

Approach for written answer questions: Identify the general concept, then illustrate or explain the general concept using a graphical or illustrative, or calculation-based approach. Then, if requested, to demonstrate knowledge of how to manipulate the specific illustration of the concept using different data.

The exam emphasizes the use of course concepts to solve problems that you have not encountered previously, an approach that many find challenging in comparison with other biology courses. Approach the questions by considering what concepts are being evaluated. Is the question about competition? If so, we addressed two conceptual models of competition, including Lotka-Volterra and Tilman's models. Is the question about the interaction between immigration and extinction rates and the number of species likely to be present in a locality? If so, the right framework (given the course material) is island biogeography. It will help a lot to identify correctly the key concept behind the question.

Short answer examples (these would be worth about 4 marks each):

Note: the answers provided are a bit more thorough than necessary to get full marks but be as thorough as possible in your answers and think quantitatively whenever possible (answers are given in red).

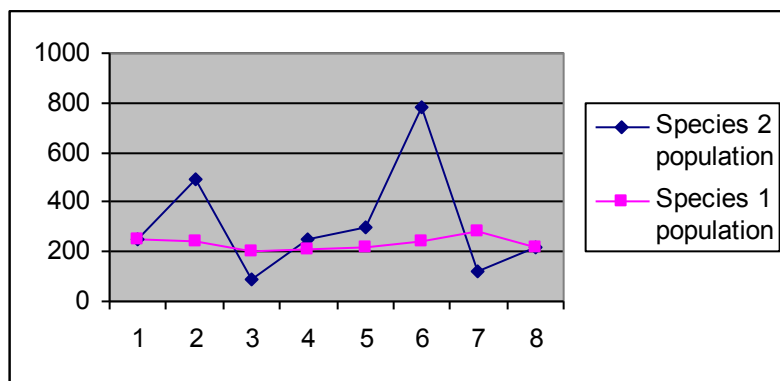
1. An ecologist observes the following population sizes for two butterflies over an 8 year period:

Species 1 – 250, 238, 199, 206, 214, 238, 279, 220

Species 2 – 250, 490, 89, 250, 299, 780, 125, 220

Which species is more likely to go extinct? Why? (4 marks)

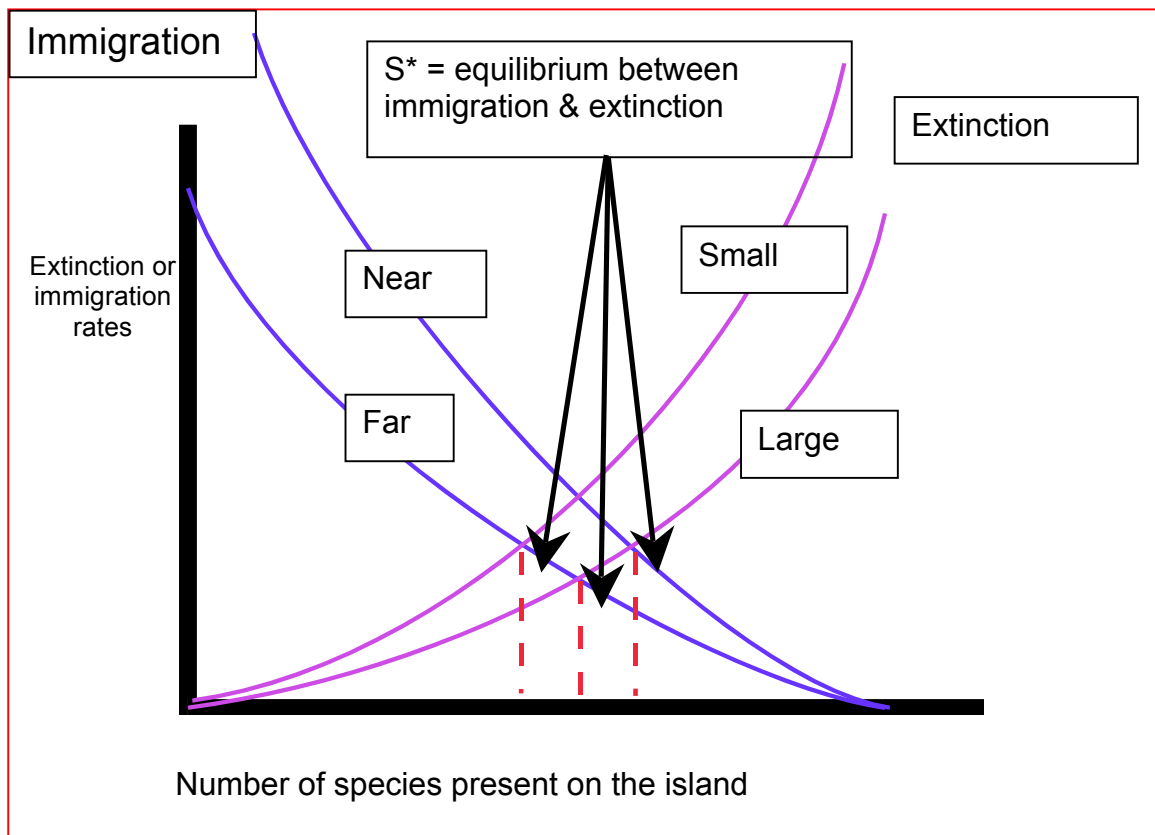
The second species is far more likely to go extinct. Its population fluctuates to a much greater degree through time, even though its mean size is similar, which makes it much more likely to drop suddenly to 0 even if its population size was quite high in a previous year. This is clearly demonstrated by considering the population drop from 490 to 89, a drop of 400 individuals to a level about 18% of the former value. Species 1 is relatively stable and seems to fluctuate only a small amount around a mean of about 220. Because the variation about that mean through time is small, it is unlikely to go extinct, particularly in comparison with species 2. It would also be possible to illustrate these points by calculating variances within each population and showing that the variance for species 2 was much higher.



2. A population has grown exponentially at a rate of 20% per year for each of seven years. Its initial population size is 250.
 - a. What kind of population growth is this? Describe its likely population trends over very long periods if this species lives exclusively on Pelee Island in Lake Erie (4 marks).

This is exponential growth through time, with a per capita rate of increase of 20% or $r = 0.2$. Exponential population growth can continue for some time under ideal circumstances but it is impossible for it to continue indefinitely, particularly if the rate of increase is high, as in this case. At the end of 7 generations, the population size of this species is ~1013 individuals (from equation: $N(t) = N_0e^{rt}$, where $N_0 = 250$, e is a constant about equal 2.718 (from the $\exp()$ function on a calculator), $r = 0.2$, and $t = 7$ generations/years). On an island, population growth will be even more constrained as resources are much more finite than on mainland environments. The result of this will be that the population is likely to crash as it overshoots its island carrying capacity. This population does not show logistic growth – although exponential and logistic growth can appear similar in the early stages, logistic growth is characterized by progressively slower rates of increase. In the example above, the rate of increase was 0.2 for every year.

3. Describe the theory of island biogeography in graphical terms. Be sure to present a clear description (use graphs if necessary) of why predicted species richness differs among islands.



This question is straight from the lecture material (Topic 15 - Island biogeography) and would require a short written explanation of the graph above or a very, very careful and clear purely written explanation for full marks.

4. Describe an experiment that tests island biogeographic theory. Be sure to present information on the predictions that this experiment tested.

This question address Simberloff and Wilson's experiment on Florida mangrove islands. A full description of the experiment is necessary but you would also have to clearly state what their predictions were for species richness (they measured richness on the islands before eliminating insects and this was their predicted equilibrium value for species richness based on island biogeography). It would be wise for this kind of question to present a graph. From Topic 15 - Island Biogeography.

5. Describe the intermediate disturbance hypothesis (include a labeled graph)? What kinds of species would you expect in very disturbed areas? Contrast their growth strategies with later successional species.

You would need to present a graph showing clearly the intermediate disturbance hypothesis mechanics. This is straight from the notes (Topic 14 - Succession and disturbance). In very disturbed areas you would expect to observe species that were very effective colonists – that is, with excellent dispersal capabilities, as these species are constantly being impacted by disturbance. Later successional species are less able colonizers but more adept at competing for light. They grow most slowly and would not be present much, if at all, in highly disturbed locales.

6. When individual plants from a wetland are grown under natural conditions but with no surrounding plants, their biomass at the end of the summer is 25 grams. If these same plants are grown in natural conditions amongst a community of other wetland plant species, their biomass is 15 grams per plant. Why? Calculate the strength of this effect.

This species is being affected by interactions with other plants. In fact, their biomass at the end of the year was about 40% less if they are grown with other plants than if they are grown alone but under otherwise identical conditions. This is diffuse competition. The pairwise interactions between these plant species are not very strong but when there are many plant species present, the total effect of those weak pairwise interactions can clearly add up to a biological significant effect that causes a 40% reduction in growth rates. To calculate the strength of this effect, you would use the diffuse competition equation:

$$DC = \left\{ \sum_{i=1}^n \frac{[(C_i - U_i)]}{C_i} \right\} n^{-1}$$

You only have data for one species, so the summation is not required and the Diffuse Competition calculation is then very simple: (25 grams – 15 grams)/(25 grams) = 0.40. (Notes to improve comprehension: The CLEARED area biomass of the species is 25 grams (in the absence of competition). The UNCLEARED area biomass of the species is

15 grams (in the presence of many competing species, the plant grows to be a smaller size). The diffuse competition calculations just produced the proportional loss of biomass due to competition, a simple concept being expressed here in the form of this equation.)

Long answer examples (10 marks each)

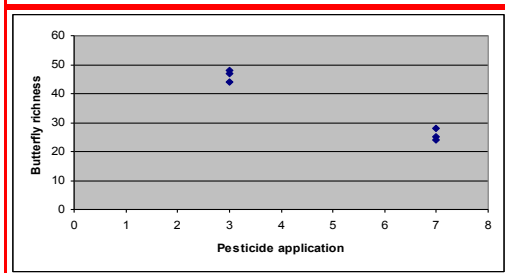
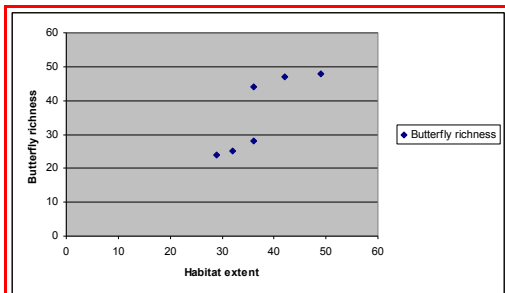
1. A conservation biologist makes a series of observations.

Year	Habitat extent (hectares)	Pesticide application (kg/hectare)	Butterfly species richness
1995	49	3	48
1996	42	3	47
1997	36	3	44
1998	36	7	28
1999	32	7	25
2000	29	7	24

a) What hypotheses is this biologist likely to be testing (be sure to state dependent and independent variables)? (2 marks)

Larger habitat support more butterfly species than smaller habitats (independent variable = habitat extent, dependent variable = butterfly species richness).
Pesticides kill butterflies (pesticides application = independent, butterfly richness = dependent variable).

b) Explain the patterns in these data (4 marks).



Area is positively related to butterfly richness – supporting the hypothesis that large habitats can support more butterfly species. Conversely, heavy pesticide applications are associated with substantial reductions of butterfly species richness, consistent with the second hypothesis. The discontinuity in the area-richness relationship appears to be because of different amounts of pesticides being used (based on the observations here).

c) Devise an experiment to test the conclusions you have drawn (4 marks).

The purpose of the experiment would be to test whether the correlations described above were causative (i.e. did pesticides *cause* butterfly species to decline or is this incidental?).

Hold pesticide applications constant and measure butterfly species richness across a series of habitats. Then experimental eliminate area from some of those habitats and observe butterfly species richness in those places relative to controls, where area was allowed to remain constant. Prediction: butterfly species richness will decline in habitats where area was experimentally reduced.

For pesticides: sample across a series of habitats that are equal in area then apply to a subset of the habitats a certain dose of pesticides. You could also apply two levels of dose similar to the levels in the observed dataset above. Butterfly species ought to decline relative to control areas (where there are no pesticides and equivalent habitat area) after pesticide applications.