OVERVIEW

African elephants are endangered. It is critically important to know how many elephants are left and where they are to guide conservation efforts. In this classroom activity, students will create a model of two different count methods: a sample count and a total count. Both of these methods are used for studying population sizes of wildlife.

INTRODUCTION

In the 1970s, researchers estimated that 1.3 million forest and savanna elephants thrived in over 35 countries in Africa. Since then, we know that populations of African elephants have been declining at an alarming rate due to habitat destruction and poaching fueled by the international ivory trade.

The Great Elephant Census, a large-scale aerial survey that counted elephants across the continent of Africa, recently determined that only 352,271 African savanna elephants remain. So how did researchers get at this number?

The researchers decided to conduct an aerial survey and they considered two options for counting: they could count every single elephant they saw while flying all over Africa, what's known as a total count, or use an alternative method called a sample count. A sample count involves dividing the survey areas into regions, called strata, of varying sizes. Surveyors then fly along the transect lines to estimate the number in that area, or stratum. Using this method, only elephants seen in the sections of the survey area are counted and used to determine elephant density in that area. These numbers are used to estimate the overall number of elephants based on a mathematical algorithm.

KEY CONCEPTS

- Estimating wildlife populations informs conservation and management strategies.
- Mathematical tools enable researchers to estimate populations.
- Different conditions can determine which counting methods are more appropriate for determining populations.

LEARNING OBJECTIVES

Students will be able to:

- differentiate between a sample and total count and identify the advantages and disadvantages of each
- collect data for both a sample count and total count for a population and calculate population densities
- analyze the variations in data

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	LS2-2; LS2-6
Common Core (2010)	RST.11-12.7; SL8.1; SL9-10.1; SL11-12.1; MP.2; MP.4; MP.5
AP Biology (2012-13)	4.B.3; 4.C.3, Science Practice 1 and 2
IB Biology (2016)	HL Option G.1; G.3; G.4
AP Environmental Science (2013)	II.A; III.A; VII.C
IB Environmental Systems & Societies (2010)	1.1.10; 2.3.2; 4.2.6; 4.3.1

KEY TERMS

Census, sample count, total count, survey, average, density, distribution, modeling

TIME REQUIREMENTS

1 class period (50 minutes, some students may need additional time to finish answering questions)

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

Density, distribution, species, population, data analysis, modeling

MATERIALS

- African Landscape sheets: one preprinted landscape sheet per group of 2-3 students
- Lentils or split peas to represent elephants: approximately ½ teaspoonful (2.5 mL) per group
- Great Elephant Census Student Worksheet
- Calculator
- Ruler: 1 per student group if you choose to have students calculate areas
- For optional warm-up activity, one jar or beaker: prefilled with small items like beans, lentils, coins, or small candies to be displayed for whole class
- Not required, clear sheet protector: one per group of 2-3. Note: if unavailable, students should be careful when distributing lentils on the landscape sheet.

TEACHER TIPS

- Lentils or split peas are recommended because they have one flat side, which eliminates some bouncing. Other beans or small objects can also be used.
- Sheet protectors can be used to set up the activity so the lentils are stored between classes if you have multiple classes throughout the day. The lentils can be poured out into a cupped hand if it is easier for students to do the dropping technique of lentil distribution, then returned to the sheet protector.

- If you do not have sheet protectors, have a beaker of lentils and a ½ teaspoon at the front of the room and have one student from each group come up to get their lentils. Or you can count out 25-30 lentils per group ahead of time and place in cups.
- Some curricula require students to use the mark-recapture method of population sampling. If your students are familiar with that method, or you plan on doing it soon, discuss the differences in the methods and why different methods are more appropriate for different species and conditions. How well would mark-recapture work for the elephant census at this scale?

EXTENSION ACTIVITIES

- Density and distribution are concepts that can be explored further in this activity. Ask students to graphically represent the average density of their elephants on a landscape. Have them draw the elephants in a 5 cm × 5 cm square to illustrate density. Then, have them calculate the density based upon the **total count** (can be their group's total count or the class total count) and represent that density in a second square. Did each student draw the density the same way? Some may have used dots, some may have shaded in a percentage of area or used other methods. What influences animal distribution on a landscape? How might researchers account for different types of distribution?
- In the film, the researchers count the elephants by gender and age (adult versus juvenile). If you use different colors of lentils, you could model this by including different colored lentils for males (14 green lentils) and females (16 red lentils), or juveniles (17 green lentils) and adults (13 red lentils). Discuss why researchers would want to know the sex and/or ages of animals when determining population sizes. What issues might make it difficult to collect that data?

PROCEDURE

1. Distribute the student handout.
2. As an optional warm-up activity, display a jar full of beans, coins, or candy in the front of the room and have students guess how many items are in the jar. As a whole class, discuss challenges to knowing actual numbers in the jar and discuss different strategies students came up with to estimate the total number.
3. Instruct students to read the introduction paragraph of the Great Elephant Census student worksheet.
4. Have students complete the **T-chart** on their student data sheet to explore the advantages and disadvantages of sample counts versus total counts for estimating populations.
5. Show the 8-minute film **The Great Elephant Census**: http://www.hhmi.org/biointeractive/great-elephant-census
6. Explain to the class that they will be creating a model (simulation) of the elephant census to compare sample versus total count methods for studying wildlife population sizes.
   - Divide students into groups of two or three.
   - Pass out one elephant landscape sheet per group and an optional sheet protector.
   - Explain the parts of the sheet to the students (counting strips, transects, and total landscape area).

7. Have students calculate and record the transect and landscape areas. (If you are pressed for time, provide the calculated areas to students rather than having them complete the calculations.)

   Transect area: length × width for each counting strip and then multiply by 2 since there are two counting strips per transect area. Repeat the process for the second transect. **Total landscape area** (length × width) of entire sheet or colored portion of landscape sheet. If students calculate their own areas, allow for a small degree of error in their measurements.

   Area of each transect:

   Transect A: 19.3 cm × 1.7 cm = 32.81 cm^2 × 2 = 65.62 cm^2

   Transect B: 23.9 cm × 1.7 cm = 40.63 cm^2 × 2 = 81.26 cm^2

   Area of entire landscape:

   Entire landscape sheet = 22 cm × 28 cm = 616 cm^2

   Colored portion of landscape sheet 20.8 cm × 26.7 cm = 555.36 cm^2

8. Provide students with lentils.

   No sheet protector method: Place a beaker of lentils and a ½ teaspoon at the front of the room and have one student from each group come up to get their lentils. A level ½ teaspoon is roughly 25-30 lentils. Or count out 25-30 lentils per group ahead of time and place in cups.

   Sheet protector method: Pour ½ teaspoon (approximately 2.5 mL) of lentils into the sheet protector or into a cup for each group. This can be done ahead of time, or call table groups up to get lentils. There should be around 25-30 lentils per group, but do not reveal this number to the students.

9. Demonstrate how to disperse lentils on the landscape sheet.

   No sheet protector method: one person should cup the lentils in both hands about 10 cm above the landscape sheet and in one motion, pull their hands apart to distribute the lentils. Runaway lentils should be returned to the landscape sheet randomly.

   Sheet protector method: make sure the landscape sheet is in a sheet protector and hold it vertically while another student pours in lentils. Then hold the protector horizontally on a table with one hand holding the opening closed and rapidly shake or wiggle the setup for a few seconds to distribute lentils.

10. Each group should disperse the lentils. Tell students that if lentils bounce off of the landscape sheet, they should toss them back onto the sheet randomly.
11. Tell students that once they are dispersed they should not move the lentils until they are finished with their sample count and their total count.
12. As a class, establish the criteria for counting lentils within the transects. Examples include: don't pick up lentils as you count, and a lentil has to be all the way in the counting strip to be counted. Students then complete their counts in the transect areas. Students will do their sample counts first.
13. Students should record the numbers of lentils for each transect on their student worksheet.
14. To calculate the density of lentils for each transect:

$$\text{Density of lentils} = \frac{\text{number of lentils}}{\text{area of the transect}}$$

15. To calculate average density for an individual landscape:

$$\text{Average Density} = \frac{(\text{Transect A Density}) + (\text{Transect B Density})}{2}$$

16. To estimate the total number of elephants in an individual landscape:

Total number of elephants = Average density × Area of the landscape

17. Now have students do a total count of their elephants. Students should count all of the lentils on their landscape sheet and record their data.
18. Students should answer question 13 on their worksheet. If you are short on time, students can move right to sharing their data and answer the question later.
19. Students should share their individual data with their classmates.
20. Students should clean up their workspace and answer the remaining questions.
21. Once students have the class data, they should calculate the total area for the class:
Total area for the class = Landscape area calculated in Table 1 × the number of groups in the class
22. Students should calculate the estimated density of elephants for the class using the class **sample count** data: Total number of elephants from the sample count total calculated in Table 3 divided by the total area for the class.
23. Students should calculate the actual density of elephants for the class using the **total count** data: Total number of elephants from the total count column in Table 3 divided by the total area for the class.

The majority of answers for this worksheet are dependent on student results, but things to consider for several of the answers are addressed on the following pages.

Answers to selected questions on student worksheet:

18. How similar were the numbers between the sample and total counts for the whole class data? *Answers will vary, but generally the sample estimates of elephant numbers are higher than the total count.*

19. Is your individual sample count data or the class sample count data more similar to the actual count? Why do you think that is? *Answers will vary, but students might write about accuracy or sample size.*

20. When counting actual elephants across most of Africa, a total count could be less accurate than a sample count. Why do you think that could happen? *Answers will vary, but students might write about accuracy of the counting method or the fact that elephants move around, they can be spread out over long distances, they live in remote habitats, and they can be difficult to find.*

21. In the sample method, did any issues arise? If so, what did your group do to address the issues? *Answers will vary, but possible issues include the lentils clumping together, one transect was closer to the release of the lentils so it received more than the transect farthest away, and lentils on the line were counted by one person but not the other.*

22. What issues do you think researchers might encounter when sampling, and how would they address these issues? *Sampling methods have assumptions about how they are being implemented. For example, it is assumed that the lentils are randomly distributed, that there are no lentils migrating in or out of the population, etc. Scientists use a number of methods, and the assumptions have been identified for each method. If conditions exist that violate the assumptions, then the method isn't valid for that situation.*

24. How does this model represent how elephants are counted? *Answers will vary but may include that the distribution was not perfectly uniform; the lentils clumped together like elephants in herds do; the transects were defined like those in the film; students had to determine methodologies for standardization like when to count a lentil and when not to; and calculating the densities and estimating the total population was similar, although not exactly, like the film.*

25. How is this model not an accurate representation of what you saw in the film? *Answers will vary but may include that elephants have behaviors that can influence their distribution not reflected by lentils randomly moved about; researchers would rely on many more samples taken to offset the influence of outlying samples taken; more statistics are used to derive a more accurate estimate of population size; and the scale of the activity was off as the size of the lentils on the landscape does not reflect the size of elephants on the actual landscape.*

26. Discuss two modifications you could make to this model to better represent an elephant census across Africa. *Answers will vary and might offer some great insight into student understanding.*

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. You can contribute to this important research through WildCam Gorongosa, an online citizen science platform.

Measuring Biodiversity in Gorongosa
http://www.hhmi.org/biointeractive/measuring-biodiversity-gorongosa
In this activity, students will calculate species richness, evenness, and the Shannon diversity index for various habitat types using data from trail cameras in Gorongosa National Park.

Tracking Lion Recovery in Gorongosa National Park
http://www.hhmi.org/biointeractive/tracking-lion-recovery-gorongosa-national-park
See how scientists in Gorongosa National Park are using GPS satellite collars and motion-sensitive cameras to gather data about the recovery of the park's lion population.

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