I. Multiple Choice and True/False: Read each statement carefully and clearly mark the answer that is most correct by circling your response. Do not circle more than one response or your answer will be marked incorrect (5 questions, 4 points each = 20 points total).

1. Which of the following accurately describes 'energy return on investment'?
   a) the amount of energy obtained from the environment relative to the amount of energy used to obtain it.
   b) difference between gross energy and expenditure
   c) equivalent to surplus energy
   d) all of the above
   e) none of the above

2. 'Energy return on investment' is quantified by examining the caloric or nutritional content of a prey item in the laboratory.
   a) true
   b) false

3. Which of the following most accurately describes Liebig's Law of the Minimum?
   a) organisms are not homogenous in resource requirements
   b) variation in the environment causes limiting factors to change in time or space
   c) whatever nutrient resource is the least abundant in the organism's environment relative to the needs of the organism will limit growth
   d) interactions among limiting factors are not small enough to neglect
   e) all of the above

4. Catania and Remple (2005) demonstrated that the morphology of the star nose of the "star nosed mole" was extremely effective in maximizing benefits through calories gained, allowing these moles to maximize benefit: cost ratios.
   a) true
   b) false

5. A broad diet will maximize returns per unit expenditure, favoring generalization in a food-scarce environment.
   a) true
   b) false

II. Short Answer Questions. Use 1-4 sentences to address each of the following questions. You will be graded on the quality of your responses (80 points total)

6. Robert MacArthur predicted that optimal foraging by predators is density dependent. Design a study that would test 1) whether or not your favorite predator exhibits optimal foraging behaviour, and 2) whether this behavior is density dependent as MacArthur envisioned. (12 marks)

- observe which clams crows eat after digging them up, and which they discard
- measure clams (both eaten and discarded) and calculate/estimate calorie content of each.
- IF $\frac{E_{\text{clams eaten}}}{\text{handling time + search time}} > \frac{E_{\text{clams discarded}}}{\text{handling time}}$ then the crows are exhibiting optimal foraging behaviour.

12

- repeat this experiment at several locations, with varying densities of crows
- if crows in denser populations choose to eat smaller clams (with lower energy return on investment), the behaviour must be density dependent.

-crows might choose smaller clams because competition is greater, thus clams are more scarce, which favours generalists. (search time for a large cl could be very long).

7. You are studying a plant species in which three types of environmental factors (nutrients, soil texture, and pH) all influence the physiology and performance of the plant. How will these factors influence this plant species according to the Theory of Tolerance? (12 marks)

7.5

Each factor will have a minimum and a maximum threshold for survival. There is an optimal level for each factor that maximizes the plant's performance. Whichever factor is farthest below the optimal level will be the limiting factor for the plant's performance.

8. If growth of a population of flour beetles is well predicted by the equation $N_t = N_0 e^{rt}$ and has an exponential growth rate (r) of 0.19 per day, how long will it take for a population of 430 beetles to double in size? (6 marks)

$2N_0 = N_0 e^{rt}$

$2 = e^{rt}$

$\ln(2) = 0.19 \times t$

$\frac{\ln(2)}{0.19} = t$

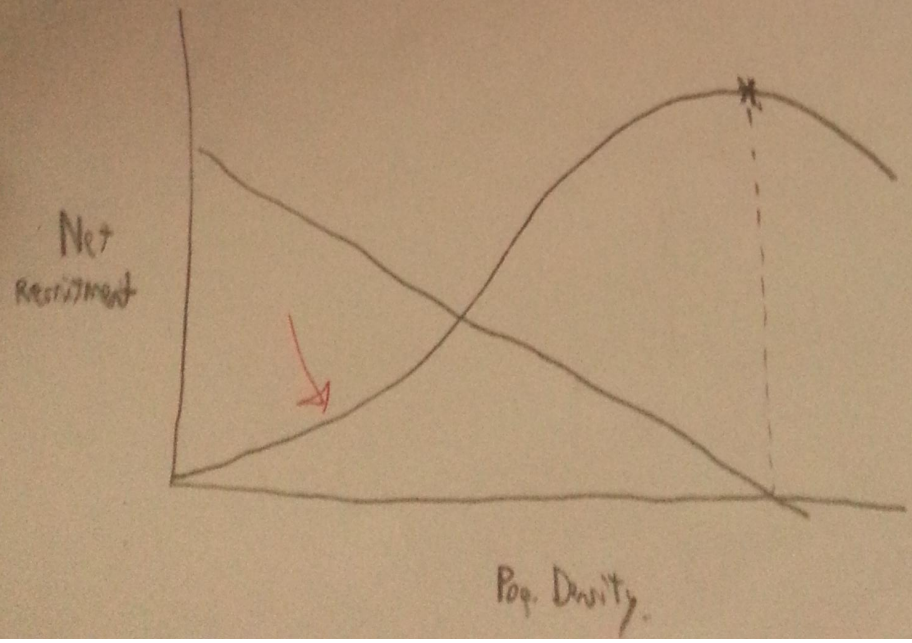
$3.65 = t$

It will take 3.65 days for the population to double.

9. Why is the net recruitment curve for the logistic model hump-shaped despite the fact that the exponential growth rate declines linearly with population density? (8 marks)

The net recruitment curve is hump-shaped because exp. growth rate declines linearly with population density. Population continues to increase with increasing density until the growth rate becomes negative. This happens at the top of the hump.

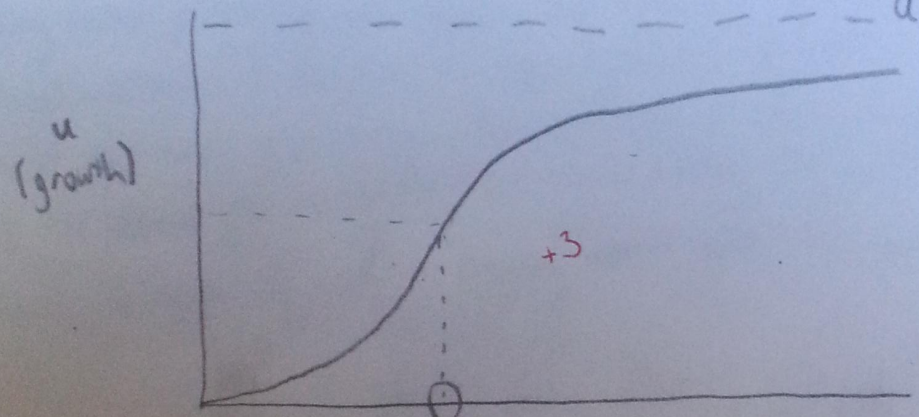
4



10. In one sentence, describe the overall goal of the Monod equation. Below, draw a relationship between μ and S that could be analyzed using the Monod equation - make sure to label your axes. On your diagram, label μmax and Ks (or Km) and briefly describe what these two variables represent (hint, don't forget to describe their units). (10 marks)

8/

+2 The Monod equation estimates growth rate based on ~~the availability of nutrients~~ a limiting resource.



The maximum rate of growth per unit time +2

+1 The nutrient concentration that gives a growth rate half of μmax units of Ks?

[5] (limiting nutrient concentration)

11. What is the difference between population limitation and population regulation? (6 marks)

Limitation refers to density independent ~~factors~~ affecting population.

Regulation refers to density dependent factors affecting population.

8

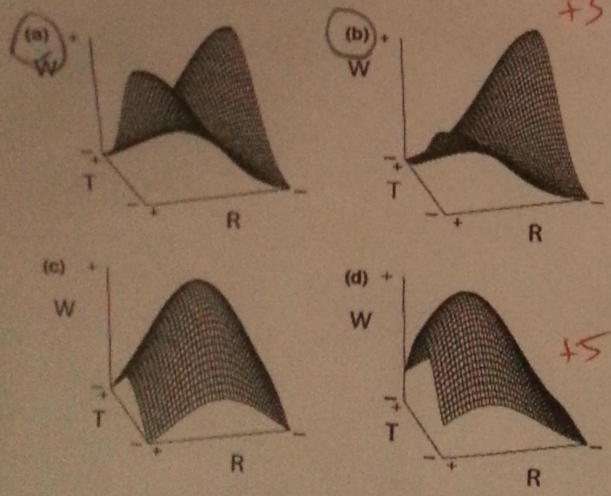
e.g. competition for resources, mates, etc.

e.g. Drought, food shortage

12. Explain how annual variation in climate might be expected to have a cascading influence on resource availability, optimal foraging decisions, body size, and demography of a population of seed-eating birds. (16 marks)

An early spring might cause the number of seeds available to new fledglings to be reduced, as seeds could be taken up more by competing species that are able to start feeding earlier in the season. Reduced seed availability could cause birds to make suboptimal foraging decisions, as they are forced to eat whatever seeds they can find, even if net energy gain is low. This could cause reduced body size as the birds age. If the reduced seed availability causes reduced lifelong fitness, then reproductive rates could be negatively impacted, creating reduced population growth. +4

13. Below are four hypothetical fitness surfaces (W is relative fitness) for the allocation to resistance (R) and tolerance (T). Which panel(s) reflect a tradeoff between resistance and tolerance? Explain why. (10 marks)



+3 (a) and (b). Fitness in (a) is highest at either extreme of resistance or tolerance, and reduced fitness at high levels of both simultaneously. This suggests that choosing either (trading off) resistance or tolerance is the most beneficial to the organism, while choosing both (NOT trading off) causes reduced fitness. This is likely because the energy input into having both +5 resistance and tolerance is too high to be beneficial. +2 Having both resistance and tolerance is redundant.