 Name____________________________

BEFORE YOU START: WRITE YOUR NAME ON EACH PAGE!!!!

Read the questions carefully before answering to ensure that you fully understand what we are looking for. Answer the questions in sufficient detail to let us know that you fully understand the critical issues. Do not use the **shotgun** approach of throwing everything under the sun into your answer in the hope that something will hit the target because we may deduct points for statements that are counter to the correct answer. Good luck and wow us with your ecological knowledge!

PART A. Shorter answers, graphs or calculations. Your answers can be in point form but must be complete.

1. Biomes provide a striking example of a match between organisms and their environment on a broad geographic level.

(i) Name two biomes and identify a key feature of each (4 points):

Biome	Feature
____________________	____________________
____________________	____________________

(ii) If we were to compare two plants that occur in the same biome, say desert, but each occurs on a different continent, would this comparison be more likely to provide an example of an adaptive radiation or an evolutionary convergence? Explain why. (2 points)

2. Outline the key features aspects that together produce the process of natural selection. Which part is ecological, and why is it ecological? (6 points).

3. The photo below shows a clear pattern: a bush surrounded by a bare area of soil with grass and other vegetation growing beyond the bare patch. Describe two different ecological mechanisms that could account for this pattern. Outline experiments you could conduct to test EACH of the two hypothesized mechanisms. For each hypothesis, discuss what result from your experiment would refute the hypothesis and what result would support the hypothesis (8 points).

Paste Krebs photo here

4. The cost of inbreeding may favor the evolution of dispersal because individuals that fail to disperse may mate with relatives leading and produce less viable or inviable offspring. Outline an experiment you could do with plants to test for a cost of inbreeding. Be sure to identify any critical assumptions you make, and indicate what result from your experiment would indicate a cost to inbreeding (5 points).

5. Graphical models of optimal foraging provide a nice way to examine the foraging decisions of an animal that is repeatedly making trips between foraging patches and a central place, as exemplified by a bird that forages for food to feed the chicks in its nest. Below is the skeleton of this graphical model which you need to complete (6 points).

(i) Label all axis including <u>the two separate parts of the x axis</u>

(ii) Draw the foraging intake curve to show prey gathered while foraging in the patch

(iii) Then show how to solve for the optimal number of prey items that maximizes the **rate** of energy returned to the nest

(iv) Also indicate the optimal number of prey items the forager should collect (it may not be an even number, don't worry about the tick marks)

6. According to population models, the density-dependent effects of intraspecific competition can have very different and interesting consequences for the population dynamics of populations with discrete breeding seasons compared to populations with continuous breeding. These consequences are best illustrated by contrasting the population dynamics (changes in N over time) predicted by the continuous logistic ($dN/dt = rN(1-N/K)$) versus the discrete logistic model ($N_{t+1} = N_t + r_D N_t(1-N_t/K)$).

(i) How do the population dynamics produced by these two models differ? (2 points)

(ii) Why specifically do these two models produce such different outcomes? (1 point)

(iii) How can we confirm the reason for the difference? (2 points)

7. The following time budget data and energetic costs or benefits of activities is gathered for two strategies in a population of Anna's hummingbirds in the UCSC arboretum:
(1) ***Territorial individuals*** and (2) ***Non-territorial individuals.***

ACTIVITY	Costs of activity (Kcal/hour)	Time spent by territorial individuals in each activity	Time spent by non-territorial individuals in each activity
Foraging	3 Kcal/h	4 hours	8 hours
Sitting	1 Kcal/h	4 hours	2 hours
Fighting	5 Kcal/h	2 hours	0 hours

BENEFITS: The rate of food intake while foraging is:

7 Kcal/ hour for a **territorial** individual
3 Kcal/hour for a **non-territorial** individual

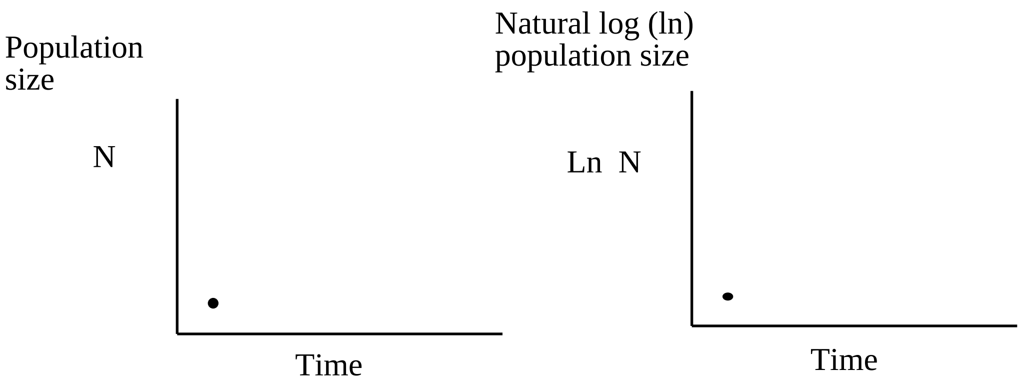
a) Based on the time budget data and the costs or benefits of each activity per hour of activity, determine whether an Anna's Hummingbird that is maximizing its **NET energy intake** (costs minus benefits) over the ten hour day should be territorial or non-territorial. Show all of your calculations (4 points).

b) Optimal foraging models are useful tools for determining what fitness currencies are important to organisms. If the currency that is being optimized by Anna's Hummingbird is minimizing their metabolic costs (not *net* costs, but Kcals spent), which strategy is better, territorial or non-territorial? Show why (you can refer to aspects of your calculations above). (2 points).

8. The population growth rate per individual, r, is a very useful population parameter that is used in many population models.

(i) If r = 2.4/year, what is r per month? (2 points)

(ii) If $r > 0$, what would the pattern of population growth look like on the two graphs below? The dot indicates the starting population size (2 points).



(iii) How could you estimate r from the right graph above? (1 point)

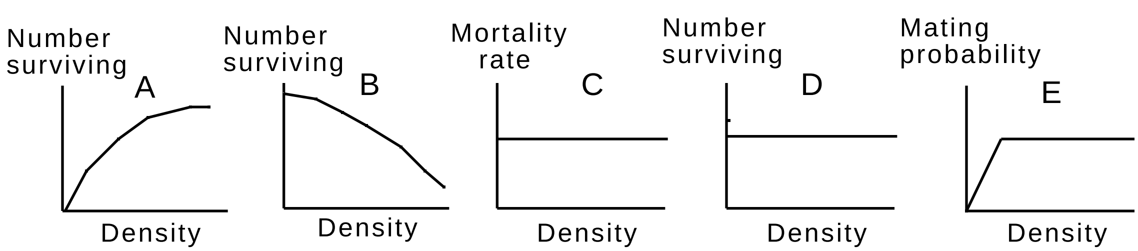
9. Match the graphs below to each of the following and write the graph letter in the space provided. There are more graphs than spaces to fill (Hint: pay attention to the axis labels). (4 points)

(a) _____ Density-independence

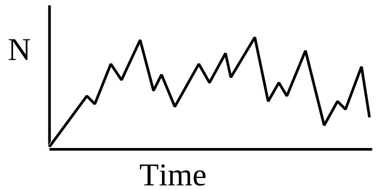
(b) _____ Exactly compensating density-dependence

(c) _____ Allee effect

(d) _____ Overcompensating density-dependence



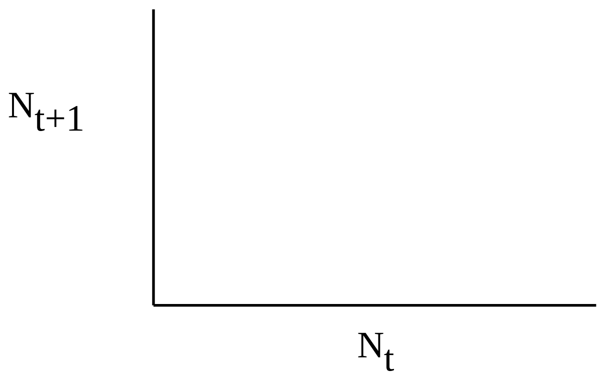
10. The graph below shows a population that fluctuates over time in a pattern known as chaos.



(i) What exactly is chaos? (2 points)

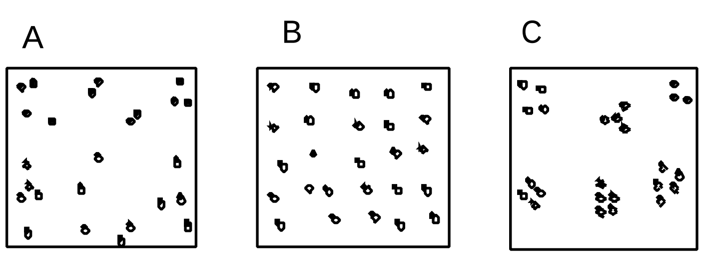
(ii) Is chaos produced by random (stochastic) events and how do you know? (2 points).

(iii) If the above population dynamics are chaotic, then we should see the signature of chaos when plotted on the graph below. Fill in the signature of chaos (2 points)



11. The spatial distributions shown below represent: (3points)

(a) _________random dispersion
(b) _________uniform or spaced dispersion
(c) _________clumped dispersion



Describe one ecological mechanism that could produce pattern B and one that could produce pattern C (2 points).

12. You are given the task of conserving a population of the Yellow-bellied Snorters. On your annual census, you notice that the population fluctuates in overall survival and production of young, and this is reflected in your estimates of λ across years. In good years you find that λ = 3.0, in bad years λ = 0.2. You also note that good and bad years occur with equal frequency. Your colleague insists that the snorter population is in fine shape because the arithmetic mean of λ is 1.6 and when they plugged this value into a deterministic population model, the population is predicted to grow quickly over the long-term. Being a well-trained ecologist, you correct them and insist that a stochastic population model is needed here.

a) What is the fundamental difference between a stochastic population model and deterministic population model? (2 points).

b). Even without running any model you can do a quick calculation with the above λ values to obtain the correct estimate of an 'average' λ value that accurately predicts long-term prospects for the bear population. Show this calculation. Is the population growing, stable or declining over the long-term? Why? (4 points).

13. Body size affects just about all aspects of an organism's life. Due to allometric relationships between body size and many fundamental physiological and ecological variables, very small and very large animals live very different ecological lives (5 points)

(i) **Whole organism** metabolic rates scale Mass $^{0.75}$ with body size in the standard log-log plot. Given this, do smaller animals have larger or smaller **whole organism** metabolic rates than bigger animals? (1 point)

(ii) **Mass specific** metabolic rates scale Mass $^{-0.25}$ with body size in the standard log-log plot. Given this, do smaller animals have larger or smaller **mass specific** metabolic rates than bigger animals? (1 point)

(iii) Describe three important ecological consequences of these relationships to the challenges faced by tiny animals (shrews, hummingbirds) versus large animals (deer, whale). (3 points)

14. Density-dependence is of special interest to ecologists because it can potentially explain what limits population growth in some species. In addition, it also provides a possible

explanation for the interesting population dynamics seen in some species (patterns of how N varies over time).

(i) What is meant by "density-dependence" (1 point)

(ii) Describe two mechanisms of that can give rise to density-dependence (2 points)

(iii) Using a graph showing, illustrate how the combination of a density-dependent birth rate (b, i.e., per individual) and a density-dependent death rate (d, also per individual) can "regulate" a population so that it will be stable at K, it's carrying capacity. Explain in words what the graph shows and why the population will be stable at K. (4 points)

PART B. LONGER ESSAY. Answer 1 of the following 2 essay questions. 20 points.
*** ONLY ANSWER 1 QUESTION!!!*****

1. The Sociable Hellbunny occurs in two habitats, pine and oak forests. Pine is a good habitat because food resources are plentiful, while Oak is a bad habitat with fewer food resources. This type of variation in habitat quality can result in two very different patterns: (1) **source** versus **sink** habitats (and populations) or (2) an **'ideal free distribution'**, where sequentially settling individuals choose the habitat to settle in a way that maximizes their potential reproductive success **at the time they settle** (shown graphically in class).

(i) Compare and contrast these two different patterns by discussing both the assumptions and predictions of each.
(ii) What data (observational or experimental) would you need to collect for the Sociable Hellbunny to show that it fits the idea of source and sink habitats? What experimental manipulation and result would convince you that the Sociable Hellbunny chooses habitats as predicted by the ideal free distribution?
(iii) Are these two patterns mutually exclusive or could source and sink populations ever result from individuals that settle according to the ideal free distribution?

2. Optimal foraging models are used to predict the foraging decisions of animals, to identify the constraints and trade-offs that shape these foraging decisions and to identify the foraging 'currencies' that are important to individuals in particular foraging contexts. In class we discussed three studies that tested for one or more foraging currencies: central place foraging by starlings flying back and forth between their nest and foraging patches, 'risk-sensitive' foraging by shrews choosing between a risky and a constant reward, and optimal territory size of sunbirds. Together, these studies illustrate how animals can vary in the foraging currency that is important to them, and how different approaches might be used to study different currencies.

(i) Describe these three studies, outlining their basic approaches to determining what currency was being optimized. Note that in the case of risk sensitivity, the currency can be the predictability of the reward (variation as opposed to just the mean).

(ii) Would you expect an animal to always optimize the same currency throughout its life? Illustrate your answer with biological reasons, either by referring to the above case studies, or with your own examples.