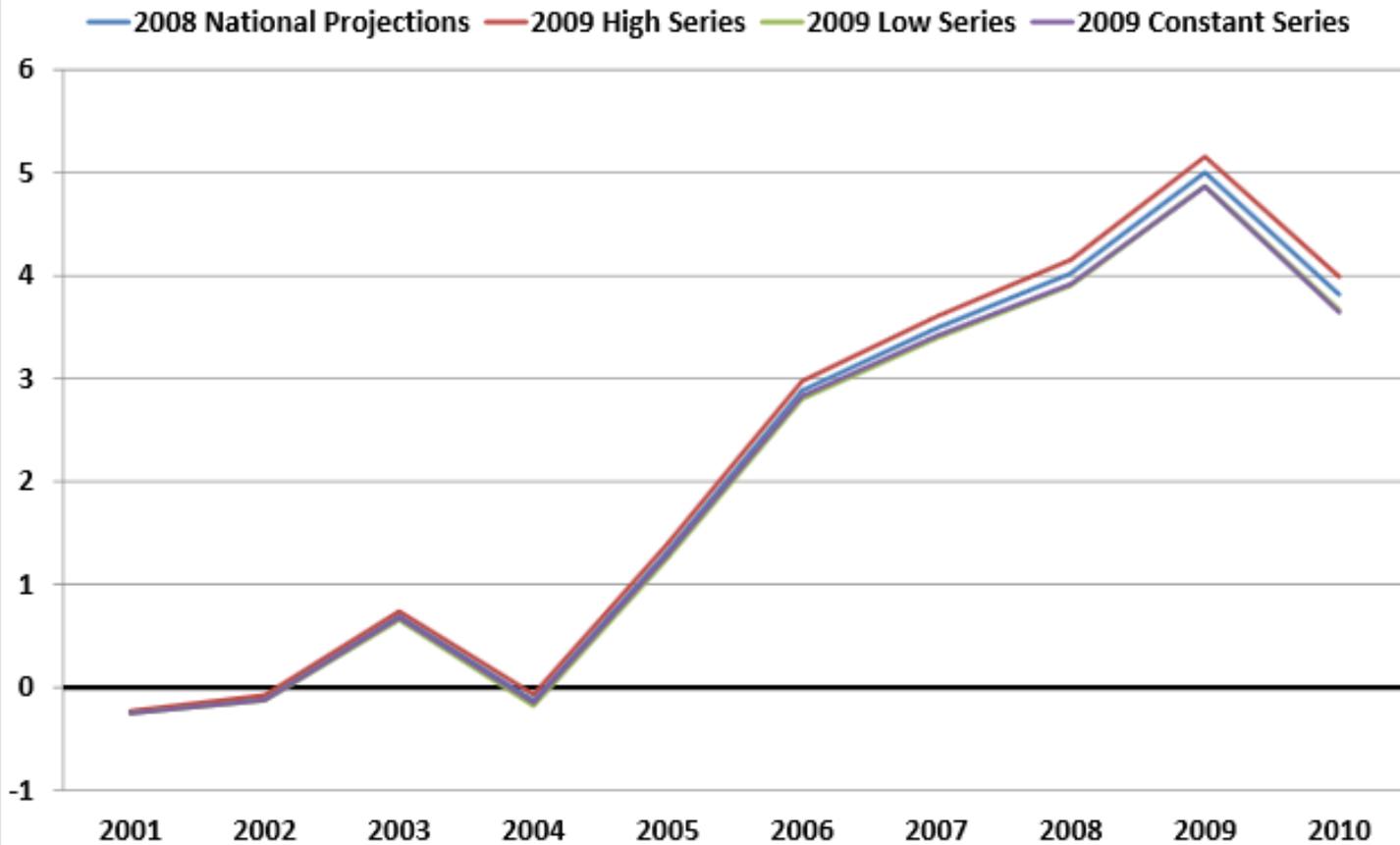
Figure 3. Percent Differences between Projected and Estimated Births: 2001 to 2010



Note: Percent difference is calculated as: $(\text{Projections} - \text{Estimates}) / \text{Estimates} * 100$.

Source: U.S. Census Bureau, 2008-2010.

Figure 5. Percent Differences between Projected and Estimated Deaths: 2001 to 2010

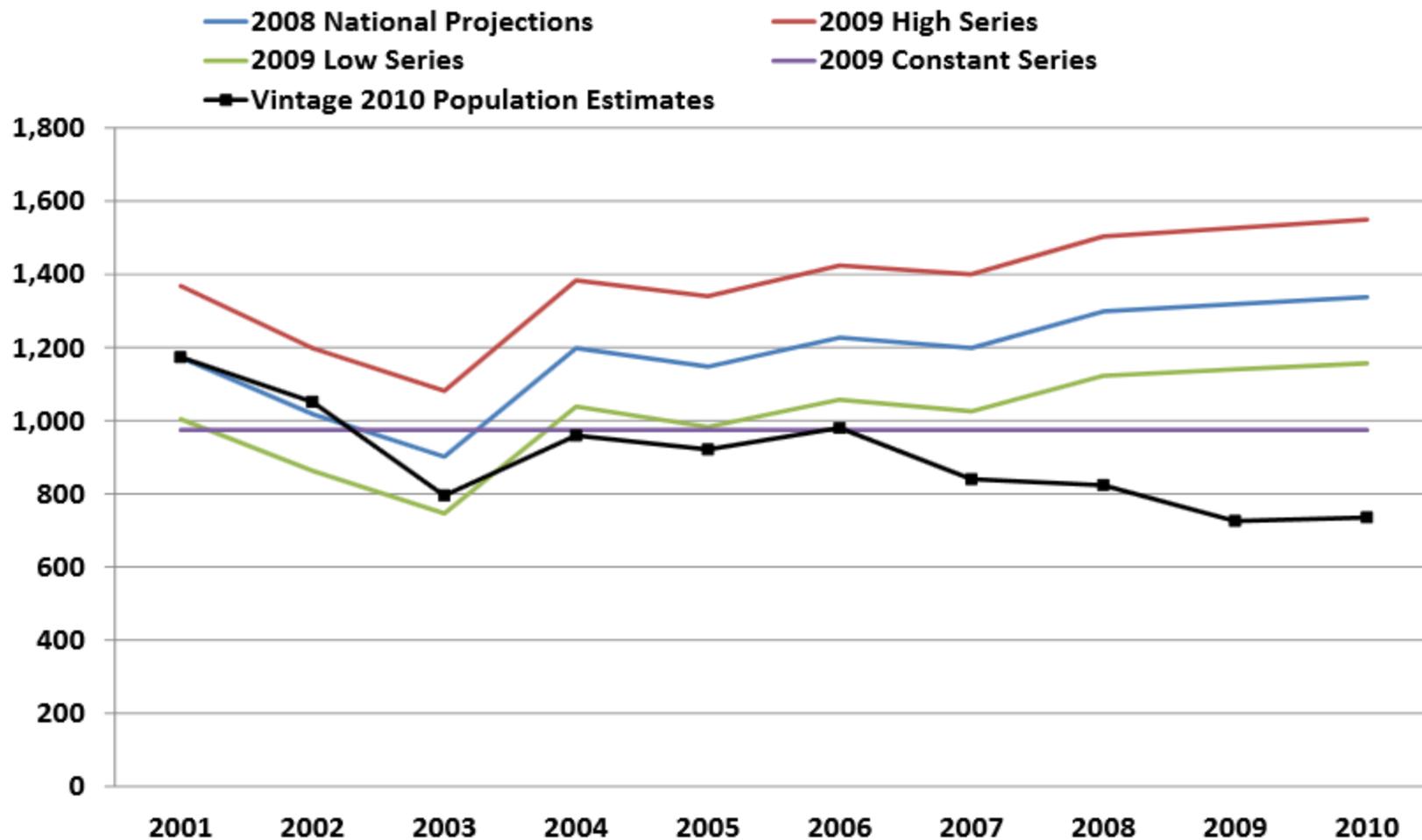


Note: Percent difference is calculated as: $(\text{Projections} - \text{Estimates}) / \text{Estimates} * 100$.

Source: U.S. Census Bureau, 2008-2010.

Figure 7. Comparison of Projected and Estimated Net International Migration: 2001 to 2010

(In thousands)



Source: U.S. Census Bureau, 2008-2010.

Areas of Uncertainty in Population Projections

- Current rates of fertility, mortality and net migration
- Trends in fertility, mortality and net migration rates over the projection period
 - Assume they do not change or only some (such as fertility levels) change or that trends in rates continue
 - Assume change in rates for “developed” nations are indicative of those for all nations
 - Assume target levels such as life expectancies, total fertility rates, (and, if applicable) immigration rates will not exceed a given level

Factors Impacting Levels of Uncertainty in Demographic Processes and Projections

- Economic conditions and trends (e.g. high, medium or low economic growth) affect fertility, mortality and migration
- Societal values and beliefs regarding demographic processes (e.g. fertility and family size)
- Religious beliefs and restrictions
- Physical capabilities and limitations related to age and disease, etc.
- Disease, health and medical service conditions (AIDS, pandemics, etc.)
- Physical and environment conditions (drought, climate change, etc.)

Summary

- Projections of population like that of other factors are subject to numerous sources of error particularly for extended periods of time into the future;
- Multiple scenarios are required for projections in order to anticipate and bracket potential patterns of growth;
- Potential for errors in projections are substantial and must be accepted as a part of the projections process and addressed as effectively as possible