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, including grassland, limestone gorges, and savanna/woodland. Because biodiversity cannot easily be captured in a single number, various indices, or measurements, are examined together to 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. You will then explore how humans may be impacting the biodiversity of the habitats found in Gorongosa.

MATERIALS

- Internet access, computers/tablets with spreadsheet software (Excel or Google Sheets)
- Calculators that include natural log (ln)

PROCEDURE

Several online/supplemental resources are used in this activity:

- Gorongosa Interactive Map
- WildCam Lab for data sets
- Tutorial for analyzing data

Follow the instructions and answer the questions in the spaces provided.

PART 1: Exploring Species Diversity in Gorongosa

Launch the Gorongosa Interactive Map (http://www.hhmi.org/biointeractive/gorongosa-national-park-interactive-map) for a brief tour and study of the natural features of Gorongosa National Park. In the menu on the left side of the interactive, select the "Vegetation Types" and "Limestone Gorge" layers. These areas will now be visible on the map. Click the names on the map to bring up the pop-up window describing the areas. Note that some pop-up windows have scrolling text. Click through the different vegetation types to read about the variety of species supported in these areas. After you explore, make some predictions about the following:

1. What elements are necessary to support a wide variety of life for a given region? Include specific examples that you read about in the interactive.

2. For this activity, we will be eliminating the Montane vegetation types (Montane Grassland, Montane Woodland, and Montane Rainforest), found only on Mount Gorongosa. Make predictions about the possible differences in biodiversity between the remaining different vegetation types and the limestone gorge feature you read about in the interactive. Include information you used to make your predictions.

PART 2: Introduction to Diversity Indices (Measuring Diversity)

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

3. **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. Based on the species list below, what is the richness of this ecosystem? **S** = _____

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

4. Richness alone misses an important component of species diversity: the abundance (number of individuals) of some species may be low while for others it may be higher. 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). For most ecosystems, the value for H ranges from 1.5 to 3.5, with the higher score being the most diverse.

   $H = -SUM (P_i * \ln(P_i))$

   Where:

   P_i = species abundance/total abundance in the community

   ln = natural log

   a. Using the table on the next page, 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 three 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				

b. 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 =** _____

5. **Evenness** (E) is a measurement to compare the abundances of each species in the community. Communities in which each species is more evenly represented are considered more diverse than communities in which 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)**

a. Use the richness value you calculated in question 3 to calculate H_{MAX}. **H_{MAX} = ln(richness) =** _____

b. Use the Shannon diversity index value you calculated in question 4 and the H_{MAX} value you calculated above to calculate E. **$E = H/H_{MAX}$ =** _____

PART 3: Measuring Biodiversity in Gorongosa

You will use the *Tutorial on Measuring Diversity in Gorongosa* to investigate the richness, evenness, and Shannon diversity index of the dominant vegetation types in Gorongosa National Park. Before you begin, you will need to download a data set from WildCam Lab and save it to your computer. Go to https://lab.wildcamgorongosa.org/ and enter the site as an Explorer. Click the data tab and download the data per your teacher's instructions. Open the downloaded spreadsheet and follow the instructions on the spreadsheet tutorial.

6. Following the directions in the tutorial, create a pivot table to produce a list of species within each vegetation type as well as their abundance. Calculate the values of diversity indices for each vegetation type and record your answers in the table below.

Vegetation Type	Floodplain Grassland	Limestone Gorge	Miombo Woodland	Mixed Savanna and Woodland
Richness				
Shannon Diversity Index				
Evenness				

7. Compare your calculated values to evaluate whether there is a relationship between richness, diversity, and evenness for each vegetation type. Explain your reasoning.

8. Make a claim using evidence from this data about which vegetation type hosts the greatest diversity.

PART 4: Human Impact on Biodiversity

Use the Gorongosa Interactive Map to note the degree of human activity in each vegetation type.

9. Name the layers that would be related to human activity.

10. Which vegetation types appear to have the most human activity?

11. Predict how human activity might affect biodiversity.

Now you will interpret data from trail cameras to determine whether species diversity changes with proximity to people. The data in WildCam can be sorted by "distance to humans" and structure type. A subset of the data was selected for analysis from three cameras at three different distances from the most commonly found human structure in the park, game drive roads. These are dirt roads used by tourists and staff for travel inside the park. The cameras selected for data analysis were also filtered to be in the same vegetation type, mixed Savanna and Woodland, over the same four-month period, August through November.

12. Using the same process as in this activity, the Diversity Indices were calculated using the data captured by these three cameras and are displayed in the table below:

Distance to Human Structure	1 m	1,195 m	3,086 m
Richness	24	19	19
Shannon Diversity Index	2.373	1.812	1.649
Evenness	0.747	0.616	0.600

13. How does the diversity change as the distance to the human structure (road) increases?

14. What might explain this change in diversity?

15. What are the limitations to only using the trail camera data from these three cameras for this investigation?

16. What else could you investigate to further study the impact of human activity on biodiversity? Consider the other variables in the data tables such as distance to water, season, and time of day.

17. How might scientists in Gorongosa use the diversity indices to inform restoration efforts?