AP BIOLOGY · UNIT 8 · TOPIC 8.4

Effect of Density on Populations

Learning objective 8.4.A Explain how the density of a population affects and is determined by resource availability in the environment.

Name: Date: Period:

Use the tool **Something Stopping It**. Parts 1 and 2 use **One term, two curves**, Parts 3 and 4 use **What does the limiting**, and Part 5 uses **Whose property is K**. This topic adds a single factor to Topic 8.3: logistic growth is exponential growth multiplied by **(K − N)/K**. That one multiplication is the only difference between a curve that rises without limit and one that levels off, and Part 1 lets you switch it on and off with everything else held constant.

Part 1 · The same population, run twice

Identical r(max) of **0.25**, identical starting size of **10**, identical **80** steps. The only difference is whether the density term is switched on. Step 0 is the starting size. Read the step 10 values from the At step 10, both models gave readout. Press Density term OFF and then Density term ON and read each step 80 value from Population after 80 steps. For steps 20 and 40, calculate the exponential value as 10 × 1.25 raised to the power of the step, and estimate the logistic value from the graph.

Step	Exponential (term off)	Logistic (term on)	Are they close?
0			
10			
20			
40			
80			

1. Describe what is meant by the carrying capacity of an environment.

2. (a) Identify the logistic growth equation.

(b) Identify the factor that distinguishes the logistic growth equation from the exponential growth equation.

3. Explain why the exponential and logistic models give similar results while the population is small.

Part 2 · What the term is doing

The factor (K − N)/K is **the fraction of the environment still unused**. Calculate it for each population size, then multiply to get the growth rate, and check each value against the table in the tool. K is **1,000** and r(max) is **0.25**.

Population, N	As a share of K	(K − N)/K	Growth rate = r(max) × N × (K−N)/K
10			
100			
250			
500			
750			
900			
990			
1,000			

4. Using the Part 2 table, explain why a logistic growth curve levels off.

5. In the Part 2 table, the growth rate is greatest when N is 500, half the carrying capacity. Explain why the growth rate is greater at this size than at a larger population size.

6. A wildlife manager plans to harvest a population sustainably by taking the largest number of individuals that the population can replace each year.
(a) Using the Part 2 table, identify the population size at which the manager should keep the population.

(b) Provide reasoning to justify your identification.

Part 3 · Two kinds of limit

A factor is density-**dependent** if its effect gets stronger as the population gets denser, and density-**independent** if it does not. Record both effect columns from the tool's factor table. Decide each factor's type from its two effect values, not from whether the factor is biological, then check your decision against the tool's Type column.

Factor	Effect at low density	Effect at high density	Dependent or independent?
Competition for food			
Disease transmission			
Predation			
Accumulation of waste			
Competition for nesting sites			
A hard freeze			
Drought			
A volcanic eruption			
A hurricane			

7. (a) Describe the difference between density-dependent and density-independent factors.

(b) Identify three density-dependent factors and three density-independent factors.

8. A student claims that predation is density-dependent because it is biological and that drought is density-independent because it is physical.
(a) Explain why the student's reasoning is not valid.

(b) Describe the correct test for classifying a factor as density-dependent or density-independent.

Part 4 · Which one can produce a carrying capacity

Two populations over **120** steps, each regulated by one kind of factor. The density-independent population is given **severe and repeated** losses (40 percent at each of nine crashes), so one factor is not simply gentler than the other. Record the tool's readouts: where the density-dependent population settles and its range over the last 30 steps, and where the density-independent population ends and its highest-to-lowest ratio over the last 30 steps.

	Density-dependent	Density-independent
Where it ends up		
How much it varies over the last 30 steps		
Does it have a carrying capacity?		
Why, or why not?		

9. Using the Part 4 table, explain why only density-dependent factors can produce a carrying capacity.

10. A hurricane kills 90 percent of a population. Explain why the hurricane does not set the carrying capacity of that population.

Part 5 · Same species, four environments

Nothing about the organism changes across these four runs: the same r(max) and the same starting population. **Only the environment changes**. Click each value of K in the tool, or read the All four together table, and record each row.

Carrying capacity, K	Population at the end	As a share of K	Steps to reach 90% of K
200			
500			
1,000			
2,000			

11. In Part 5, only the environment changed between the runs. Using the Part 5 table, explain why the carrying capacity depends on the environment while r(max) depends on the species.

12. In the Part 5 table, the carrying capacity increases 10-fold, from 200 to 2,000, but the number of steps to reach 90 percent of K increases only from 21 to 32. Explain why the time to fill the habitat increases so much less than the carrying capacity.

13. (a) Explain how population density affects resource availability.

(b) Explain how resource availability determines population density.

What the model simplifies

The logistic equation is run in discrete steps rather than as a differential equation. With a large enough r(max) a discrete logistic model can overshoot its carrying capacity and even oscillate chaotically, which the continuous version never does; the r(max) used here is small enough that it approaches K smoothly.

Real populations frequently do overshoot, because organisms respond to the resources available when they were born rather than the resources available now. That time lag is left out here, and it is the main reason real populations oscillate around a carrying capacity instead of settling on it.

Carrying capacity is treated as a fixed number. In reality it moves with the seasons, with rainfall and with what else is living there, so a population is usually tracking a moving target rather than approaching a fixed one.

The strength figures for each limiting factor are illustrative, not measurements. What is asserted about them is the structural claim: every factor labeled density-independent has an identical figure at both densities, so the labels follow the numbers rather than being applied by hand.

The regulation comparison gives the density-independent population occasional catastrophes on top of a constant growth rate. That is a deliberately generous version of density independence: even with severe repeated mortality it produces no carrying capacity, which is the point.

Splitting factors cleanly into two kinds is itself a simplification. Predation is density-dependent up to a point and then saturates, because a predator can only eat so much; disease can become less effective once a large share of the population is immune. The categories are useful and they are not absolute.