BUILDING ECOLOGICAL PYRAMIDS WORKSHEET

OVERVIEW

This activity provides students with an opportunity to gather and analyze real data using the citizen science website WildCam Gorongosa (www.wildcamgorongosa.org). The WildCam Lab is a part of WildCam Gorongosa where you can view trail camera data on a map, filter it, and download the data to investigate scientific questions. Students will make predictions about, develop a plan for, and build a biomass pyramid within an assigned vegetation type in Gorongosa National Park using data they gather about species from WildCam photos. They will calculate the relative biomass of each species present in the vegetation type, analyze data using the WildCam field guide to determine which species belong at which trophic level based on diet, and categorize the species appropriately into a biomass pyramid. This encourages students to make connections between species, trophic levels, and vegetation types in the ecosystem and assess the stability of ecological communities within the park by interpreting and constructing explanations based on the evaluation of data. This activity also provides students with platforms for developing and using models, applying mathematical and computational thinking by organizing and analyzing real scientific data, and using Excel to perform calculations and create a biomass pyramid.

KEY CONCEPTS

- Trophic levels are the levels of a food chain where the organisms at higher positions eat those directly below them.
- Ecological pyramids are diagrams that show the relationships between trophic levels and the position of species among trophic levels.
- 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.
- The shape of a biomass pyramid and the relationships among the trophic levels can provide insight into the relative stability of the ecosystem.
- 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.

LEARNING OBJECTIVES

Students will be able to:

- Make predictions about the biomass relationships between trophic levels in an ecosystem.
- Analyze quantitative data to create a biomass pyramid.
- Describe the relationships between trophic levels and between ecosystems based on the shape of a biomass pyramid.

- Formulate hypotheses and make observations about the stability of ecosystems based on the biomass relationship between trophic levels.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	HS-LS2-1, HS-LS2-4, HS-LS2-6, HS-LS4-5
Common Core (2010)	RST.9-12.3, RST.9-12.7, RST.9-12.9
AP Biology (2012–13)	2.D.3, 4.A.5, 4.A.6, 4.C.4
IB Biology (2016)	SL & HL: 4.1, 4.2; SL & HL Option: C.1, C.2, C.4
AP Environmental Science (April 2013)	II.A, II.C
IB Environmental Systems & Societies (2010)	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.1.7; 2.3.1, 2.3.2; 2.3.3; 2.4.1, 2.4.2; 2.5.1, 2.5.3, 2.5.5, 2.5.6

KEY TERMS

Gorongosa National Park, biomass, trophic level, ecosystem, ecological pyramid, floodplain grassland, limestone gorge, savanna, woodland, producer, consumer, species abundance, intensity of use, stability

TIME REQUIREMENTS

2-3 (45-min) class periods depending on the level of scaffolding and student capabilities with Excel and analyzing data.

SUGGESTED AUDIENCE

This activity is appropriate for high school biology (all levels including AP and IB), high school environmental science (all levels including AP and IB), and introductory college biology or ecology.

PRIOR KNOWLEDGE

Trophic levels, biomass, data analysis, Excel (spreadsheet tutorial provided)

MATERIALS

Option 1: Excel

Internet-connected computers, student worksheet, printer, scissors, glue/tape, overhead projector

Option 2: Paper

Internet-connected computers, student worksheet, graph paper, scissors, glue/tape, overhead projector

PROCEDURES

Prior to Class

- Set up a Wildcam Gorongosa account (https://panoptes.zooniverse.org/users/sign_in#/), enter the WildCam Lab (http://lab.wildcamgorongosa.org), set up a classroom, and email your students a link to invite them to join the classroom.
- Determine how students will be grouped within your class and which groups will be assigned each of the four vegetation types: Limestone Gorge, Floodplain Grassland, Miombo Woodland, or Mixed Savanna and Woodland.
- Be prepared to display the WildCam Lab site on an overhead projector.

Part 1: Meet the Organisms

1. Distribute the "Building Ecological Pyramids" worksheet. Ask your students to read the introduction and Part 1 of the worksheet.
2. Model for students how to log on to WildCam Gorongosa and how to classify a trail camera image.
3. Give your students a set amount of time (10 minutes) to look at photos, identify the animals, and write down observations on their handout.

Part 2: Make a Prediction

1. Ask your students to read Part 2 of their worksheet. Before students make predictions, you should explain the three types of ecological pyramids (number, biomass, and energy) and be sure that students know what "biomass" means.
2. Give your students time to make predictions about the species that would be at each trophic level by filling out the table in question 2. Help them access the WildCam Gorongosa Field Guide for additional information on the species in their photos (https://www.wildcamgorongosa.org/#/field-guide).
3. Have your students make predictions about the proportion of biomass they think would be at each trophic level by filling out the table in question 3. There are no right or wrong answers at this stage.
4. In question 4, have your students draw their predicted biomass pyramid based on the percentages they assigned in question 3. Check that they are drawing a horizontal bar on the bottom to represent producers, with the primary consumer bar on top of that, and so on. They should label each bar with the species and the percent biomass from table 2.

Part 3: Formulate a Plan

1. For question 5, students will work with their group to select the data from a sample spreadsheet that they will need to filter on the map. The data from the spreadsheet they will need are: Season, Species, Species Count, and Veg Type. Of these, they will filter by Dry Season and their assigned vegetation type.
2. For question 6, explain that not all of the data necessary to build a biomass pyramid is found in the spreadsheet and give students a set amount of time to make a list of what data is still necessary (i.e., diet, predators, and biomass).

3. For question 7, debrief with your students about the data that they will use from the spreadsheet and the data that is missing. If they need prompting, explain that the WildCam Gorongosa field guide will be used to calculate average biomass for each species using the weight range provided. The diet and predators listed for each species will help them determine the trophic level. Additionally, data from trail camera images do not provide enough information to estimate producer biomass. They will estimate producer biomass in Part 5.
4. Based on your feedback, students can modify their plans for building the pyramid with their group.

Part 4: Analyze Your Data

Students will gather data to build a biomass pyramid for their vegetation type. They will use the spreadsheet tutorial and the data tables in the student handout to organize their data. Students will follow the following steps:

1. Use the WildCam Lab database to filter by their vegetation type and dry season, then download and open the spreadsheet in Excel. Open the spreadsheet tutorial in Excel as well. Students will copy all of the columns in their data set and paste it into the data tab of the tutorial.
2. Complete Parts 1 and 2 of the Biomass Calculation tab to calculate the number of individuals for each species. Record the list of species in the first data table on the student handout.
3. Use the WildCam Gorongosa field guide (https://www.wildcamgorongosa.org/#/field-guide) to determine the average biomass and trophic level for each species in their table. [*Note: If biomass is listed in grams, it should be converted to kilograms.]* Record this information in the data table.
4. Complete Parts 3 and 4 of the "Biomass Calculation" tab of the spreadsheet tutorial to calculate the total biomass for each species and trophic level and record it in the table.

Part 5: Estimate Producer Biomass & Build the Pyramid

Now that students have built the pyramid, they must add in the producers. To do this, students must apply the 10% rule of energy transfer.

1. Students should read the introduction to Part 5 of the student handout. Clarify the 10% rule if there is confusion.
2. Students will complete Parts 1 and 2 of the "Biomass Graph" tab of the spreadsheet tutorial to calculate the producer biomass.
3. Two options are provided for building the pyramids, using Excel or graph paper to create bar graphs. Depending on your resources and time available, you can choose which option best suits your students' needs.
4. Students will create a bar graph in Excel by completing Part 3 of the "Biomass Graph" tab of the Excel spreadsheet, then print the graph. Alternatively, draw a bar graph on graph paper using the second table in Part 4 of the student handout along with the producer biomass they calculated.
5. Students will cut out the bars in their graph and paste or tape them onto a larger piece of paper by stacking the bars horizontally with primary producers on the bottom.

6. Students will label each of the bars of the pyramid with the name of the trophic level, the species present, and the total biomass.

Part 6: Biomass Ratio

1. Students will complete Part 4 of the "Biomass Graph" tab of the spreadsheet tutorial to calculate the ratio of biomass between trophic levels. They will analyze the relationship among the real data from their trophic levels and compare it to the theoretical 10% rule.

Part 7: Ecosystem Stability

1. Have students complete questions 10 through 14 of the student handout within their group.

Part 8: Comparing Pyramids Across Ecosystems

1. Groups will compare their pyramid to that of another group that was assigned the same vegetation type, then complete question 15.
2. Groups will compare their pyramid to those of two groups that were assigned different vegetation types, then complete question 16.
3. Complete question 17.

TEACHING TIPS

- The activity is divided into eight parts, and each part builds upon the section before it. If you have limited time or need to provide scaffolds for your students, you can begin by providing students with the plan for gathering data in Part 3 and have them execute the plan in class. You can also assign Parts 7 and 8 as homework after they create the pyramid in class. Students can take pictures of each other's pyramids on their smart phones or tablets to compare the pyramids outside of class.
- Consider assigning Part 1 as homework prior to the activity to help students familiarize themselves with the animals and the species identification process.
- As an extension, you can provide biomass pyramids from other ecosystems, such as aquatic ecosystems, based on examples in textbooks or scientific papers. Students can compare their pyramids with those from other ecosystems.

RELATED RESOURCES

WildCam Gorongosa
(http://www.hhmi.org/biointeractive/wildcam-gorongosa)
Researchers in Gorongosa National Park use remote trail cameras to study the park's wildlife. This online citizen science platform allows participants to help scientists identify animals in these photos.

Creating Chains and Webs to Model Ecological Relationships
(http://www.hhmi.org/biointeractive/creating-chains-and-webs-model-ecological-relationships)
In this activity, students use cards to build model food webs and evaluate how ecological disturbances affect each trophic level.

Gorongosa: Making Observations
(http://www.hhmi.org/biointeractive/gorongosa-making-observations-activity)
In this activity, students use trail camera photos from WildCam Gorongosa to make observations and ask scientific questions as part of the scientific process.

Tracking Lion Recovery in Gorongosa National Park
(http://www.hhmi.org/biointeractive/tracking-lion-recovery-gorongosa-national-park)
This Scientist at Work film explores how scientists in Gorongosa National Park are using GPS satellite collars and motion-sensitive cameras to gather information about the park's lion population.

Gorongosa National Park Interactive Map
(http://www.hhmi.org/biointeractive/gorongosa-national-park-interactive-map)
This interactive map of Gorongosa National Park allows users to explore different features of the park, including key components of the conservation strategy.

The Guide: A Biologist in Gorongosa
(http://www.hhmi.org/biointeractive/the-guide-a-biologist-in-gorongosa)
This is a short film about a young man from Gorongosa who discovers a passion for science after meeting world-renowned biologist E.O. Wilson.

AUTHORS

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