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:

- $\ell_x = p_1 \times p_2 \times \ldots p_{x-1}$
- $\mathcal{R} = \sum \ell_x f_x$

1. Researchers studying a gypsy moth population make the following estimates: The average reproductive female lays 300 eggs; 60% of these eggs are female; 10% of eggs hatch into larvae; 20% of larvae mature into pupae; 50% of pupae mature into adults; 60% of adults survive to reproduce. What is the correct value of fecundity f for this population?

A. 0.9
B. 1.08
C. 1.8
D. 2.16
E. There is not enough information to answer this question

2. For a population to grow exponentially,

A. Its absolute birth and death rates must remain constant
B. Its *per capita* birth rate must decrease with population size
C. The death rate must be greater than the birth rate
D. It must have no competing species
E. R must be > 1

3. If we are thinking about a simple, continuous-time model, then for a population to be regulated:

A. The average reproductive number $\mathcal{R}$ must be low at high density and higher at either low or intermediate density
B. The birth rate b must be low at high density and higher at either low or intermediate density
C. The death rate d must be high at high density and lower at either low or intermediate density
D. All of the above
E. None of the above

4. The carrying capacity for an organism in an environment is the density at which crowding reduces the average of ________ to zero:

A. The birth rate
B. The death rate
C. The reproductive number $\mathcal{R}$
D. The instantaneous growth rate r
E. The finite-time growth rate λ

5. An ecologist is studying several small lakes with small populations of bass (a predatory fish). After several unusually cold years, the bass in all of these populations go extinct. A nearby, similar population in a warmer valley does not go extinct. This outcome is most likely the result of:

A. Allee effects
B. Competition
C. Demographic stochasticity
D. Environmental stochasticity

See the picture above.

6. The panel on the __________ shows population on a log scale. Compared to the other panel, it shows __________.

A. left; individual density instead of total density
B. left; the same numbers, but from a different perspective
C. right; individual density instead of total density
D. right; the same numbers, but from a different perspective

7. The values in the 'f' column of a life table

A. Reflect birth rates but not survival probabilities
B. Incorporate the survival of newborns between birth and the first census
C. Reflect cumulative survival up to each age class
D. Are usually measured in units of total offspring per female

8. When would it be *necessary* to use a stage-structured rather than an age-structured population model?

A. For a long-lived organism
B. For an organism that can shrink (regress) as well as grow
C. For a population that experiences regulation
D. For a population with stochastic variation in the life table over time
E. For a population with lower fecundity in very old organisms

Use this information for the next 4 questions. In a population of squirrels, newborn females have a 20% probability of surviving to reproduce in the next breeding season. One-year-old females have a 50% chance of surviving the next year, and older females have a 80% chance of surviving each year. We census *after* reproduction (we call the first group we count, the newborns, $x = 1$; thus the one-year-olds correspond to $x = 2$).

In a population of squirrels, newborn females have a 20% probability of surviving to reproduce in the next breeding season. One-year-old females have a 50% chance of surviving the next year, and older females have a 80% chance of surviving each year. We census *after* reproduction (we call the first group we count, the newborns, $x = 1$; thus the one-year-olds correspond to $x = 2$).

We also measure fecundity in this population, to complete our after-reproduction life table, and find that the reproductive number $\mathcal{R} = 0.8$.

9. What is the value of p_2 in this population?

A. 0.08
B. 0.16
C. 0.4
D. 0.5
E. 0.8

10. What is the value of ℓ_3 in this population?

A. 0.08
B. 0.1
C. 0.4
D. 0.5
E. 0.8

11. What can you say about λ based on this information?

A. $\lambda < 0.8$
B. $\lambda = 0.8$
C. $0.8 < \lambda < 1$
D. $\lambda = 1$

12. We infer from our measurements that this population is currently:

A. increasing
B. decreasing
C. stable
D. oscillating

13. Which of the following cases would be the most appropriate situation for using a structured, unregulated population model?

A. An endangered population of annual plants
B. An endangered population of perennial plants
C. A population of bacteria in stable phase
D. A forest where strong competition for light occurs
E. An invading population of annual plants

14. In an environment where seed survival is highly variable from year to year, we expect that semelparous plants (reproducing only once) are likely to invest relatively ________ than iteroparous plants in ________.

A. more; mechanisms for seed dispersal
B. less; mechanisms for seed dispersal
C. more; each individual seed
D. less; each individual seed

15. A species of annual plant produces an average of 80 seeds per reproductive adult. Half of these seeds, on average, land in forest clearings – these seeds have a 4% chance of surviving to be reproductive adults. The other half land in the forest, and have only a 1% chance of surviving. What is the finite rate of increase λ for these plants?

A. 1
B. 1.6
C. 2
D. 2.5
E. 4

16. Which of the following is *not* an example of a tradeoff?

A. Birds with heavier beaks that allow them to access more kinds of food take longer to reach maturity
B. Bushes which produce more defensive chemicals live longer, and have higher seed survival.
C. Trees that grow quickly in full sunlight are more likely to die when shaded
D. Rabbits which need less food to survive produce fewer offspring when food is plentiful

17. Which of the following is an advantage of dispersal?

A. Averaging across patches within years allows for a geometric average, which is always greater than or equal to the arithmetic average
B. Increased carrying capacity K
C. Improved competitive ability
D. Less competition with relatives
E. Increased inbreeding

18. Which of the following is *not* a life-history tradeoff?

A. Reproduction vs. longevity
B. Many offspring vs. large investment per offspring
C. Rapid maturation vs. large final size
D. Offspring that grow quickly vs. offspring that disperse well
E. High r vs. low r

19. Which trait below would be most characteristic of a K-strategist?

A. Rapid maturation
B. Good dispersal
C. Production of many inexpensive offspring
D. Short lifespan
E. Iteroparity

20. Which of the following would you expect to evolutionarily favor a greater number of males being produced in a population?

A. Increased cost of producing females
B. Increased cost of producing males
C. Higher population density
D. Increased mortality rate of males
E. Increased mortality rate of females

21. Which of the following best describes bet hedging?

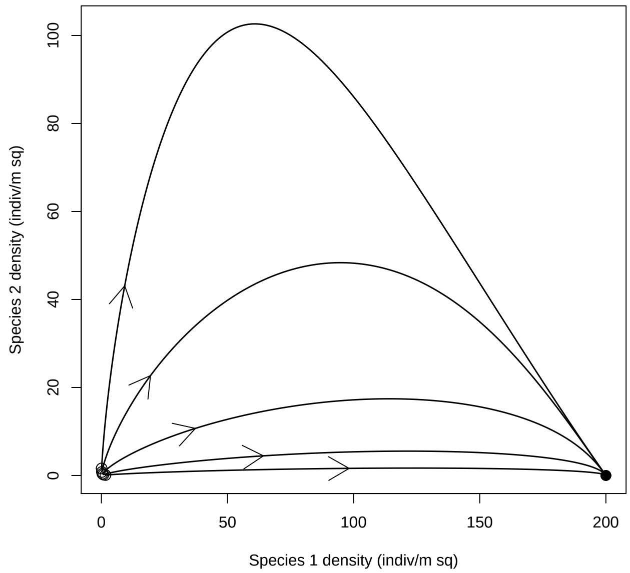
A. Avoiding inbreeding
B. Avoiding competition between your own offspring
C. Making sure that your own offspring are not all exposed to the same risk
D. Making sure your offspring have the chance to find good places to reproduce

22. In theory, if two species are competing only for a single resource, we expect

A. The species with the larger value of K (indiv/ha) to dominate
B. The species with the larger value of α (measuring its impact on the other species) to dominate
C. A tendency for co-existence
D. A tendency for mutual exclusion
E. Balanced competition (neither of the above two tendencies)

23. The growth rate of species 1 in the presence of species 2 is given by $\frac{dN_1}{dt} = r(N_1 + \alpha_{21}N_2)N_1$. If species 1 is counted in units of indiv_1, species 2 in units of indiv_2, and time is counted in units of years, then the units of α_{21} are:

A. $\text{indiv}_1/\text{indiv}_2$
B. $\text{indiv}_2/\text{indiv}_1$
C. $\text{indiv}_1/\text{year}$
D. $\text{indiv}_2/\text{year}$
E. 1/year

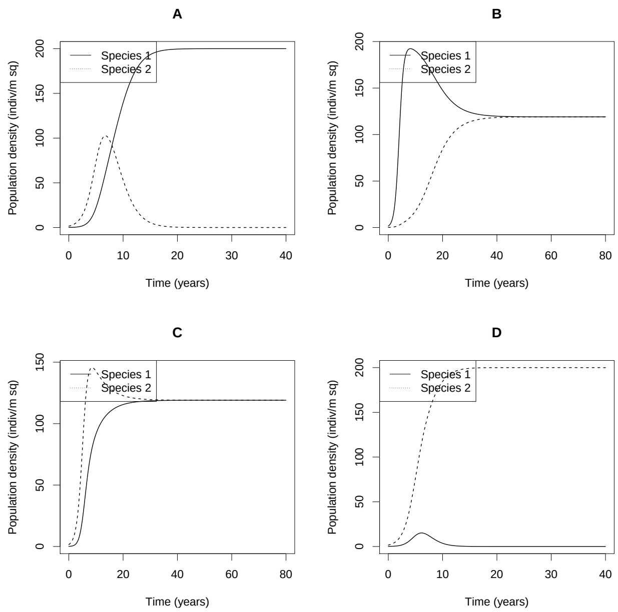


Use the picture above for the next 3 questions. These are plots from a simple model of two competing species.

24. The picture shows:

- **A.** Dominance by species 1
- **B.** Dominance by species 2
- **C.** Mutual exclusion
- **D.** Coexistence

25. Which of the time plots below matches the *upper path* from the phase plot above?



A. A
B. B
C. C
D. D

Name ______________ **Macid** ______________**Tutorial section** _______**VVV**

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.