Use this information for the next two questions. The simple, time-delayed continuous model we studied is written $\frac{dN(t)}{dt} = (b(N(t-\tau)) - d(N(t-\tau)))N(t)$

1. In this model, τ represents:

A. The characteristic time for exponential growth
B. **The time delay for the population size to affect growth rates**
C. The carrying capacity
D. Density dependence

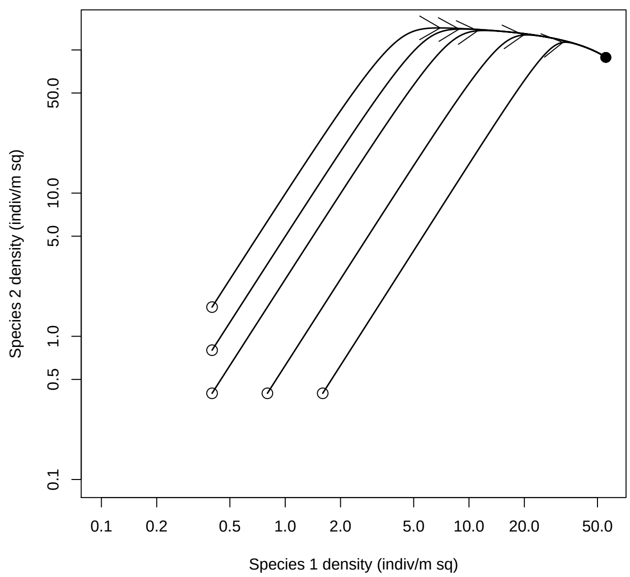
2. This model shows what range of behaviour?

A. Smooth convergence to equilibrium only
B. Smooth convergence and damped cycles only
C. **Damped cycles and persistent cycles only**
D. Persistent cycles or chaotic behaviour only
E. All of the above behaviours

3. Consider a 500kg moose, a 30kg beaver and a 15kg fox. Which animal is the most different in mass from the others?

A. **The moose is most different on any scale**
B. The fox is most different on any scale
C. The beaver is the national animal of Canada and therefore cannot even be compared to the other two animals!
D. The moose is most different when considered on the linear scale and the fox is most different when considered on the log scale
E. The fox is most different when considered on the linear scale and the moose is most different when considered on the log scale

Use the picture below for the next three questions. The path in the middle corresponds to a density of $0.4\,\mathrm{indiv/\,m^2}$ for each species.



4. This picture shows what sort of competition outcome?

A. Species 1 dominates
B. Species 2 dominates
C. **The species co-exist**
D. There is mutual exclusion

5. Assuming density dependence can be neglected at low densities, which species has the higher value of $r_{\max}$?

A. Species 1
B. **Species 2**
C. They have the same value of $r_{\max}$
D. Either species can have a higher value, depending on initial conditions.

6. From this picture, we can conclude that:

A. Both of the competition coefficients $\alpha < 1$.
B. Both of the competition coefficients $\alpha > 1$.
C. **Both of the population-level competitive effects $E < 1$.**
D. Both of the population-level competitive effects $E > 1$.
E. We cannot make any of these conclusions from this picture.

It is possible for one of the α to be > 1, as long as their product is < 1. The advantage of the large-α species would have to be balanced by a difference in carrying capacity.

7. Malaria no longer spreads effectively in the Southeastern United States, although the mosquito and human populations that used to spread it are still present. We interpret this to mean that for the malaria parasite in this region and at this time:

A. $\mathcal{R}$ (but not necessarily λ) < 1
B. $\mathcal{R}$ and λ are both < 1
C. $\mathcal{R}$ (but not necessarily λ) > 1
D. $\mathcal{R}$ and λ are both > 1
ANS: B

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.

8. This population is

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

9. 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 $0.9 < \lambda$

Since the lifespan is long, we expect λ to be closer to 1 than 0.9. This relates to the theme of slow life cycles producing higher lambda under bad conditions, and so on.

10. A new species is trying to invade a stable resident population (we don't know whether it will be successful). Which of the following is a true statement about reproductive numbers in this situation?

A. The resident has $\mathcal{R} > 1$
B. The invader has $\mathcal{R} > 1$
C. **The resident has** $\mathcal{R} = 1$
D. The invader has $\mathcal{R} = 1$

Note that we said the new species is *trying* to invade.

11. A species of introduced rat reproduces very well on islands near South America with no other rats, but does not survive under very similar conditions on the mainland, where other species of rat are present. It is likely that the mainland environment __________ part of the fundamental niche and __________ part of the realized niche for this species.

A. is; is
B. **is; is not**
C. is not; is
D. is not; is not

12. Which of these is *not* an effect that tends to *balance* the tendency of populations to grow or decline exponentially without limit?

A. **Allee effects**
B. Competition for access to resources
C. Resource depletion
D. Dynamics of natural enemies

13. Two species are said to be *competitors* when

A. **The growth rate of each is lower in the presence of the other**
B. They do not affect each other's growth rates
C. The growth rate of each is higher in the presence of the other
D. The growth rate of one is higher in the presence of the other, but the growth rate of the other is lower in the presence of the first one

14. We expect founder effects to occur when

A. Each species does better in an environment dominated by competitors than in an environment dominated by its own species
B. **Each species does better in an environment dominated by its own species than in an environment dominated by competitors**
C. One species does better in an environment dominated by its own species, while the other does better in an environment dominated competitors
D. One species does better than the other in environments dominated by either species

15. Suppose that adults of a species of annual plants each have 500 seeds per year. On average, 3% of the seeds germinate to become sprouts; on average, 10% of the sprouts survive to become adults in the next year. If we use a time step of one year, what is the finite rate of increase λ?

A. 0.075
B. 0.15
C. 0.75
D. **1.5**
E. There is not enough information to say

16. A species of annual plant produces an average of 100 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. 1.25
C. 1.5
D. **2.5**
E. 5

17. 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 have higher mortality before reaching maturity

B. Bushes which survive better in dry conditions grow more slowly in wet conditions

C. **Trees grown in full sunlight grow faster and have more resistance to diseases**

D. Rabbits which need less food to survive produce fewer offspring when food is plentiful

18. A species of plant produces 50 seeds on average in the first year after it is born, and 80 seeds on average in the second year after it is born, assuming it survives. Seeds survive the first year (and become adults) with probability 0.03, and first-year adults survive to become second-year adults with probability 0.5. Second-year adults always die (presumably in order to be nice to 3SS students).

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).

We choose to count before reproduction. f_x is the number of offspring we expect to see at next year's census for each individual in group x seen at this year's census.

The first age group we count has already survived for a year. They will produce 50 seeds on average, of which 0.03*50 $= 1.5$ will survive to be counted the next year. The second group produces 80 seeds on average, of which 0.03*80=2.4 will survive to be counted. So $f_1 = 1.5$ and $f_2 = 2.4$.

b) (2 points). Explain briefly what p_x means, and why you use the values you do to be consistent with the previous answer.

p_x is the probability that an individual counted in group x will survive to be counted the next year. Since we are counting before reproduction, individuals we observe have already been alive for one year. We therefore want the probabilities that 1 (or 2) year old adults will survive until the next year. These are 0.5 and 0.

c) (2 points) Explain briefly what ℓ_x means, and show how you calculate the values.

ℓ_x is the probability of surviving from the first time being counted until age group x. ℓ_1 is always 1. We get ℓ_2 by multiplying ℓ_1 by p_1 to get 0.5.

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

Life table

x	f_x	p_x	ℓ_x	$\ell_x f_x$
1	1.5	0.5	1.000	1.5
2	2.4	0	0.5	1.2
R				2.7

Alternative life table will be added soon.

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