Science Olympiad
Ecology Key
Seven Lakes Invitational

Directions:

- **This test is a class set.** Please do not write any answers on this paper.
- Please write all answers clearly; illegible answers will not be scored.
- There is no penalty for wrong answers. Answer every question, even if you aren't sure if you're correct.
- Ties will be broken using free response questions #128, #113, #127, #125, #108 in that order. After this point, free response section score then first multiple choice question missed will be used to break ties.
- Good luck on the test!

For grading use only

Page:	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Points:	10	12	7	11	8	12	10	11	15	4	10	9	12	14	11	156

General Principles of Ecology

1. (1 point) Grass is best described as a:
A. Primary Producer B. Secondary Producer C. Primary Consumer
D. Secondary Consumer E. Tertiary Consumer

2. (1 point) Which of the following are characteristics of r-selected species? (select all that apply)
A. Long lifespans B. High parental care **C. Many offspring** **D. Precocial offspring**

3. (1 point) Which of the following is an example of a density-dependent factor?
A. Disease B. Drought C. Pollution D. Wildfire

4. (1 point) A group of aliens from the faraway planet Sigma arrive on Earth, crash-landing in Central Asia on March 1st. The population of aliens grows exponentially. A group of researchers found that from September 1st to December 1st of the same year, the alien population increased from 108 to 290. To the nearest whole number, what was the initial population of aliens when they crash-landed on Earth?
A. 9 B. 12 **C. 15** D. 18

5. (1 point) If a population grows at a rate of 1% each year, which of the following is closest to the doubling time of the population in years?
A. 10 B. 35 C. 50 **D. 70** E. 100

6. (1 point) Emperor penguins are highly territorial and have areas around their nests that they vigilantly defend. Emperor penguins exhibit which type of population dispersion pattern?
A. Cartesian B. Clumped C. Random **D. Uniform**

7. (1 point) What type of selection occurs when conditions favor organisms with intermediate attributes?
A. Stabilizing B. Normalizing C. Directional D. Mediating

8. (1 point) What best describes blue carbon?
   A. Carbon that is released by non-anthropogenic sources
   B. Carbon that is trapped by glacial ice
   C. Carbon that is captured by marine and coastal ecosystems
   D. Carbon that is utilized by photosynthetic bacteria

9. (1 point) In one particular ecosystem, hawks eat snakes. However, a disease has been spreading among snakes, causing their population to drop precipitously. Which of the following is most likely to occur among the hawk population?
   A. Increase in hawk population
   B. Decline, then increase in hawk population
   C. Decline in hawk population
   D. No significant change to the hawk population

10. (1 point) What is the difference between allopatric and sympatric speciation?
   A. Allopatric speciation occurs due to a geographic barrier, whereas sympatric speciation occurs in the same geographic area.
   B. Allopatric speciation occurs in the same geographic area, whereas sympatric speciation occurs due to a geographic barrier.
   C. Allopatric speciation occurs primarily in plants, whereas sympatric speciation primarily occurs in animals and fungi.
   D. Allopatric speciation occurs primarily in animals and fungi, whereas sympatric speciation primarily occurs in plants.

11. (1 point) A population of baboons that grows logistically has a carrying capacity of 1120. What is the population size when the rate of population increase is the highest?
A. 560 B. 672 C. 840 D. 1008

12. (1 point) Which of the following famous animals has a population that is most likely to follow a type I survivorship curve? (select all that apply)
A. Donald Duck B. Barry the Bee **C. Moo Deng, a pygmy hippopotamus** **D. Clifford the Big Red Dog**

13. (1 point) Which of the following nutrients does not have a prominent gas phase in its nutrient cycle?
A. Nitrogen B. Water **C. Phosphorus** D. Carbon

14. (1 point) Plants that utilize CAM photosynthesis are more adapted to:
    A. Cold environments because it creates an antifreeze substance as a byproduct
    B. Cold environments because it strengthens plant tissue with more layers of cells
    C. Arid environments because it physically divides stomata from chloroplasts
    D. Arid environments because it temporally divides carbon fixation and photosynthesis

15. (1 point) Which of the following describes the amount of energy that is transferred from one trophic level to the next?
A. Ecological efficiency B. Transfer ratio C. Energy differential D. Trophic resourcefulness

16. (1 point) Which of the following describes the idea that long food chains are less stable than short food chains?
A. 10% rule **B. Dynamic stability hypothesis** C. Jordan's rule D. Theory of stratification

17. (1 point) Which of the following refers to changes in allele frequency due to random change?
A. Artificial selection B. Gene flow **C. Genetic drift** D. Mutation E. Natural selection

18. (1 point) Which of the following refers to an interaction where one organism lives in the nest of another without harming the host?
A. Inquilinism B. Kleptoparasitism C. Metabiosis D. Mycorrhizae E. Phoresis

19. (1 point) The example from the question #18, where one organism lives in the nest of another, is an example of what type of ecological interaction?
A. Amensalism **B. Commensalism** C. Competition D. Mutualism E. Parasitism

20. (1 point) Alfred Redfield discovered that in oceans, the ratio of carbon to nitrogen to phosphorus is:
A. 38:56:15 B. 120:4:3 **C. 106:16:1** D. 80:27:10

21. (1 point) Which of the following is true about niches? (select all that apply)
    A. Multiple species often occupy the same niche in the same environment
    B. Species is matched to a role within specific environmental conditions
    C. Fundamental niche is free from interference from other species
    D. Realized niche is the ideal, encompassing niche that a species inhabits.
    E. Realized niche is always larger than fundamental niche

22. (1 point) Which of these definitions best describe phyletic gradualism?
    A. Model of evolution that suggests species evolve in rapid bursts, followed by long periods of instability
    B. Species evolve in isolated populations and later merge.
    C. Model of evolution that says most speciation is slow and uniform.

D. Genetic mutations change the allele frequencies and make drastic changes to the species.

23. (1 point) Which of the following best describes a guild? (select all that apply)

A. Group of species that exploit the same resources.

B. Group of species that exploit different resources in similar ways.

C. Group of species that occupy the same niche.

D. Species go extinct due to multiple different species having the same niche.

24. (1 point) What is the role of decomposers in the nutrient cycle?

A. Assimilate nitrogen from the atmosphere for growth

B. Break down organic matter and release inorganic nutrients back into the environment

C. Fix carbon into an organic molecule

D. Convert phosphorus into a gaseous form usable by plants.

25. (1 point) Which of the following best describes the size and distance from the mainland that would result in an island expected to have the highest biodiversity?
A. Small, close B. Small, far **C. Large, close** D. Large, far

26. (1 point) Myrmecomorphy is best defined as the mimicry of which group of insects?
A. Ants B. Bees C. Butterflies D. Dragonflies E. Mantises

Use the information below for the following three (3) questions:

A hypothetical population of rabbits released into a desert is heterozygous for 5 genes: AaBbCcDdEe. For each dominant gene, the length of the rabbit's appendages is 2% longer than that of the fully recessive phenotype. As an example, a rabbit of genotype AAbbccDdee would have appendages 4% longer than a rabbit of genotype aabbccddee.

27. (1 point) If 2 of the rabbits in the initial population mate, what is the probability that an offspring will have limbs at least 6% longer than a fully recessive rabbit?
A. 26.4% B. 34.3% C. 60.0% D. 63.3% **E. 89.6%**

600 rabbits were released into the wild. The following table shows how many rabbits of each phenotype were present and how many survived.

Percent Length Larger Than Fully Recessive Phenotype

	10%	8%	6%	4%	2%	0%
Number released into the wild	100	100	100	100	100	100
Number surviving	100	80	60	40	20	0

28. (1 point) Given this data, what is the mean population fitness for the rabbit population in the desert?
A. 0.25 B. 0.375 C. 0.5 **D. 0.75** E. 0.875

29. (1 point) What type of selection will occur with respect to the phenotype of the progeny of the heterozygous rabbits, and which rule supports this?

A. Disruptive selection, Allen's Rule

B. Stabilizing selection, Bergmann's Rule

C. Artificial selection, Bergmann's Rule

D. Directional selection, Allen's Rule

E. Sexual selection, Bergmann's Rule

30. (1 point) Which of the following describes female animals having multiple male mates?
A. Polyandry B. Monogamy C. Polygyny D. Monotropy

31. (1 point) Which letter of the alphabet most closely portrays population growth in an ideal environment with no density-dependent factors?
A. I **B. J** C. S D. U

32. (1 point) When organisms must compete for highly limited resources, their population distribution is likely—
A. Clumped B. Normal C. Random **D. Uniform**

33. (1 point) Which of the following refers to migration where migratory individuals in a population can be distinguished from individuals that will not migrate by a physical trait like age?
A. Complete **B. Differential** C. Partial D. Selective

34. (1 point) Which of the following is the largest reservoir for carbon in the carbon cycle?

A. Limestone rock as carbonates

B. The stratosphere as Ozone (O_3)

C. Deep ocean waters where carbon is stored as bicarbonate ions.

D. The atmosphere stored as Greenhouse Gasses like CO2 and CH4

35. (1 point) Which consumer-resource interaction describes a lectivore?

A. A termite, organism that gathers dead plant material

B. A cat, organism that preys on live animals

C. A white-backed vulture, organism that scavenges animal carcasses

D. A blowfly, organism that mines dead flesh

36. (1 point) What is a seral community?

A. A community that catalyzes restoration of habitat and organisms

B. The intermediate stage in succession

C. Community that is in equilibrium with biodiversity and biomass

D. A community that halts succession during the middle of its lifespan

37. (1 point) A population of 200 rabbits has an instantaneous growth rate of 30 and follows a logistic curve. If the carrying capacity is 1200, what is the intrinsic growth rate of the population?
A. 5.56 **B. 0.18** C. 0.15 D. 0.025

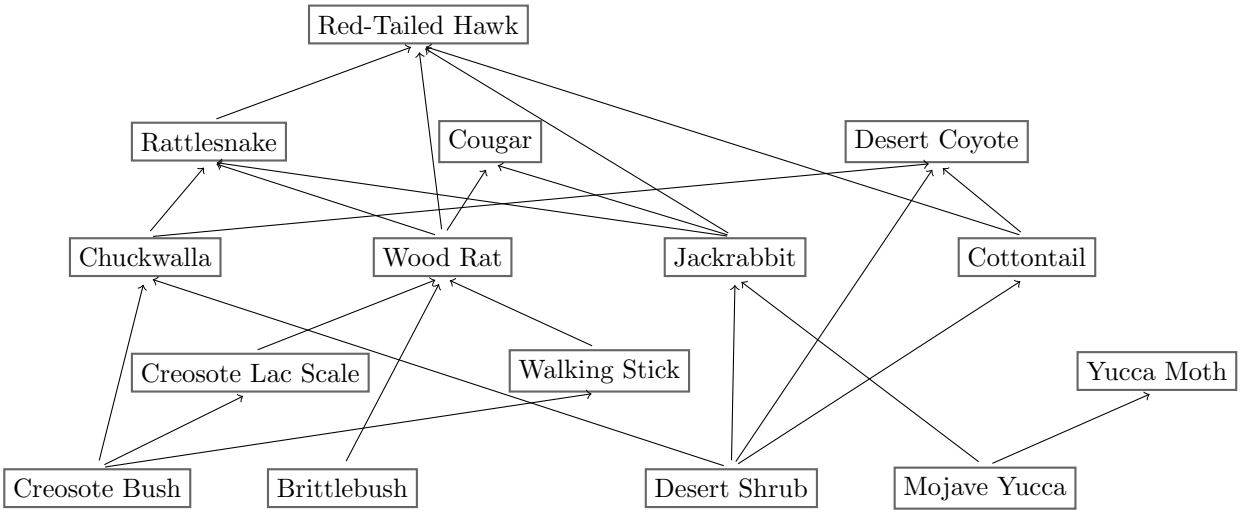
38. (1 point) Using the intrinsic growth rate calculated above, what is the instantaneous growth rate of the population when the population size is 600?
A. 90 B. 45 **C. 54** D. 60

39. (1 point) All of the rabbits have suddenly gained a mutation allowing them to photosynthesize, increasing the carrying capacity to 2400. What is the new instantaneous growth rate at 600 rabbits? Assume the intrinsic growth rate remains the same.
A. 108 B. 180 **C. 81** D. 90

40. (1 point) Which country is an example of stage 5 in the demographic transition model? (select all that apply)
A. Italy B. Australia C. India D. USA **E. Japan**

Terrestrial Ecosystems

Use the following food web to answer the next 13 questions.



41. (1 point) Which of the species in the food web above would be classified as a primary producer? (select all that apply)
A. Brittlebush B. Chuckwalla **C. Mojave Yucca** D. Walking Stick E. Yucca Moth

42. (1 point) An increase in which species would likely lead to a decrease in the Walking Stick population? (select all that apply)
A. Brittleblush B. Chuckwalla C. Cougar **D. Wood Rat** E. Yucca Moth

43. (1 point) How many primary consumers exist in this food web?
A. 4 B. 5 C. 6 D. 7 **E. 8**

44. (1 point) Researchers are worried that a disease will wipe out the Jackrabbit population. If this happens, which of the following species would likely increase in population as a result? (select all that apply)
A. Cougar B. Red-Tailed Hawk **C. Mojave Yucca** **D. Desert Shrub** **E. Yucca Moth**

45. (1 point) Which of the following species in the food web can be classified as secondary consumers? (select all that apply)
A. Chuckwalla B. Cottontail C. Creosote Lac Scale **D. Rattlesnake** **E. Wood Rat**

46. (1 point) Removal of which of the following species will most likely result in a top down trophic cascade?
A. Brittlebush B. Creosote Lac Scale C. Jackrabbit **D. Red-Tailed Hawk** E. Walking Stick

47. (1 point) If the Mojave Yucca has 10,000 kJ of energy, what is the net secondary productivity of the Yucca Moth if 95% of its energy is used for respiration?
A. 9500 kJ B. 950 kJ C. 500 kJ **D. 50 kJ**

48. (1 point) Imagine that there is a mining spill that contaminates the soil with cadmium. Which of the following species would likely have the highest concentration of cadmium?
A. Brittlebush B. Creosote Lac Scale C. Jackrabbit **D. Red-Tailed Hawk** E. Walking Stick

49. (1 point) What is the name for the process that was occurring in the previous question (#48)?
A. Bioaccumulation **B. Biomagnification** C. Biotransformation D. Biosparging

Use the following information for the next four (4) questions:

A specific gene in a Chuckwalla population in a desert has a natural mutation rate of 0.005. However, after human deposition of radioactive material near the Chuckwalla population's habitat, the mutation rate is now 0.1.

50. (1 point) Prior to the introduction of the radioactive material, the expected number of mutations within 1 generation in the Chuckwalla population was 1. How many individuals were in this population?
A. 20 **B. 100** C. 200 D. 1000 E. 2000

51. (1 point) Assuming that the radioactive material does not kill any of the Chuckwallas, what is the probability that a mutated gene at this locus would be eliminated from this population (eg. not fix in the population)?
A. 100 B. 99.975 C. 99.95 D. 99.75 **E. 99.5**

52. (1 point) What is the difference in the expected number of generations it would take a mutation to fix in this population of Chuckwallas before and after the introduction of the radioactive material? Assume that a mutation occurs in both scenarios at the same time.
A. 0 generations B. 19 generations C. 38 generations D. 57 generations E. 76 generations

53. (1 point) You now find out that a Red Viscacha Rat population also lives near this radioactive material. The rate of mutation at a certain gene locus in this species was 0.005 prior to the introduction of the radioactive material, and 0.1 after its introduction. However, the Red Viscacha Rat is a unique animal: it is tetraploid. Given this information, how many years would it take for a mutation in the Red Viscacha Rat to fix in the population, assuming there are 300 rats in the population? The generation time of this rat population is $\frac{1}{3}$ of a year.
A. 400 years **B. 800 years** C. 2000 years D. 4000 years E. 8000 years

54. (1 point) Which of the following is a regulating ecosystem service provided by grasslands?
A. Cultural heritage **B. Erosion control** C. Food from crops D. Bison pelts

55. (1 point) What order of soil is found in deserts?
A. Mollisol B. Gelisol C. Alfisol **D. Aridisol**

56. (1 point) Fill in the blank: Savannas typically have _____ trees than prairies.
A. the same number of B. sometimes more, sometimes less **C. more** D. less

57. (1 point) What is a animal called that is adapted to live in the desert?
A. Burrowing Animal B. Crepuscular C. Realized Niche **D. Xerocole**

58. (1 point) Which of the following best describes alpha diversity?

A. Biodiversity measured across a large geographic area

B. Similarity between species of different communities

C. Species diversity in a local community

D. Biodiversity regulated by apex predators

59. (1 point) Which human activity is most directly linked to desertification?
A. Urbanization B. Deforestation of rainforests **C. Overgrazing** D. Nonpoint source pollution

60. (1 point) What is the main reason deserts experience big fluctuations of temperature between day and night?

A. Lack of moisture in air

B. Albedo of the sand due to the absence of the sun in the night

C. Low vegetation cover

D. The temperatures of desert are relatively stable and don't fluctuate

61. (1 point) Why are desert soils poor in nutrients even though they have a high mineral content?

A. High levels of salinity neutralizes the nutrients

B. Frequent wildfires kill all the organic material

C. Heavy rainfall and lack of strong roots washs away nutrients

D. Lack of organic matter due to limited plant growth

62. (1 point) Many deserts like the Atacama and Mojave experience the rain-shadow effect. What is this phenomenon?

A. Air descending on the windward side of mountains becomes warmer and drier

B. Air descending on the leeward side of mountains becomes warmer and drier

C. It's a shadow that makes it rain for 10 days, essential for organisms living in the desert

D. It's when winds above deserts that bring in cold, dry air form a low pressure system causing heavy rainfall

63. (1 point) Which of the following are common adaptations that you would expect to find in a typical grassland? (select all that apply)
A. Broad leaves **B. Intercalary meristems** **C. Serotiny** D. Shade tolerance

64. (1 point) Planting alfalfa might be used to increase the concentration of what plant nutrient in the soil?
A. Calcium B. Phosphorus C. Potassium **D. Nitrogen** E. Sulfur

65. (1 point) Which of the following refers to a plant with deep roots that obtains much of its water from the groundwater?
A. Edaphophyte B. Mesophyte **C. Phreatophyte** D. Xerophyte

66. (1 point) Which of the following species is characterized by migration that is not completed by any individual (for example, one cohort goes north and the next goes south)?
A. Arctic tern B. Globe skimmers **C. Monarch butterfly** D. Whooping crane

67. (1 point) Which of the following are plant adaptations to deserts? (select all that apply)
A. C3 photosynthesis **B. Crypts** **C. Reflective trichomes** D. Thin cuticles

68. (1 point) Which of the following is not a type of ecosystem service?
A. Cultural **B. Nourishing** C. Provisioning D. Regulating E. Supporting

69. (1 point) An aeolian process relies on which agent of erosion?
A. Glaciers B. Gravity C. Ice D. Water **E. Wind**

70. (1 point) What biome is most dominated by herbaceous vegetation?
A. Chaparral B. Desert **C. Grassland** D. Taiga E. Temperate forests

Human Impact on Environment

71. (1 point) Which of the following is not a renewable source of energy?
A. Geothermal B. Hydroelectric **C. Nuclear** D. Solar E. Wind

72. (1 point) Which of the following is/are benefits of geothermal energy? (select all that apply)
A. Renewable **B. Consistent energy source** **C. Low carbon emissions** D. Can be used anywhere

73. (1 point) Which renewable energy source currently produces the most energy in the world?
A. Geothermal **B. Hydrothermal** C. Nuclear D. Solar E. Wind

74. (1 point) What type of geothermal power station is most commonly in use today?
A. Binary cycle B. Dry steam **C. Flash steam** D. Tetracycle E. Wet steam

75. (1 point) Which of the following is not an advantage of solar power?
A. Consistent output B. Low carbon emissions C. Low maintenance D. Renewable energy source

76. (1 point) Which of the following is not a valid disadvantage of wind as a renewable energy source?
A. Wind power can injure or kill flying animals if they collide with turbine blades
B. Wind power contributes to noise pollution in an area
C. Wind power generation is variable depending on meteorological conditions
D. Wind power is economically unsuitable for implementation in rural areas

77. (1 point) Which of the following is not a benefit of Traditional Ecological Knowledge?
A. Guiding sustainability across the passage of time
B. Fostering success in commercial farming
C. Empowering indigenous voices and perspectives
D. Bolstering conservation efforts

78. (1 point) Fishing was historically important for the Kwakwaka'wakw people. As such, they employed—
A. Oral traditions to pass down stories about taking care of river systems
B. Monthly meetings to discuss the salmon population and overall river health
C. Ecological experts to regulate where and when people could fish
D. Poetry to inspire biannual river-cleaning events

79. (1 point) According to Navajo traditions, the coyote, a keystone species in parts of North America, is ecologically successful because of its—
A. Carefully-constructed cognitive maps
B. Opportunistic and mischievous nature
C. Fierce predatory techniques and behaviors
D. Clever scavenging methods

80. (1 point) What is the study of how humans and their cultures interact with organisms and environments?
A. Anthropoecology **B. Ethnobiology** C. Biosociology D. Ecoanthropology

81. (1 point) What is the term for the elimination of a species in a specific area?
A. Aestivation **B. Extirpation** C. Reintroduction D. Species extinction

82. (1 point) Which of the following is/are potential issues with reintroduction of species back into areas where they were locally extinct? (select all that apply)
A. Adaptation to captivity B. High heterozygosity **C. Low genetic diversity** **D. Low seed viability**

83. (1 point) Which of the following is an example of in situ sourcing for species introduction?
A. Cultivating seeds from a distant wild population
B. Planting seeds from a seed bank
C. Raising individuals in captivity until they are mature and ready to be released
D. Waiting for the species to reestablish itself naturally

84. (1 point) Monterey cypress is found in only one place in the world (Monterey Bay in California). It used to have a significantly larger range, but the recession of the glaciers at the end of the last ice age gradually reduced its available habitat, eventually leaving it with just the bay. Based on the description given, which of the following best describe Monterey cypress?
A. Dominant **B. Endemic** C. Invasive D. Keystone **E. Relict**

85. (1 point) What protocol helped reduce the hole in our ozone layer by stopping the use of hydrofluorocarbons (HCFCs)?
A. NEPA B. Stockholm Convention **C. Montreal Protocol** D. Kyoto Protocol

86. (1 point) Approximately how many meters thick is a Dobson Unit (DU)?
A. 1 B. 10 C. 100 D. 1000 **E. Impossible to determine**

87. (1 point) Which of the following are typically used to reduce sulfur dioxide emissions? (select all that apply)
A. Aerated pond B. Catalytic converters C. Cyclones **D. Scrubbers**

88. (1 point) Which of the following is not a negative effect of sulfur dioxide?
A. Acid rain **B. Global warming** C. Haze D. Irritating skin

89. (1 point) Which of the following gases has a GWP equal to 1?
A. CH_4 **B. CO_2** C. H_2O D. NO_2 E. SF_6

90. (1 point) Which of the following is not a use of SF_6?
A. High voltage circuit breakers B. Magnesium production **C. Lithium isolation** D. Tracer gas

91. (1 point) Which bacteria is also known as "superbug" because it is able to biodegrade hydrocarbons?
A. *Bifidobacterium longum* B. *Cronobacter sakazakii* C. *Gardnerella vaginalis* **D. *Pseudomonas putida***

92. (1 point) Which of the following refers to a method of bioremediation that uses fungi?
A. Phytoremediation **B. Mycoremediation** C. Fungaremediation D. Plactoremediation

93. (1 point) Which of the following are disadvantages of ex situ bioremediation?
A. Only degrades partially **B. High cost** **C. High soil disturbance** D. Low versatility E. Slow

94. (1 point) Which of the following is an example of nonpoint source pollution?
A. Factory smokestack B. Oil spill **C. Agricultural runoff** D. Sewage pipe

95. (1 point) Which of the following species are invasive species due to human activity? (select all that apply)
A. Zebrafish **B. Zebra mussel** **C. Asian carp** **D. Kudzu vine**

96. (1 point) Which 2 acids contribute most to the toxicity of acid rain?

A. Sulfuric acid and nitrous acid

B. Sulfuric acid and nitric acid

C. Sulfurous acid and nitrous acid

D. Sulfurous acid and nitric acid

E. Sulfoxylic acid and nitrous acid

97. (1 point) Why is the pH of normal rainwater not 7 (neutral)?

A. There are always some acidifying pollutants in rainwater, making even the "purest" rainwater slightly acidic

B. Certain minerals in rainwater, such as calcium, tend to make rainwater slightly acidic due to ionic interactions with hydrogen ions

C. The ionizing energy of direct light rays from the sun leads to a low percentage of free hydrogen ions, lowering the pH slightly

D. Electrostatic forces among clouds ionize certain hydrogen molecules, lowering the pH of the water inside the clouds slightly; this would also explain why only the water in clouds has a pH of 6 whereas the surrounding atmospheric water has a neutral pH of 7

E. The water in rainwater reacts with the carbon dioxide in the atmosphere, forming carbonic acid, a weak acid that lowers the pH of rainwater

98. (1 point) Which anthropogenic activity causes a positive feedback loop of climate change?

A. Switching to non-renewable energy increases the amount of carbon sequestration held in earth, decreasing climate change

B. Fertilizer runoff causes algal blooms, which decreases carbon dioxide absorption

C. Thawing permafrost by man-made heating releases methane, increasing the average temperature of the Earth

D. Building urban infrastructure decreases the amount of greenhouse gases in the atmosphere

99. (1 point) A environmental disaster has occurred and 1,400 tons of molasses spilled into Honolulu Harbor. Based on your knowledge of ecology, which of the following most likely occurred? (select all that apply)

A. Just like fertilizer runoff, the spill caused a huge loss of marine life due to hypoxic waters

B. High algal populations increase the dissolved oxygen of the water through high rates of photosynthesis

C. There is a massive build up of algae preventing other producers in the water to photosynthesize

D. Excess algae provides ample food to primary consumers, leading to a permanent increase in the populations of all consumers

100. (1 point) What is a major consequence of acid deposition on marine ecosystems?

A. A rise in pH levels, causing an increase in organisms that thrive in basic solutions

B. Increase in toxic metals in the water, leading to bioaccumulation

C. Increase eutrophications because there is more NO_x and SO_2

D. Degrades the water quality by neutralizing its pH level

Free Response Questions

101. (1 point) What is the name of the hypothesis that states that species must constantly evolve to adapt to their constantly evolving predators?

Red-queen hypothesis

102. (1 point) What is the type of competition where two species do not directly compete for resources but instead are prey for the same predator?

Apparent competition

103. (3 points) Write and order the four stages of the invasion curve. Indicate the relative cost of each stage in your answer.

Solution: Prevention, eradication, containment, management (1 for correct order, 1 for correctly naming all 4 [accept long term management or similar for the last stage as well]). Cost increases for each stage (1 for anything about how cost strictly increases)

104. (2 points) In one sentence or less, explain how the rescue effect affects for small populations in a metapopulation. Your response should include both the mechanism through which this effect affects small populations and its effect on small populations.

Solution: Refers to the migration of species from source populations into sink populations (1 for anything about migration/immigration into small populations) to sustain small populations that might otherwise go extinct by providing new genes or individuals (1 for something about how it sustains the low population/helps smaller populations)

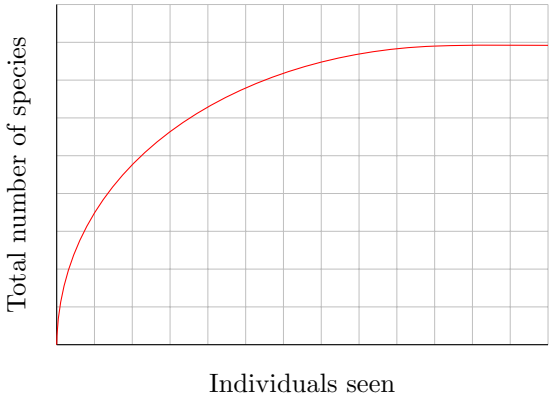
105. (2 points) Briefly contrast the reproductive strategies of semelparity and iteroparity based on the number of reproductive events.

Solution: In semelparity, an organism has a single reproduction event (1 point). In iteroparity, an organism has multiple reproduction events (1 point).

106. (1 point) Name the concept discussed by ecologist Garrett Hardin that a populace tends to overuse—or even deplete — a valuable shared resource out of self-interest.

Tragedy of the Commons (1 point; also may write "Tragedy of Commons")

107. (3 points) John ventures to into a grassland, walking through the grassland and taking note of each new species that he sees. Sketch an idealized curve on the provided graph that estimates the number of species encountered using the total number of individuals seen. In the box to the right, justify your response.



Solution: As John walks, he will initially encounter many species; however, as he sees more of the common species, it will take more individuals seen to see each rarer species, causing this asymptotic behavior (1 point for anything similar).
Accept anything about how common species will be seen at a faster rate, total number of species is capped, or rare species take longer to find.
Graph: 1 point for drawing an increasing, nonlinear function, 1 point for a decreasing slope (second derivative is negative/concave down)

108. (2 points) (TB #5) While in that grassland a month ago, he had marked 100 meadowlarks with a specific tag. During this visit, he collects a sample of 57 meadowlarks and finds that 13 of them have his tag. Assuming there was no immigration, emigration, births, or deaths in the month between samples, estimate the size of the meadowlark population using the Lincoln-Peterson method (hint: this is the method you probably know). Round to the nearest whole number.

Solution: 438 or 439 (2 points, accept either)
$\frac{100}{N} = \frac{13}{57}$, $N = \frac{100 \cdot 57}{13}$ **so** $N = 438.462$**. If they got the answer wrong, give one point for any equivalent expression to the above.**

For the next five (5) questions, use the following life table.

Age class (x)	n_x	d_x	q_x
1	90	#110	0.644444
2	32	18	0.5625
3	14	2	0.1429
4	12	1	#111
5	11	3	0.2727
6	#112	5	0.625
7	3	3	1
8	0	0	-

109. (1 point) Based on the life table, which type of survivorship curve does this species most likely exhibit?
Type III

110. (1 point) What number should go in the box labeled #110?
58

111. (1 point) What number should go in the box labeled #111?
0.0833 (1/12)

112. (1 point) What number should go in the box labeled #112?
8

113. (4 points) (TB #2) Calculate E_0, the life expectancy at birth for this cohort. Remember that partial credit will be awarded if your answer follows the correct procedure. Work outside of the provided box may not be graded.

Solution: 1.38889 (3 if they get this)
If they get any L_x values, which is the average of each column and the next one (61, 23 , 13, 11.5, 9.5, 5.5, 1.5), give 1 point
If they get any T_x values (125, 64, 41, 28, 16.5, 7, 1.5), also give 1 point unless they find specifically T_0 (125), in which case they earn 2 points.

114. (2 points) Why do goats contribute more to desertification than sheep?

Solution: Goats eat the roots of plants as well, preventing them from regrowing, whereas sheep do not (2 points for anything about goats eating roots of plants or preventing regrowth)

115. (2 points) Briefly compare C3 and CAM photosynthesis in terms of water loss and indicate which would be favored in a desert ecosystem.

Solution: C3 requires open stomata during the day and lose more water, while CAM opens stomata during the night and loses less water (1, requires either)
CAM is favored (1)

116. (1 point) Phytoextraction uses special plants that are capable of growing in soils contaminated with metals, extracting contaminants from the soil, and concentrating them inside its tissues. What term best describes these plants?

Hyperaccumulator

117. (2 points) Write the two step chemical reaction that occurs in the air to convert SO_2 into sulfuric acid.

Solution: $SO_2 + H_2O \longrightarrow H_2SO_3$
$2\,H_2SO_3 + O_2 \longrightarrow 2\,H_2SO_4$

118. (1 point) Minamata disease is caused by which heavy metal pollutant?

Mercury (Hg)

Use the following information for the next seven (7) questions.

A prairie contains only these species with the following populations.

Species	Population
Bristlegrass	129
Petunia	23
Clematis	78
Switchgrass	201
Pimpernel	97

119. (2 points) All of these plants are smaller shrubs or grasses. Compare the typical effects of frequent fires on grasses and trees in grasslands.

Solution: Fires largely hinder the growth of trees because they kill off young saplings, while grasses can thrive after a fire because nutrients are replenished to the soil. (1 point for saying that fire makes it harder for trees to grow. 1 point for saying grasses are more tolerant or beneficiary of fires or able to regrow faster after fire)

120. (1 point) Switchgrass is believed to be a good source of ethanol, producing several times more ethanol than corn. What plant compound is the primary source of the heightened ethanol yield of switchgrass?

Cellulose

121. (2 points) Briefly compare the amount of energy and land required to produce an equivalent weight of corn and switchgrass.

Solution: Switchgrass requires less land (1) and less energy (1) than corn

122. (3 points) How are Hill numbers and sensitivity to rare species related? Calculate ${}^0D$ for this ecosystem, the Hill diversity when the Hill number (q) is 0.

Solution: Sensitivity to rare species decreases as Hill number (q) increases (2 points, all or nothing)
5 (1, ${}^0D$ is species richness)

123. (2 points) Calculate the Shannon index for this ecosystem. Round to 3 decimal points.

1.442 (accept 1.437-1.447, all or nothing)

124. (2 points) Write the equation for the evenness based on the Shannon index (also known as Pielou's J) in terms of S (the total number of species), N (the total number of individuals), p_i (the proportion of individuals of species i), and any necessary constants.

Solution:

$$J = \frac{-\sum_{i=1}^{S} p_i \cdot \ln p_i}{\ln S}$$

2 points; also accept log instead of ln. The $J =$ portion is not required for full credit. Give 1 point for $\frac{H}{H_{max}}$ because it is not in terms of the variables given.

125. (2 points) (TB #4) Calculate Pielou's J for the given ecosystem. Round to the nearest 3 decimal points.

0.896 (2, accept 0.891-0.901; all or nothing)

For the next five (5) questions, use the following information.

A community is composed of 5 unique species with abundances $n_1, n_2, \cdots, n_5$. There are N total individuals in the community.

126. (1 point) What is the species richness of this ecosystem?

5

127. (3 points) (TB #3) What is the probability that a random interaction between two individuals is between individuals of species 1 (i.e. what is the probability that two random individuals are picked and both are species 1)? Find this probability both with and without replacement and label as such.

Solution: With replacement: $\left(\frac{n_1}{N}\right)^2$ **(1 point)**
Without replacement: $\left(\frac{n_1}{N}\right) \cdot \left(\frac{n_1-1}{N-1}\right)$ **(1 point)**
1 point for labeling correctly (cannot earn this point without having two different formulas)

128. (3 points) (TB #1) Using your answer to the previous question (#127), find the probability that a random interaction between any two individuals has two individuals of the same species (i.e. what is the probability of an intraspecific encounter) in this 5 species case. If you understand summation/sigma notation, please write your answer with that, but you will not be penalized for writing it out manually. Find this probability both with and without replacement and label as such.

Solution: With replacement: $\sum_{i=1}^{5}\left(\frac{n_i}{N}\right)^2$ **or** $\left(\frac{n_1}{N}\right)^2 + \left(\frac{n_2}{N}\right)^2 + \left(\frac{n_3}{N}\right)^2 + \left(\frac{n_4}{N}\right)^2 + \left(\frac{n_5}{N}\right)^2$ **(1 point)**
Without replacement: $\sum_{i=1}^{5}\left(\frac{n_i}{N}\right) \cdot \left(\frac{n_i-1}{N-1}\right)$ **or** $\left(\frac{n_1}{N}\right) \cdot \left(\frac{n_1-1}{N-1}\right) + \left(\frac{n_2}{N}\right) \cdot \left(\frac{n_2-1}{N-1}\right) + \left(\frac{n_3}{N}\right) \cdot \left(\frac{n_3-1}{N-1}\right) + \left(\frac{n_4}{N}\right) \cdot \left(\frac{n_4-1}{N-1}\right) + \left(\frac{n_5}{N}\right) \cdot \left(\frac{n_5-1}{N-1}\right)$ **(1 point)**
1 point for labeling correctly (cannot earn this point without having two different formulas)

129. (2 points) The formula with replacement you found in the previous question (#128) is the formula for an important ecological diversity index. What is the name of this index?

Simpson index (2, also accept Simpson diversity index, 1 point for HHI/Herfindahl–Hirschman index)

130. (2 points) When you subtract the equation from #128 from 1, what does this value represent in this context? When this value is higher, what does that suggest about the diversity of the ecosystem?

Solution: Represents the probability of an interspecific encounter (1); also accept probability of randomly choosing two individuals different species, probability that two random individuals are of a different species, or anything else equivalent
Higher values signifies higher diversity (1)