INTRODUCTION

Gorongosa National Park is a 1,570-square-mile protected area in Mozambique. Decades of war, ending in the 1990s, decimated the populations of many of Gorongosa's large animals, but thanks to a large-scale restoration effort some are now rebounding. Gorongosa's researchers are working to discover and catalog animal species in Gorongosa in order to track their recovery using remote trail cameras. To fulfill the restoration goals of Gorongosa, it is important for biologists to collect data on the current status of biodiversity in the park.

Biodiversity can be defined simply as the variety of life, but biodiversity can be studied at many levels, including genetic diversity, species diversity, and ecosystem diversity. High biodiversity is an indicator of ecological resilience, or the ability of an ecosystem to resist change or recover from disturbances. E.O. Wilson has championed the importance of assessing biodiversity and supports the work of conservation scientists like those working in Gorongosa National Park.

The high biodiversity of organisms found in Gorongosa is due, in part, to the different vegetation types, which characterize habitats, including grassland, limestone gorges, and savanna/woodland. Because biodiversity cannot easily be captured in a single number, there are various indices, or measurements, that when examined together provide a more comprehensive picture of biodiversity. In this activity you will calculate and analyze richness, Shannon diversity index, and evenness to compare the biodiversity of different habitats in Gorongosa using real data captured by trail cameras.

PROCEDURES AND QUESTIONS

Part 1: Introduction to Diversity Indices

Before measuring biodiversity using a large data set, like the trail camera data, you will be introduced to calculating richness, evenness, and the Shannon diversity index by hand using a small sample data set.

Richness (S) is the total number of species in an ecosystem. Richness does not take into account the number of individuals, proportion, or distribution of each species within the ecosystem.

1. Based on the species list below, what is the richness of this ecosystem?

    Species: Wildebeest, Warthog, Elephant, Zebra, Hippo, Impala, Lion, Baboon, Warbler, Crane

    S =
    _____

Richness alone misses an important component of species diversity: the abundance (number of individuals) of some species may be rare while others may be common. The **Shannon**

diversity index (H) accounts for species abundance by calculating the proportion of individuals of each species compared to the total number of individuals in the community (P_i).

$H = -SUM (P_i * ln(P_i))$
Where:
P_i = species abundance/total abundance in the community
ln = natural log

For most ecosystems, the value for H ranges from 1.5 to 3.5, with the higher score being the most diverse.

2. Using the table below, calculate the total abundance in the community and the P_i value for each species. Next, calculate the natural log of P_i for each species ($ln(P_i)$) and then multiply the two columns to calculate $P_i * ln(P_i)$. Limit your numbers to 3 decimal places.

Species	Abundance	P_i	$ln(P_i)$	$P_i * ln(P_i)$
Wildebeest	3			
Warthog	3			
Elephant	2			
Zebra	1			
Hippo	1			
Impala	4			
Lion	1			
Baboon	15			
Warbler	25			
Crane	18			
Total Abundance				

3. Calculate H by adding each of the values in the $P_i * ln(P_i)$ column of the table above and taking the negative of that value.

    H = _____

Evenness (E) is a measurement to compare the abundances of each species in the community. Communities where the abundance of each species are more evenly represented are considered more diverse than communities where a few species are very common and other species are very rare. Low values indicate that one or a few species dominate, and high values

indicate that all of the species in a community have similar abundances. Evenness values range from 0 to 1, with 0 signifying low evenness and 1, complete evenness.

$E = H/H_{MAX}$
Where:
H = Shannon Diversity Index
H_{MAX} = the highest possible diversity value for the community (calculated by ln(richness))

4. Use the richness value you calculated in question 1 to calculate H_{MAX}.

$H_{MAX} = ln(richness)) = $ _____

5. Use the Shannon diversity index value you calculated in question 3 and the H_{MAX} value you calculated in question 4 to calculate E.

$E = H/H_{MAX} = $ _____

Part 2: Vegetation Types
Open the Gorongosa Interactive Map
(http://www.hhmi.org/biointeractive/gorongosa-national-park-interactive-map) and turn on the vegetation layer and the limestone gorge layer. Read about each of the different vegetation types within the park.

6. Predict which vegetation type will have the greatest biodiversity. What information did you use to make your prediction?

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Part 3: Measuring Biodiversity in Gorongosa
Your instructor will demonstrate how to access and download data from the WildCam Lab (lab.wildcamgorongosa.org). Open the spreadsheet that you downloaded and also open the spreadsheet tutorial that was provided. Copy all of the columns from your data spreadsheet and paste them into the "Data" tab of the spreadsheet tutorial. Open the "Species Richness"

tab in the tutorial and read the instructions for making a pivot table, which will produce a list of species within each vegetation type as well as their abundance.

7. Complete Parts 1 and 2 of the "Species Richness" tab. What are the two variables that you are using to group the data?

8. Complete part 3 of the "Species Richness" tab to calculate richness for each vegetation type. Record the values below.

Vegetation Type	Richness
Grassland	
Limestone Gorge	
Savanna/Woodland	

9. Which vegetation type in Gorongosa has the greatest species richness? Propose a possible explanation for differences in species richness from one vegetation type to another.

10. Calculate the **Shannon diversity index** for the three vegetation types by completing parts 1 through 4 on the "Shannon Diversity Index" tab. Record the values in the table below.

Vegetation Type	Shannon Diversity Index
Grassland	
Limestone Gorge	
Savanna/Woodland	

11. Is there a relationship between the Shannon diversity index and the richness for each vegetation type? Explain your reasoning.

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12. Calculate the **evenness** for the three vegetation types by completing parts 1 and 2 on the "Evenness" tab. Record the values in the table below.

Vegetation Type	Evenness
Grassland	
Limestone Gorge	
Savanna/Woodland	

13. Is there a relationship between the evenness and richness for each vegetation type? Explain your reasoning.

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Part 4: Interpreting Diversity Indices

14. Based on the calculations you performed, which vegetation type has the overall greatest diversity? Use evidence from the data to support your claim.

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15. What additional information would be valuable for analyzing the diversity of the different vegetation types that can't be captured in trail camera photos?

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16. In ecology, resilience is defined as the ability of an ecosystem to resist change or recover from a disturbance quickly. Which vegetation type do you predict would have the greatest resilience? What evidence supports this claim?

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17. An ecological niche is the function of an organism in its environment, which includes the conditions under which it can live, what resources it uses, and how it reproduces. Use the concept of ecological niche to explain the difference in richness from the grassland to the savanna/woodland vegetation type.

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18. Use the interactive map to see how much human activity exists in each vegetation type. How might human activities influence the amount of biodiversity in different vegetation types in Gorongosa?

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19. How might biologists in Gorongosa use the diversity indices you calculated to inform their restoration efforts?

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