Formulas

discrete time growth:

- $N_T = N_0 \lambda^T$
- $\lambda = f + p$
- $\mathcal{R} = f/(1-p)$

continuous time growth:

- $N(t) = N(0)\exp(rt)$
- $r = b - d$
- $\mathcal{R} = b/d$

structured growth:

- $\ell_x = p_1 \times p_2 \times \ldots p_{x-1}$
- $\mathcal{R} = \sum \ell_x f_x$
- $\sum \ell_x f_x \lambda^{-x} = 1$
- $\mathrm{SAD}(x) \propto \ell_x \lambda^{-x}$

Use the following information for the next two questions. A population of oak trees is estimated to be at stable age distribution, with a constant life table, with reproductive number $\mathcal{R}$= 0.9. It takes the trees several years to reach maturity and reproduce.

1. This population is

A. declining
B. stable
C. increasing
D. showing damped oscillations
E. there is not enough information to answer this question

2. What is the *most accurate* statement you can make about the finite rate of growth λ, measured with a time step of one year?

A. We expect $\lambda < 0.9$
B. We expect $\lambda = 0.9$
C. We expect $\lambda < 1$
D. We expect $0.9 < \lambda < 1$
E. We expect $0.9 < \lambda$

3. Anthrax bacteria can survive for a long time in the soil, even though they are not active, do not feed, and do not reproduce. If each bacterium has a certain small chance of dying each day, regardless of how long it has been inactive in the soil, we expect the population to show what behaviour? *Choose the most precise correct answer.*

A. Linear decrease
B. Linear decrease or increase
C. Exponential decrease
D. Exponential decrease or increase

4. In which of the following circumstances can an older age class have more individuals than a younger age class? Choose the broadest correct answer

A. Always: Older age classes are always larger than younger age classes
B. Never: Older age classes are never larger than younger age classes
C. In a decreasing population
D. In a stable population
E. In an increasing population

5. In logistic growth model, $\frac{dN}{dt} = r_{\max} N(1 - N/K)$, the unit of population density (N) is indiv/km^2 and the unit of time (t) is yr. The units of $r_{\max}$ are ________, and the units of K are ________.

A. *yr*; indiv.
B. *yr*; indiv/km^2.
C. 1/yr; indiv.
D. 1/yr; indiv/km^2.

6. A certain large island does not have any native snakes, despite the fact that snakes are occasionally washed there by storms. Which of the following is *not* a likely explanation for their failure to thrive?

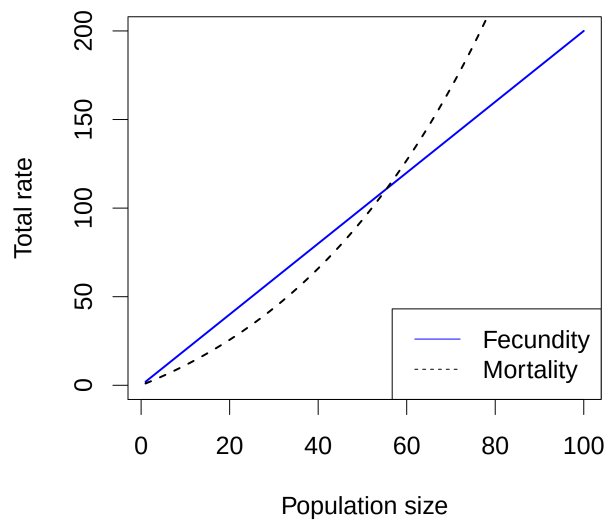
A. Snakes experience Allee effects on the island
B. Snakes experience density dependence on the island
C. Snakes have very high death rates on the island
D. Snakes have very low birth rates on the island

7. Which of these traits would be *most* typical of a K-strategist?

A. Has a low individual density at equilibrium
B. Has a high individual density at equilibrium
C. Competes poorly in crowded conditions
D. Competes well in crowded conditions

8. Which of these traits would be *most* typical of an r-strategist?

A. Large final size
B. Good dispersal
C. Production of a small number of high-quality offspring
D. Good competitive ability
E. Iteroparity

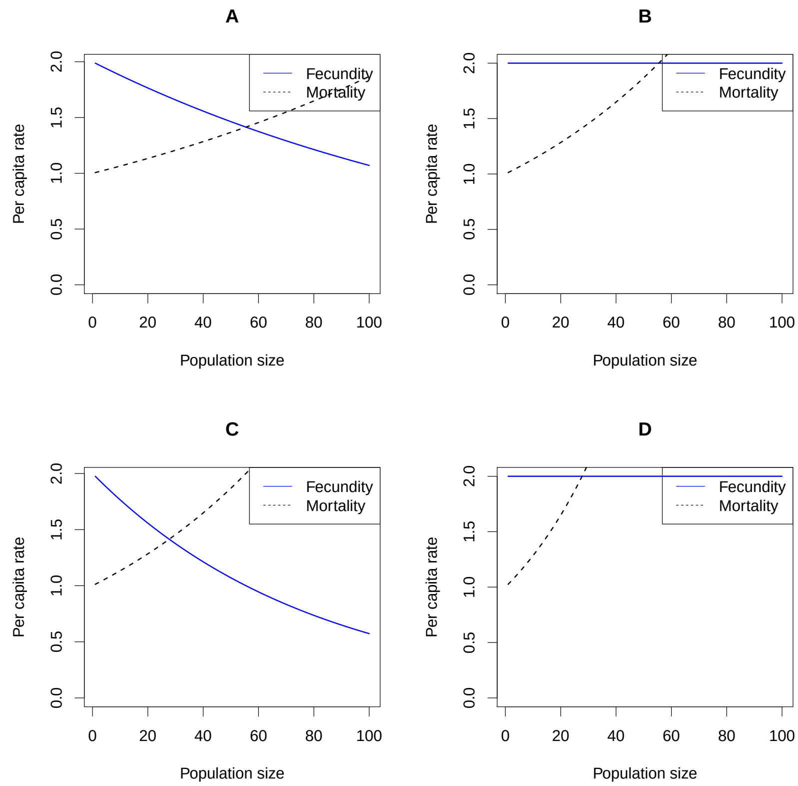


The figure above shows the assumptions made for a discrete-time birth-death model. *Use it for the next 3 questions.*

9. The figure shows:

A. No density dependence
B. Density dependence in fecundity only
C. Density dependence in mortality only
D. Density dependence in both mortality and fecundity

10. Which of the four pictures below was generated by the same model as the picture above?



11. A population following this model will:

A. Increase exponentially without limit
B. Decrease exponentially to zero
C. Approach an intermediate equilibrium
D. Decrease to zero if started near zero, and increase to an intermediate equilibrium otherwise

12. Cole's paradox suggests that, from a population biology point of view, it is a mystery why some plants:

A. Reproduce only once
B. Reproduce many times
C. Produce a large number of small seeds
D. Produce a small number of large seeds

13. A simple population model has *structure*, but not *regulation* (individuals are assumed to be independent). Cohorts are not independent. If the model has $\mathcal{R}_0 > 1$, then: The modeled population __________ grow exponentially at first, and __________ grow exponentially as it approaches a stable age distribution (SAD)

A. will; will
B. may not; will
C. will; may not
D. may not; may not

Use this information for the next three questions. A population of phytoplankton reproduces on a strict daily cycle. They survive each day with probability 1/2 (so their average life span is 2 days). Surviving phytoplankton produce an average of 0.8 offspring that will survive to be counted the next day.

14. What is the reproductive number $\mathcal{R}$ for this population?

A. 0.4
B. 0.8
C. 1.3
D. 1.6
E. 2.4

15. What is the finite rate of increase reproductive number λ for this population?

A. 0.4
B. 0.8
C. 1.3
D. 1.6
E. 2.4

16. What can you say about the units of the quantities above?

A. λ is unitless, while $\mathcal{R}$ has units [1/day]
B. $\mathcal{R}$ is unitless, while λ has units [1/day]
C. Both are unitless, but $\mathcal{R}$ is "associated" with the time step of 1 day
D. Both are unitless, but λ is "associated" with the time step of 1 day

17. Scientists need to be careful calculating the case fatality proportion of novel coronavirus and other new diseases because

A. It is hard to define what should count as a disease fatality (the numerator)
B. It is hard to define what should count as a case of disease (the denominator)
C. People may become immune to the disease through time

Name ______________ **Macid** ______________**Tutorial section** _______**Version 2**

Short-answer questions

Answer questions *in pen.* *Briefly* show necessary work and equations. Points may be *deducted* for wrong information, even when the correct information is also there.

18. Individuals in a marigold population produce 30 seeds on average in the first year after it is born, and 50 seeds on average in the second year after it is born, assuming it survives. Seeds survive the first year (and become adults) with probability 0.05, and first-year adults survive to become second-year adults with probability 0.7. Second-year adults always die.

a) (2 points). Explain *briefly* what f_x means, and show how you calculate the values of f_x for this population. You should explain whether you are counting before or after reproduction (either is fine).

b) (2 points). Explain briefly what p_x means, and why you use the values you do *given your decision about when to count.*

c) (2 points) Fill in the life table and calculate $\mathcal{R}$ for this population.

x	f_x	p_x	ℓ_x	$\ell_x f_x$
1				
2				
$\mathcal{R}$				

19. We learned that tradeoffs are widespread in biology

a) (1 point) Give an example of a tradeoff in nature

b) (1 point) Give a reason why tradeoffs are common under natural selection

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