PROJECT G. (10%)

POPULATIONS, RAIN FORESTS, CHESAPEAKE BAY, BELIZE and THE WORLD

This assignment was originally designed to expand upon certain information presented at the Baltimore Aquarium "Rain Forest Exhibit. Perhaps you've seen it. It is not necessary to go to the Aquarium to do this exercise and you need not worry about references to the "exhibit" (like the sentence that follows) in this document. The rain forest exhibit with world map, lights, and numbers illustrates a model of projected changes in the number of human inhabitants and the number of rain forest acres that exist on earth. The number of people is increasing and the number of trees (acreage) is declining. Both the human population growth and tropical forest destruction are changing exponentially (geometrically) as illustrated on the graph below. If the population were growing arithmetically, the graph would be a straight line. In geometric growth the population grows faster and faster as time goes on. The rate of growth is also increasing and the line curves upward. The following exercise is designed to introduce you to the arithmetic of geometric changes. You will need a calculator with a Y^x key. A kid's 4 function "Barbie" or "Ninja Turtle" calculator will not do, but a half-way decent scientific calculator will be fine.

The most famous and seminal writing related to the subject of human population growth, and which Darwin extended to natural populations and used to support his theory of evolution is:


Trends in Deforestation and Population Growth, 1850-1987


1
According to Dr. Paul Jokiel of the Hawaii Institute of Marine Biology there are 3 major problems assaulting the earth’s environment. They are:

A. Uncontrolled human population growth (more people)
B. Increased per capita consumption (each wanting and using more stuff, cars, TV's, VCR's etc)
C. Ignorance and/or denial of A & B

Regardless of social, religious, political and economic issues that might be attached to any discussion of human population growth, the underlying and undeniable arithmetic of this growth is easily, although not widely, understood.

Think of any 5 different environmental problems affecting human society today and list them below.

☐ 1.
☐ 2.
☐ 3.
☐ 4.
☐ 5.

2. Put a check next to those problems where you can see a direct relationship between that problem and increased human population and/or increased per capita consumption. For each item you choose, write one or two sentences below about how they are related to those two factors.
One formula often used by biologists studying population growth is:

\[ P_n = P_o \left[1 + \left(\frac{i}{100}\right)\right]^n \]

(Don’t faint, have a fit of apoplexy or a case of the vapors. If I can do this, you can do this!!!)

We will focus on this equation to explore the meaning of geometric rates of increase of human populations. (the same equations hold true for natural populations of trees, mice, parrotfish, bacteria, etc. I want you to: 1) understand where the numbers in the rain forest exhibit come from and how such projections of global population growth are made, 2) apply this arithmetic to local, regional and global populations, and 3) be able to evaluate the meaning of these projections and draw your own conclusions as to what, if anything, needs to be done about them by the citizens of our democracy and the rest of the planet too. GET OUT YOUR CALCULATOR.

**Example 1:** The relationship between population size and annual rate of increase is shown in the following expression:

\[ P_n = P_o \left[1 + \left(\frac{i}{100}\right)\right]^n \]

where...
- \(P_o\) = the population size "right now" (at time zero or the start of the study)
- \(P_n\) = the population "n" years after "now"
- \(i\) = % increase of the population per year
- \(n\) = the number of years

For example, if a region had a population of one million now (2007 A.D.) and a growth rate of 1.5% per year, the population in 20 years would be calculated as follows:

a. \(P_n = P_o \left[1 + \left(\frac{i}{100}\right)\right]^n\)

b. \(P_{2020} = P_{2000} \left[1 + \left(\frac{i}{100}\right)\right]^{20}\)

c. \(P_{2020} = 1,000,000 \left[1 + \left(\frac{1.5}{100}\right)\right]^{20}\)

d. \(P_{2020} = 1,000,000 \left[1 + \left(\frac{0.015}{1}\right)\right]^{20}\)

e. \(P_{2020} = 1,000,000 \left[1.015\right]^{20}\)

f. \(P_{2020} = 1,000,000 \left[1.34685\right]\)

g. \(P_{2020} = 1,346,850\)

Use the exponent key (\(y^x\)) on your calculator and work through this example yourself:

\[ 1 + 1.5\%/100 = 1 + 0.015 \text{ which equals } 1.015 \text{ so...} \]

now you have to raise 1.015 to the 20\(^{th}\) power. do it like this...

enter 1.015

press the \(y^x\) key

enter 20

press =
and you get 1.34685
now, multiply this by 1,000,000 (the starting population to get a population that has grown
to 1,346,850 by the year 2027 A.D. (i.e. 20 years after 2007.)
By the way, this is exactly the same formula you would use for compounded interest in a bank
account or stock fund. If you put $1000 in the bank at 3.5% interest per annum in 2007 A.D., how
much money would you have 10 years later in 2017 A.D.? Change the P for population to M for
money.

\[
\begin{align*}
\text{a. } \quad M_n &= M_0 \left[1 + \left(\frac{i}{100}\right)\right]^n \\
\text{b. } \quad M_{2011} &= P_{2001} \left[1 + \left(\frac{i}{100}\right)\right]^{10} \\
\text{c. } \quad M_{2011} &= \$1000 \left[1 + \left(\frac{3.5}{100}\right)\right]^{10} \\
\text{c. } \quad M_{2011} &= \$1000 \left[1 + (0.035)\right]^{10} \\
\text{e. } \quad M_{2011} &= \$1000 \left[1.035\right]^{10} \\
\text{f. } \quad M_{2011} &= \$1000 \left[1.410599\right] \\
\text{g. } \quad M_{2011} &= \$1,410.60 \\
\end{align*}
\]

Here’s a little trick… you can find the doubling time (of your money or a population) by dividing 69
by the percent growth rate. So… your $1000 would double in 69/3.5 = 19.7 years.
If you got 8%, you would double it in 69/8 = 8.6 years. There are a few underdeveloped countries
with population growth rates of 6%. How many years will it take for them to double their
population? _________ years!!! (Hint: 69 ÷ 6)
The growth rate of the USA (2006 est) 0.91%. How long will it take for the population to double
from its present 300,000,000 to 600 million? _________________. Go to the Internet and
answer these questions: What is the most populous country on Earth? _____________; second
most populous? ________; third _________ fourth _____________ fifth? __________.
The growth rate of Belize is 2.31% (2006 est) and the population (probably grossly
underestimated) was 288,000 people. How long will it take for the population of Belize to double
its population? ________________.
I have heard that a recent estimate of the population of San Pedro was 4,000 but when a
hurricane was approaching more than 10,000 people evacuated the island. So, estimates are often
incorrect and not exactly “in the ballpark.”

**Example 2:** The 2 main factors affecting the growth rate of a population are how many
individuals are **BORN** compared to how many **DIE**. (Birth rate or natality compared to death rate
or mortality.) Russia, at the present time, has a natality of 20 births per 1000 people and a
mortality rate of 10 deaths per 1000 people per year. The population growth rate is (Births -
Deaths) ÷ Population size.

\[
\frac{20 - 10}{1000} = \frac{10}{1000} = \frac{1}{100} = 1\% \quad \text{growth per year}
\]
In some countries the birth rate may be 50 per 1000 per year with a death rate of 10 per thousand per year. What would the population growth rate be in a country with numbers like that? Figure it out below.

**Example 3**: Consider the following example from the state of Hawaii. Kaneohe (con-ee-oh-ee) Bay is a small ocean bay on the island of Oahu, the most populous of the Hawaiian Islands (where Honolulu and Pearl Harbor are located.) Much of the population growth on Oahu is due to immigration exceeding emigration. (The difference between **immigration vs emigration** and **natality vs mortality** pretty much determine the population size for all organisms including people everywhere. That is the relations hip between how many are born and how many die and how many arrive and how many leave determines the population size.)

a. Calculate the % increase in the Kaneohe Bay human population **FOR EACH DECADE** by dividing the increase in the # of people during that decade by the number of people at the start of the decade, e.g., for the 1st decade of the 20th century the % increase was

\[
\frac{(1900 - 1700)}{1700} = \frac{200}{1700} = 0.118 \\
0.118 = 11.8\%
\]

That's an 11.8% increase in the Kaneohe Bay population between 1900 and 1910. Now you do the remaining decades up to 1990.

**Human population on the Kaneohe Bay watershed.**
*(Census tract 31 which includes area from Kualoa to Kailua.)*

<table>
<thead>
<tr>
<th>YEAR</th>
<th>POPULATION</th>
<th>DECADE'S % INCREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>1,700 (est)</td>
<td>xxxxxxxx</td>
</tr>
<tr>
<td>1910</td>
<td>1,900 (est)</td>
<td>11.8%</td>
</tr>
<tr>
<td>1920</td>
<td>2,990</td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td>4,142</td>
<td></td>
</tr>
<tr>
<td>1940</td>
<td>5,387</td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>9,559</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>29,622</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>46,299</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>47,335</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>56,000 (est)</td>
<td></td>
</tr>
</tbody>
</table>

*The Pali Tunnel, built in 1957, greatly improved access from Honolulu to the Kaneohe Bay Region.*

*H-3 Tunnel constructed in 1995 provided more access for more people to Kaneohe Bay.*
Calculate a projected future population of Kaneohe 50 yrs and 100 yrs after 1990 if the growth rate is 1.5%, 3.0%, and some higher value that you choose by looking at the historical data above.

<table>
<thead>
<tr>
<th>Year</th>
<th>1.5%/yr.</th>
<th>3.0%/yr.</th>
<th>Your Estimate @ ?%/Yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2090</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Example 4:** Now consider some data from the Chesapeake Bay watershed region. This includes counties in New York, Pennsylvania, Maryland, Virginia, Delaware, The District of Columbia, and West Virginia.

The current human population of the Chesapeake Bay watershed is more than 14 million people. Between 1940 and 1986, the population grew from 7,579,653 to 14,142,300. Calculate the % increase of humans inhabiting the watershed during this 46 year period.

____________ %

What would the population be 46 years after 1986 (i.e., 2032) if the 1986 population also increased by another 86.6%?

____________________ people

(Using the 69 rule, calculate how many years it would take to double a population of 14 million if the growth rate were, say, 1.5%. _______________ years.)

Predict 3 ways you think the Chesapeake Bay and its watershed would change if the population grew to more than 26 million people.

1. _____________________________________________
   _____________________________________________
   _____________________________________________

2. _____________________________________________
   _____________________________________________
   _____________________________________________

3. _____________________________________________
   _____________________________________________
   _____________________________________________
Population
1940
Each Dot = 1000

Totals for Portion of States Within the Watershed:
DC: 836,235
DE: 84,559
MD: 1,706,959
NY: 495,710
PA: 3,008,538
VA: 1,530,935
WV: 118,617
Total: 7,579,653

CHESAPEAKE BAY WATERSHED
Map compiled by S. Everitt and R. Cardone
Chesapeake Biological Laboratory, University of Maryland, Solomons, MD 20688
Population
1986
Each Dot = 1000

Totals for Portion of States Within the Watershed:
DC.......................... 626,100
DE.......................... 214,900
MD.......................... 4,436,800
NY.......................... 672,400
PA.......................... 3,514,300
VA.......................... 4,510,900
WV.......................... 165,500
Total........................ 14,142,300

CHESAPEAKE BAY WATERSHED
Map compiled by S. Tenenbaum and R. Castello
Chesapeake Biological Laboratory, University of Maryland, Solomons, MD 20688
The average growth rate in the Maryland and Virginia portions of the watershed were about 1.35% per year between 1972 and 1986. Again, a recent (1986) county by county census of the population of the Chesapeake watershed estimates 14,142,300 inhabitants. Compute the projected watershed populations 64 and 114 years after 1986 if the growth rates are 1%, 1.35% or 1.5%.

<table>
<thead>
<tr>
<th>Year</th>
<th>1% per yr.</th>
<th>1.35% per yr.</th>
<th>1.5% per yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>14,142,300</td>
<td>14,142,300</td>
<td>14,142,300</td>
</tr>
<tr>
<td>2050</td>
<td>33,361,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using a growth rate of 1.35%, calculate the projected population of the watershed every 20 years for the century following 1986.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>14,142,300</td>
</tr>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>2026</td>
<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
</tr>
<tr>
<td>2066</td>
<td></td>
</tr>
<tr>
<td>2086</td>
<td></td>
</tr>
</tbody>
</table>

Plot your data on the graph below.

![Graph](image-url)
Example 5: As a (very) crude example of environmental modeling, use the following data and your previous calculations to answer these questions.

1. Between 1952 and 1986, the per capita energy use has increased 36.5% from 567,000 to 744,000 BTU per day. Suppose it stays at 744,000 BTU per person per day. How many total BTU's of energy did the 14,142,300 inhabitants of the watershed use on an average day in 1986?

2. How many total BTU's will the watershed’s population require in the year 2100 (at a 1.35% annual increase) if the use rate stays at 744,000 BTU/day/person?

3. What percent increase would this be? ______________%

4. What effect do you think this would have on the coal, oil and nuclear power plants of companies like PEPCO, Marant, SMECO and Baltimore Gas and Electric?

5. What effect do you think this would have on the Chesapeake Bay? Explain (intelligently).

6. Solid waste (trash) production increased from 2.2 lbs. per day to 3.7 lbs. per day per capita between 1952 and 1986. This is a ______% increase. With 14,142,300 people in the watershed in 1986___________________total pounds of solid waste were produced per day in 1986.
7. How many pounds of solid waste did we produce over the entire year? __________________

8. Suppose we completely reverse this trend and go back to producing 2.2 lbs. per day per capita, but our population grows at the rate of 1.35% per year. Use your previously calculated value for the projected population size in the year 2100 and calculate the total pounds of solid waste produced in the watershed in one year (2100 A.D.!

9. If we cut back to 2.2 lbs. per capita per day, will we be producing MORE or LESS solid waste in 2100 than in 1986? __________________ By what %? __________% 

My calculator says with a 1.35% rate of increase the watershed will have 65,227,074 people in 2100 (compared to 14 million in 1986, that’s a 361% increase. We would need 3.61 times more garbage trucks, 3.61 times more landfill (just for that year!) not to mention the amount of landfill that would have been filled in the 114 years between 1986 and 2100. The numbers are truly staggering! If 14 million people are producing 3.7 lbs of trash per day in 1986, 65 million would have to cut back to 0.8 lbs per day. That’s 13 ounces! My Washington Post for Monday, April 7, 2003, weighed 466 grams. That’s more than one pound! Perhaps “Failure to Recycle” will be a crime in 2100!

Blue Plains Wastewater Treatment facility discharges about 200 million gallons per day of wastewater into the Potomac River while the Back River Plant in Baltimore releases about 180 million gallons per day. We have substantially reduced the amount of nitrate and phosphate released with this water over the past decade, but at considerable expense. Further improvement of these facilities especially the cost of removing nitrate is very expensive. How will we pay to upgrade wastewater treatment to tertiary levels in Maryland’s 160 public and 50 industrial treatment plants, especially if the population doubles or triples? Do you think the taxes collected from all those people would offset their potential environmental impact. (And, don’t forget I am counting on YOUR taxes to pay for MY social security.)

Any fisheries scientist would agree that most of the problems of fisheries management have little to do with managing fish but a lot to do with managing people (who kill fish by catching them, polluting them, destroying the places where they lay their eggs, etc., etc.) Likewise the scientists who study the total Chesapeake Ecosystem report "The Chesapeake Bay has 200,000 people living in the drainage basin for every km³ of water in the Bay (the Baltic Sea has 4000 people/km³, and the Mediterranean has 85 people/km³ by way of comparison). Even if all of these people were minimizing their environmental impacts (which they are not) their sheer numbers are daunting to a system as sensitive as the Chesapeake. If these numbers continue to increase as they have been in the past, the prospects for America’s largest estuary seem bleak."

Example 6: Now consider the entire planet. The population arithmetic for the earth as a whole is even more daunting than that for the Chesapeake Bay.

"ONE MISSISSIPPI" -- In the one second it took you to say those two words, 5 new people were added to the world's population (+240,000/day, +90,000,000/yr, 2006 est.) About 17 million people (net, 2006 est) join the human race each week. At that rate the entire population of Maryland (about 5.7 million) is produced in about 3 weeks! With population growth rates of 3%, Africa seems to be in the greatest trouble. At 3% annual growth rates, populations double in 24 years. Paul Ehrlich writes:

"In order to just keep the standard of living at the present inadequate level, the food available for the people must be doubled every 24 years. Every structure and road must be duplicated. The amount of power must be doubled. The capacity of the transport system must be doubled. The number of trained doctors, nurses, teachers, and administrators must be doubled...This would be a fantastically difficult job in the United States--a rich country with a fine agricultural system, immense industries, and access to abundant resources. Think of what it means to a country with none of these."

Population of the planet earth:

1 A.D. 200,000,000
1850 1,000,000,000
<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>2,000,000,000</td>
</tr>
<tr>
<td>1990</td>
<td>5,300,000,000</td>
</tr>
<tr>
<td>Presently</td>
<td>6.5 billion +</td>
</tr>
</tbody>
</table>

**Problem 1:** Calculate future population of Earth (50 yrs, 100 yrs)

<table>
<thead>
<tr>
<th>%/yr</th>
<th>Your best estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5%</td>
<td></td>
</tr>
<tr>
<td>3.0%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040</td>
<td></td>
</tr>
<tr>
<td>2090</td>
<td></td>
</tr>
</tbody>
</table>

**Problem 2:** Increase in per capita consumption

Developing nations are calling for as much as a 3% annual increase in "sustainable development". Increased use of resources per capita, combined with population growth will place increasing demands on the environment. Food must be produced, energy must be provided, waste disposal must be handled. Calculate the increase in demand on these resources given a 1.5% annual population increase and a 3.0% annual development increase (total 4.5%) over the next 20 yrs ___________ 50 yrs ___________ 100 yrs ___________

Future Environmental Demand = Present Demand x \[1 + (i/100)]^n

\[i = \% \text{ increase per year}\]
\[n = \text{number of years}\]

Simply set Present Demand = 1

To complete this exercise (finally!), choose ONE of the following three "points of view" and write a 1 page (250 word) essay supporting that option. Give your own carefully considered opinions.

a. Ehrlich, Tannenbaum, Costanza and Jokiel are what former NY Congressman Jack Kemp would call "Malthusian Alarmists". Despite current trends the population "problem" is not nearly as bleak as it seems. But if I were in charge of San Pedro and its coral reef I would adopt the following policies because ...... OR

b. This population "problem" does indeed paint a bleak picture for the future of the Belize Barrier Reef and Ambergris Caye. If I were in charge of San Pedro and its coral reef I would adopt the following policies because ...... OR

c. The situation is even bleaker than the environmentalists project because they are only talking about resources, infrastructure, pollution, etc. There are many other social problems that could result from overpopulation in addition to environmental ones. The following additional problems would exacerbate (worsen) even Ehrlich’s predictions and make the situation worse. If I were in charge of San Pedro and its coral reef I would adopt the following policies because ..........
Appendix 1: The following letter is from a student who graduated with a degree in computer science from the National University of Rwanda. Innocent is a friend of mine and I send him some money every year to support him in his efforts to survive in the third world. His family was directly and profoundly affected by the Rwanda Genocide of 1994 when about 750,000 people were slaughtered in less than four months. Another 250,000 fled to a marginally better existence in the neighboring Congo.

He has tried vigorously to “make it” in his homeland, Rwanda, and has migrated to Kenya, Mauritius, and recently Zambia to make a better life for himself. This is an email he sent to me in 2007. (His native language is Kenyawandan, he is fluent in French and English is his third language.)

Dearest Prof, hello ! I’m so happy that you’ve received the card before your birthday ! I reckon you have had so much fun at that special day ! Excuse me for bothering you, you are turning 58 years, am I right ?

I’m right know working here in Zambia as a teacher, but this is just a temporary job, as I’m looking for something better ? But will I ever find it here ? I’m like a sinking man clasp at a serpent ! That serpent is Zambia ! In fact, Zambia is so poor but mathematically, it wasn’t supposed to ! It has got large and fertile lands and a limited population, plenty natural resource, particularly copper, a rich and diversified flora and fauna, which could attract thousand of tourists. Surprisingly, people are living in poverty ! I think it’s because of mental poverty !

Well, I’ve got another idea, and I think with your help, my project could thrive ! Here, like in so many poor countries, the environment has been neglected ! Rubbish are everywhere, sewage system is always blocked, in many neighborhood, there are no bins. The biggest environmental problem here in Lusaka is plastics envelops which are put everywhere ! According to my observations, 90% of all goods sold in groceries here, from sweets to the cooking oil, passing by the juices are enveloped in plastics. So, there are hundred of thousands of plastics which are thrown away everyday ! As you can see, people here are running toward a disaster !

So I think of setting up a non profit organization which will try to fight against the plastics wastes novice effects ! Be a lie if I told you that a son humble organization could resolve such a problem which is a real quagmire, but we can just lessen the effects.

In my home country, I’ve tried to found two organizations but they failed ! I have always believed that those failures are due to the fact that nobody is a prophet at his own land ! I’m now looking for some members, and I invite you to be one ! Maybe, we could collaborate with the other organization that you’ve found !

Next time, I’ll tell you much more about it !

I’ll close now, please give my hugs to everyone !
faithfully yours !

Innocent