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BIOLOGY 101L
Laboratory 6: Biodiversity

Objectives

(1) Students can define biodiversity and outline the different scales at which biodiversity are studied.
(2) Students can outline the importance of preserving biodiversity.
(3) Students can describe three major threats facing biodiversity.
(4) Students can calculate two measures of biodiversity.

I. Introduction

Biological diversity, or **biodiversity**, is defined by Article 2 of the Convention on Biological Diversity as "…the variability among living organisms from all sources including, inter alia [but not restricted to], terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." In a nutshell, this means that biodiversity includes all of the life on the planet and all of the different environments in which life exists.

Scope/ Scale of Biodiversity

Most people tend to think of biodiversity as the total number of species in a place or in the entire world. However, we can see from the definition above that biodiversity exists at many scales. At the finest scale, biodiversity includes all of the genetic variation within a single gene. At the largest scale, biodiversity includes all of the species and all of the environments in which they live. Why do we include the habitats that species live in? An ecosystem can be thought of as the biological community and its physical environment. Organisms depend on the environment in which they live to provide all of the essential resources they need to live and reproduce. The many different environments on earth help to support the diversity of life. Consequently, it is important to consider not only the organisms, but also the environments in which they live.

Biodiversity has been noted to have specific patterns or distributions, depending on the scale that we are examining. Where resources are abundant and many habitats exist, many species can share the same ecosystem, which results in high biodiversity. Conversely, when resources are limited and habitats few, only a small number of species can occupy the same ecosystem. For example, if we consider numbers of species, very roughly, diversity is highest at the resource-rich tropics and lowest at the resource-poor poles. Similarly, diversity is highest at sea level and lowest at the tops of mountains or bottom of ocean floors. These patterns are approximately proportional to the availability of resources. This relationship between the availability of resources and amount of biodiversity allows us to make predictions about the numbers of species we are likely to encounter in different locations. If resources were abundant, e.g., lots of food, habitat, water, and shelter, we would expect to find higher species diversity than in locations where resources are scarce.

Speciation and the Mechanisms of Biodiversity

How many species of life are there on earth? Recent studies suggest that there may be as many as 8.7 million species. Of these, we have catalogued slightly more than 1.2 million species (i.e., only 14%). How did we end up with so many species? Over the course of millions of years, the slow march of evolution has allowed different species to find the perfect home in the multitude of diverse environments that exist on earth. Consequently, individual species tend to inhabit specific environments and have natural ranges defined by geographic or environmental barriers. Species with a narrow range of requirements may be more susceptible to changes in their environment than species with broad ranges of requirements.

High diversity is often an indication of a healthy, stable ecosystem. When there are many species in an ecosystem, there is a good chance that more than one species is doing the same job as another species, e.g., using the same organism for prey. Consequently, loss of one or more species from the system generally has a small impact on other species. In contrast, low biodiversity may indicate an unstable ecosystem that is susceptible to change. Loss of a single species may have devastating consequences for remaining species in the ecosystem.

Why should we care?

Eight million species seem a staggering number and yet we are losing diversity at an alarming rate. It is estimated that species are going extinct at a rate 10 to 100 times greater than before humans dominated the planet. Why is this diversity important and why should we care about mass extinctions?

High biodiversity is associated with many of the things we consider important, not only for our survival on earth, but also our continued well-being. **Ecosystem services** are the direct and indirect benefits that derive from ecosystems and they include: food, fresh water, oxygen, local climate and air quality, medicinal resources, erosion prevention and soil fertility, pollination, tourism, recreation and a great many more. Loss of biodiversity directly impacts our future ability to preserve these important services and our very survival.

The Convention on Biological Diversity's 'Global Biodiversity Outlook 3' report states: “We can no longer see the continued loss of biodiversity as an issue separate from the core concerns of society: to tackle poverty, to improve the health, prosperity and security of present and future generations, and to deal with climate change. Each of those objectives is undermined by current trends in the state of our ecosystems, and each will be greatly strengthened if we finally give biodiversity the priority it deserves.”

Threats to diversity

There are many threats to biodiversity, but they generally fall into two broad categories: 1) Habitat loss and fragmentation; and 2) the introduction of non-native species.

Urban development, logging, manufacturing, and pollution all contribute to the degradation and **loss of habitat** around the world. Loss of habitat results in the direct loss of the species that live there and their associated ecosystem services. Loss of species may mean a local extinction, or extirpation, or it may involve the complete extinction of the species. Species, which have very small ranges, e.g., species of Hawaiian Tree Snails, are highly susceptible to development and loss of habitat.

Native species are those species, which have evolved in or migrated naturally to an area. **Non-native species** are those that have been brought to an area via non-natural means. The three most common sources of introductions of non-native species derive from: 1) Human expansion and migration, 2) agriculture and horticulture, and, 3) accidental introductions, e.g., organisms attached to the hulls of ships.

Non-native species include new predators, competitors (without their natural predators) and diseases. In cases where the conditions are not suitable for them to establish healthy communities, non-native species may be a small, unobtrusive part of a community. However, if, for example the new resident has no natural predators present to keep them in check, non-native species may become **invasive** or weedy. In these cases, they are often able to outcompete and displace native species. This is typically more of a problem in stressed habitats that have already experienced loss of biodiversity.

II. In-Class Activity (26 pts)

Biologists use two different measures to quantify species diversity: 1) how many species are in a given area (richness); and, 2) the abundance of those species in the area, relative to other species in the area (relative abundance, or, evenness).

Species richness gives us an overall picture of the diversity in the community; the higher the number, the higher the diversity.

Relative abundance tells us something about the composition of the community. Does one species have a much higher abundance than all other species, or are all species equally abundant? Relative abundance is the proportion of any given species within the entire community. Relative abundance is calculated in the following way: where n is the total number of individuals of all species in the study area, and x_i is a species in the area, and n_i is the number of individuals of x_i **,**
Relative Abundance = n_i/n X 100.
For example, you record a total of 74 individuals for all species observed, and 30 of those are zebra doves; the relative abundance of zebra doves in the population is: 30/74 X 100 = 41%

We can also look at whether one or two species dominate a habitat in another way. The **Community Dominance Index (CDI)** measures the proportion of the two most abundant species in a community. The higher this number, the greater the dominance of only one or two species. In a diverse, healthy community, we generally expect several species to have similar relative abundances, rather than to have one or two species dominating the community. Therefore, we expect lower values of the Community Dominance Index. The CDI is calculated in the following way: where n is the total number of species in the study area, x_1 is the most abundant species in the study area, n_1=number of individuals of x_1, x_2 is the second most abundant species in the study area, and n_2=number of individuals of x_2,
Community Dominance Index = $(n_1 + n_2)/n$ X 100.
For example, in a sample of 74 individual birds, the population of zebra doves is 30 and the population of Myna birds is 19, the CDI is (30+19/74) X 100 = 66%.

Today we will use richness, relative abundance and Community Dominance to ask questions about the birds that can be found on campus. The exercises were adapted from exercises written by David Eatough for the Harvard LS-HHMI Summer Curriculum Project, 2010.

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Part 1: Diversity of Beans (9 pts)
Each table has a container of beans that represents the species in a given community. You will be sampling the container to determine the types of species present and their relative abundance.

1. Each student collects a scoop of beans from the container on your table.
2. Identify and count your beans.
3. Pool your results with the results from the other members of your table/group.
4. Record the total number of beans for each species for your group.
5. Calculate the total number of all beans sampled.
6. Calculate the relative abundance of each species.
7. Determine the richness of the community (total number of species encountered).
8. Calculate the Community Dominance Index.
9. Return your beans back to their original container.

(3 pts)

Bean Community (circle one) A B C D			
Species/ Bean type	**Number of Beans**		**Relative Abundance (Number of Each Kind of Bean/ Total Number of Beans X 100)**
	Individual	**Group**	**Group**
Total Number of Beans			
Richness			
Community Dominance Index			

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1. For each group enter the relative abundance (transfer group data from table on page 4).
2. Enter relative abundance from all groups in your class.

Bean/ Species	**A**	**B**	**C**	**D**
Richness				
Community Dominance Index				

Answer the following questions:

1. Which community of beans (A, B, C, or D) had the greatest richness? (1 pt)

2. Which bean species had the greatest relative abundance in each community? (1 pt)

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3. Which bean species is most likely to become extinct? (Assume a great disaster awaits that will drastically reduce the available resources.) (1 pt)

4. Which community has the greatest biodiversity? Use richness and abundance to explain your answer. (1 pt)

5. Urbanization is the process by which humans occupy and modify ecosystems. It is a matter of degrees, with densely populated areas like Waikiki representing one end of the spectrum and wilderness areas representing the other. How does urbanization affect habitat quantity and quality? (2 pts)

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Part 2: Diversity of Campus Birds (9 pts)
In this exercise, you will use the skills you practiced with the beans to investigate the diversity of birds on campus. Your TA will direct you to a location where you will **observe and record all the species and total number of each species that you see in 30 minutes**.

1. Decide who will observe and who will record.
2. The recorder should note the location, start time and end time of observations.
3. Using the laminated cards or guide books, observers should note the type and number of each species of bird they observe in the 30-minute period.
4. When you have finished observing, go back to the class room and determine the richness, relative abundance and CDI for your location

(4 pts)

Location:		
Date:	**Start time:**	**End time:**
Bird Species	**Number of Individuals Observed**	**Relative Abundance**
Total Number of Birds Observed:		
Species Richness:		
Community Dominance Index:		

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6. Which species has the greatest relative abundance? (1 pt)

7. What was community dominance index for your campus site. What does this tell you about the species composition? (2 pts)

8. It is difficult to control variables in field studies. How might factors such as time of day and weather account for variation in the richness, relative abundance and/or Community Dominance Index? (2 pts)

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Part 3: Comparison of Campus and Forest Birds (8 pts)

On the datasheet below are abundance data for birds living in a forest site on Oahu. These data were collected from a site on Oahu in July 2010. The site is located near Mt. Ka'ala in the Waianae Range. It is near the top of the ridge where there is a mix of native and non-native plants. Birds were trapped in mist nets, counted, and released.

Calculate the richness, relative abundance and Community Dominance Index for this location in the table below and identify which species are native or non-native.

Location: Honouliuli, Oahu			
Date: July 28, 2010			
Bird Species	**Number of Individuals Observed**	**Relative Abundance**	**Native/ Non-native?**
Apapane	1		
Chestnut Munia	3		
Common Waxbill	4		
House Finch	46		
Japanese Warbler	4		
Japanese White Eye	63		
Northern Cardinal	15		
Nutmeg Mannikin	25		
Oahu Amakihi	46		
Red-billed Leiothrix	21		
Red-crested Cardinal	5		
Red-vented Bulbul	1		
Red-whiskered Bulbul	9		
Spotted Dove	5		
White-rumpled Shama	5		
Yellow-faced Grassquit	2		
Zebra Dove	3		
Total Number of Birds Observed:			
Species Richness:			
Community Dominance Index:			

Compare the forest site with the campus site.

Think about all the different ways that a forest differs from an urban site (e.g., amount of sunlight, ability to hide from predators, type of predators, food availability, etc.). How might those differences affect the differences in community composition between the campus locations and the forest?

Answer the questions on the next page.

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9. Are any species common to both areas? List these species. (1 pt)

10. What is the most abundant species in the forest location? (1 pt)

11. What does the community dominance index of the forest site suggest about its health? (1 pt)

12. For both sites, identify which are native and which are non-native species. (2 pts)

13. Using the information you have, outline which habitat you think has been more strongly impacted by humans. Support your conclusions using species richness, relative abundance, species composition and community dominance index. (3 pts)

Answer more questions on biodiversity on your homework assignment on the next page.

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III. **Homework** (14 pts)

14. What is biodiversity? Include a description of the different scales at which biodiversity can be measured. (3 pts)

15. Why is protecting biodiversity important? (2 pts)

16. What are the major threats to biodiversity? (2 pts)

17. Identify and describe three sources of habitat loss. (3 pts)

18. Visit the Convention on Biological Diversity at https://www.cbd.int . **In your own words**, describe why the Convention was established and outline three of the major strategic goals defined by the Convention *(Hint: review the 'Key Elements of the Strategic Plan 2011-2020')*. (4 pts)