INTRODUCTION

Gorongosa National Park is a 1,570-square-mile protected area in Mozambique. After several decades of war devastated Gorongosa's wildlife populations, park scientists and conservation managers are now working to restore the Gorongosa ecosystem and the wildlife that depend on it. Lion researcher Paola Bouley and her team use motion-detecting trail cameras to learn more about Gorongosa's lions. Lions are not the only animals that are captured on these cameras. Gorongosa National Park is home to wildebeests, elephants, zebras, and many other types of animals. These photos can provide valuable information for science and conservation in Gorongosa, such as the quantity and type of animals within ecosystems.

Scientists often depict this information in ecological pyramids, which are 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), 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 (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 be an ecologist studying the structure of the trophic levels in different vegetation types in Gorongosa. Using the trail camera photos, you will identify and make observations about the species present in this ecosystem. Then you will create a biomass pyramid showing the relationships among trophic levels within your vegetation type and compare it with other vegetation types.

PROCEDURES AND QUESTIONS

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 understanding the species and their interactions with one another in an ecosystem. The steps below will familiarize you with the vegetation type you were assigned and the species within it that will become the basis for your pyramid.

1. Log in or register for an account on WildCam Gorongosa (www.wildcamgorongosa.org). With your partner, spend 10 minutes observing and identifying species in photos. As you work, record the name of the species and any relevant observations or questions you have about the species you are identifying.

Observations → What do you notice (body size, quantities, animal type)?

Now you will gather information about the species you observed to create a biomass pyramid in order to answer the following questions:

1) How does biomass differ between trophic levels within your vegetation type?
2) How does the structure of the biomass pyramids differ across vegetation types?
3) What do these patterns suggest about the stability of the trophic structures in Gorongosa?

Part 2: Make a Prediction

When making predictions about the biomass pyramid, you may use the WildCam field guide (https://www.wildcamgorongosa.org/#/field-guide) for additional information about the species in your vegetation type.

2. Based on the animals you saw on WildCam, which species do you think will be at each trophic level for your assigned vegetation type? Why? (Note: you may not have tertiary consumers and you may have multiple species at each trophic level. All of the species in your photos should be listed.)

Species name	Trophic level prediction (producer, primary consumer, secondary consumer, tertiary consumer)	Reason/rationale

3. Predict which trophic level will have the most biomass, based on your observations about each species for each trophic level:

Trophic level	Species list	Estimated proportion of biomass (out of 100%)
Producers	*It won't be possible to record the species of the producers. Simply estimate the proportion of the biomass you think they make up.*	
Primary consumer		
Secondary consumer		
Tertiary consumer		

4. Use your predictions in questions 2 and 3 to draw a biomass pyramid. Beginning with the producer level at the bottom, draw a horizontal bar for each trophic level. The width of the bars should match the proportion of biomass that you estimated in question 3. Label the trophic levels and, at each level, list the species you observed and your predicted percent biomass.

Part 3: Formulate a Plan

Now that you have a better understanding of what a biomass pyramid represents, you will work with your group or partner to develop a plan for building a biomass pyramid. Trail camera images do not provide enough information for you to estimate the biomass of the producer level. For now, you will focus on the consumer levels, and you will learn how to estimate producer biomass in part 5.

5. Circle the data in the example spreadsheet below that would be useful for calculating the biomass of each trophic level within your assigned vegetation type. The time period of your study will be the dry season, so this will be the variable that you use to filter the data set.

image_id	camera	longitude	latitude	date	month	year	season	time_period	veg_type	human_structure	distance_human_m
681504	C15	34.5406	-18.9522	11/17/13	Nov	2013	DryWet Oct-Dec	Day 0623-1709	Floodplain Grassland	Road	4
687882	C08	34.3215	-18.9672	8/10/13	Aug	2013	Dry Jul-Sep	Day 0623-1709	Mixed Savanna and Woodland	Road	3
688612	C21	34.676	-19.0319	9/24/13	Sep	2013	Dry Jul-Sep	Day 0623-1709	Limestone Gorge	Ranger Outpost	6466

water_type	distance_water_m	species	species_count	percentage_resting	percentage_standing	percentage_moving	percentage_eating	percentage_interacting	young_present	horns
River	222	Warthog	1	0	0.2	0.2	0	0	FALSE	
River	3677	Warthog	1	0	0.1	0.1	0	0	FALSE	
River	16	Baboon	1	0.047619048	0.047619048	0.047619048	0.047619048	0	FALSE	

6. With your group/partner, brainstorm and list the additional information you will need to calculate the biomass of each trophic level within your assigned vegetation type.

7. Debrief with your classmates and instructor about the data that you need to build your biomass pyramid, make any necessary modifications, and describe your plan for gathering and analyzing the data to build your pyramid.

Part 4: Analyze Your Data

To build a biomass pyramid, you typically begin by estimating the number of individual animals of each species. This variable, the number of individuals per species in a given area, is known as species abundance. Because trail cameras cannot provide us with a completely accurate measure of species abundance, we will use "intensity of use" as a proxy for "species abundance." Intensity of use is a measure of how many photos were taken of each species over a set period of time. Thus, you can use intensity of use to calculate the *relative* biomass of each species in your vegetation type.

Your instructor will demonstrate how to use the WildCam Lab (lab.wildcamgorongosa.org) to filter and download data. Use your plan to gather the appropriate trail camera data for your vegetation type. You will focus your study on the dry season, so choose the dry season as another filter. Download a spreadsheet of your data, select and copy the entire data set. Open the spreadsheet tutorial and paste your data into the "Data" tab. Follow the instructions on the

"Biomass Calculation" tab, parts one and two, to calculate the relative abundance for each species.

Record the species from the relative abundance table you created in the spreadsheet tutorial in the table below. Next, determine the average biomass and trophic level of each species. Remember to use the WildCam field guide (https://www.wildcamgorongosa.org/#/field-guide) for additional information. Depending on the vegetation type you were assigned, you may or may not find any tertiary consumers.

Species	Average Biomass	Trophic Level

Continue the spreadsheet tutorial by completing parts three and four of the "Biomass Calculation" tab. Use the data you collected in table 1 to complete the analysis. Record the total biomass you calculated for each trophic level in the table below.

Trophic Level	Total Biomass
Primary Consumers	
Secondary Consumers	
Tertiary Consumers	

Part 5: Estimate Producer Biomass & Build the Pyramid

Trail camera photos don't provide you with the information you need to calculate producer biomass. Because of this, you must turn to the 10% rule to help estimate the producer biomass. The 10% rule refers to the phenomenon that approximately 10% of the energy of an organism in one trophic level is passed on to the trophic level above it when it is consumed. The remaining 90% is used in cell respiration or lost as heat. For example, if the producers contain 1000 kcal of energy, the primary consumers will only get 100 kcal of energy (10%) from the producers they eat. Because of this, the biomass required to support each trophic level is affected by the 10% rule.

8. In parts one and two of the "Biomass Graph" tab in the spreadsheet tutorial, record the consumer biomass and calculate producer biomass.

9. Now you have the information you need to begin building your biomass pyramid.

   Option 1: Excel
   - Open the "Biomass Graph" tab of the spreadsheet tutorial.
   - Complete part three to create a bar graph.
   - Print the graph, cut out the bars, and stack them appropriately on a blank white piece of paper to create your pyramid.
   - For each trophic level, label it, record the species, and list the total biomass.

   Option 2: Graph Paper
   - Using graph paper and the table you created above, as well as the producer biomass you calculated, create a bar graph.
   - Cut out the bars and stack them appropriately on a blank white piece of paper to create your pyramid.
   - Label each trophic level, record the species, and list the total biomass.

Part 6: Biomass Ratio

10. In part four of the "Biomass Graph" tab, calculate the ratio of the biomass between each trophic level. Use the table below to organize your calculations.

Primary Consumer/Producer (%)	Secondary/Primary Consumer (%)	Tertiary/Secondary Consumer (%)

11. Compare the biomass ratios between the trophic levels. How do these ratios compare to the 10% rule? What is a possible explanation for this?

Part 7: Ecosystem Stability

12. Analyze the biomass pyramid you have created. What observations and trends do you notice within your pyramid between the different trophic levels?

13. Compare the pyramid you created with the original prediction you made in question 4. What similarities and differences do you notice between your actual pyramid and your prediction? Explain why there were differences.

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

15. 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

16. Compare pyramids with another group who had the same vegetation type as you. Record any similarities and differences between your pyramids (include factors such as numbers of species, abundance, shape, etc.).

17. Compare pyramids with other groups for at least two different vegetation types. Record any similarities and differences between your pyramids (include factors such as numbers of species, abundance, shape, etc.).

18. 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?