What are Population Growth Models?

Worksheet

Exponential growth (Nt = Ne^rt) assumes unlimited resources, leading to ever-faster population increase and a J-shaped curve. Logistic growth (dN/dt = rN[KN]/K) includes carrying capacity K, slowing growth as population approaches resource limits, forming an S-shaped curve.

Exponential: N(t) = N_0 e^{rt}; Logistic: @frac{dN}{dt} = rN(1 - @frac{N

Questions

1. A population starts at 100 and triples every year. After 3 years, how many?

A) 300
B) 900
C) 2,700
D) 10,000

2. What shape does exponential growth form?

A) S-curve (sigmoid)
B) J-curve (exponential)
C) Flat line
D) Declining curve

3. In logistic growth, what limits population size?

A) Predators only
B) Disease only
C) Carrying capacity (K) - food, water, space, competition
D) Time only

4. A population is at carrying capacity K = 1,000. What is dN/dt (rate of change)?

A) Highly positive (still growing)
B) Zero (stable)
C) Highly negative (declining)
D) Cannot be determined

5. A bacterial colony starts with 1,000 cells and doubles every hour under unlimited food. What is the population after 5 hours? Predict the model.

6. A lake's fish population grows logistically with r = 0.5/year and carrying capacity K = 5,000 fish. Starting from 100 fish, find population at year 2.

7. A deer population in a forest follows logistic growth with K = 2,000. If poachers remove 400 deer/year, will the population be stable at 2,000?

8. Define: What is exponential population growth?

9. Define: What is logistic population growth?

10. Define: What is carrying capacity?

Answer Key

1. C) 2,700 - Year 1: 1003 = 300. Year 2: 3003 = 900. Year 3: 9003 = 2,700 (exponential growth).

2. B) J-curve (exponential) - Exponential growth J-shaped curve (starts slow, then accelerates steeply).

3. C) Carrying capacity (K) - food, water, space, competition - Carrying capacity includes all resources: food, water, shelter, space, and competition.

4. B) Zero (stable) - At carrying capacity, growth stops; dN/dt = 0 (stable equilibrium).

5. This is exponential growth: Nt = N 2^t where t = hours. N = 1,000 N = 1,000 2^5 = 1,000 32 = 32,000 cells after 5 hours. Pattern: 1h = 2,000; 2h = 4,000; 3h = 8,000; 4h = 16,000; 5h = 32,000 J-shaped curve (doubles forever, unrealistic for long term). If food becomes limited after 10 hours, population slows and follows logistic growth instead.

6. Logistic formula: Nt = K / (1 + [KN]/N e^(rt)) N = 100, K = 5,000, r = 0.5, t = 2 Nt = 5,000 / (1 + [5,000100]/100 e^(0.52)) Nt = 5,000 / (1 + 49 e^(1)) Nt = 5,000 / (1 + 49 0.368) Nt = 5,000 / (1 + 18.03) Nt = 5,000 / 19.03 262 fish at year 2. Population is growing but slowing as it approaches K = 5,000 (S-curve).

7. At K = 2,000, dN/dt = 0 (stable, no growth). But if 400 deer are harvested annually, the population cannot stay at 2,000. New equilibrium: dN/dt = rN(KN)/K 400 = 0 If r = 0.3, then 0.3 N (2,000N)/2,000 = 400 Solving: 0.3N(2,000N) = 800,000 600N 0.3N = 800,000 N 1,500 to 1,600 fish. Population crashes below K and stabilizes lower unless harvesting reduces.

8. Growth with unlimited resources where population increases at a constant rate, doubling (or tripling, etc.) at regular intervals. Forms a J-shaped curve.

9. Growth limited by carrying capacity K. Population slows as it approaches K, forming an S-shaped curve.

10. The maximum population size an environment can sustainably support given resources (food, water, space).