

## Appendix D

Ecology Concept Inventory given in WEI-1010 in Fall 2004\*

Correct answers in bold.

Question: On a visit to Great Smoky Mountains National Park (GSMNP) in Tennessee, you meet a group of botanists who are among the biologists participating in the All Taxa Inventory (ATI) of organisms in the park. You learn that the goal of the ATI at GSMNP and other locations in the US is to inventory all of the species in the US. Why is the US species inventory important? In 1-4, choose “a” if statement correctly answers question, or choose “b” if it does not.

1. Although we have identified and named all but a few of the species that live in the United States, we are doing the inventory because we do not know which ones are present in GSMNP or other places. a or **b**
2. **The United States is experiencing a mass extinction of animal and plant species with some 30% being in danger of going extinct in the foreseeable future. So the inventory is being done to establish base-line data to establish more precisely what is the status of species in the US.** a or **b**
3. **Since most of the species in the world, and many species in the United States, are not known or named, the inventory is being done to discover and name all species in the US.** a or **b**
4. Since most species have no economic importance (they are not bought or sold), the benefits of the inventory will be scientific, not economic. a or **b**

Question: On the morning of 27 August 1883 a series of huge volcanic eruptions eliminated the island of Krakatau in the Pacific Ocean and left a smoldering island named Rakata with surface temperatures that morning between 300° and 850°C. Nothing alive remained on Rakata. If you went to see Rakata today, you would find an island not very different biologically from Krakatau on 26 August 1883, except in the forest you would find none of the long lived tree species originally found on Krakatau. The recovery of the biodiversity on Rakata is explained by which of the following? In 5-8, choose “a” if the statement correctly answers the question, or choose “b” if it does not.

5. The rich volcanic ash on Rakata provided the environment in which the organisms that managed to get to Rakata evolved to create a biodiversity similar to that of the original island. a or **b**
6. **Dispersed by air and water to Rakata during the years after the eruptions, species that existed elsewhere re-established the island’s biodiversity to pre-eruption levels.** a or **b**
7. **The lack of long-lived tree species indicates that local extinction can be permanent when immigration does not occur or is extremely improbable.** a or **b**
8. If left free from major catastrophes, even totally devastated ecosystems will eventually recover to their previous state. a or **b**

9. The figure below shows how five species of warblers differ with regard to their foraging zones within trees in northern forests. This is a classic example of niche differences amongst a group of similar species that coexist together in the same habitats at the same time.

(The figure visually illustrated resource partitioning for each of five insect eating species of North American warblers that searches for food in different regions of spruce trees.)

On certain islands off the coast of Maine that have forests of similar height and insect food as those on the mainland, the myrtle warbler occurs without the four other species. Based on your knowledge of ecological interactions in nature, what do you think are the most likely changes in the abundance and foraging niche of myrtle warblers on these islands compared to populations of the same species on the mainland? Choose one of the following possibilities (Note: ↑ stands for expands or increases, ↓ stands for contracts or decreases, ↔ stands for no change.)

- a. Niche ↑      Abundance ↓
  - b. Niche ↓      Abundance ↓
  - c. Niche ↔      Abundance ↑
  - d. **Niche ↑      Abundance ↑**
  - e. Niche ↔      Abundance ↔
10. When optimal conditions for growth and reproduction persist, all populations of organisms show which of the following growth patterns?
- a. Logistic growth curve with single maximum
  - b. Logistic growth curve with oscillation around single maximum
  - c. **Exponential growth curve**
  - d. Series of boom-bust exponential growth curve

Statement: The following information is needed to answer questions below. In the diagram on the left, the two islands have the same area but lie at different distances from the mainland. In the diagram on the right, the two islands are the same distance from the mainland, but the larger is 2 ½ times the area of the smaller. The following graphs show the relationships between the rate of extinction and the rate of colonization for various islands. From the information in the above figure, you should be able to determine the rates that apply to each island.

(Figure showing visually what was described in the above paragraph)

(Figures of the four choices (a, b, c, d) graphed as Rate vs. Number of species on islands with different plots for colonization rates and extinction rates on the islands.)

11. Which of the above graphs would apply best to the island system in the left hand figure?

**a**                      b                      c                      d

12. Which of the above graphs would apply best to the island system in the right hand figure?

a                      b                      c                      d

Question: Given the initial size of an isolated population of a species, you can calculate the future population sizes of the species if you know which of the following? In 13-19, choose “a” if the statement provides information which is necessary to make this calculation, or “b” if the statement does not provide information which is necessary to make this calculation.

13. The age at which the species becomes reproductive.                      a or **b**  
14. The annual birth rate.                      **a** or **b**  
15. The age at which the species ceases to be reproductive.                      a or **b**  
16. The average number of offspring per generation.                      a or **b**  
17. The age distribution of the population.                      a or **b**  
18. The annual death rate.                      **a** or **b**  
19. The survivorship curve for the species.                      a or **b**

20. Which figure shown below most closely correlates with the growth pattern of the global human population over the past five hundred years?

(Figure with four curves that each plots Number of Individuals vs. Time)

- a. Logistic growth curve that oscillates around a single horizontal maximum  
b. Logistic growth curve that then oscillates while still increasing  
c. **Exponential growth curve**  
d. A straight line ascending at 45 degrees

Statement: Humans have large populations, high densities, and inhabit virtually all terrestrial environments on the earth. As a species, humans have achieved their biological prominence because ... In 21-24, choose “a” if the statement is correct, or choose “b” if the statement is not correct.

21. our superior intelligence means we are not subject to the biological principles that limit the population sizes and densities of other animals.                      a or **b**  
22. culture has enable us to expand our niche breadth so that we have, for a period of time, increased the number of us that can live in an area.                      **a** or **b**  
23. we are omnivores and can eat a variety of foods.                      a or **b**  
24. we are unique among all organisms and can manipulate the environment to accommodate our needs as required with no foreseeable limit to the size or density of our population.                      a or **b**

Question: Seeing a mountain lion or a jaguar is a thrilling and rare event. Why are such animals rare compared to their prey like deer? In 25-29, choose “a” if the statement is correct, or choose “b” if the statement is not correct.

25. Mountain lions and jaguars are as common as deer, but because they are very reclusive and people are not their natural prey, we just don't see them very often. a or b
26. Because of the necessarily inefficient transfer of energy from prey to predator, it takes a lot of deer to maintain populations of mountain lions and jaguars. a or b
27. Top predators like mountain lions and jaguars have high metabolic requirements and must spend huge amounts of energy and time hunting, and often starve to death. a or b
28. Mountain lions and jaguars are the exception among animals; other top predators (e.g. eagles and hawks) are about as common as their prey. a or b
29. Top predators like mountain lions and jaguars require many square kilometers of territory because this amount of land is needed for the resources used by the prey they eat. a or b
30. *Littorina* is a small snail that lives in the intertidal zone and grazes for algae in tide pools. Why does species diversity peak at intermediate levels of *Littorina* density (left graph) and disturbance (right)? (NOTE: Disturbance for the boulder communities is measured as the number and strength of waves which move the boulders and disrupt the communities that live on them.)

(Two data figures. First figure is a plot of Number of Algae Species vs. *Littorina* density (# per square meter). Second figure is 3 plots of Percent of Boulders vs. Number of Species showing levels of disturbance and diversity of marine algae and invertebrates: 1. high disturbance, 2. intermediate disturbance, 3. low disturbance.)

- a. **Intermediate levels of disturbance and herbivory allow inferior competitors to invade the community and coexist with dominant space competitors.**
- b. At intermediate levels of herbivory in tide pools and intermediate levels of disturbance on intertidal boulders, conditions for resident species will be better than at other disturbance levels and all species will have the highest intrinsic rates of increase.
- c. At intermediate levels of disturbance and herbivory, predation will be at its lowest level both in tidepools and on boulders.
- d. Productivity of both tide pools and boulder communities is highest at intermediate levels of herbivory and disturbance respectively which allows more species to coexist together because there is more food.

Question: Caterpillars of the monarch butterfly exclusively eat the leaves of the milkweed plant but no other animals eat milkweed leaves because the leaves contain powerful toxins. In fact, if you ate them, you would get very sick. These observations are explained by which of the following? In 31-34, choose "a" if the statement answers the question, or choose "b" if the statement does not.

31. Insects like the monarch have a primitive digestive system compared to animals like humans and the compounds in the milkweed leaves are only toxic to animals with sophisticated digestive systems. a or **b**
32. Milkweed plants evolved to produce substances that are toxic to all animals except monarchs. a or **b**
33. The energy costs and other disadvantages in eating toxic leaves provide negative selection pressures that mean the monarchs will eventually go extinct. a or **b**
34. Milkweed plants evolved to produce substances that are toxic to all animals and over time monarchs evolved resistance to these toxins. a or **b**

Statement: In the past several years ecosystems in North America, especially in the western part of the United States, have experienced substantial disturbance because of intense fires and frequent flooding. Which of the following statements are true for ecological disturbance in general. In 35-38, choose “a” if the statement is true, or choose “b” if the statement is false.

35. Natural disturbances (e.g., fire, drought, flooding, etc.) are required for maintaining diverse ecosystems that are then not substantially changed by these natural disturbances. True (a) or False (b)
36. The more natural disturbances experienced by an ecosystem the greater the species diversity and the higher the capacity to withstand change. True (a) or False (b)
37. Without natural disturbances the diversity of species is maintained and the abundances of most species that are present increase significantly. True (a) or False (b)
38. Since natural disturbance is beneficial for preserving species diversity, human activities that disturb ecosystems (e.g., clearing forest for fields and pasture, clear-cutting forests in a pattern similar to severe forest fires, etc.) lead to more diverse ecosystems that are resilient to substantial change. True (a) or False (b)

Statement: The various terrestrial ecosystems around the world exhibit sufficient similarities that they can be classified into types called biomes: tropical rainforest, deciduous forest, coniferous forest, tundra, desert, etc. In 39-42, choose “a” if the statement is correct, or choose “b” if the statement is not correct.

39. **As we move up high mountains in the tropics from sea level to higher elevations, the sequence of biomes observed is essentially the same as that observed when going from the tropics to the poles of the Earth.** a or **b**
40. The key factors that correlate with the kind of biome observed in a particular place are the atmospheric pressure and the length of day (i.e., relative amount of light and dark). a or **b**

41. **By knowing the amount of rainfall (water availability over the year) and the annual temperature range for a particular area, it is possible to predict the biome that would be present in that area.** a or b
42. **Each biome has a unique set of species associated with it (e.g., cacti in deserts, evergreen trees in coniferous forest), but the overall number of species is similar in a particular type of biome regardless of the exact location of the biome.** a or b

Question: Human synthesized herbicides and insecticides have been used for more than fifty years to control plants and insects in agricultural settings and in the places where we live. In most cases which of the following happens? In 43-46, choose “a” if the statement answers the question, or choose “b” if the statement does not.

43. Herbicides and insecticides help maintain ecological balance in human designed ecosystems because they reduce the populations of organisms that have gotten out of control. a or **b**
44. Herbicides and insecticides move in food webs and are, by design, not toxic to non-target organisms like beneficial insects, birds, and humans. a or **b**
45. Because of dilution in the soil and in the water, herbicides and insecticides become so low in concentration that they have little influence on non-target organisms. a or **b**
46. After years of use, herbicides and insecticides that were initially effective in killing pest organisms became less effective until they no longer killed pest organisms. a or **b**

Statement: The following information is needed to answer questions 47-51. The diagram shows the pyramid of energy for a four trophic level river ecosystem.

(Figure is a diagram of a pyramid of energy for a river ecosystem showing the gross primary productivity and net primary productivity given as kilocalories per square meter per year.)

What do you think might be the effects on the abundance of organisms in the lower three trophic levels if we removed the top predator (bass)?

Abundance	Increase	Decrease	No Change
47. Secondary consumers	<b>a. (correct)</b>	b.	c.
48. Primary consumers	a.	<b>b. (correct)</b>	c.
49. Primary producers	<b>a. (correct)</b>	b.	c.

What do you think might be the effects on the abundance of organisms in the lower two trophic levels if we removed the top two trophic levels (bass and bluegills)?

Abundance	Increase	Decrease	No Change
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- 
- |                       |                     |                     |    |
|-----------------------|---------------------|---------------------|----|
| 50. Primary consumers | <b>a. (correct)</b> | b.                  | c. |
| 51. Primary producers | a.                  | <b>b. (correct)</b> | c. |

Question: In the Galapagos islands there is a group of 14 finch species, all closely related, that are found nowhere else. Similarly, in the Hawaiian islands there are over 20 endemic species of honeycreepers that are very similar and share a common ancestor. In Africa, certain lakes have over 1000 species of cichlid fish, most of which do not occur in other lakes in Africa. About 120 million years ago, the number of beetle species began to increase rapidly and tens of thousands of new species arose in a relatively short period of time. What do all of these phenomena have in common? In 52-55, choose “a” if the statement answers the question, or choose “b” if the statement does not.

52. When conditions are right, the DNA of any species – plant, animal, or microbe – can mutate very rapidly leading to the proliferation of new types. This must have occurred in all of the above mentioned groups. a or **b**
53. All of the above phenomena are driven by divergent natural selection. **a** or b
54. The proliferations of species in all of these groups undoubtedly involved genetic drift which the dominant evolutionary force that led to rapid reproductive isolation and diversification. a or **b**
55. All of the examples involved evolutionary changes that produced different phenotypes and allowed closely related species to exploit different niches. **a** or b

Statement: The figure below pertains to four different ecosystems. Ecosystem 1 has one trophic level consisting of producers; ecosystem 2 has two trophic levels, producers and herbivores; ecosystem 3 has three levels, etc. **Questions 56 through 65 are below.** Within the rectangles that represent all species in a trophic level, choose the letter “a” if you think competition is the major force controlling the abundances of the species in that particular trophic level, or the letter “b” if you think predation is the major force controlling abundances.

**Competition (a)    Predation (b)**

Secondary carnivore						<b>62</b>	a    b
Primary carnivore				<b>59</b>	a    b	<b>63</b>	a    b
Herbivore		<b>57</b>	a    b	<b>60</b>	a    b	<b>64</b>	a    b
Plant	<b>56</b>	a    b	<b>58</b>	a    b	<b>61</b>	a    b	<b>65</b>
	Ecosystem <b>1</b>		Ecosystem <b>2</b>		Ecosystem <b>3</b>		Ecosystem <b>4</b>

\* This concept inventory was developed only for use at Rensselaer. A number of faculty contributed questions taken from their personal files, test banks, and perhaps from published sources. Since we had no intention of publishing these questions (it was requested by reviewers and editor), we did not keep records as to who contributed which questions and their sources. Some of the questions are likely not original, but we have no way of identifying them. We acknowledge these possible unknown published sources.