Issue 1

HUMAN POPULATION GROWTH
HOW LONG WOULD IT TAKE TO FILL UP THE EARTH?

KEY QUESTIONS

- What is the Earth's population and how fast is it growing?
- Where is population growing fastest?
- What is population projected to be in the future?
- How does human population growth threaten the environment?
- What can we do to lessen these threats?
- Who is responsible for solving the problem?

BACKGROUND

Population growth is one of the most contentious subjects in the entire field of environmental studies; it is also basic to any environmental issue.

Why is human population growth an environmental issue? Although humans exert a substantial positive impact with our enormous ingenuity, we also have a profound physical impact on our local, regional, and global environment. First, we take up space—space that at one time was forest, wetland, prairie, or hillside. The space an individual occupies may be minimal, as in cities in New Guinea (Figure 1-1), or it may be large, as in newer U.S. single family houses (Figure 1-2), which averaged over 2100 ft^2 (0.05 acres, or 0.02 hectares) by the late 1990s.[1]

In addition, since humans must eat, we require land for agriculture, and much of that land is irrigated. In most instances this land is also fertilized, usually with industrially produced fertilizers. An additional pollution load is generated by animal waste during meat production in factory farms (also known as Confined or Concentrated Animal Feeding Operations, or CAFOs). The incidence of large-scale fish kills in streams draining agricultural areas and CAFOs is increasing.[2]

People also require transportation. Roads generate polluted runoff, cover permeable land with impervious paving, and take formerly productive land off the tax base. Roads also take an enormous toll on animals (including humans) and other wildlife, divide habitats (which may accelerate species loss), and provide human access to wilderness and for-

[1]U.S. Bureau of the Census. 1999. Characteristics of New Housing (http://www.huduser.org/publications/destech/newhsg99.html).

[2]Spills and Kills: Manure Pollution and America's Livestock Feedlots: A Report by the Clean Water Network, the Izaak Walton League of America, and the Natural Resources Defense Council. 2000. (http://www.cwn.org/docs/reports/spillkill/spillkillmain.html).

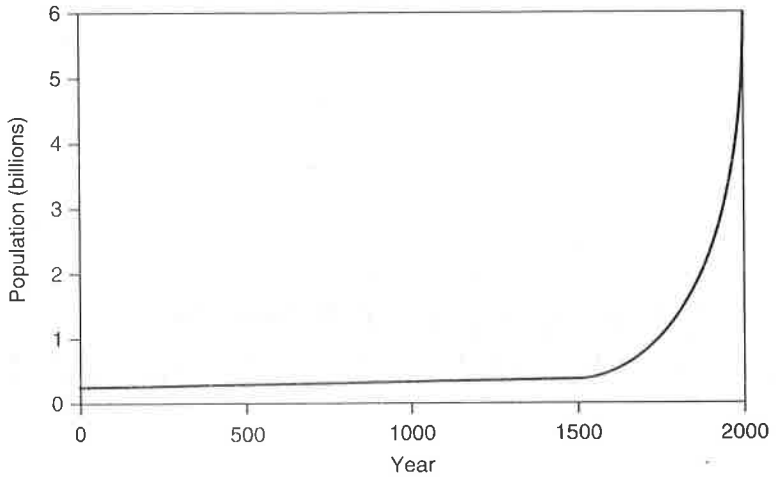


FIGURE 1-3 World population growth.

$$\textbf{future value} = \textbf{present value} \times e^{kt}$$

where **e** equals the constant 2.71828 . . . , **k** equals the rate of increase, and **t** is the number of years (or other units) over which the growth is to be measured.

Replacing the words with symbols, the equation reads:

$$N = N_0 \times e^{kt}$$

The variable N_0 equals the quantity at time zero, i.e., the starting point.

The compound growth equation allows demographers to project future population size, assuming the current population and the population growth rate. Using it is not as intimidating as it may seem at first and is demonstrated in *Using Math in Environmental Issues,* pages 14–15.

In using the compound growth equation to project population growth, we are making two assumptions. First, we assume that our data are accurate. Second, we assume that the population growth, rate (equal to birth rate minus death rate) we are using remains constant over the period we are projecting. Both assumptions may not always be accurate. Population estimates are compiled from censuses all over the world. As you might imagine, making accurate estimates in both developing countries and large nations like China and India is difficult. Growth rates also vary as government policies on family planning and immigration change, along with numerous other variables such as famine, war, and the impact of AIDS. Still, the compound growth equation is a particularly useful tool for examining growth scenarios and planning for the future. Let's practice using it by projecting world population growth.

Question 1: The mid-year 2001 world population was 6.16 billion and was growing at a rate of 1.24%. Project what the world population would be in 2025, 2050, and 2100 at this constant growth rate.

The compound growth equation can also be rearranged. If you know the starting and ending population sizes over a given period, you can calculate the average growth rate over that period using the formula $\mathbf{k = (1/t)\ ln(N/N_0)}$. Also, you can calculate how long it would take a population of a given size to grow (or decrease) to a different size at a specified growth rate using $\mathbf{t = (1/k)\ ln(N/N_0)}$.

Question 2: Given a 1987 world population of 5 billion and a 1999 world population of 6 billion, calculate the average annual growth rate over the 12 year period.

Question 3: Given an annual growth rate of 1.5%, how long would it take a population of 5 billion to grow to 10 billion?

Another useful tool for projecting population growth is the *doubling time* formula. For any population that is growing exponentially, the time it takes for the population to double is calculated using $t = 70/k$. (In the doubling time formula, in contrast to the other growth formulas, k is entered as the decimal growth rate $\times$ 100; e.g., a growth rate of 0.07 is entered as 7). The doubling time formula is explained and demonstrated in *Using Math in Environmental Issues,* pages 15–16.

Question 4: Use the doubling time formula to estimate how long would it take a population of 5 billion to double in size given an annual growth rate of 1.5%.

THE IMPACT OF AIDS

According to the United Nations Population Division.[7] AIDS is enacting a devastating toll on countries in sub-Saharan Africa. They report that life expectancy in the 29 hardest-hit African countries is seven years less than it would have been in the absence of AIDS. In Botswana (Figure 1-4), the hardest-hit country, one of every four adults is infected with HIV, the virus that causes AIDS. Table 1-1 contains both actual (historical) and projected population growth rates for Botswana.

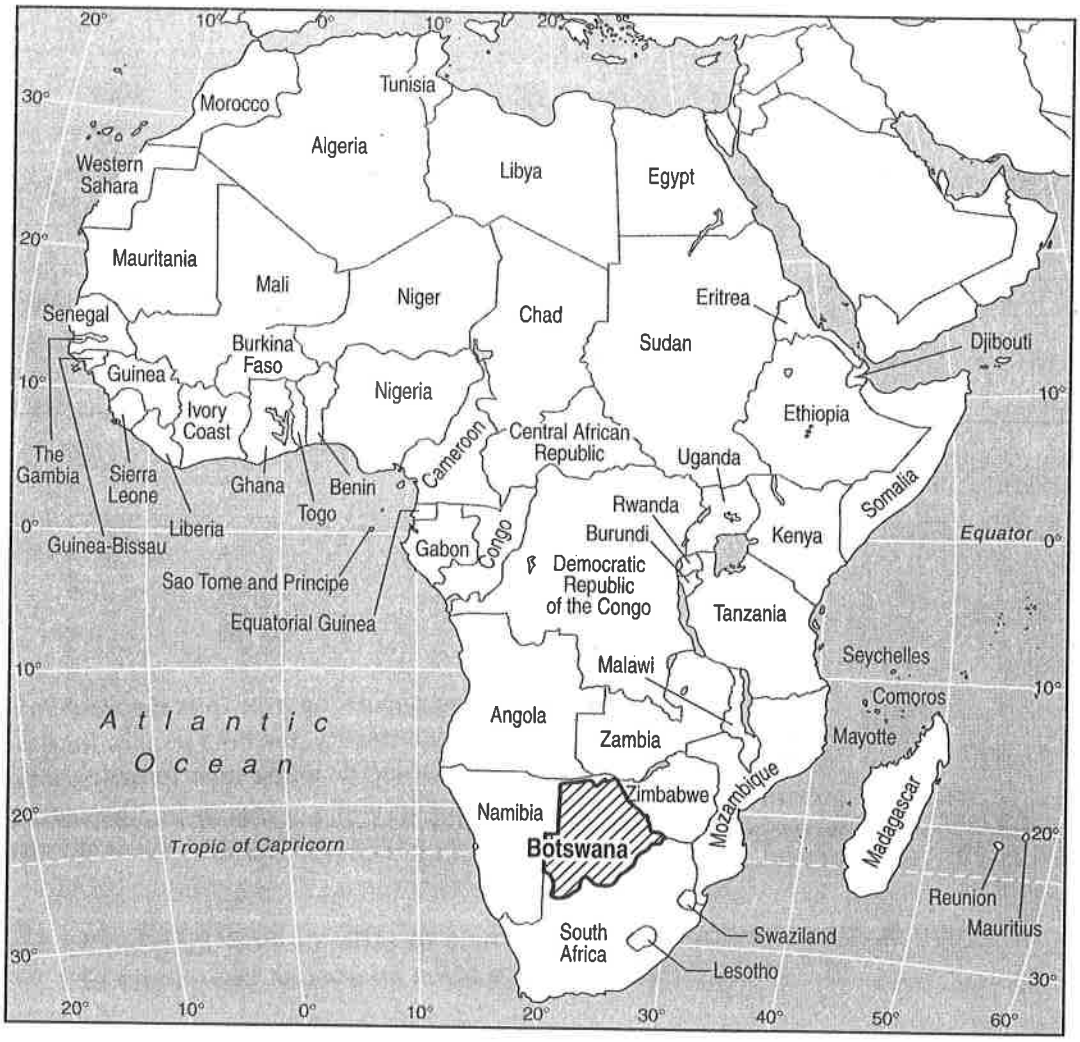


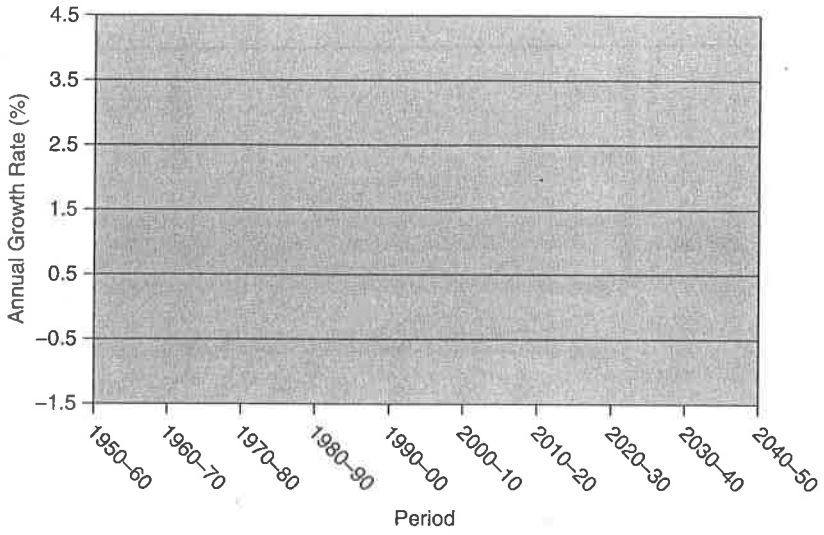
FIGURE 1-4 Map of Africa showing location of Botswana.

[7]United Nations Population Division. The Demographic Impact of HIV/AIDS (http://www.popin.org/pop1998/6.htm).

TABLE 1-1 ■ Average Annual Growth Rates for Botswana for 10-year periods from 1950 to 2050.[8]

Period	Growth Rate
1950–60	1.4
1960–70	1.6
1970–80	4.4
1980–90	3.7
1990–00	1.9
2000–10	−0.5
2010–20	−1.3
2020–30	−1.1
2030–40	−0.5
2040–50	0.5

Question 12: On the axes below, plot the population growth rates (both actual and projected) for the ten-year periods from 1950 to 2050.



Question 13: Interpret the graph. When does the population growth rate first begin to decline?

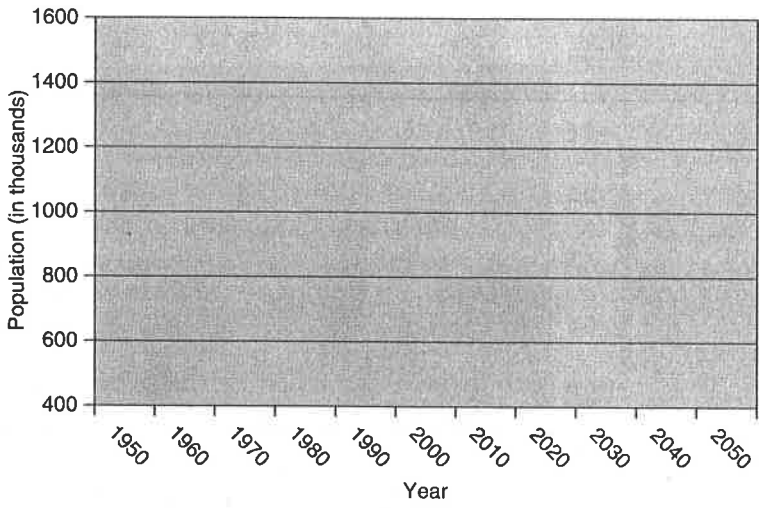
[8]U.S. Census Bureau. IDB Summary Demographic Data for Botswana (http://www.census.gov/cgi-bin/ipc/idbsum?cty=BC).

Table 1-2 (below) contains population data for Botswana for the same period.

Table 1-2 ■ Midyear Population Estimates (in thousands) for Botswana for 1950 to 2050[9]

Year	Population	Year	Population
1950	430	1996	1,498
1960	497	1997	1,523
1970	584	1998	1,545
1980	903	1999	1,563
1990	1,304	2000	1,576
1991	1,338	2010	1,502
1992	1,372	2020	1,318
1993	1,406	2030	1,175
1994	1,438	2040	1,114
1995	1,469	2050	1,167

Question 14: Plot the population data from Table 1-2 on the axes below.



Question 15: Interpret the graph. When does population actually begin to decrease in Botswana? How does this compare to when the growth rate first began to decline?

Next, we will project population growth in Botswana in the absence of AIDS.

[9]Ibid.

Question 16: Using the highest growth rate in Table 1-1 and beginning with the 1970 population of 584,000, calculate the population of Botswana in 2000 and project it for 2050. Use the formula $N = N_0 \times e^{kt}$. How many more Botswanans would there have been in 2000 in the absence of AIDS? In 2050?

Question 17: Identify and discuss ways in which AIDS might impact Botswana both socially and environmentally.

Question 18: The impact of AIDS on sub-Saharan Africa has been described as devastating. What actions do you think the United States and other developed countries should undertake to lessen the impact of AIDS?

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POPULATION DENSITY

Using the modification of the compound interest formula introduced above, $t = (1/k) \ln(N/N_0)$, we could determine when, at a growth rate of 1.24% per year, the world's 2001 population of 6.16 billion would grow to occupy the Earth at a density of one person per square meter (1 person/m^2) of dry land. The earth has 1.31×10^{14} m^2 of dry land. Thus, this number also represents the population size that would fill the earth if one person occupied an area of one meter.

Question 19: Starting with the 2001 world population and using a population growth rate of 1.24%, in what year would the Earth reach this impossible density of 1 person/m^2 of dry land?

Question 20: There are places where population densities approaching 1 person/m^2 already exist. A two-story building in Delhi, India was found to house 518 people[10], a density of 1 person/1.5 m^2. Calculate the floor area of this building in Delhi. How does this compare to the average floor area of a typical U.S. single family home (2100 ft^2 for a new home built in the late 1990s[11])?

Question 21: Identify the problems associated with accommodating large populations by putting people in high-rise buildings and identify any assumptions you used. What point of view did you bring to the question?

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[10]World Resources Institute. 1996. *World Resources 1996–97—the Urban Environment.* (New York: Author).
[11]U.S. Bureau of the Census. 1999. *Characteristics of New Housing* (http://www.huduser.org/publications/destech/newhsg99.html).

Question 22: High population densities in urban areas have advantages and disadvantages. List as many of each as you can and defend your conclusion. How could the disadvantages be eliminated or reduced? Use evidence to support your conclusion.

Question 23: Many experts feel that calculations like these transform the discussion about controlling world population from one of *whether* growth will be controlled to one of how and when. Do you agree? Explain why or why not.

FOR FURTHER STUDY

- What are some of the implications of human population growth? Consider open space and species loss and how they are affected by the increase in human population. Do you feel that these are causes for concern? Can we solve this problem (if it is a problem) by putting animals in zoos or setting aside land for parks or other green spaces? Why or why not?
- Developing countries are experiencing the most rapid population growth. Is this a problem? Do developed countries have a responsibility to help them control this growth? Specifically, what measures, if any, should be taken?
- How do you respond to those whose opinion differs from yours as to whether population growth is a problem? Make a list of significant points in your argument.
- The developed world's population is aging. Identify the implications. Consider local, regional, national, and global ramifications.
- Herman Daly, a University of Maryland ecological economist, has asserted that population control doesn't deny anyone the "right" to be born, it just asks that they "wait their turn." Do you agree? Discuss and explain your reasoning.