INTRODUCTION

Gorongosa National Park is a 1,570-square-mile (4,066-square-kilometer) protected area in Mozambique, Africa. The park is home to lions, wildebeests, elephants, zebras, and many other animals. Several decades of war devastated Gorongosa’s wildlife populations. Park scientists and conservation managers are now working to restore the Gorongosa ecosystem.

Some ecosystem information can be depicted using ecological pyramids: diagrams that show the relationships between trophic levels and the position of species among trophic levels. Trophic levels are the levels of a food chain where the organisms at higher positions eat those directly below them. The bottom level is producers (usually plants for ecosystems on land), which are eaten by primary consumers, followed by secondary consumers, and so on.

Ecological pyramids can represent a variety of relationships, such as the numbers of organisms (numbers pyramid), energy flow among organisms (energy pyramid), or biomass of organisms (biomass pyramid). A biomass pyramid is constructed by calculating the total mass, or weight, of all living organisms within each trophic level in an ecosystem.

In this activity, you will study the structure of trophic levels in different vegetation types (which correspond to different habitats) in Gorongosa. Using photos, you will identify and make observations about the species present in one vegetation type. Then you will create a biomass pyramid showing the relationships among trophic levels within your vegetation type and compare it with those of other vegetation types.

This activity will help you answer the following questions:
• How does biomass differ between trophic levels within your vegetation type?
• How does the structure of the biomass pyramids differ across vegetation types?
• What do these patterns suggest about the stability of the trophic structures in Gorongosa?

MATERIALS
• access to the WildCam Gorongosa and WildCam Gorongosa Lab websites
• the Excel “Tutorial” spreadsheet, if you are using Microsoft Excel
• graph paper or a printer
• scissors
• glue or tape

PROCEDURE

Follow the instructions below and complete the tasks in the spaces provided.

PART 1: Meet the Organisms

The first step in building an ecological pyramid is to understand the species in the ecosystem and how they interact. This part of the activity will familiarize you with a specific habitat and its species, which will become the basis for your pyramid. You’ll start by using a website called WildCam Gorongosa to access photos taken by trail cameras: motion-detecting cameras that scientists use to observe wildlife. The photos from these trail cameras provide valuable information about Gorongosa’s ecosystem, such as the quantity and type of animals.
Your instructor will send you a link to join a WildCam Gorongosa classroom. Make sure you create and log into an account on Zooniverse before clicking the link. Once you’ve joined the classroom, go to the “Student” section of the WildCam Gorongosa Lab, then to “View Assignments.”

Open the assignment that your instructor made for you. It will ask you to observe the species in a series of photos for a specific vegetation type. You can find more information about these species in the WildCam Gorongosa “Field Guide,” which appears as a labeled tab on the right side of the page.

1. Spend some time (e.g., 10 minutes) observing and identifying species in the photos. As you work, record your observations in the space below. This could include:
   a. names of the species you have identified
   b. relevant observations about the species (e.g., body size, number of individuals)
   c. questions you have about these species

PART 2: Make Predictions
You will now make predictions about the species you observed to create an initial biomass pyramid.

2. Fill out the table below for all of the species you observed in Part 1. You’ll need to predict the trophic level for each species and give a reason for your prediction.
   a. To help you make your predictions, use the species information in the WildCam Gorongosa “Field Guide.” The guide appears as a labeled tab on the right side of the webpage in Part 1. You can also find it on the right side of the WildCam Gorongosa “About” page.
   b. You will probably have multiple species at the same trophic level. In some cases, you may not have any producers or tertiary consumers.

<table>
<thead>
<tr>
<th>Species</th>
<th>Predicted trophic level (producer, primary consumer, secondary consumer, or tertiary consumer)</th>
<th>Reason/rationale</th>
</tr>
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<tbody>
<tr>
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3. Fill out the table below with the species that you think are at each trophic level. Once you have listed all the species, estimate how much biomass each trophic level has (as a percentage out of 100%). Since this is just your first guess, there are no right or wrong answers.

<table>
<thead>
<tr>
<th>Trophic level</th>
<th>Species list</th>
<th>Estimated percentage of biomass (out of 100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer</td>
<td>You won’t be able to record the species of the producers since they aren’t in the WildCam Gorongosa species list. Just estimate the percentage in the next column.</td>
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<tr>
<td>Primary consumer</td>
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<tr>
<td>Secondary consumer</td>
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<tr>
<td>Tertiary consumer</td>
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4. Use your predictions in Question 3 to draw a biomass pyramid.
   a. Beginning with the producer level at the bottom, draw a horizontal bar for each trophic level. The width of the bars should match the percentage of biomass that you estimated in Question 3.
   b. Label the trophic levels. At each level, list the species you observed and your predicted percentage of biomass.

PART 3: Formulate a Plan

You will now develop a plan for building your biomass pyramid with data. The trail camera data do not provide enough information for you to estimate the producer biomass. So, for now, you will focus on consumer biomass. (You will learn how to estimate producer biomass in Part 5.)

5. The table below shows a small sample of the WildCam Gorongosa trail camera data. There are three rows split into two sections. Indicate (e.g., circle or highlight) the columns of this data that would be useful for calculating the biomass of each trophic level. Note that:

   a. You will be asked to focus on a specific vegetation type (habitat): “Limestone Gorge,” “Floodplain Grassland,” “Miombo Woodland,” or “Mixed Savanna and Woodland.” If you are unsure which vegetation type you were assigned, check with your instructor.

   b. You will be asked to focus on a specific season: “Wet-Dry” (April to June).

   c. To learn more about each column, refer to the WildCam Gorongosa “Data Guide.”
6. List any additional information you will need to calculate the biomass of each trophic level.

7. Get feedback from your instructor about the data you are planning to use. Make any necessary modifications, then describe your plan for gathering and analyzing the data to build your pyramid.

PART 4: Analyze Your Data

You will now use your plan from Part 3 to gather the appropriate trail camera data. To obtain your data:

- Go to the “Explore Data” section of the WildCam Gorongosa Lab.
- Filter the data, picking your assigned vegetation type under “Habitats” and “Wet-Dry (Apr-Jun)” under “Seasons.”
- Click the “Download” button to download the data as a CSV file.

If you are using Microsoft Excel, your instructor will provide you with an Excel “Tutorial” spreadsheet, which will guide you through the calculations. To use this tutorial:

- Open your downloaded CSV file, then select and copy the entire data set.
- Open the “Tutorial” spreadsheet, and paste the data into the “Data” tab.
- Follow the instructions in Parts 1 and 2 of the “Biomass Calculation” tab to calculate the relative abundance for each species.

The relative abundance is a measure of how many photos were taken of each species over a set period of time, also known as “intensity of use.” You can use the relative abundance to calculate the relative biomass of each species. (To build a biomass pyramid, you’d typically calculate the species abundance: the number of individual animals of each species in a given area. However, trail cameras can’t give a completely accurate measure of species abundance. So, we’re using relative abundance as a proxy for species abundance.)
8. Record all the species from your “Tutorial” spreadsheet in the table below, then determine the average biomass and trophic level of each species.
   a. Use the WildCam Gorongosa “Field Guide” for additional information, including biomass (“weight”) ranges. Remember that the guide appears as a labeled tab on the right side of the webpage in Part 1. You can also find it on the right side of the WildCam Gorongosa “About” page.
   b. Record all biomasses in kilograms (kg).

<table>
<thead>
<tr>
<th>Species</th>
<th>Average biomass (kg)</th>
<th>Trophic level</th>
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9. Return to the “Tutorial” spreadsheet and complete Parts 3 and 4 of the “Biomass Calculation” tab. Use the information you collected in the table above to complete the analysis. Record the total biomass you calculated for each trophic level in the table below.

<table>
<thead>
<tr>
<th>Trophic Level</th>
<th>Total Biomass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary consumer</td>
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<tr>
<td>Secondary consumer</td>
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<tr>
<td>Tertiary consumer</td>
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</table>
PART 5: Estimate Producer Biomass and Build the Pyramid

The trail camera photos don’t provide enough information to calculate producer biomass. But you can estimate the producer biomass using the **10% rule**, which describes how much energy is passed from one trophic level to the next. When an organism is eaten, about 10% of its energy is passed on to the organism that ate it (the trophic level above it). The remaining 90% of the energy is used in cellular respiration or lost as heat. For example, if the producers contain 1,000 kcal of energy, the primary consumers that eat these producers will only get 10% of this energy (100 kcal).

The biomass required to support each trophic level is affected by the 10% rule. For example, we’d expect the producer biomass to be **10 times** that of the primary consumer biomass in order for the producers to support the primary consumers.

10. Return to the “Tutorial” spreadsheet and complete Parts 1 and 2 of the “Biomass Graph” tab. Record the producer biomass you calculated below.

11. Build your biomass pyramid following these steps:
   a. Create a bar graph that shows the biomasses at each trophic level, which you recorded in Questions 9 and 10. You can draw your graph by hand on graph paper. Or you can make it in the “Tutorial” spreadsheet by completing Part 3 of the “Biomass Graph” tab, then print it out on paper.
   b. Cut out the bars with scissors, then stack them on a blank piece of paper. Make sure to arrange the bars horizontally with the producers on the bottom.
   c. Tape or glue the bars in place when you’re done.
   d. Label each bar with the name of the trophic level, the species present, and the total biomass.

PART 6: Biomass Ratios

12. In the “Tutorial” spreadsheet, complete Part 4 of the “Biomass Graph” tab to calculate the ratio of the biomass between each trophic level. Record your results in the table below.

<table>
<thead>
<tr>
<th>Primary Consumer/Producer</th>
<th>Secondary/Primary Consumer</th>
<th>Tertiary/Secondary Consumer</th>
</tr>
</thead>
</table>

13. Compare the biomass ratios between the trophic levels.
   a. How do these ratios compare to the 10% rule?

   b. What is a possible explanation for this?

PART 7: Ecosystem Stability

14. Analyze the biomass pyramid you have created. What observations and trends do you notice within your pyramid between the different trophic levels?
15. Compare the pyramid you created with the original prediction you made in Question 4 of Part 2.
   a. What similarities and differences do you notice between your actual pyramid and your prediction?

   b. If there were any differences, how might you explain them?

16. What can you conclude about the stability of the ecosystem based on the shape of your pyramid?

17. Why do you think a pyramid shape is indicative of a stable ecosystem, in terms of representing biomass across trophic levels?

PART 8: Comparing Pyramids Across Ecosystems

18. Compare pyramids with another person/group who had the same vegetation type as you. Record any similarities and differences between your pyramids, including factors such as numbers of species, abundance, shape, etc.

19. Compare pyramids with other people/groups for at least two different vegetation types. Record any similarities and differences between your pyramids, including factors such as numbers of species, abundance, shape, etc.

20. From what you know about how trail cameras collect data, what are some of the potential biases with this type of data? How might that impact your biomass pyramid?