

WACPack: Population Growth and Carrying Capacity

I. Introduction

What will the population of the United States be in the year 2020? in 2050? And what are the implications of the projected population size for the future needs of our citizens in the areas of housing, education, health care, food production, and transportation? It is clear that we need to make some reasonably accurate estimate of future population size in order to be able to plan for the future.

Or consider the Pacific salmon, a species whose population in California is very near collapse. If we make efforts to restore the salmon population in California, we will want to monitor the size of the population on a yearly basis and to make projections for the size of the population in the future. This is of critical importance because it will enable us to determine whether our efforts at restoration have been sufficient, or whether we need to take additional steps.

The study of the size of populations, either human or animal, is of great importance to governments, policy planners, wildlife biologists, and concerned citizens. In this WACPack you will be asked to examine data about two populations, the moose of Isle Royale and the human population of the world. You will be given records of the sizes of each of the populations in the past and, in each case, asked to identify a trend for the population and to extend that trend into the future in order to make predictions about the size of the population in the future.

For a truly accurate description of a population trend, we would want to use mathematics to construct a mathematical model; we could then use that model to make predictions for the future. But we can do a reasonable job of identifying a trend by using a graphical approach, so that we do not have to get involved in the mathematical details. We will be using a graphical approach in this WACPack.

Before we get started with a discussion of graphing and the details of the two populations, we need to introduce one critical concept. Given a particular species (animal or human) in a particular environment, there is a limit to the size of the population that the environment can support. We call this limiting size the carrying capacity. If the population grows beyond the carrying capacity, the environment will not offer enough resources for the population (food, or water, or space), and, as a consequence, the population will collapse. The collapse may be partial or it may be total, leading to extinction. In either case many individuals in the population will die. Thus, in any study of population trends, we will need to consider the carrying capacity for the population.

II. Review of Graphing:

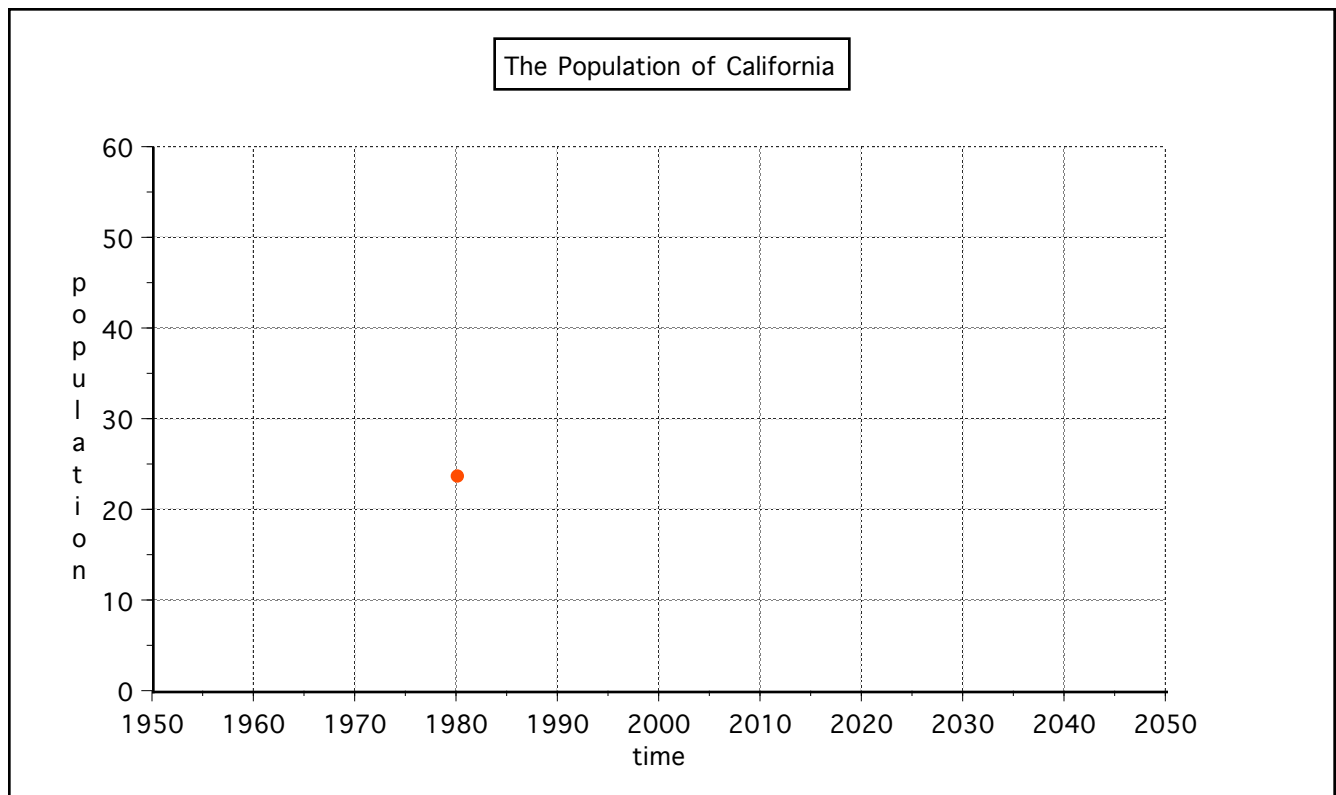
We review the fundamental ideas involved in constructing a graph for a data set. Our graphs will have a horizontal axis (used for time) and a vertical axis (used for population size). Consider the data below for the population of California, given in millions, since 1950.

year	population of California
1950	10.5
1960	15.7
1970	20.0
1980	23.7
1990	29.8
2000	33.9

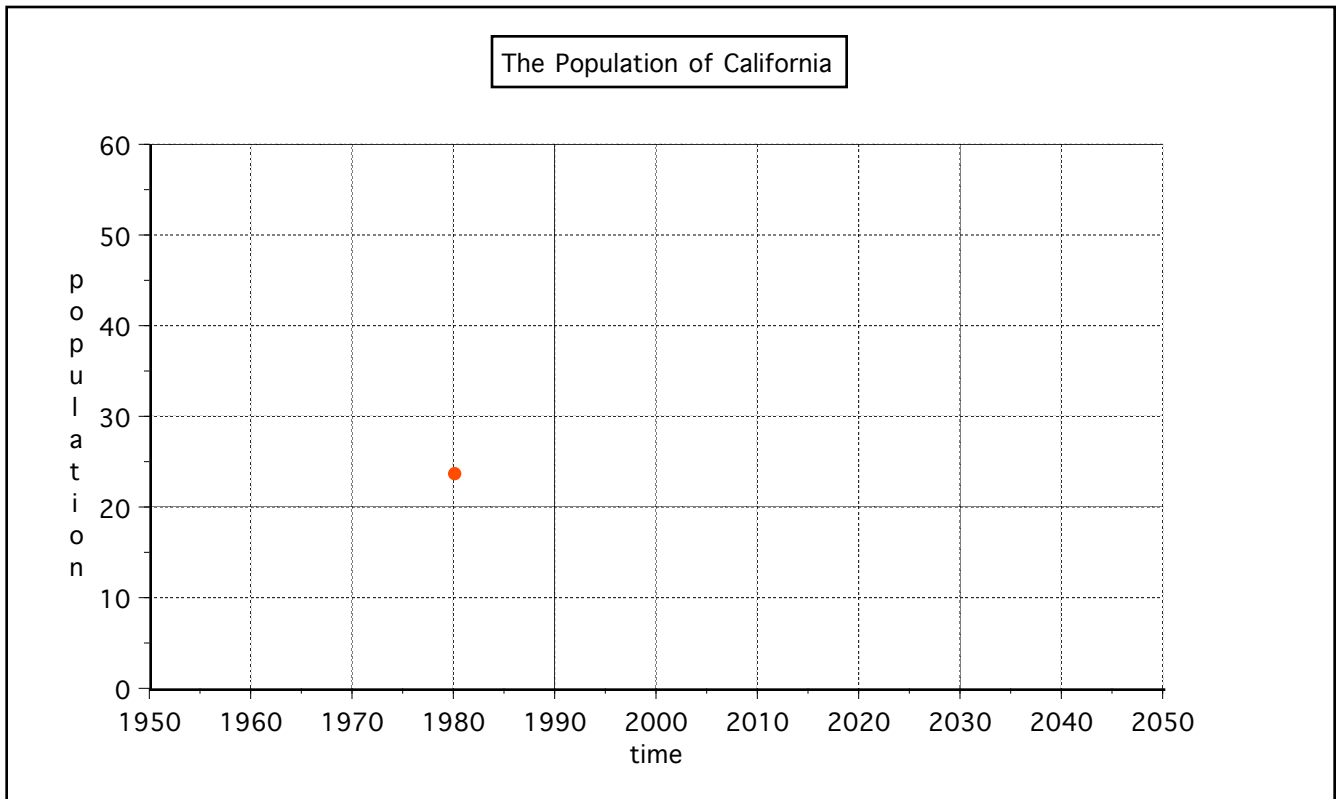
Data source:

The World Almanac and Book of Facts, 2007

Each piece of information in the table (the population of California in a given year) can be represented by a point on the graph. For example, in 1980 the population of California was 23.7 million people; this is represented by the point on the graph below. Can you read to graph to see how this point represents the 1980 population of California?



On the next page, we reproduce the graph, and ask you to complete it by plotting the remaining data points, to draw (by hand) a trendline for the graph, and then to use the trendline to make projections.



Now it's time for you to do some work.

- Graph the five points corresponding to the additional information given in the table (the populations for the years 1950, 1960, 1980, 1990, and 2000).
- Examine the six points on the graph, and visualize the trend of the data points. Is the trend you are visualizing a straight line or a curve?

Answer: _____

- Carefully draw the trend line or curve on the graph, and extend the trend into the future to the year 2050. [Note: we will refer to this as a trendline, even if it is a curve.] It is important that you draw the line or curve with great care. The result should be a smooth (not wiggly) line or curve on your graph that accurately shows the trend of the six data points.
- Use your trendline to predict the population of California in the year 1985, in the year 2020, and in the year 2050.

Answers: _____

- Use your trendline to predict the year in which the population of California will reach 50 million.

Answer: _____

III. Moose on Isle Royale

Isle Royale is a sizable island (45 miles long and 8 miles wide) in Lake Superior between the United States and Canada. The entire island is a National Park, and it has no permanent human residents. In the summer, a few Park Service employees live on the island, and tourists visit the island to camp and hike; there are no residents in the winter.



Because of the remote location, the island has a relatively simple ecosystem with only two populations of large animals: moose and wolves. One consequence of the isolation of the Isle Royale is that there is almost no outside impact on the island's ecosystem. Wildlife biologists, therefore, have an almost completely natural environment to study, and they have been following the moose and wolf populations for over fifty years. Historically, the moose were food for the wolves, and the wolves kept the moose population in check at a level of about 1000 moose. In the early 1980's, a dog introduced parvovirus to the island, and the impact on the wolf population was severe. There were still a few wolves on Isle Royale, but not enough to keep the moose population under control. As a result the moose population grew dramatically.

Data for the moose population is given by the table below:

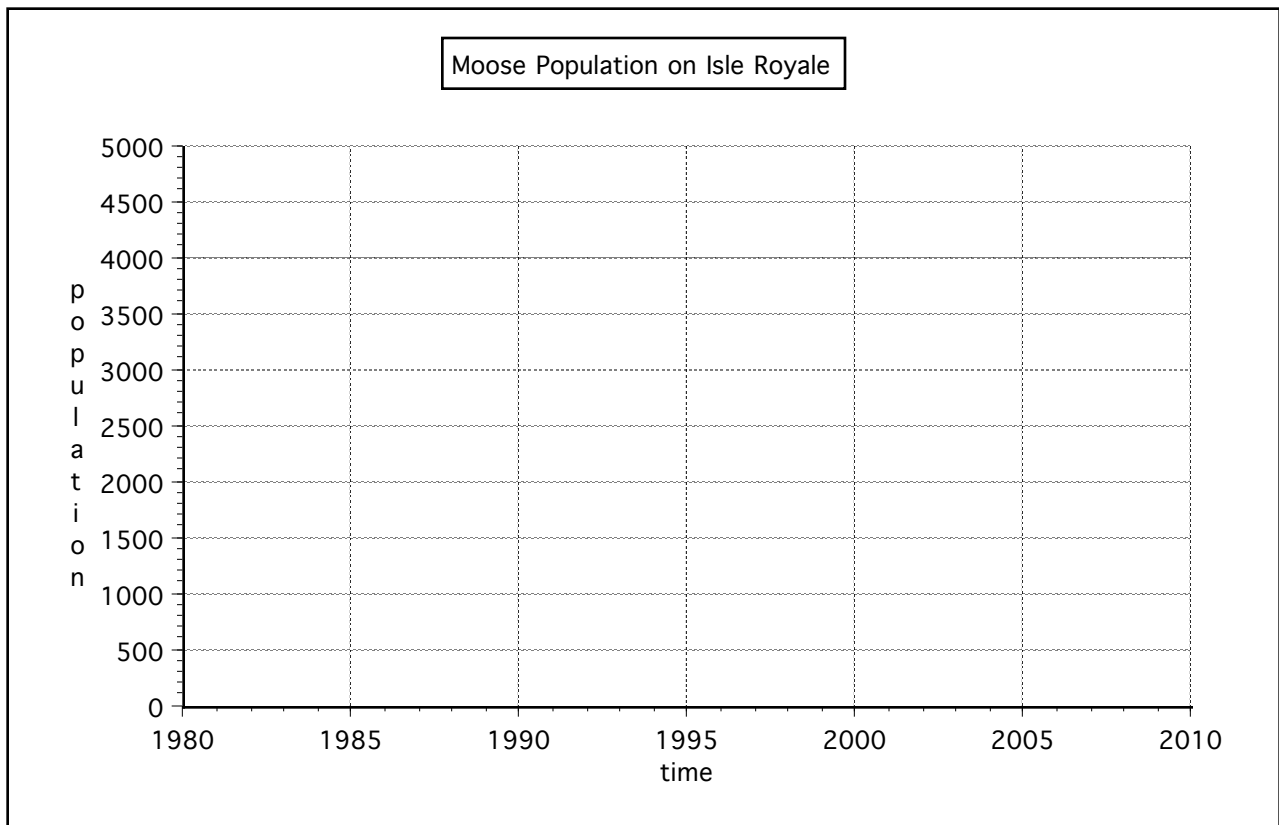
year	number of moose
1980	910
1981	863
1982	872
1983	932
1984	1,038
1985	1,115
1986	1,192
1987	1,268
1988	1,335
1989	1,397
1990	1,216
1991	1,313
1992	1,590
1993	1,879
1994	1,770
1995	2,422

Data Source:

The Wolves and Moose of Isle Royale:
Wolf and Moose Abundances

available on the web at

www.isleroyalewolf.org/data/data/womoabund.html



Complete the following exercises to examine the past trend of the moose population, and to make projections into the future.

1. Graph the data points on the graph.
2. Examine the data points on the graph, and visualize the trend of the data points. Is the trend you are visualizing a straight line or a curve?

Answer: _____

3. Carefully draw the trendline on the graph, and extend the trendline into the future to the year 2050. [Recall: the trendline may actually be a curve.] It is important that you draw the line or curve with great care; it should be smooth, not wiggly, and it should accurately show the general trend of the data points. [Note: the data points you have graphed exhibit some variation from a smooth trend, so your trendline will not hit every data point.] Just draw a smooth line or curve that comes reasonably close to the points, illustrating the general trend.

4. Use your trendline to predict the Isle Royale moose population in the year 1998 and the year 2001.

Answers: _____

5. Use your trendline to predict the year in which the Isle Royale moose population will reach 5000.

Answer: _____

6. Your graph should indicate a dramatic increase in the moose population. What conditions on Isle Royale would be necessary to support such an increase? List three.

Your projections for the years 1998 and 2001 were based on the trendline you drew using the trend for the years before 1996. The wildlife biologists were busy counting moose each year, and the actual moose counts (as opposed to your projections) for the years 1996 through 2003 are given in the data table below.

year	number of moose
1996	1,163
1997	500
1998	699
1999	750
2000	850
2001	900
2002	1,100
2003	900

7. Add these additional data points to your graph on the previous page.
8. How do your projections compare with the new data, the actual moose counts? Were your projections accurate, or were your projections significantly too high, or too low? If your projections were wrong, were they wrong by a small amount or were they dramatically incorrect?

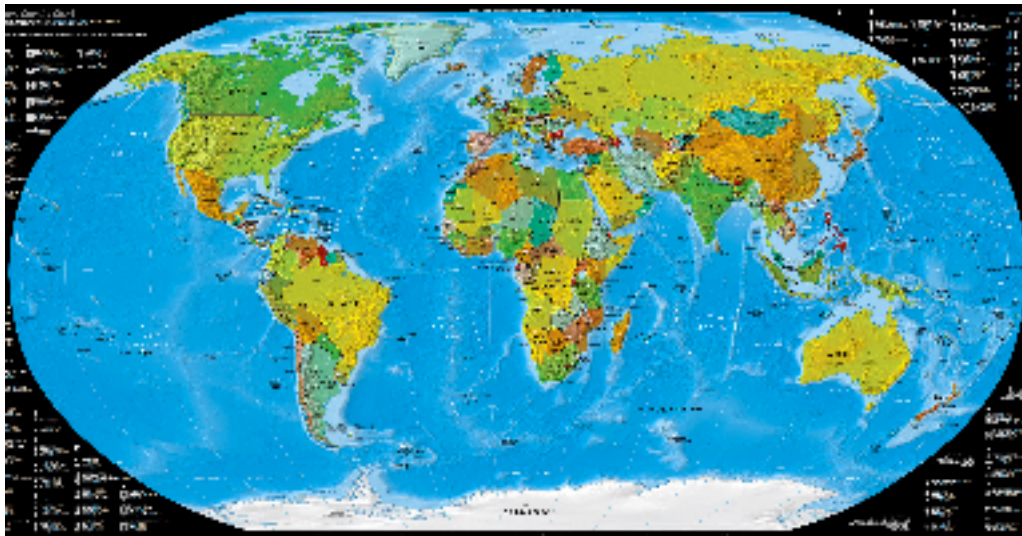
9. Why do you think your projections were so far off? Discuss.

10. Based on the work you did with the data, and the data set itself, make a reasoned guess about the carrying capacity of the moose population on Isle Royale.

Carrying Capacity: _____

IV. World Population

The population problem, the idea that population of the Earth continues to grow and that we are approaching the carrying capacity of the Earth (or perhaps we have already exceeded it), has worried both scientists and concerned citizens for some time now. In this exercise, we examine data on the population of the Earth in order to better understand the population problem and to begin to think about possible solutions.



Data on the population of the Earth, from 1500 to the present, are given in the table below. A perusal of the numbers will indicate that population growth was relatively slow between 1500 and 1750, but that, more recently the population has been growing at a much faster rate. We can get a better idea of the current trend in population growth if we graph the data and draw a trendline. We will graph the data since 1900.

year	world population (in billions)
1500	0.50
1750	0.79
1800	0.98
1850	1.26
1900	1.65
1910	1.75
1920	1.86
1930	2.07
1940	2.30
1950	2.52
1960	3.02
1970	3.70
1980	4.44
1990	5.27
2000	6.06

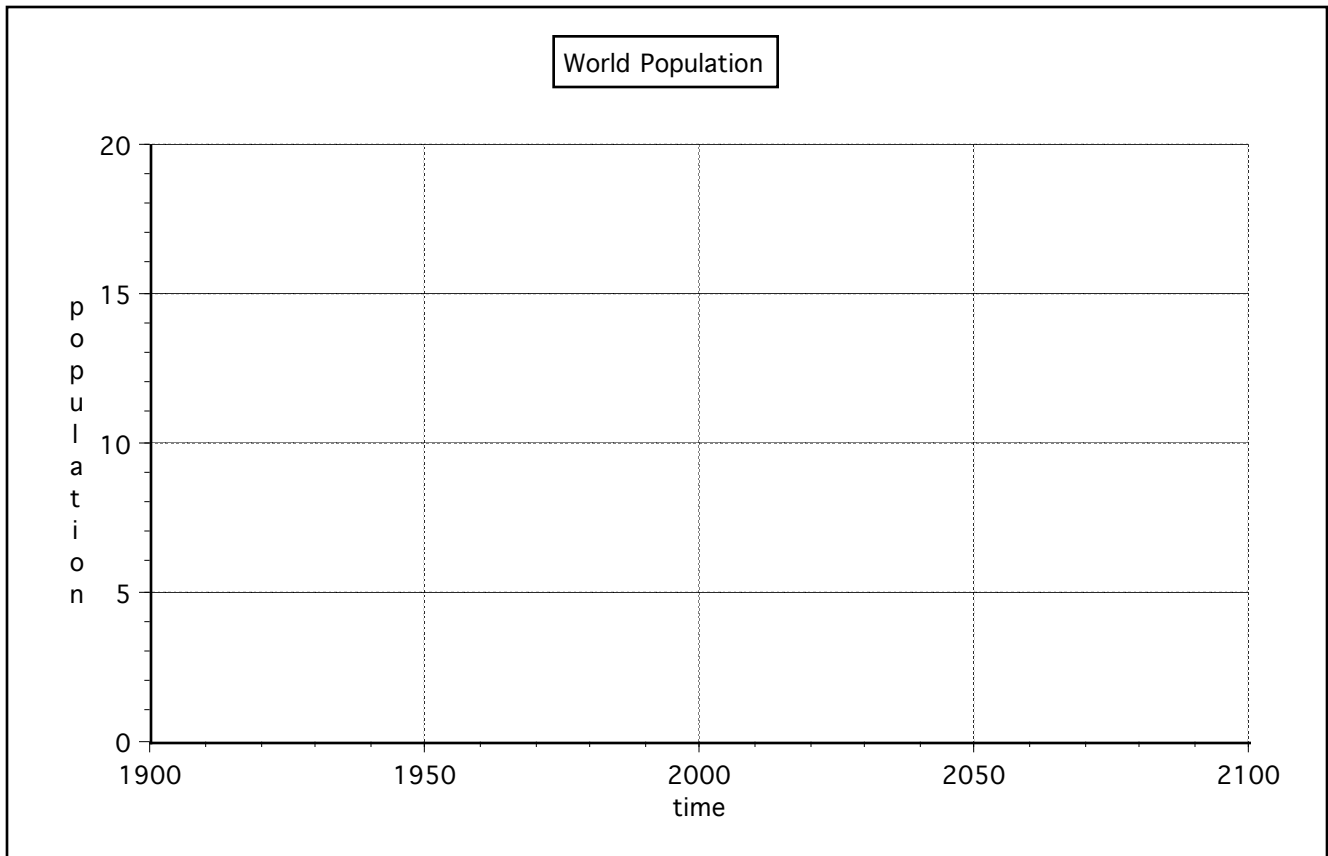
Data Source:

The United Nations Report: The World at Six Billion

available on the web at

www.un.org/esa/population/publications/sixbillion/sixbilpart1.pdf

Note: the data are reproduced on the next page to make the task of graphing easier



year	world population (in billions)
1500	0.50
1750	0.79
1800	0.98
1850	1.26
1900	1.65
1910	1.75
1920	1.86
1930	2.07
1940	2.30
1950	2.52
1960	3.02
1970	3.70
1980	4.44
1990	5.27
2000	6.06

Complete the following exercises to examine the past trend of the world population, and to make projections into the future.

1. Graph the data points since 1900 on the graph.
2. Examine the data points on the graph, and visualize the trend of the data points. Is the trend you are visualizing a straight line or a curve?

Answer: _____

3. Carefully draw the trendline on the graph, and extend the trendline into the future to the year 2100. [Recall: the trendline may actually be a curve.] It is important that you draw the line or curve with great care; it should be smooth, not wiggly, and it should accurately show the general trend of the data points. [Note: the data points you have graphed exhibit some variation from a smooth trend, so your trendline will not hit every data point.] Just draw a smooth line or curve that comes reasonably close to the points, illustrating the general trend.

4. Use your trendline to predict the population of the Earth in the year 2020 and the year 2050.

Answers: _____

5. Use your trendline to predict the year in which the population of the Earth will reach 10 (billion).

Answer: _____

6. Your graph should indicate a dramatic increase in the population of the Earth. What conditions would be necessary to support such an increase? List three.

7. Your projections for the future were based on the trendline you drew using the trend for the years from 1900 to 2000. Do you think the trend you identified will continue into the future? Or do you think the population will crash at some point (like the moose on Isle Royale)?

To answer this question, you might want to consider your answers to Question 6. You might also want to think about the carrying capacity of the Earth.

V. Essay Assignment

You have examined the data on the growth of world population by graphing it, identifying a trendline, and making projections for the future. Now it is your turn to summarize and evaluate what you have learned.

Write an essay which addresses the following three questions:

1. Is the “population problem” truly a problem? Why or why not?

You will want to support your answer to this question with relevant data and analysis. Your paper must include your graph of the trend in world population and an analysis of that graph, along with your projections for the future. You may want to discuss

2. If the “population problem” is truly a problem, when will things become critical?

Your discussion of this question should examine the question of the carrying capacity of the Earth. Speculate about what the carrying capacity might be. As you think about carrying capacity, you might want to consider various resources: food, water, forests, the oceans, energy (fossil fuels), climate, air, and others.

3. What actions do you recommend to deal with the issue of population growth?

Describe the actions that you think we should take. Discuss who or what entity should take these actions: individuals? corporations? local governments? federal governments? the United Nations? other organizations? How would each of the actions that you recommend work to ameliorate the problems associated with the growth of the world’s population?

Your essay should be well formed with clear thesis statements, supportive paragraphs, a clear and easily readable graph, and a strong concluding paragraph. Your body paragraphs should synthesize coherently both relevant quantitative information you have studied as well as the content and opinions you have gleaned from readings and discussion. You may also discuss relevant important questions that need further research.