

Open Ended Questions

- (3 points) Birds have a type 2 or II Survivorship curve, trees have a type 3 or III Survivorship curve, and elephants have a type 1 or I Survivorship curve.
- (3 points) During immobilization of the phosphorus cycle, inorganic compounds are converted to organic compounds by plants/algae/microorganisms.
- (2 points) A hypothetical ecosystem has 5 species, each of which has 10 individuals. What is the Shannon Diversity Index of this ecosystem? $\ln(5)$ or 1.609
- (1 point) What is the value of the species evenness for the ecosystem in the previous question? There are multiple ways to calculate species evenness, but use the equation with the Shannon Index for this question. 1
- (2 points) The bioremediation process that is performed at the original site of contamination is known as in-situ remediation. The bioremediation process that is performed on contaminants after they are removed from the original site is known as ex-situ remediation.
- (2 points) What is the theory that describes how individuals have a tendency to deplete a natural resource out of self-interest? Tragedy of the Commons
- (4 points) A highway will be built in a region, splitting the habitat in half. What is this process known as? What are some ways it might affect a population living in that area? Answer with at least 3 different effects on the population.

Solution: Habitat Fragmentation (1) Includes 3 of the following for up to 3 points: cuts total area of population (1), genetic isolation/loss of diversity (1), more likely to introduce invasive species (1), Edge Effects (1), Less Movement (1), Less Seed Dispersal (1), Extinction (1), Genetic Drift (1)

- (4 points) The spread of taiga into tundra biomes would have what effect on carbon dioxide concentrations and temperature? Why?

**Solution: Increase temperature (1) due to lower albedo (1)
Decrease CO₂ (1) due to carbon sequestration by trees (1) - just needs something about how trees/plants can use up carbon dioxide**

9. (6 points) Define both fundamental and realized niche. Is it possible that the realized niche is larger than the realized niche. Why?

Solution: Realized - niche that is actually occupied (1)
Fundamental - niche that could theoretically be filled without species interactions (1)
Yes (2), positive species interactions allow the realized niche to be higher (2)

10. (6 points) Provide 2 characteristics and 1 example of r-selected organisms and K-selected organisms each.

Solution: Solution: r-selected characteristics - generally smaller, fast growing, live in unstable environments, produce large number of offspring, provide less care for offspring, Type 3 Survivorship Curve (2)
r-selected examples - frogs, toads, salamanders, insects, fish (1)
K-selected characteristics - generally larger, slower growing, live in stable environment, produce lower amount of offspring, provide more care for offspring, Type 1 Survivorship Curve (2)
K-selected examples - humans, elephants, bison (1)

11. (3 points) In one sentence, define the invasion paradox.

Solution: Invasive species (1) have been shown to both increase and decrease (1) species richness/number (1) of native species at broad and fine scales
+1 if answer include invasive species, +1 for mentioning both positive and negative effect, +1 for identifying that the effect is on the number of native species/richness/diversity

12. (4 points) Explain briefly (1 sentence each) the difference between alpha diversity, beta diversity, and gamma diversity.

Solution: Alpha Diversity is the diversity in a singular ecosystem/community(1)
Beta Diversity is the diversity in 2 ecosystems/communities(1)
Gamma Diversity is the diversity in a large geographic area/region(1)
+1 points if everything is right

Use the following diagram to answer the next three questions.

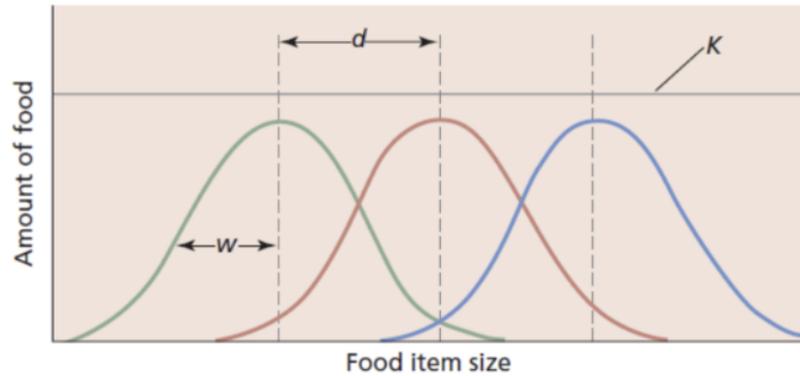


Figure 1: Food item size vs. amount of food of three different competing species

13. (2 points) Which region of the graph above represents the food sizes that all three species eats?

Solution: Area of overlap between green and blue curves (very center of the graph)

14. (3 points) Explain how increasing the variable "d" affects the chances of coexistence between three competing species.

Solution: Increases chances of coexistence (1); means of food size are further apart so niches less likely to overlap (2)

15. (3 points) Explain how increasing the variable "w" affects the chances of coexistence between three competing species.

Solution: Decreases chances of coexistence (1); standard deviations of food sizes make them more likely to overlap so species compete (2)

The latitudinal diversity gradient states that lower latitudes (the equator and tropics) are more biologically diverse than higher latitudes (polar regions). This has proven to be the case for all types of biodiversity, including functional diversity, genetic diversity, and species diversity. Answer the following three questions based on this knowledge of the latitudinal diversity gradient.

16. (2 points) Some ecologists have proposed the mid-domain effect as the reason behind the latitudinal diversity gradient. To explain the mid-domain effect, imagine a box of pencils being shaken up (each pencil representing a species range). Most of the pencils will overlap at the center of this box. What is the most obvious flaw in this hypothesis? (Hint: Think about the cardinal directions).

Solution: It would also apply in the east-west direction and not the north-south direction (2)

17. (3 points) Another hypothesis for the latitudinal diversity gradient is called the time-integrated hypothesis. Explain BRIEFLY how repeated ice ages and glaciations in the poles could help explain the latitudinal diversity hypothesis. (Hint: "Time" is evolutionary).

Solution: More stable and benign tropical environments steadily accumulate species (1) while "ice ages" and glaciations repeatedly set back the diversity clock in the poles (2)

18. (4 points) Analyze the contour plot of the number of marine brachiopod genera over time in different latitudes. Does this contour plot prove, disprove, or not indicate anything about the hypothesis suggested in the previous question?

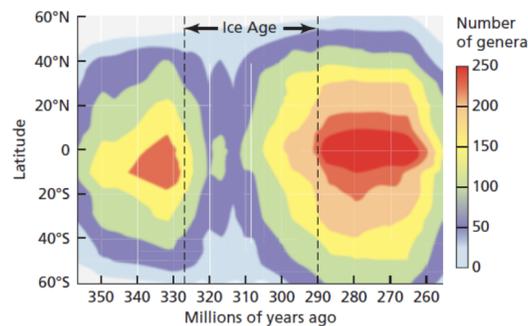


Figure 2: Brachiopod genera diversity

Solution: Disproves the time-integrated area hypothesis; number of genera of marine brachiopods across the LDG has strengthened and weakened over time including in the tropics (2), disproving the idea that lineages (at least amongst lower taxa, e.g. genera and species) have accumulated over evolutionary time in the tropics (2)

Hutchinson made another key insight in regards to the ecological niche when studying different species of desert mice that use similar resources. Desert mice species that were similar, except in the sizes of the food they eat, differed by a constant size ratio: a factor of 1.3 in length and 2.0 for body mass. This was true across different deserts, as shown by the data recorded below. Use this information to solve the next two questions.

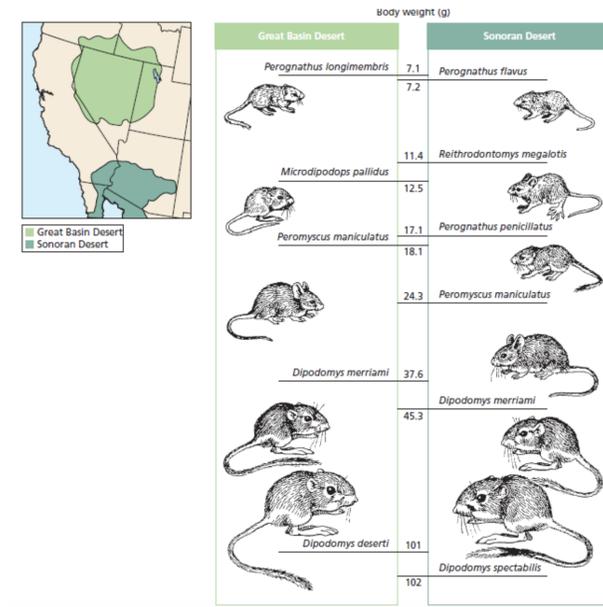


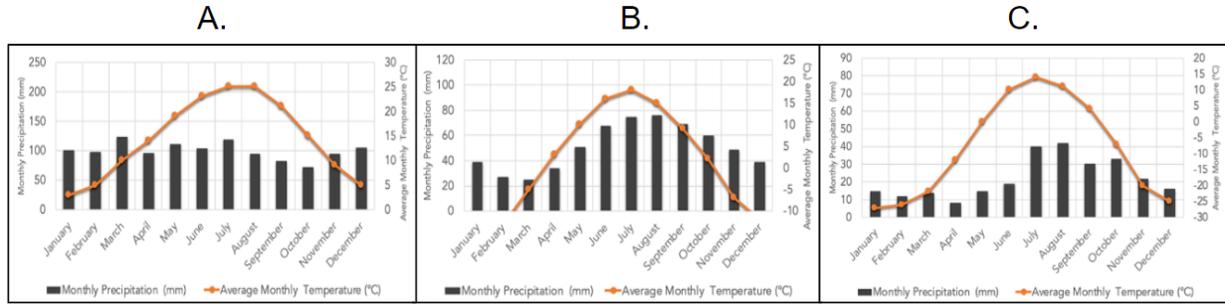
Figure 3: Mice of two different deserts

19. (3 points) Explain briefly (1 sentence or less) why the differences in body size are regular as opposed to irregular, even amongst mice of different desert ecosystems.

Solution: There must be a minimal difference in niches (word "niches" is not necessary if it's implied in answer) that would allow for species of mice with different sizes to coexist on the same food/resources (2); most species would differ in size by this "minimal" difference (1)

20. (3 points) Objects in nature that are not biological in origin also exhibit size ratios of 1.3. Does this strengthen or weaken the idea that the Hutchinsonian ratios in the Great Basin and Sonoran desert are a result of niche differentiation? Briefly justify.

Solution: Weaken (1); it implies that this size distribution of organisms is found by random chance in nature and is not a result of niche differentiation (2)



21. (3 points) Match the temperature and rainfall graphs above to tundra, taiga, and deciduous forest.

Solution: A. Deciduous Forest B. Taiga/Boreal Forest C. Tundra

Use the following table for the next 11 questions:

Species	Number of Individuals
Jack Pine	15
White Spruce	267
Quaking Aspen	105
Black Spruce	31
Paper Birch	45

22. (1 point) What is the total abundance of this ecosystem?

463

23. (2 points) Berger Parker Dominance is calculated with the following formula. Calculate and interpret the value of the Berger Parker Dominance index for this ecosystem. Answer to three decimal places.

$$d = \frac{N_{max}}{N}$$

where N is the number of individuals and N_{max} is the number of individuals in the most abundant species.

Solution: .577 (1), 58% of individuals are from the most dominant species (1). Also accept anything about the ecosystem being dominated by the most prevalent species or just acknowledging that Berger Parker dominance represents the proportion of individuals that are of the most common species

24. (1 point) What is the species richness of this ecosystem?

5

25. (2 points) What is the value of the Shannon Diversity Index for this ecosystem.

1.1726

26. (2 points) Calculate the value of evenness (E_H) using the Shannon Diversity from the previous question. If you did not answer the previous question, assume that the Shannon Diversity was 1, and solve using this number.

0.728602076, accept 0.621334935 if they assume $H = 1$

27. (5 points) MacArthur (1965) suggested that we measure Shannon Diversity as e^H , where H is the Shannon Diversity and e is Euler's number ($e \approx 2.718$). Calculate and interpret the value of e^H with units. You may assume $H = 1$ if you did not answer the previous questions.

Solution: 3.230509303 (1) species
Units are equivalent species (species is fine too) (1)
We would need an ecosystem with 3.231 species of equal abundance to achieve the same value of H as this community (3)

28. (2 points) What is the biggest advantage of measuring transforming H in this way?

Solution: Allows us to compare to richness, $1/D$, etc that are also in species (also accept something about less abstract unit or easier to think about) (2)

29. (2 points) Calculate e^H for this community if each species has exactly 50 individuals.

5

30. (3 points) Calculate the inverse Simpson Index with units. Use the formula below to calculate the index.

$$D = \frac{1}{\sum_{i=0}^S p_i^2}$$

where S is the number of species and p_i is the relative abundance of the species.

D = 2.5065 (2) species (1)

31. (2 points) Calculate the Simpson Evenness of this ecosystem. Use the formula below to calculate the index.

$$E_D = \frac{D}{S}$$

0.5013

32. (3 points) Is E_D higher, lower, or the same as E_H . Explain why this is the case.

Solution: Lower (1) because E_D values rare species less/common species more (2)