

Before starting please **write your name on each page!** Last name, then first name.

Take your time and **read each question carefully** to ensure you fully understand **exactly** what we are after. **Don't jump to conclusions too quickly!** Please ask us for clarification if you do not fully understand any question. You have tons of time! Good luck ecologists.

SCRATCH PAPER. The last page is scratch paper for you to use to organize your thoughts.

1. Each term on the left below has a matching term on right that is directly associated with it. In each space on the left write the letter of the term on the right that is the best match. (10 points).

- | | |
|---|--|
| 1. Numerical response _____ | A. $K_2 = N_2 + \beta N_1$ |
| 2. Evolution due to competition _____ | B. increase in predator population |
| 3. Metapopulation _____ | C. species turnover |
| 4. Coevolution _____ | D. $dP/dt = 1 - u/m$ |
| 5. $\alpha = 1$ _____ | E. commensalism |
| 6. r-selected _____ | F. warning colors on nasty beast |
| 7. Competition isocline _____ | G. habitat variation |
| 8. Beta diversity _____ | H. cuckoos and their hosts |
| 9. Aposomatism _____ | I. decreased niche overlap |
| 10. Equilibrium Theory of Island
Biogeography _____. | J. density-independence |
| | K. intraspecific competition = interspecific competition |
| | L. $\lambda > 1$ |
| | M. epidemic |

2. List 3 anti-predator adaptations shown by animals. (3 points)

a) _____

b) _____

c) _____

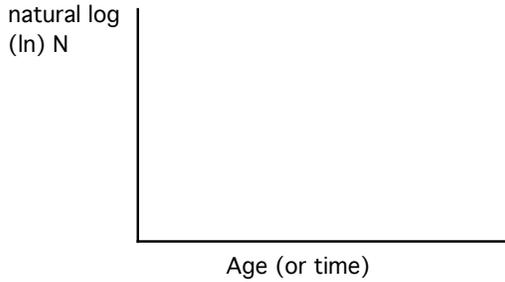
A

2

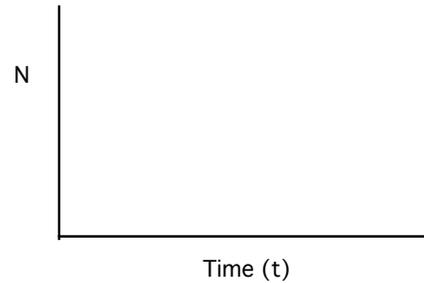
Name _____

3. Fill in each graph below with the curves or lines described by the equation or phrase at the top of the graph beside the large letters. For graphs that you intend to draw a straight line, please write "straight" beside the line since it is sometimes hard to tell what you have drawn. READ EACH AXIS LABEL CAREFULLY, AS GRAPHS MAY BE DIFFERENT VERSIONS OF ONES COVERED IN CLASS!! (all 1 point except G which is worth 2 points).

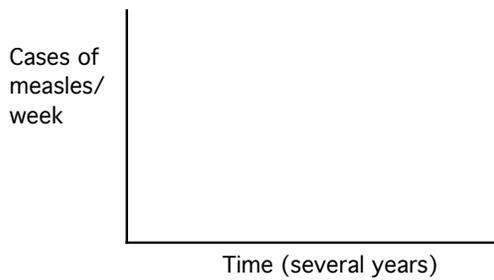
A Type III Survivorship curve



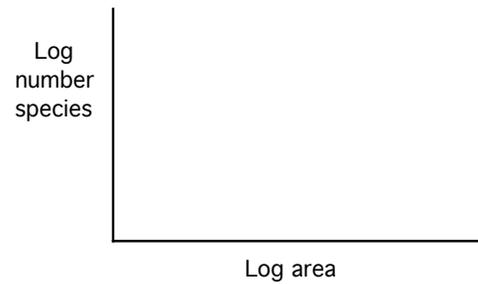
B Stable limit population cycle



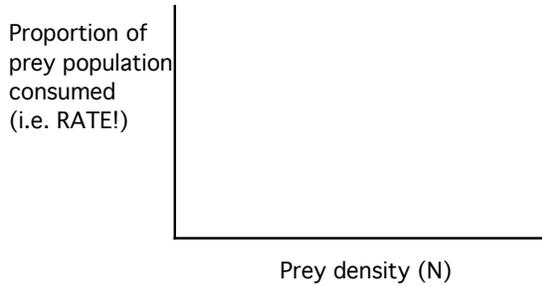
C Measles dynamics ($R_p = S\beta L$)



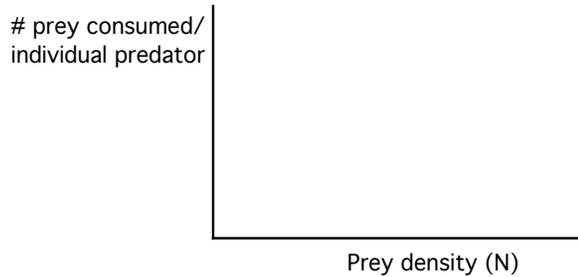
D Species area curve



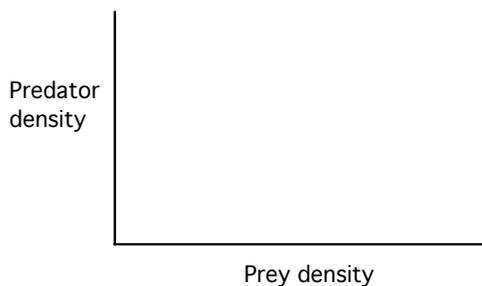
E Type III Functional response



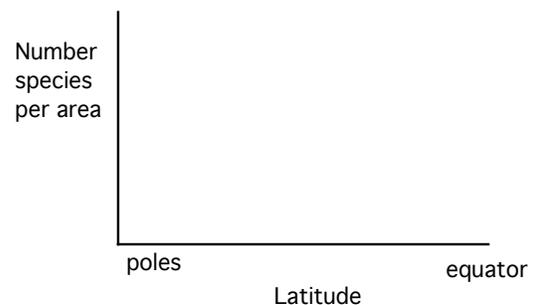
F Type III Functional response



G Predator and prey isoclines (label both)
($dV/dt = rV - \alpha VP$ and $dP/dt = \beta VP - qP$)



H Latitudinal species diversity gradient



A

3

Name _____

4. The following experiment is performed to assess the number of trophic levels in the food web in Scum Lake. Before the experiment, the lake is scummy green with lots of algae. Then, when you experimentally remove all of the individuals of one species, the Skinny Puppyfish, the lake quickly clears up and the algae disappear. Based on the result of the experiment, and knowledge that the Puppyfish is not a herbivore, draw the shortest food web (i.e. minimum number of trophic levels) for this lake that can account for this result. Label all trophic levels and indicate what trophic level the Puppyfish occupies. Then explain briefly in words how you determined the number of trophic levels, based on the effects that each trophic level has on the level below it, and why the removal of the Puppyfish caused the observed change. (6 points)

5. Some organisms that live in habitats that are patchily distributed in space may have 'metapopulation' structure.

a) What two key population parameters or variables are key to understanding metapopulation dynamics and stability? Don't just give the symbols — use full words. (2 points)

b) If you did a one-time survey of habitat occupancy in two species, one of which has metapopulation structure and the other one which does not, what would be the single most important difference between the two species that your survey would reveal? (2 points)

c) List two reasons why metapopulations matter or are interesting to ecologists or conservation biologists. (2 points)

6. The Lotka-Volterra competition model allows for a graphical approach to determine the outcome of competition between two competing species. Below is a state space graph that needs to be completed for the following specific case: Species 1 does not impact the carrying capacity of Species 2 (this effect is represented by the parameter β). In contrast, Species 2 does affect the carrying capacity of Species 1 (the effect is represented by the parameter α). Despite the competition, both species can coexist.

(a) Fill in the graph below by adding the following: (5 points)

- the isocline for each species, indicating which one is for Species 1 versus Species 2
- the equilibrium point
- label both the x and the y axis (whole axis label, not specific values where isoclines intersect axes)



(b) What is the numerical value of β ? i.e. $\beta = \underline{\hspace{2cm}}$ (1 point)

(c) What kind of experimental evidence would indicate that the **specific** outcome outlined above is occurring in nature? Describe both the experiment and the result from the experiment. (3 points)

7. This question asks you to link r-and-K selection life history theory with the Lotka-Volterra competition models. According to r-and-K selection, would you expect to find r-selected species to compete in the manner predicted by the Lotka-Volterra competition models? Explain in one or two sentences why or why not? (2 points)

8. Mortality rates have a profound influence on the evolution of many life history traits. In a transplant evolutionary life history experiment, fish are taken from Risky Lake, a lake with a very high annual mortality rate, and released into Safe Lake, a lake with very few predators where the fish now enjoy very low annual mortality (the fish were not formerly found in this lake). After ten years, the biologist returns to both lakes and studies two key life history traits in the populations in each lake, senescence and timing of maturity. Assuming that enough time has passed for an evolutionary response to the different mortality rates in Safe Lake and that there was genetic variation in all life history traits for natural selection to operate on, answer the following questions.

a) Did the fish in Safe Lake evolve an earlier or later onset (start) of senescence compared to the fish in Risky Lake, and why? Your explanation can be general but should be based on the relation between life table patterns and genes for ageing effects. (Note that the next question asks for more specific mechanisms) (3 points).

b) What are two specific mechanisms or reasons for why patterns of mortality affect the evolution of ageing genes? (2 points)

c) If you raised the fish in captivity with zero predation, which Lake has the longer average lifespan? (1 point)

d) Did the fish in Safe Lake evolve an earlier or later timing of maturity relative to the fish in Risky Lake and why? (2 points)

9. You conduct the standard reciprocal removal experiment to assess the importance of interspecific competition in two species of frogs. When you remove species A from plots, the density of species B increases, relative to control plots where both species are present. Similarly, when you remove species B from plots, the density of species A increases, relative to control plots. Although this experimental result is consistent with competition, it is also consistent with a different mechanism that does not involve competition, but instead involves other interactions. Note that in the above experiment, the only species that were manipulated were the frogs and all other players in the community were ignored.

a) What other type of interactions could explain this pattern? Use a simple drawing to illustrate the interacting species, and use arrows with either a plus or a minus sign to indicate the direct effects of each species on other species in this interaction (3 points).

b) What is this other situation or mechanism called? (1 point)

c) What additional experiment, in conjunction with the experiment described above, would allow you to distinguish between competition and this other non-competition explanation? What result would support the competition hypothesis and rule out the alternative non-competition hypothesis. (3 points)

10. You have just completed your study of a cohort of your favorite organism, the Leapin Lizard. You began your study by ear-tagging 1000 female babies, followed the entire cohort until the last one died, and noted the number of female babies each of these female produced, on average, at each age. You then compiled all of your data and found the following: of the original 1000 newborns (age 0) you followed, 500 survived to year 1 where they had (on average) 1 baby each, 250 survived to year 2, where they had 1 baby each, 100 survived to year 3, where they had 2 babies each, and none survived to year 4.

Age	Number alive	Babies/ female		
X	s_x	b_x		
0				
1				
2				
3				
4				

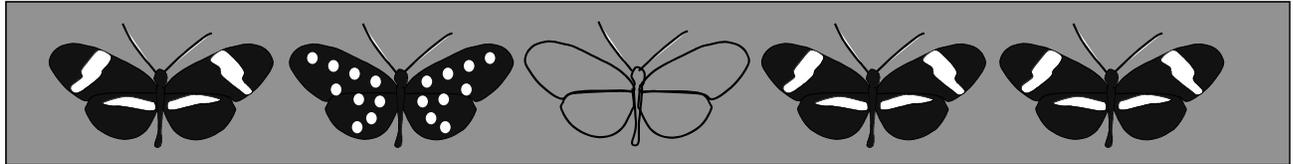
(a) Is this population growing, declining or stable? To answer, complete the life table, calculate R_0 and explain, based on the value of R_0 , what the population is doing. (4 points)

(b) If this population is part of a source and sink population dynamic, is it the source or the sink population and how did you know? (2 points)

(c) Complete the life table that will result in the following: a stable population (i.e. $R_0 = 1$) of an annual plant where each adult female produces 5 seeds. Consider seeds as babies (age 0) and start with a cohort of 100 total seeds. Hint: because we are dealing with an annual organism, generation time = 1, hence $R_0 = \lambda$. It might be helpful to recall our simple life history model of λ for an annual plant. You need to fill in the rest of the s_x and b_x columns and your table should also include the columns used to calculate R_0 . Your answer must be complete enough that we can see how you figured this out. (2 points)

Age	Number alive	Babies/ female		
X	s_x	b_x		
0	100			
1				
2				

11. The diagram below shows five species of butterflies, which vary both in coloration and in toxicity. The grey background shown in the box is the natural background on which the butterflies occur. (6 points)



Species A
toxic

Species B
toxic

Species C
non toxic

Species D
non toxic

Species E
toxic

a) Identify all butterfly species (i.e. letter) that fit each of the following type of mimicry. If there is more than one species that fits a description, include all of them:

Mullerian mimicry _____.

Batesian mimicry _____.

Crypsis _____.

b) Mullerian and Batesian mimicry have different dynamics, in terms of whether the convergent evolution of the signal represents cooperation or conflict between the signaling species. Explain.

12. It is thought that mutualisms can evolve from interactions that start out as harmful or parasitic. What specific evidence from yucca moths and their close relatives provides clear support for this idea, in an evolutionary framework? Your answer should also include a brief description of the key aspects of interaction between yucca moths and yucca plants, and you should identify which specific trait or behavior was responsible for shifting the interaction from harmful to mutualistic. (6 points)