OVERVIEW

This activity complements WildCam Gorongosa (http://www.wildcamgorongosa.org), an online citizen science platform for identifying animals photographed by motion-detecting trail cameras in Gorongosa National Park. The WildCam Lab is a part of WildCam Gorongosa where students can view trail camera data on a map, filter, and download the data to investigate scientific questions.

In this activity, students will calculate diversity indices – richness, Shannon diversity index, and evenness – in three different vegetation types in Gorongosa National Park using data from trail camera photos. Students will begin by calculating these indices by hand using a very small sample data set. After becoming familiar with equations for indices and how they relate to one another, students will download a larger dataset from the WildCam Lab. They will use the Gorongosa Interactive Map (http://www.hhmi.org/biointeractive/gorongosa-national-park-interactive-map) to explore the three vegetation types to make predictions about the animal diversity they may find there. They will then use a spreadsheet tutorial to calculate diversity indices for three vegetation types and interpret their findings.

This activity can be differentiated for students with different levels of prior experience with solving equations and analyzing data in spreadsheets. Students are introduced to diversity calculations by breaking down the equations into manageable parts before working with a large data set from the WildCam Lab. A tutorial helps to support students with managing large data sets and making calculations in Excel.

KEY CONCEPTS

- Biodiversity is the variety of life and can be measured on multiple scales including genetic diversity, species diversity, and ecosystem diversity.
- Indices that measure species diversity include species richness (the number of species in a given area) and evenness (similarity in the abundances of species).
- The location and abundance of animals are determined by the availability of resources and community interactions, such as competition, predation, and human influences.
- An ecological niche is the role of an organism in its environment, which includes the conditions under which it can live, what resources it uses, and how it reproduces.
- The diversity of an ecosystem, including soil, plant, structural, topographic, and climatic diversity, can positively impact animal species diversity.

LEARNING OBJECTIVES

Students will be able to:

- Calculate diversity indices (richness, Shannon diversity index, and evenness) by hand and using Excel.

- Make predictions and use evidence to explain why certain vegetation types may have higher diversity than others.
- Explain the relationships between diversity indices.
- Predict how diversity could support ecosystem resilience.
- Explain how ecological niches relate to diversity.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	HS-LS2-2, HS-LS2-7, HS-LS4-6
AP Biology (2012–13)	4.A.5, 4.C.4
IB Biology (2016)	HL Option C.1, C.4
AP Environmental Science (April 2013)	II.A, II.C, VII.C
IB Environmental Systems & Societies (2010)	4.1.1, 4.1.5; 4.2.1, 4.2.7; 4.3.1, 4.3.2, 4.3.4, 4.3.5

KEY TERMS

Gorongosa National Park, ecosystem, vegetation type, community, diversity, richness, Shannon diversity index, evenness, floodplain grassland, limestone gorge, savanna, woodland, species abundance, ecological niche

TIME REQUIREMENTS

2 (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

biodiversity, ecosystem, species abundance, data analysis, Excel (spreadsheet tutorial provided), ecological niche

MATERIALS

Internet-connected computers with Excel, student worksheet, calculators that include natural log (ln), spreadsheet tutorial file, 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.
- Provide the spreadsheet tutorial file to your students so they can open it on their computers.
- Be prepared to display the WildCam Lab site on an overhead projector.

Part 1: Introduction to Diversity Indices

1. Distribute the "Gorongosa: Measuring Biodiversity" worksheet. Ask your students to read the introduction and Part 1 of the worksheet.
2. Instruct your students to work through questions 1 through 5 using a calculator.

Part 2: Vegetation Types

1. Ask your students to read Part 2 of their worksheet.
2. Instruct students to open and explore the Gorongosa Interactive Map on their computers (http://www.hhmi.org/biointeractive/gorongosa-national-park-interactive-map) and turn on the vegetation layer and limestone gorge layer on the map. They can click on each vegetation type to read about them.
3. Instruct your students to complete question 6.

Part 3: Measuring Biodiversity in Gorongosa

1. Ask your students to read Part 3 of their worksheet.
2. On the overhead projector, model for students how to register for an account on WildCam Gorongosa. Instruct them to click on the link you provided to join your classroom.
3. Model for students how to view the map of trail cameras in the WildCam Lab. Your students will not need to apply any filters to the data set. Show them how to download the entire data set (by clicking the "Download" button) and save the file to their computers.
4. Instruct your students to open the data file in Excel and also open the spreadsheet tutorial you provided. Then, they will copy all of the columns in the data file and paste them into the "Data" tab in the spreadsheet tutorial.
5. Instruct your students to complete questions 7 through 13 while completing all of the steps in the spreadsheet tutorial as indicated in their handout.

Part 4: Interpreting Diversity Indices

1. Have your students complete questions 14 through 19 of the student handout.

TEACHING TIPS

- The activity is divided into four parts. The first part involves students making calculations by hand using a small sample data set. Parts 2 and 3 involve calculations in Excel using the trail camera data set. If time is limited, parts 2 and 3 can be done together as a standalone activity.
- Consider assigning Part 4 as homework after completing parts 1 through 3 in class.

- As an extension, you can provide species abundance data from a local ecosystem and have your students compare it with the diversity in Gorongosa.
- The video "Tracking Lion Recovery in Gorongosa National Park" and the WildCam Gorongosa website can be introduced before the activity to give students background information on the trail camera project.
- The video "Surveying Gorongosa's Biodiversity" can be shown as an introduction or as a follow-up to discuss the importance of measuring biodiversity.

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.

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.

Surveying Gorongosa's Biodiversity
(http://www.hhmi.org/biointeractive/surveying-gorongosas-biodiversity)
Biologists Piotr Naskrecki and Jennifer Guyton identify and record the diversity of species in Gorongosa National Park's Cheringoma Plateau.

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.

ANSWER KEY

1. *Based on the table below, what is the richness of this ecosystem?*

   S = **10**

2. *Using the table below, 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	**.041**	**-3.194**	**-.131**
Warthog	3	**.041**	**-3.194**	**-.131**
Elephant	2	**.027**	**-3.612**	**-.098**
Zebra	1	**.014**	**-4.269**	**-.060**
Hippo	1	**.014**	**-4.269**	**-.060**
Impala	4	**.055**	**-2.900**	**-.160**
Lion	1	**.014**	**-4.269**	**-.060**
Baboon	15	**.205**	**-1.585**	**-.325**
Warbler	25	**.342**	**-1.073**	**-.367**
Crane	18	**.247**	**-1.398**	**-.345**
Total Abundance	**73**			

3. *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 = **1.737**

4. *Use the richness value you calculated in question 1 to calculate H_{MAX}.*

   H_{MAX} = ln(richness)) = **2.303**

5. *Use the Shannon diversity index value you calculated in question 3 and the H_{MAX} value you calculated in question 4 to calculate E.*

   $E = H/H_{MAX}$ = **.754**

6. *Predict which vegetation type will have the greatest biodiversity. What information did you use to make your prediction?*

Answers will vary. Diversity in the vegetation should increase animal species diversity; therefore, vegetation types with a greater diversity of plant species and greater vertical structure (combination of grass, shrubs, and trees of varying heights) should have greater animal diversity. The savanna/woodland vegetation type is most likely to have the highest animal diversity, followed by the limestone gorge, and the floodplain grassland.

7. Complete parts 1 and 2 of the "Species Richness" tab. What are the two variables that you are using to group the data?

   The two grouping variables are vegetation type and species.

8. Complete Part 3 of the "Species Richness" tab to calculate richness for each vegetation type. Record the values below.

Vegetation Type	Richness
Grassland	**Answers will vary**
Limestone Gorge	**Answers will vary**
Savanna/Woodland	**Answers will vary**

9. Which vegetation type in Gorongosa has the greatest species richness? Propose a possible explanation for differences in species richness from one vegetation type to another.

   Answers will vary.

10. Complete the calculation of the **Shannon diversity index** for the three vegetation types on the "Shannon Diversity Index" tab. Record the values in the table below.

Vegetation Type	Shannon Diversity Index
Grassland	**Answers will vary**
Limestone Gorge	**Answers will vary**
Savanna/Woodland	**Answers will vary**

11. Is there a relationship between the Shannon diversity index and the richness for each vegetation type? Explain your reasoning.

The Shannon diversity index is calculated by taking the sum of $P_i * \ln(P_i)$ for each species. If more numbers are added based on the number of species present (or richness), then higher richness should increase the Shannon diversity index if the relative species abundance remains the same.

12. Complete the calculation of **evenness** for the three vegetation types on the "Evenness" tab. Record the values in the table below.

Vegetation Type	Evenness
Grassland	**Answers will vary**
Limestone Gorge	**Answers will vary**
Savanna/Woodland	**Answers will vary**

13. Is there a relationship between the evenness and richness for each vegetation type? Explain your reasoning.

    Richness does not impact the evenness of an ecosystem. Evenness is calculated by dividing the Shannon diversity index (H) by the natural log of the richness (H_{MAX}). If the species abundances within a community are completely proportional (even), then H would be the same as H_{MAX}, so evenness (E) would be equal to 1 for that community. If two communities have even species abundances but richness is higher in one than the other, the evenness (E) would still be equal to 1 of each community.

Part 4: Interpreting Diversity Indices

14. Based on the data you examined and the calculations you performed, which vegetation type has the overall greatest diversity? Use evidence from the data to support your claim.

    Answers will vary

15. What additional information would be valuable for analyzing the diversity of the different vegetation types that you can't be captured in trail camera photos?

    Trail camera photos do not capture all species, especially very small species. They are biased toward larger animals, such as large mammals. To calculate diversity more accurately, you would need species abundance data for all taxa.

16. In ecology, resilience is defined as the ability of an ecosystem to resist change or recover from a disturbance quickly. Which vegetation type do you predict would have the greatest resilience? What evidence supports this claim?

    Answers will vary. The vegetation type with the highest diversity should have the highest resilience.

17. Use the concept of ecological niche to explain the difference in richness from the grassland to the savanna/woodland vegetation type.

    An ecological niche is the function of an organism in its environment, which includes the conditions under which it can live, what resources it uses, and how it reproduces. Different species can coexist in the same habitat by occupying different niches. A vegetation type in Gorongosa that has greater soil, plant, structural, and microclimate diversity is likely to have a high diversity of available niches, and thus a higher number of species to occupy those niches.

18. Use the interactive map to see how much human activity exists in each vegetation type. How might human activities influence the amount of biodiversity in different vegetation types in Gorongosa?

    The presence of humans can cause some species to avoid the area and other species to be attracted to the area. The human impact on species diversity also depends on the type of human activity and how disruptive it is to wildlife. The interactive map shows a tourist camp and game drive roads throughout a portion of the savanna/woodland vegetation type and small portions of the grassland vegetation type. There appears to be low human infrastructure in the grassland vegetation type and no human infrastructure in the limestone gorges. The vegetation type where human activity is most likely to negatively impact species diversity is the savanna/woodland vegetation type because this is the area with the highest human presence.

19. How might biologists in Gorongosa use the diversity indices you calculated to inform their restoration efforts?

    Biologists in Gorongosa might use diversity indices to prioritize their conservation and restoration efforts. Areas with the highest levels of biodiversity may get more resources allocated to them, such as antipoaching teams. Also, biodiversity can be monitored over time to detect changes that may signal an issue that needs to be remedied.

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