**INTRODUCTION**

Gorongosa National Park is a protected area in Mozambique. Lion researcher Paola Bouley and her team use motion-detecting trail cameras in the park to learn more about Gorongosa’s lions and other wildlife in the photos. These photos are posted on a citizen science website called WildCam Gorongosa ([www.wildcamgorongosa.org](http://www.wildcamgorongosa.org)), where the public can identify animals and collect data. This information is available to view or download via the WildCam Lab, an area within WildCam Gorongosa for investigating scientific questions. In this activity you will use the trail camera data to answer a scientific research question about human impacts on species diversity in Gorongosa.

Humans are a part of the ecosystem in Gorongosa: tourists travel in vehicles on the park roads while viewing wildlife, park rangers protect wildlife by patrolling the area, and local people live in villages and on farms surrounding the park. Humans’ impact on wildlife may be positive, negative, or both. Rather than looking at impacts on individual species, scientists may choose to investigate how humans impact species diversity, which will provide information on all of the species in the community.

**Species diversity** is the variety of species in an ecological community and cannot be determined by a single direct measurement. Species diversity is represented by an index, or a formula, that takes into account both the number of species present and how even the abundances are among species. In this activity you will compare the species diversity at different distances from humans using the Shannon-Wiener diversity index.

**PROCEDURES AND QUESTIONS**

**Part 1: Planning Data Collection**

In this activity, you will use data from WildCam Gorongosa to answer the following research question:

> "Does the species diversity of the animals captured by a trail camera decrease when the camera is placed closer to locations where people are present?"

Before attempting to answer this question, let’s first determine which data will be needed. A research question usually refers to the relationship between two types of variables, an independent and dependent variable. The **independent variable** is the variable the researcher is studying the effect of, and the **dependent variable** is the variable that is affected by (or depends on) the independent variable.

1. Identify the independent variable(s) in the research question. Justify your selection.
2. Identify the dependent variable(s) in the research question. **Justify your selection.**

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3. Based on your answers above, identify the data that is needed to answer the research question. For every variable you identify, explain its role in answering our research question.

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**Part 2: Data Analysis**

Before measuring biodiversity using a large data set, you will be introduced to calculating the Shannon-Wiener diversity index by hand using small sample data sets, each filtered by a different distance to humans. Then you will compare the Shannon-Wiener diversity index between these data sets.

The **Shannon-Wiener 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 \( (P_i) \), which is calculated using the equation below.

\[
H = -\text{SUM} (P_i \times \ln(P_i))
\]

Where:

\( H \) is the Shannon-Wiener diversity index
\[ P_i = \frac{n}{N} \]

Where:

- \( n \) is the number of individuals of a species.
- \( N \) is the total number of individuals of all species.

\( \ln \) is the natural log, which is a mathematical function.

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

4. Data set #1: The table below shows how the Shannon-Wiener diversity index is calculated using a small data set, filtered by a “distance to humans” metric. Spend some time examining the table and reading about what each of the columns mean.

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
<th>Column 6</th>
<th>Column 7</th>
<th>Column 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Number of Individuals</td>
<td>( p_i )</td>
<td>( \ln p_i )</td>
<td>( p_i \ln p_i )</td>
<td>Distance to Humans (m)</td>
<td>Distance to Water (m)</td>
<td>Vegetation Type</td>
</tr>
<tr>
<td>Baboon</td>
<td>10</td>
<td>0.1724</td>
<td>-1.7579</td>
<td>-0.3031</td>
<td>3,086</td>
<td>67</td>
<td>Savanna / Woodland</td>
</tr>
<tr>
<td>Bushbuck</td>
<td>8</td>
<td>0.1379</td>
<td>-1.9810</td>
<td>-0.2732</td>
<td>3,086</td>
<td>67</td>
<td>Savanna / Woodland</td>
</tr>
<tr>
<td>Civet</td>
<td>2</td>
<td>0.0345</td>
<td>-3.3673</td>
<td>-0.1161</td>
<td>3,086</td>
<td>67</td>
<td>Savanna / Woodland</td>
</tr>
</tbody>
</table>
5. Data set #2: Fill in the data table below using a scientific calculator or the “data table” spreadsheet provided. This data set is filtered by a new “distance to humans” value. Remember that column 5 is the Shannon-Wiener diversity index.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Individuals</th>
<th>pi</th>
<th>ln pi</th>
<th>pi ln pi</th>
<th>Distance to Humans (m)</th>
<th>Distance to Water (m)</th>
<th>Vegetation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baboon</td>
<td>10</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bushbuck</td>
<td>3</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civet</td>
<td>8</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honey Badger</td>
<td>1</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mongoose</td>
<td>1</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyala</td>
<td>9</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oribi</td>
<td>2</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porcupine</td>
<td>2</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sable Antelope</td>
<td>1</td>
<td>8.2</td>
<td>1,029.20</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Data set #3: As you did above, fill in the data table below using a scientific calculator or the “data table” spreadsheet provided.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Individuals</th>
<th>$pi$</th>
<th>$ln(p_i)$</th>
<th>$pi \ln(p_i)$</th>
<th>Distance to Humans (m)</th>
<th>Distance to Water (m)</th>
<th>Vegetation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baboon</td>
<td>13</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bird (other)</td>
<td>4</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bushbuck</td>
<td>1</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bushpig</td>
<td>1</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civet</td>
<td>4</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genet</td>
<td>2</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Hornbill</td>
<td>1</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honey Badger</td>
<td>1</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impala</td>
<td>6</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyala</td>
<td>3</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oribi</td>
<td>1</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porcupine</td>
<td>2</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redbuck</td>
<td>3</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sable Antelope</td>
<td>3</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vervet Monkey</td>
<td>1</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warthog</td>
<td>4</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterbuck</td>
<td>7</td>
<td>0.01</td>
<td>3,077.70</td>
<td>3,077.70</td>
<td>Savanna / Woodland</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Totals**

$H = \text{Total}$
Part 3: Discussing Results

In an experiment, a researcher should make every attempt to keep constant all variables other than the independent and dependent variables. The other variables that are successfully held constant are called **controlled variables**.

7. Which is the controlled variable in all three data sets?

8. In the data analysis you performed, other than the dependent variable, identify the variable that was not a controlled variable. Justify your selection.

9. Based on your calculations in Part 2 and your analysis of the data, propose a claim about the research question: “Does the species diversity of the animals captured by a trail camera decrease when the camera is placed closer to locations where people are present?” Justify your response.

10. Explain how the other variables in the data table like the distance to water and the type of vegetation in the vicinity of the trail camera could have influenced the results and introduced uncertainty into the answer to the research question.
11. Identify three other limitations and/or biases due to using trail cameras to collect data on biodiversity. For each limitation and/or bias you identify, discuss how it could have influenced the results.

Part 4: Verifying Results

One of the hallmarks of science is the reproducibility of experimental results. Now that you have proposed a claim about the research question, it does not mean that a scientific theory or fact has been established. The elevation of a scientific finding to the level of scientific theory or fact requires that many scientists, working independently, are able to replicate the experiments with the same results.

In this part of the activity, you will use the WildCam Lab (lab.wildcamgorongosa.org) to collect additional data that can be analyzed to answer our research question. Your instructor will demonstrate how to access and download data. Open the spreadsheet that you downloaded and also open the spreadsheet tutorial that was provided. Copy all of the columns from the
data spreadsheet you downloaded and paste them into the “Data” tab of the spreadsheet tutorial.

12. Open the “Shannon-Wiener Diversity Index” tab in the spreadsheet tutorial and complete the calculations by following the instructions. Attach a copy of your data tables containing all calculations and the value of the Shannon-Wiener diversity index.

13. Explain whether these additional results confirm or contradict your claim about the research question you proposed in Part 3.

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14. Identify the controlled variable(s) in the data you processed, and justify your selection(s).

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15. Identify other variables in the data you processed, other than the independent variable, which were not controlled variables. Justify your selection.

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Part 5: Proposing a New Research Question

Consider other research questions that could be asked related to human impacts on the wildlife in Gorongosa National Park. In this section you will state an original research question that can be answered using the data available from the WildCam Lab.

Ask yourself, “What are some other ways the WildCam Gorongosa data can be used to study how humans are impacting wildlife in Gorongosa National Park?”

Begin by reviewing the data you downloaded from WildCam Lab in Part 4. As you think about possible research questions, use the strategies you used above to consider the data needed to answer those research questions, and ensure that the data is available. If you need additional background information, review the ecology page or the field guide on the WildCam website.

Here are a few things to consider as you try to come up with questions:

- Human impacts can have positive, negative, unknown, and even no effects on wildlife.
- For various reasons, some animals prefer living around humans.
- Species diversity is not the only way to measure impacts on wildlife. For example, you may choose to focus on a specific species or group of animals.

16. Propose your new and unique, original research question.

17. Download the data necessary to answer your research question from the WildCam Lab. Analyze the data you downloaded. Attach a copy of your data tables containing all calculations.

18. Identify the independent, dependent, and controlled variables in the data you processed.

19. List some variables that you couldn’t control for that may have influenced your results.
20. Propose a claim about the original research question that is supported by the data and provide an explanation using evidence from your data and background research.

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21. Suggest other data that, if available, could be used to support your results.

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