TJHSST Senior Research Project
A Dynamic Model of Human Populations
2007-2008

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June 11, 2008

Abstract

The world is becoming better interconnected. As more and more people in developing countries seek to live in economically secure ones, less and less people stay in their own. This constantly changing flux of movement highlights just how important understanding the dynamics of human population is. This project attempts to analyze and understand the growths of a population and the migrations of people across the world. Through understanding how human populations develop, we can predict changes in the future.

1 Introduction

1.1 What is so important about population models?

The human population of the world is now at 6 billion and counting. It is constantly growing, constantly moving. To even try to use human power to analyze all of this data would require thousands of people and thousands of hours of man power to complete. By using computers, we can drastically cut down on the man power needed.

1.2 Why does it matter?

This project can be useful for a great variety of problems. Most prominently, the US takes a census report every ten years. But every decade in between,

the census department uses the data gathered to estimate population values. A dynamic model such as the one this project would achieve would be invaluable in assisting their efforts.

2 Background

Similar research:

1. Surface modelling of human population distribution in China
    - The researchers of this project split the population into units of grid-like nature. They analyzed this data in order to create two concurring predictions for 2015 under different assumptions. It is a similar project to mine, but limited to only China, with a great amount of emphasis on historical context.
2. Human Population Dynamics Revisited with the Logistic Model: How Much Can Be Modeled and Predicted?
    - The researchers in this project attempt to analyze the problems and reliabilities of logistics curves use to model and predict human populations. They concluded that although logistics models can be used to predict death within 80 percent, long-term birth and death rates cannot be fully predicted. Therefore, my project will attempt to predict values in the near future, at most a hundred years.
3. A Stochastic Population Model Related to Human Populations
    - The researchers use probabilistic factors in order to predict population data. They take into account factors of marriage, age, sex, and migrations. This project is very mathematical in nature, and applies less to this project than other research does.
4. POPSIM: A General Population Simulation Program
    - POPSIM is a general population interaction program, written in C. The program creates a virtual representation of every individual, makes no prior assumptions but the Mendelian rules of genetics, and allows populations of several million individuals in size to be generated and to be followed over hundreds of generations.

5. Populus: Simulations of population biology

    - Populus is a program designed to teach population biology and evolutionary ecology. Simulation models can be chosen, and students can input various parameters for the simulation. Several different graphical outputs are available.

6. Human Demographic Dynamics: Within the Population Curve?

    - This article discusses the limits of human populations, in terms of prediction by the way of exponential growth and traditional logistic organism population growth models, as well as in the sense of resource limitations.

7. Population Growth Over Human History

    - This lecture discusses various aspects of human population. An analysis of past human populations shows that human population exhibits a J-shaped growth curve, and it is continuing to accelerate. It also states that age pyramids are important descriptors of a populations recent history and medium-term future. Age pyramids show that a countys level of development is highly influential on its population growth rate as well. The stabilization of growth rates, referred to as demographic transitions, is signified by a decline in both growth and death rates. Finally, most current and future growth is taking place in developing countries, which have experienced only a partial demographic transition.

8. Human Carrying Capacity and Human Health

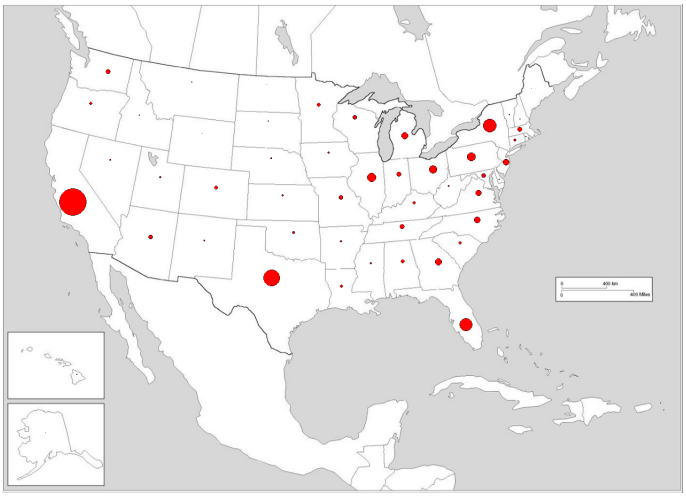
    - This article analyzes the fact that the issue of human overpopulation has fallen out of favor among most contemporary demographers, economists, and epidemiologists. Discussing population control has become a taboo topic. Yet, this taboo has major implications for public health. The silence around overpopulation prevents the global health community from making the necessary link between the planet's limited ability to support its people and health and development crises. It describes how popular thinking on population control has been shaped over the last 200 years,

and how our failure to address the population explosion may be one cause of recent epidemics and social unrest.

3 Development and Procedures

3.1 General Development

This project works by calculating a population growth rate value using population data for a certain group. First, it starts from the states level. Then, it moves on to the entire US, in which it obtains the growth rate for each and every state. It takes those rates, displays a graphical representation of the growing population with it, and calculates the growth rate of population for the entire country. A migration factor has also been added to the project.



3.2 Basic Methodology

The program, after reading in a text file of population data, calculates a population graph using a logistic growth curve that it then uses to display population changes on a US map. The new population every year is calculated using a compound interest equation reworked to equal the new growth rate, which is, in turn, used to calculate the actual population. This is done for every state with the same equations, but different data sets.

4 Testing and Analysis

4.1 Testing

Testing is simply done by my program's ability to calculate future populations as closely as possible. For comparison's sake, the only two values compared are the actual projected future populations during 2005 to 2050, and projected growth rates, for the time periods 1990 to 1995 and 2040 to 2050, through a somewhat convoluted method to compare growth rates in contrast to the direct approach in comparing projected populations. The Census does not give clear values to anything else useful to compare.

Table 2a. Projected Population of the United States, by Age and Sex: 2000 to 2050
(In thousands except as indicated. As of July 1. Resident population.)

Population or percent, sex, and age	2000	2010	2020	2030	2040	2050
POPULATION						
TOTAL						
TOTAL	282,125	308,936	335,805	363,584	391,946	419,854
0-4	19,218	21,426	22,932	24,272	26,299	28,080
5-19	61,331	61,810	65,955	70,832	75,326	81,067
20-44	104,075	104,444	108,632	114,747	121,659	130,897
45-64	62,440	81,012	83,653	82,280	88,611	93,104
65-84	30,794	34,120	47,363	61,850	64,640	65,844
85+	4,267	6,123	7,269	9,603	15,409	20,861
MALE						
TOTAL	138,411	151,815	165,093	178,563	192,405	206,477
0-4	9,831	10,947	11,716	12,399	13,437	14,348
5-19	31,454	31,622	33,704	36,199	38,496	41,435
20-44	52,294	52,732	54,966	58,000	61,450	66,152
45-64	30,381	39,502	40,966	40,622	43,961	46,214
65-84	13,212	15,069	21,337	28,003	29,488	30,579
85+	1,240	1,942	2,403	3,340	5,573	7,749
FEMALE						
TOTAL	143,713	157,121	170,711	185,022	199,540	213,377
0-4	9,387	10,479	11,216	11,873	12,863	13,732
5-19	29,877	30,187	32,251	34,633	36,831	39,632
20-44	51,781	51,711	53,666	56,747	60,209	64,745
45-64	32,059	41,510	42,687	41,658	44,650	46,891
65-84	17,582	19,051	26,026	33,848	35,152	35,265
85+	3,028	4,182	4,866	6,263	9,836	13,112
PERCENT OF TOTAL						
TOTAL						
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
0-4	6.8	6.9	6.8	6.7	6.7	6.7
5-19	21.7	20.0	19.6	19.5	19.2	19.3
20-44	36.9	33.8	32.3	31.6	31.0	31.2
45-64	22.1	26.2	24.9	22.6	22.6	22.2
65-84	10.9	11.0	14.1	17.0	16.5	15.7
85+	1.5	2.0	2.2	2.6	3.9	5.0
MALE						
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
0-4	7.1	7.2	7.1	6.9	7.0	6.9
5-19	22.7	20.8	20.4	20.3	20.0	20.1
20-44	37.8	34.7	33.3	32.5	31.9	32.0
45-64	21.9	26.0	24.8	22.7	22.8	22.4
65-84	9.5	9.9	12.9	15.7	15.3	14.8
85+	0.9	1.3	1.5	1.9	2.9	3.8
FEMALE						
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
0-4	6.5	6.7	6.6	6.4	6.4	6.4
5-19	20.8	19.2	18.9	18.7	18.5	18.6
20-44	36.0	32.9	31.4	30.7	30.2	30.3
45-64	22.3	26.4	25.0	22.5	22.4	22.0
65-84	12.2	12.1	15.2	18.3	17.6	16.5
85+	2.1	2.7	2.9	3.4	4.9	6.1

Source: U.S. Census Bureau, 2004, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," <http://www.census.gov/ipc/www/usinterimproj/>
Internet Release Date: March 18, 2004

Table 2b. Projected Population Change in the United States, by Age and Sex: 2000 to 2050
(In thousands except as indicated. As of July 1. Resident population.)

Numerical or percent change, sex, and age	2000-2050	2000-2010	2010-2020	2020-2030	2030-2040	2040-2050
NUMERICAL CHANGE						
TOTAL						
TOTAL	**137,729**	**26,811**	**26,869**	**27,780**	**28,361**	**27,908**
0-4	8,862	2,208	1,506	1,340	2,027	1,781
5-19	19,736	479	4,146	4,877	4,494	5,740
20-44	26,822	369	4,189	6,115	6,912	9,237
45-64	30,665	18,573	2,641	-1,373	6,331	4,493
65-84	35,050	3,326	13,243	14,487	2,790	1,204
85+	16,594	1,856	1,145	2,334	5,806	5,452
MALE						
TOTAL	**68,065**	**13,404**	**13,278**	**13,469**	**13,843**	**14,071**
0-4	4,517	1,116	769	683	1,037	912
5-19	9,981	169	2,082	2,494	2,297	2,939
20-44	13,857	438	2,234	3,034	3,450	4,701
45-64	15,833	9,121	1,464	-344	3,339	2,252
65-84	17,367	1,857	6,267	6,666	1,485	1,091
85+	6,510	702	462	937	2,233	2,176
FEMALE						
TOTAL	**69,664**	**13,407**	**13,591**	**14,310**	**14,519**	**13,837**
0-4	4,345	1,092	737	657	990	869
5-19	9,755	310	2,064	2,382	2,197	2,801
20-44	12,965	-69	1,955	3,081	3,463	4,536
45-64	14,832	9,451	1,177	-1,029	2,992	2,241
65-84	17,683	1,469	6,975	7,821	1,305	113
85+	10,085	1,154	684	1,398	3,573	3,277
PERCENT CHANGE						
TOTAL						
TOTAL	**48.8**	**9.5**	**8.7**	**8.3**	**7.8**	**7.1**
0-4	46.1	11.5	7.0	5.8	8.4	6.8
5-19	32.2	0.8	6.7	7.4	6.3	7.6
20-44	25.8	0.4	4.0	5.6	6.0	7.6
45-64	49.1	29.7	3.3	-1.6	7.7	5.1
65-84	113.8	10.8	38.8	30.6	4.5	1.9
85+	388.9	43.5	18.7	32.1	60.5	35.4
MALE						
TOTAL	**49.2**	**9.7**	**8.7**	**8.2**	**7.8**	**7.3**
0-4	45.9	11.4	7.0	5.8	8.4	6.8
5-19	31.7	0.5	6.6	7.4	6.3	7.6
20-44	26.5	0.8	4.2	5.5	5.9	7.7
45-64	52.1	30.0	3.7	-0.8	8.2	5.1
65-84	131.4	14.1	41.6	31.2	5.3	3.7
85+	525.2	56.7	23.8	39.0	66.9	39.0
FEMALE						
TOTAL	**48.5**	**9.3**	**8.6**	**8.4**	**7.8**	**6.9**
0-4	46.3	11.6	7.0	5.9	8.3	6.8
5-19	32.6	1.0	6.8	7.4	6.3	7.6
20-44	25.0	-0.1	3.8	5.7	6.1	7.5
45-64	46.3	29.5	2.8	-2.4	7.2	5.0
65-84	100.6	8.4	36.6	30.1	3.9	0.3
85+	333.1	38.1	16.4	28.7	57.0	33.3

Source: U.S. Census Bureau, 2004, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," <http://www.census.gov/ipc/www/usinterimproj/>
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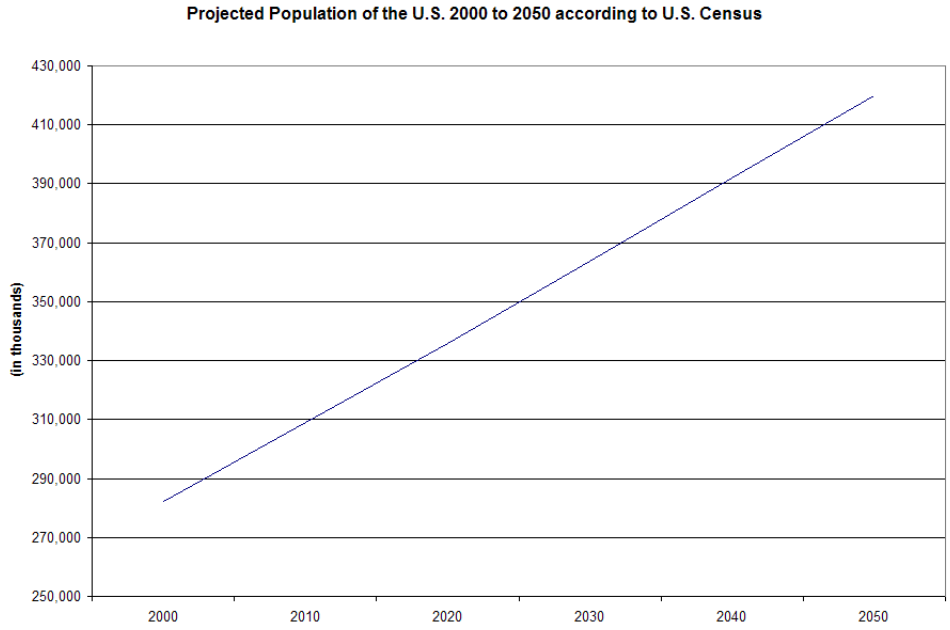
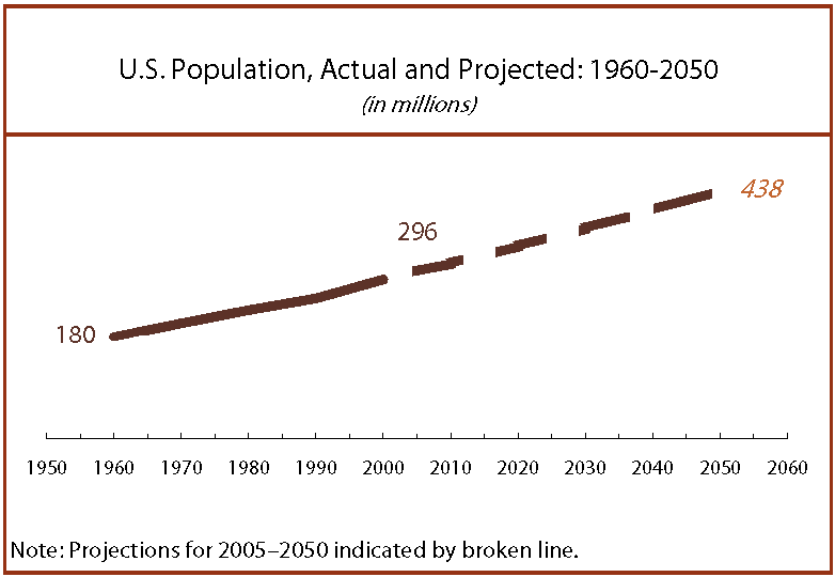
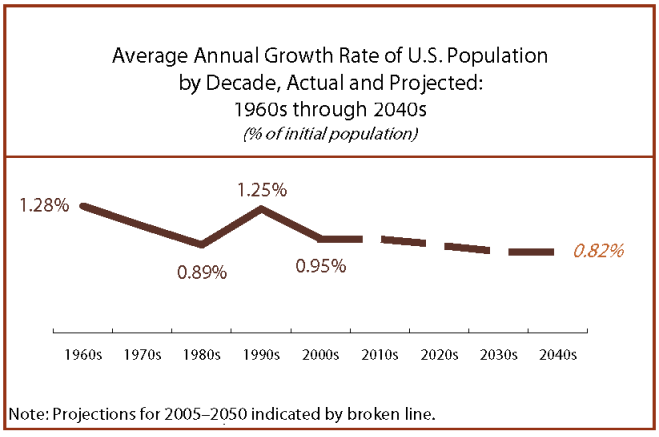
4.2 Analysis

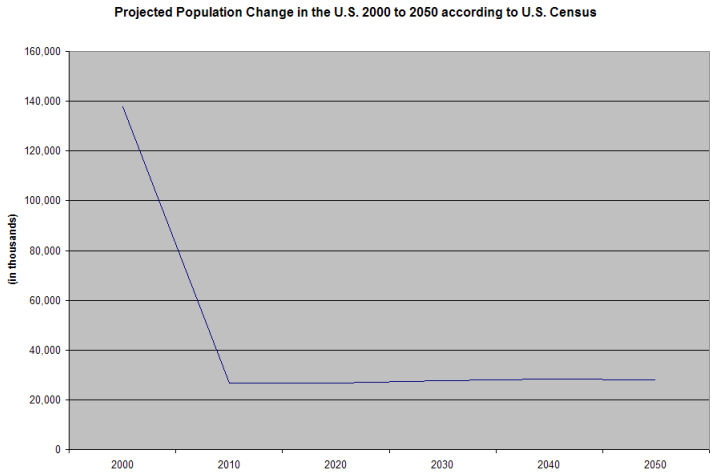


This project was only mildly to relatively successful in achieving its goals for several reasons. In considering the project's sucess in some part, the errors in projections, on average, were about 4.62 percent off from the U.S. Census Projections for actual populations for the entire time period between 2005 to 2050. This was a satisfactory margin of error, considering the fact that the project was not factoring in many, many of data that the U.S. Census does. It was also successful in reducing the error margin over time. In 2005, the margin of was about 4.92 percent, while in 2050, the margin of error was about 4.32 percent. This reduction was actually quite puzzling if one considers the project's failure to predict growth rates very successfully, as is explained in the next paragraph. I suspect that the reduction could be attributed, in part, to the logistics curve used, which has an inherent limit to consider that may have been much lower than what actually is projected.



As stated before, the project was not as successful in predicting growth rates as it was in predicting population values. The U.S. Census Bureau's U.S. Population Projections article (see bibliography item 9) states that the growth rate for the time period 1990 to 1995 was 1.10 percent while their projected growth rate for the time period 2040 to 2050 is .54 percent. The project's growth rate projections for the first time period has a margin of error of about 5 percent, while the growth rate projections for the second time period has a high margin of error of about 46.85 percent. This is a huge increase in errors that could most likely be attributed to the many known data not factored in.





Due to the large margin of errors in growth rate projections, and its relation to calculating the projected population, this project seems only mildly successful, although if one were to consider the fact that so many factors were not attriuted, it could be seen as a relatively large sucess.

4.3 Factors not Considered

The three most prominent factors not considered in this project were age, sex, and race. The U.S. Census Bureau gavbe a great amount of attention to those data, Modifying immigration in relation to race, births in relation to sex, and methodology in relation to age.

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