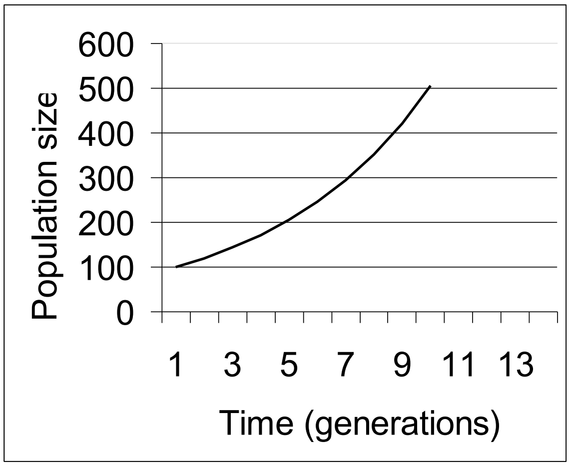
Example questions from past midterm exams

1. (4 marks) A biologist observes that an invertebrate species' population grows continuously according to the following data:



a. After 10 generations, this population size reaches 505. How large will the population size be three (30) generations after this, assuming the population continues to grow at the same pace (per capita growth rate = 0.18)? Show your calculations.

Ln (N_t) = Ln (N_0) + rt, where r = 0.18, and t = 3 (i.e. three generations)
N_t is the population size at time = 13 generations. N_0 is pop. size at 10 generations. r is 0.18.
Ln (N_{13}) = Ln (N_{10}) + (0.18 X 30)
= Ln (505) + (0.18 X 30)
= 11.6246

So, N_{40} = $e^{11.6246}$
= 111,810 (approximately) (3 marks)

b. Is it likely that this population will continue to grow at the same pace? Explain.

It is NOT likely that this population will continue to grow at this pace. It is growing exponentially, and no population can grow exponentially for an indefinite period. The reason for this is lack of resources (which may be lack of space or lack of some other resource, like food or light) or possibly some other sort of inter- or intraspecific interaction (such as aggression among or within species). (1 mark)

2. (4 marks) A scientist creates two hypotheses. The first hypothesis states that butterfly population size around Ottawa increases with increasing net primary production. The second hypothesis states that butterfly population sizes is a function of net primary productivity, mean summer temperature, pesticide use, and summer precipitation levels. The scientist fully tests both hypotheses and finds that she can predict butterfly

population sizes with an R^2 of 0.71 for both hypotheses. Which, if any, hypothesis is better from a scientific perspective. Why? Under what circumstances would you reach the opposite conclusion?

Both hypotheses make good predictions – 71% of the variation in butterfly population size can be explained using the predictor (independent) variables. However, Ockham's razor (the law of parsimony) says that, all other things being equal, the simpler hypothesis should be preferred to the more complex hypothesis (1 mark). So, the first hypothesis is the better hypothesis (1 mark).

If the second hypothesis made *better* predictions (i.e. a higher coefficient of determination, R^2, than the first hypothesis' predictions), one could consider it to be a better hypothesis, even though it is more complex. It is obvious that if the predictions of hypothesis 1 were simply wrong (i.e. butterfly populations did not go up with net primary production), than hypothesis 2 would be better (stating just this would only be worth 1 mark for this part of the question, instead of 2 marks.

Note: This decision might be a somewhat subjective one: if hypothesis 1 made only slightly better predictions than hypothesis 2, it might be a clearly better hypothesis because it is still much more complicated. The decision in this case might revolve around how important it was to be accurate compared with how important it was to be parsimonious.

3. (4 marks) Consider the annual climatic data for the following two locations:

	Precipitation			
	February	*May*	*August*	*November*
Location 1	400mm	450mm	520mm	390mm
Location 2	200mm	40mm	20mm	150mm

	Temperature (in degrees C)			
	February	*May*	*August*	*November*
Location 1	19	23	25	21
Location 2	17	29	33	23

Describe the likely vegetation in these two locations. Explain your conclusions. In August, what is a likely limit on NPP in both areas?

The vegetation in the first place is likely to be relatively high biomass, perhaps even tropical rainforest (judging from the temperatures, the forest might be at high elevations, perhaps elfin rainforest). Total annual precipitation in this area is around five metres (calculate the monthly average precipitation and multiply by 12) and it is spread out throughout the year, so there's around 1.5cm rain/day. It is also warm all year round, which is likely to lead to very high biomass vegetation under the circumstances. (1.5 marks)

The second locale is much more seasonal in terms of both temperature and precipitation. It isn't extremely dry on average, but has a long summer with little precipitation, so water deficits during this time might be very significant. The temperature during the driest part of the year is at its peak. This environment might be shrubby, or perhaps a grassland ecosystem. There are some forested areas that have similar environmental characteristics to these as well but they are often at higher elevations and the typical summer climate is cooler – e.g. ponderosa pine forests (1.5 marks).

In August, it is raining a fair bit in the first location. Solar radiation (not temperature) probably limits productivity there. In the second place, water availability is most likely to be the limiting factor. (1 mark)

4. (4 marks) Describe the key biological characteristics of the mixed wood plains ecozone. Why are there more endangered species in this ecozone than in other parts of Canada? Provide an example of an endangered species found in this area.

Mild winters but fairly humid with a decent amount of precipitation. Rich soils. Forests are mostly deciduous (e.g. maples and oaks), some conifers. Deer are common in much of the area, though this may arise because of human modification of these landscapes. Species richness/diversity is generally high. (2 marks – people should say perhaps three distinct things; for example: temperature is warmer, precipitation is higher than the boreal, soils are more productive, all leading to higher species richness for most taxa than areas further north in Canada)

More endangered species because habitat loss is quite high – most of the ecozone is heavily agricultural or urban. One endangered species found in the mixed wood plains is spiny softshell turtle, another is the Massassauga Rattlesnake, another is (was) the Karner Blue butterfly, the Acadian Warbler, etc. (2 marks – 1 mark for saying why there are lots of endangered species and one mark for identifying one).

1. Natality rates in Asclepia have declined from 6.1 births per woman to 4.4 births per couple in the past 28 years. During the same period, mortality has declined by 60%. Asclepia appears to be experiencing:
    a) Decelerating population growth as part of the demographic transition.
    b) Accelerating population growth as part of the demographic transition.
    c) A population crash because of prolonged exponential growth.
    d) Demand-induced scarcity leading to the demographic transition.
    e) Decelerating population growth because of increasing human ecological footprint.

Island biogeography: Island 1 has an area of 3km^2 and 131 species, Island 2 has an area of 9km^2 and 173 species and Island 3 has an area of 34km^2 and 241 species, and Island 4 has an area of 50 km^2. (z = 0.25). There is only one habitat on each island.

2. How many species will be on Island 4?
    a. 249
    b. 227
    c. 265
    d. 282
    e. 289

Solve for the value of the constant, c, first. Then use the value of the constant (which is 100, or 2 when converted to logs) to calculate species richness.

16. In a winking patch metapopulation, you expect that:
    a. individual patch populations are constantly appearing and disappearing.
    b. one patch in particular serves as the primary source of colonists for other patches.
    c. that some patches are unlikely to be recolonized following extinction.
    d. that some patches serve predominantly as sinks.
    e. that larger patch populations wink out (go locally extinct) most frequently.

17. A biologist observes the following four patterns. Which is/are consistent with island biogeographic theory?
    1. Islands that are distant from a source of colonists have fewer species than close islands.
    2. Islands with high species richness have higher extinction rates.
    3. Larger islands are farther from a source of colonists.
    4. Distant islands have lower immigration rates.

a. **Statements 1, 2, and 4 are true**
b. Statements 1, 2, and 3 are true
c. Statements 2, 3, and 4 are true
d. Statements 1, 3, and 4 are true

e. Statement 2 is true only.
f. Statement 4 is true only.

**

Plants require CO_2 for photosynthesis. Atmospheric concentrations of CO_2 have been increasing since the start of the industrial revolution but plant growth is not faster than when plants are grown with pre-industrial atmospheric concentrations of CO_2. Which of the following hypotheses is most likely to explain why this is so?

a. Water is limiting when the climate is warmer.
b. Plants grow best when they allocate resources to their roots.
c. **CO_2 is not the primary limiting nutrient for plants.**
d. Increased CO_2 inhibits plant photosynthesis.
e. Plants did not evolve under high CO_2 conditions are not adapted to use abundant CO_2 resources.

1. A biologist observes experimental population sizes of a *Paramecium* species ("*Paramecium* A") in two environmentally identical systems, but in system 2, there is a competing *Paramecium* species ("*Paramecium* B"), which has a constant population size of 120. Describe fully, including complete calculations, the effect that an individual of *Paramecium* B has on *Paramecium* A given the observations below.

Time	System 1 population size of *Paramecium* A	System 2 population size of *Paramecium* A
1	209	152
2	209	153
3	216	150
4	204	146
5	210	149
6	209	149
7	215	151
8	208	150

Refer here to Lotka-Volterra equations, specifically, (for 2 marks)

$$N_1 = K_1 - \alpha N_2$$

, where N1 is population size of Paramecium A, N2 is pop size for Paramecium B, K1 is the carrying capacity for Paramecium A, and alpha is the coefficient that "converts" individuals of the first species into the second.

Recognize that the mean population size through time of Paramecium A without the competitor is 210. The mean population size of Paramecium A with the competitor is 150. So the calculations are:

Rearranging the equation and substituting to solve to alpha gives (210-150)/120 = 0.5 = alpha. So these species can coexist (1 mark) and the effect of Paramecium B on Paramecium A is to reduce its maximum population size by 60 individuals because Paramecium B uses resources at about half the rate of Paramecium A.

1. Given a hypothesis that warmer winter temperatures cause more rapid population growth among mosquitoes, which of the following observations support that hypothesis?

i. **mosquito larvae die more frequently in very cold winter weather.**
ii. mosquito adults die more frequently in very hot summer weather.
iii. mosquito larvae die less frequently in very cold winter weather.
iv. mosquito adults die more frequently in relatively warm winter weather.
v. mosquito larvae are more abundant in Labrador than the United Kingdom.

a. i is true
b. ii is true
c. iii is true
d. i and ii are true
e. i, ii, and v are true

2. A biologist knows that the loss of predators from a forest will cause deer populations to increase. The biologist observes that deer populations have increased and concludes that predators have been lost. This is an example of:

a. Deductive reasoning
b. **Affirming the consequent**
c. A successful prediction
d. An unsuccessful prediction
e. Inductive reasoning.

3. Based on patterns of extinction among freshwater fish, it is possible to conclude that:
    a. extinctions seem more common among aquarium fish species.
    b. extinctions seem less common among well-studied fish species.
    c. extinctions seem more common among tropical fish species.
    d. **extinctions seem more common among well-studied fish species.**
    e. extinctions seem less common among tropical fish species.

4. The "field of bullets" hypothesis, developed from a study of extinction patterns among freshwater fish, suggests that:
    a. **no particular life history characteristics are associated with increased extinction risk.**
    b. that predatory fish are more likely to go extinct.
    c. that predatory fish are more likely to eat herbivorous fish.
    d. long-lived fish species are more likely to go extinct.
    e. that very broadly distributed fish species are more likely to go extinct.

5. An ecologist observes that the mean trophic level of fish caught by humans in a particular part of the Pacific Ocean declines significantly from 3.1 to 2.3 over a 20 year study period. This probably suggests that:
    a. **fish species at high trophic levels are decreasing in abundance because of the fishery.**

b. fish species at high trophic levels are increasing in abundance because of the fishery.
c. human fishing activities can continue at this intensity indefinitely.
d. carnivorous fish have shifted their life history characteristics to become herbivores.
e. fish species at low trophic level are increasing in abundance because of the fishery.

6. A scientist observes low plant species richness in an environment that is subject to high ultraviolet radiation. She develops a hypothesis stating that plant species richness generally declines with increasing ultraviolet radiation. She predicts that low UV environments will have greater plant species richness than high UV environments, all other factors being equal. Which of the following best describes the reasoning processes she has followed:
   a. The use of inductive reasoning to develop the hypothesis and predictions.
   b. The use of deductive reasoning to develop the hypothesis and inductive reasoning to develop the predictions.
   c. The use of inductive reasoning to develop the hypothesis and deductive reasoning to develop the predictions.
   d. The use of deductive reasoning to develop the hypothesis and predictions.
   e. The use of inductive reasoning to eliminate the impossible, leaving only the possible, however unlikely.

7. A biologist must decide which of two hypotheses is more successful. If Hypothesis 1 is true, predictions A and B must be observed. If Hypothesis 2 is true, predictions B, C, and D must be observed. The biologist observes the following: A is true, B is false, C is true, and D is true. What should the biologist conclude about the two hypotheses?
    a. Hypothesis 1 and Hypothesis 2 are both true but Hypothesis 1 is more successful.
    b. Hypothesis 1 is false but Hypothesis 2 is true.
    c. Hypothesis 1 is true but Hypothesis 2 is false.
    d. Hypothesis 1 and Hypothesis 2 are both false.
    e. Hypothesis 1 and Hypothesis 2 are both true but Hypothesis 2 is more successful.

8. A biologist is interested in determining how the abundance of a mammal species is affected by particular environmental characteristics. She measures net primary productivity, mammal population size, minimum temperature during mating season, and nutrient availability in the vegetation. In this study:
    a. net primary productivity and mammal population size are dependent variables and minimum temperature and nutrient availability are independent variables.
    b. mammal population size is the independent variable and all others are dependent variables.
    c. net primary productivity is the independent variable and all others are predictor variables.
    d. nutrient availability is the independent variable and other variables are irrelevant.
    e. mammal population size is the dependent variable and all other variables are predictor variables.

9. An ecologist is measuring the rate at which a plant species grows. There are four groups of plants, all of which consist of the same species. He adds phosphorus to the first group of plants and observes a 7% increase in plant growth rates compared with the fourth group of plants. He adds nitrogen to the second group of plants and observes a 12% increase in growth rates compared to the fourth group of plants. He adds nitrogen and phosphorus to the third group of plants and observes a 18% increase in growth rates compared to the fourth group of plants. Nothing is added to the fourth group. Which nutrients are most limiting in this experiment?
    a. Nitrogen is the most limiting nutrient, followed by phosphorus.
    b. Phosphorus is the most limiting nutrient, followed by nitrogen.
    c. Nitrogen and phosphorus are equally limiting.
    d. Nitrogen and phosphorus are equally limiting but a third nutrient is clearly missing.
    e. Experimental results are uncertain because nothing was added to the fourth group of plants.

10. A parasite of deer, *Democritus shrubphobii*, used to be present on all deer in the Washington area. A second species of deer parasite, *Weebrainii nitwitus*, was recently introduced to this region, and now *Democritus shrubphobii* is found on only 49.4% of deer around Washington. Why might this be?
    a. The fundamental niche of *Democritus shrubphobii* is too small to allow it to occupy the whole area indefinitely.
    b. The realized niche of *Democritus shrubphobii* is much smaller than its fundamental niche in the presence of *Weebrainii nitwitus*.
    c. The fundamental niche of *Weebrainii nitwitus* is larger than the realized niche of *Democritus shrubphobii.*
    d. The realized niche of *Democritus shrubphobii* is larger than its fundamental niche in the presence of *Weebrainii nitwitus.*
    e. The fundamental niche of *Weebrainii nitwitus* has expanded following the decline of *Democritus shrubphobii*.

11. Coral species often tolerate a small range of water temperatures. Climate change has generally led to increasing water temperatures, causing some coral species to disperse toward cooler waters. Coral species are *most* likely to avoid extinction due to climate change if:
    a. climate warms quickly and dispersal rates are low.
    b. climate warms slowly and dispersal rates are high.
    c. climate warms slowly. Dispersal does not matter.
    d. climate warms quickly and dispersal rates are high.
    e. climate warms quickly. Dispersal does not matter.

12. Solar radiation is most intense in atmosphere around the equator. This phenomenon leads to the following climatic patterns and consequences:
    a. Warm, moist tropical air rises, cools off, and causes heavy precipitation in equatorial areas.
    b. Cool, moist tropical air rises, warms up, and causes heavy precipitation in equatorial areas.
    c. Cool, moist tropical air sinks north and south of the equator and causes desert-like conditions near continental boundaries.
    d. Dry, warm tropical air rises, cools down, and causes heavy precipitation in equatorial areas.
    e. Cool, moist tropical air sinks in equatorial regions and causes relatively heavy precipitation.

13. Travelling from equatorial central Africa toward north Africa, net primary productivity is generally limited by:
    a. Temperature and then solar radiation
    b. Solar radiation and then temperature
    c. Moisture and then solar radiation
    d. Solar radiation and then moisture
    e. Moisture and then temperature

14. Climatic conditions in the central Amazon basin of Brazil are warm, moist, and often cloudy. Climate change is expected to cause the area to become sunnier and drier. Net primary productivity in this region of Brazil is probably limited by:
    a. solar radiation but may become temperature limited in the future.
    b. temperature but may become moisture limited in the future.
    c. solar radiation but may become cloud limited in the future.
    d. temperature and likely to remain that way in the future.
    e. solar radiation but may be limited by moisture in the future.

15. Plants require CO_2 for photosynthesis. Atmospheric concentrations of CO_2 have been increasing since the start of the industrial revolution but plant growth is not faster than when plants are grown with pre-industrial atmospheric concentrations of CO_2. Which of the following hypotheses is most likely to explain why this is so?
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    e. Plants did not evolve under high CO_2 conditions and cannot use extra CO_2.

15. In an area with high primary productivity at all times of year, it would be surprising to find a plant species with:
    a. defenses against herbivores.
    b. woody stems.
    c. freeze tolerance.
    d. chlorophyll.
    e. a and b are both correct.
    f. b and c are both correct.

16. The boreal forest of Canada is:
    a. mostly old-growth forest on nutrient-poor soils.
    b. variable in age due to moose grazing and grows on nutrient-poor soils.
    c. variable in age due to forest fires and grows on nutrient-poor soils.
    d. variable in age due to human overfishing and grows on nutrient-rich soils.
    e. mostly old-growth forest on nutrient-rich soils.

17. Around Dunedin, New Zealand, vegetation on north-facing slopes of hills will often differ from vegetation on south-facing slopes by:
    a. resembling vegetation from much further north.
    b. resembling vegetation from much further south.
    c. resembling vegetation from hilltops in the area.
    d. resembling vegetation from north-facing slopes much further north.
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27. Solar radiation is most intense in atmosphere around the equator. This phenomenon leads to the following climatic patterns and consequences:
    a. Warm, moist tropical air rises, cools off, and causes heavy precipitation in equatorial areas.
    b. Cool, moist tropical air rises, warms up, and causes heavy precipitation in equatorial areas.
    c. Cool, moist tropical air sinks north and south of the equator and causes desert-like conditions near continental boundaries.
    d. Dry, warm tropical air rises, cools down, and causes heavy precipitation in equatorial areas.
    e. Cool, moist tropical air sinks in equatorial regions and causes relatively heavy precipitation.

28. Travelling from equatorial central Africa toward north Africa, net primary productivity is generally limited by:
    a. Temperature and then solar radiation
    b. Solar radiation and then temperature
    c. Moisture and then solar radiation
    d. Solar radiation and then moisture
    e. Moisture and then temperature

29. Climatic conditions in the central Amazon basin of Brazil are warm, moist, and often cloudy. Climate change is expected to cause the area to become sunnier and drier. Net primary productivity in this region of Brazil is probably limited by:
    a. solar radiation but may become temperature limited in the future.
    b. temperature but may become moisture limited in the future.
    c. solar radiation but may become cloud limited in the future.
    d. temperature and likely to remain that way in the future.
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    e. Plants did not evolve under high CO_2 conditions and cannot use extra CO_2.

30. In an area with high primary productivity at all times of year, it would be surprising to find a plant species with:
    a. defenses against herbivores.
    b. woody stems.
    c. freeze tolerance.
    d. no chlorophyll.
    e. a and b are both correct.
    f. b and c are both correct.

31. The boreal forest of Canada is:
    a. mostly old-growth forest on nutrient-poor soils.
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    b. resembling vegetation from much further south.
    c. resembling vegetation from hilltops in the area.
    d. resembling vegetation from north-facing slopes much further north.
    e. resembling vegetation from south-facing slopes much further south.