

POPULATION PRACTICE PACKET
AP Environmental Science
Population Growth, Curves & Reproductive Strategies

Growth Curves

The number of individuals in a population can change based on many variables. Density independent factors affect all individuals in a population the same and may include physical factors such as climate, weather or salinity or catastrophic events such as floods, fires or drought. Density dependent factors are more effective with a high-density population and include food supply, disease, parasitism, competition and predation.

1. In *cooler* climates, aphids (plant lice) go through a huge population increase during the summer months. In the fall, their numbers decline sharply. Identify one density dependent and one density independent factor that regulates this seasonal fluctuation.

Populations show two types of growth, exponential and logistic.

With exponential growth, a population increases by a fixed percent and its resulting graph is the classic “J-shaped” curve. Exponential growth occurs in nature with a small population and ideal conditions; however, it cannot be sustained indefinitely.

With logistic growth, due to of environmental resistance, population growth decreases as density reaches carrying capacity. Carrying capacity (K) is the maximum number of individuals a habitat can support over a given period of time due to environmental resistance. The graph of individuals vs. time yields a S-curved growth curve. The maximum rate at which a population can increase is its biotic potential. The biotic potential of a species is influenced by the age at which reproduction begins, the time the species remains reproductive, and the number of offspring produced during each period of reproduction.

Complete the following table for the two types of growth curves:

growth curve	shows unlimited, unchecked growth	growth limited by extrinsic or intrinsic factors	shape of curve (S or J)	shows carrying capacity for a population	typical of short term or long term growth
2. exponential					
3. logistic					

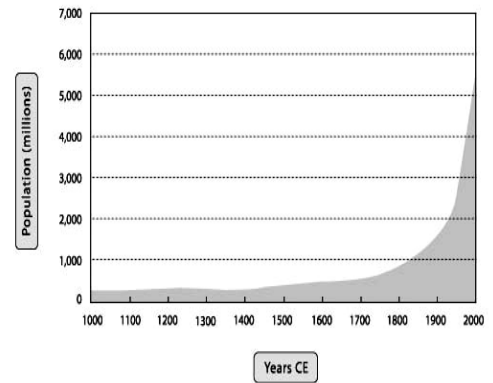
For each of the following scenarios circle whether the population growth would best be represented by a logistic or exponential growth curve.

4. a strep bacterium invades your throat and reproduces for 4 hours
exponential or logistic
5. the flea population on a rat is monitored for 5 weeks with flea powder added
exponential or logistic
6. loggerhead turtle populations are tracked for 5 years in the Atlantic
exponential or logistic
7. a lucky yeast cell falls into your glass of grape juice and reproduces for 10 hours
exponential or logistic
8. bull frog population in a local pond is monitored for 3 seasons
exponential or logistic

Exponential Model

When a population of organism's increases grows in a geometric or exponential manner, the increase in the number of organisms gets larger during each time interval. When a geometric set of data is graphed, the curve resembles the letter J and is thus sometimes referred to as a J-curve.

9. Explain what the characteristics are in this population that makes the graph take on this shape.



The exponential graph (J curve) can be represented by an equation. $N_t = N_0e^{rt}$

- N_t = estimate of the populations future size after some time
- N_0 = starting population size
- r = growth rate
- t = time
- e = the base of the natural logarithms (e^x on calculator or 2.72)

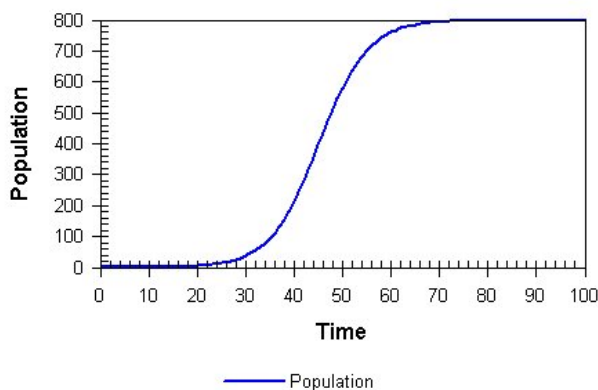
Example: A population of rabbits that has an initial population size of 10 individuals ($N_0=10$). The growth rate for a rabbit is $r=0.5$ (or 50%), which means that each rabbit produced a net increase of 0.5 rabbits each year. With this information, we can predict the size of the rabbit population 1 year from now:

- $N_t = N_0e^{rt}$
- $N_t = 10 \times e^{0.5 \times 1}$
- $N_t = 10 \times e^{0.5}$
- $N_t = 10 \times 1.6$
- $N_t = 16$ rabbits

10. You have a new population of 10 rabbits. Their growth rate is 1.0. Calculate and predict the size of the population after 1, 5, and 10 years. Show all of your work, box in your answers.

Logistic Model

Environments cannot support an unending population increase. Eventually the population reaches or exceeds its maximum sustainable level; also know as its carrying capacity. Given enough time, the size of a population will maintain itself at a level equal to the carrying capacity. If you start with a small initial population there is typically an initial period of slow arithmetic growth, followed by a period of rapid geometric growth which then levels off when the population reaches the carrying capacity. When graphed, the shape of this curve is somewhat like the letter S, and is known as an S-curve.



11. Explain what the characteristics are in this population that makes the graph take on this shape.

12. What is the growth rate of the population in the graph above at time 90?

13. At what time on this graph did the population reach its carrying capacity?

14. Did the graph above experience overshoot or die-off?

Reproductive Strategies

Be specific and write in complete sentences.

Two plant species grow together in an oak savanna. One is fairly long-lived and produces few large seeds. The other is short-lived and produces many small seeds.

15. Which species is most likely an r-selected species and which species is most likely a K-selected species?

16. List one ecological advantage and one ecological disadvantage of an r-selected and K-selected species.

17. List three traits of an r-strategist and three traits of a K-strategist. Give an example of each.

18. Compare and contrast the type of environment to which r-selected and K-selected species are adapted.

19. Draw a population growth curve of a typical r- and K-selected species and explain why these life histories produce the type of growth curve they do.

Population Calculations

You will need to be familiar with these equations for this unit.

POPULATION DENSITY

$$\left(\frac{\text{population}}{\text{area}} \right) = \text{Population Density}$$

for example: $\left(\frac{270,000,000 \text{ people}}{9,166,605 \text{ sq. km.}} \right) = 29 \text{ people per square kilometer}$

BIRTH OR DEATH RATES:

$$\left(\frac{\# \text{ of births or deaths per year}}{\text{Total population}} \right) = \text{Birth or Death Rate}$$

NOTE: to find Crude Birth/Death Rates(# per 1000 people), multiply the rate by 1,000

for example: $\left(\frac{23,452 \text{ births}}{942,721 \text{ people}} \right) = 0.025 = 2.5\% \text{ birth rate}$
25 = Crude Birth Rate (25 per 1000 people)

FINDING POPULATION GROWTH RATE/NATURAL INCREASE RATE (r):

(This does not include immigration or emigration)

$$\left(\frac{\text{crude births} - \text{crude deaths}}{10} \right) = r \%$$

for example: $\left(\frac{40 - 30}{10} \right) = 1.0\%$

FINDING THE DOUBLING TIME OF A POPULATION: THE RULE OF 70!!!

How many years will it take for a location's population to double??

$$\left(\frac{70\%}{r \text{ (in percent form)}} \right) \text{ or } \left(\frac{0.7}{r \text{ (in decimal form)}} \right) = \text{Doubling Time (dt) in years}$$

for example: $\left(\frac{70\%}{7\%} \right) \text{ or } \left(\frac{0.7}{0.07} \right) = 10 \text{ years}$...meaning that it will take 10 years for this population to double in size!

Instructions: Complete the following problems NEATLY. Calculators are NOT allowed on the AP Exam. All problems are to be solved WITHOUT using a calculator.

- ___ If a problem involves an equation – you must write out the equation for every problem. (Yes I understand that you will be writing the same equation over and over, but equations earn you points on the exam!)
- ___ You must show ALL work. (This also earns you points on the exam!)
 - List all variables.
 - Show how numbers are plugged into the equation.
- ___ If the problem involves units, you must include them. Numbers without units are meaningless. (Units earn you points on the exam! – seeing a pattern here?)
- ___ Box your final answer.

Given the following information, answer questions 20-23.

Schuhlsville is an island of 5,000 square miles off the coast of Jabooty. There are currently 250,000 inhabitants of the island. Last year, there were 12,000 new children born and 10,000 people were recorded as deceased.

20. What is the current population density?

21. What are the birth and death rates?

22. What is the population growth rate (r)?

23. In how many years will the population of Schuhlsville double?

Given the following information, answer questions 24-27.

The country of Transylvania contains 2.3 million people (vampires not included) and covers 800,000 square miles. In the year after the last census, there were 109,000 new children born and 111,000 people died.

24. What is the current population density?

25. What are the birth and death rates?

26. What is the population growth rate (r)?

27. In how many years will the population of Transylvania double?

28. Calculate the growth rates and doubling times for the countries listed below.

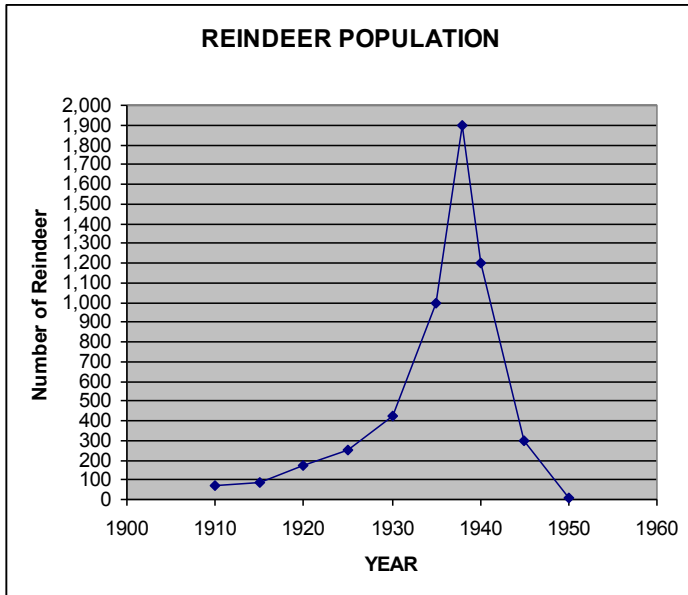
Country	Birth Rate % (2001)	Death Rate % (2001)	Growth Rate (r)	Doubling Time
United States	15	9		
Mexico	24	5		
Japan	9	8		
United Kingdom	12	11		
China	15	6		
India	26	9		
Nigeria	41	14		
South Africa	25	14		
Canada	11	8		
Italy	9	10		

Rate of Change

The change in size of a population over a period of time is the rate of change of the population. To calculate the rate of change of a population, divide the change in the size of population by the period of time during which the change took place. To calculate the rate of change of the density of a population, divide the change of density by the time period in which the density change occurred.

Reindeer Population/Rates of Change Procedure:

In 1911, 75 reindeer- 15 males and 60 females – were introduced onto St. Paul Island, one of the Pribilof Islands in the Bering Sea near Alaska. St. Paul Island is approximately 106 km² in size (41 square miles), and is more than 323 km (200 miles) from the mainland. On St. Paul Island there were no predators of the reindeer, and no hunting of the reindeer was allowed.



30. What was the size of the population at the beginning of the study?

31. In 1920?

32. What was the difference in the number of reindeer between 1910 and 1920?

Use the following equation and examples for average annual increase or decrease.

$$\frac{(\text{the amount of an organism during the most recent date} - \text{the amount of an organism during the later date})}{(\text{the amount of time between those two dates/times})}$$

Example 1

In 1960, there were 400 maple trees in a forest in Wisconsin. Thirty-five years later, in 1995, there were 925 maple trees in the same forest. The population of maple trees increased by 525 over a 35-year period. The average rate of increase of maple trees in the forest was 15 trees per year.

$$\frac{(925 \text{ maple trees in } 1995 - 400 \text{ maple trees in } 1960)}{(35 \text{ years})} = 15 \text{ trees per year}$$

Average rate of increase

Example 2

On the first day of fall in 1972, a group of biologist counted 475 deer in a nature preserve. Eight years later, in 1980, the biologists counted 379 deer in the persevere on the first day of fall. The population of deer decreased by 96 deer. The average rate of decrease of deer in the nature preserve was 12 deer per year.

$$\frac{(375 \text{ deer in } 1980 - 475 \text{ deer in } 1972)}{(8 \text{ years})} = -12 \text{ deer per year (12 fewer deer per year)}$$

Average rate of decrease

33. What was the average annual increase in the number of reindeer between 1910 and 1920?

34. What was the difference in population size between the years 1920 and 1930?

35. What was the average annual increase in the number of reindeer between 1920 and 1930?

36. What was the average annual increase in the number of reindeer between 1930 and 1938?

37. During which of three periods- 1910-1920, 1920-1930, or 1930-1938 - was the increase in the population of reindeer greatest?

38. What was the greatest number of reindeer found on St. Paul Island between 1910 and 1950? In what year did this occur?

39. In 1950, only eight reindeer were still alive. What is the average annual decrease in the number of reindeer between 1938 and 1950?

Discussion

40. Could emigration or immigration have played a major role in determining the size of the reindeer population? Explain your answer.

41. What might account for the tremendous increase in the population of reindeer between 1930 and 1938, as compared with the rate of growth during the first years the reindeer were on the island?

42. What effect might 2,000 reindeer have on the island and its vegetation?

43. Consider all the factors an organism requires to live. What might have happened on the island to cause the change in population size between 1938 and 1950?

44. Beginning in 1911, in which time spans did the population double? How many years did it take each of those doublings to occur? What happened to the doubling time between 1911 and 1938?

45. If some of the eight reindeer that were still alive in 1950 were males and some females, what do you predict would happen to the population in the next few years? Why?

46. What evidence is there that the carrying capacity for reindeer on this island was exceeded?

47. What does this study tell you about unchecked population growth? What difference might hunters or predators have made?

Human Population

48. In Microsoft Excel, plot the data below in a line graph. Print your final graph and attached below.

YEAR	HUMAN POPULATION (MILLIONS)
1	250
1000	280
1200	384
1500	427
1650	470
1750	694
1850	1,100
1900	1,600
1920	1,800
1930	2,070
1940	2,300
1950	2,500
1960	3,000
1980	4,450
1985	4,850
1990	5,300

49. Use your graph to determine the doubling times for the human population between AD 1 and 1990. How much time elapsed before the human population of year 1 doubled the first time?

50. Using the most recent growth rate on your graph and extend your graph to the year 2010 (make this a dashed line because it is hypothetical).

51. What do you estimate the human population will be in that year? How close is your number to the actual population for 2010?

52. Using the doubling equation, find the doubling time for the current population based on the rate of growth from 1980 to 1990. In what year will the present population double?

53. What similarities do you see between the graph of the reindeer population and your graph of the human population?

54. In what ways is the earth as a whole similar to an island such as St. Paul? Does the earth have a carrying capacity? Explain your answer.

55. What might happen to the population of humans if the present growth rate continues?

56. What methods could be used to reduce the growth rate?

57. Suggest several problems in your country that are related to the human population.

58. What are the most important three or four factors to think about with regard to sustaining the world population?