ECOS
Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry Template

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2. NAME OF INQUIRY: Sampling Safari

3. GOALS AND OBJECTIVES:

a. Inquiry Questions: 1. How to biologists accurately count organisms?
2. How to estimate population size?

b. Ecological Theme(s): sampling design, population monitoring, population increase/decline, field biology in practice

c. General Goal: The goal of this exercise is teach students that sampling design can affect the accuracy of an estimate.

d. Specific Objectives:

Academic:

1) determine the sampling effort required for species distributed differently across the landscape
2) learn about technical terms such as sample and distribution
3) understand concept of scaling
4) introduce concept of randomization in science

Procedural/technical:

1) graphing skills – labeling axis, identifying points from own data
2) math – determine scaling factor and calculate population estimate
3) data recording

Social:

1) work in a team to collect data

e. Grade Level: This exercise is aimed at sophomores – seniors in high school, but could easily be scaled down to 5^{th}? Grade and up to lower level college courses

f. Duration/Time Required:

→ Prep time: outside the classroom includes acquiring animals and setting up the sampling grid. The grid can be painted on with field paint, which will take ~ 2 hours or made with string, ~3 hour

→ Implementing Exercise During Class: Introduction ~30min.
Activity ~1 hour
Review ~ 30min.

→ Assessment ~15 min

4. ECOLOGICAL AND SCIENCE CONTEXT:

a. Background (for Teachers): Teachers: Estimating population size can be done in a number of ways. Often, a full census is impractical due to lack of resources to count every organism and the inability to detect all organisms even when trying to count a majority of animals. Biologists design ways to sample a portion of the population to estimate what they are really interested in: population size.

One way is to determine the density of animals in a small area and extrapolate that to your area of interest. Important considerations in this include

1) **Sampling design**: sampling designs can be very diverse. The simplest sampling design is simple random sampling, which is where every item in the sample has an

equal probability of being included. When one wants to ensure the population is well covered by the sampling effort, stratified sampling can be implemented, where the sampling units are divided into non-overlapping strata and random samples are drawn from within the strata. Systematic sampling can be used when a population covers a well-defined area. The advantage of systematic sampling is it is often easier and can be more representative of a population, thereby giving a more precise estimate.

2) **Species distribution**: the way individuals are spread out across a landscape. For example, many species are found in clumps, such as herd animals like deer and elk. Other species are spread across the landscape in a random pattern, such as mountain lions or giraffes. Organisms are rarely uniformly distributed across landscape, such as common weeds. An organism's distribution will affect how you best sample. Clumped species will take more effort to sample effectively because you may count alot if you are in an area with a herd, or count none if you are not. Therefore you must count more areas to assess the real number on the landscape.
3) **Movement of organisms**: If organisms are able to move in and out of your sampling units while you are counting them it may cause you to over or under count them.
4) **Density**: If you are interested in the density of animals, it is important to define the area you are interested in before sampling. For example, you may be interested in the number of deer in western Montana or in Missoula County. One would design a sampling effort differently for each case based on the resources available.
5) **Resources available**: what is a realistic amount of effort that can be used in total, including hours of effort, gas, etc.
6) **Detectability**: some animals are easy or harder to count because they are hiding, etc.
7) **Time frame**: when estimating abundance or density, it is important that the population is considered "closed". A closed population does not have any births, deaths, immigration or emigration. So you have to be able to sample your areas in a time frame that will follow these assumptions, such as one week.
8) **Random**: the concept of randomness is important to reduce bias, if one picks random samples through the use of a random number generator or a similar method, one can reduce bias in their estimate
9) **Accuracy vs. precision review**: The goal is to get an accurate sample, which means it is as close to the true value as possible. A precise estimate is one that has little variation, that is, if you conducted the same sampling procedure ten times, you would get a similar result. However a precise result can still be very biased (or wrong).

b. Background (to present to Students): Students: Often, field ecologists are interested in knowing the number of individuals present in a certain area. However, it is usually not possible to count every individual
So we count animals in smaller areas and estimate the population size from there.

1) sample – define
2) introduce idea of counting smaller areas and scaling up
3) scaling – define
4) introduce species distributions, examples
5) accuracy – define
6) why important to know population size
7) why ecologists have to sample vs. census
8) how ecologists sample in similar ways to exercise (i.e. flights for ungulates)

5. MOTIVATION AND INCENTIVE FOR LEARNING:

The motivation for this lesson can be in the introduction when explaining to kids how we actually count animals. Great example in areas where hunting is popular is talking about ungulate counts and how that relates to hunting tags. In more urban areas, great examples are trends in migratory bird counts such as the Breeding bird survey. Lesson is held outdoors, so atmosphere is relaxed. Safari animals can lead into great stories of the African safari

6. VOCABULARY:

Simple random sample: a sample that is drawn from a population in such a way that all items are given the same chance of selection.

Sample with replacement: sampling in a manner that the same "unit" can be chosen repeatedly

Sample without replacement: sampling in a manner that the same "unit" can be chosen only once and then is taken out of the possible choices.

Subsample: individual unit of measurement that is obtained to form a sample. A sample can consist of numerous subsamples

Species distribution: the way individuals are spread out across a landscape. For example, some species are found in clumps, some species are randomly found in the landscape and some are uniformly distributed.

Accuracy: The measure of the correctness of data, as given by the difference between the measured value and the true or standard value.

Precision: the quality of being reproducible

Effort: in this case, number of subsamples taken per estimate

7. SAFETY INFORMATION:

8. MATERIALS LIST (including any handouts or transparency masters):

- 50 animals for even distribution (zebra, giraffe)
- 50 animals for clumped distribution (elephant, hippo)
- string or field paint to make a 10m x 10m grid
- meter tape for measuring grid
- pin flags helpful in marking out grid corners
- clipboards or other tools for outdoor data collection
- data sheets
- bucket/hat
- random numbers (squares of paper with numbers that correspond to grid cells; include figure)

Cost of materials: ~$40 for animals (could reduce cost on less expensive animals), field paint ~ $5, pin flags ~$5

9. METHODS/PROCEDURE FOR STUDENTS:

The goal of this activity is to demonstrate to students how to sample a small area and use the number of animals counted in the small area to estimate the number in the larger area. This idea is expanded upon by using animals with two different distributions, clumped and even (or random). We do this by designing a grid in the schoolyard and placing animals in the grid according to their distribution (clumped/even). We use the same number of animals in each case to demonstrate the difference in accuracy and precision for each distribution at different levels of sampling effort. This activity is conducted easily in any schoolyard area. Preparation for activity is setting up a 10 x 10 m grid and distributing animals in an even and clumped distribution.

A short classroom introduction that explains the background concepts to the students is helpful, see the attached handout for what can be covered introduction. This activity works best for students in groups of 2 –3, one student recording the data and one/two student (s) collecting the data (counting animals). This activity is designed to have students estimate population size with two different levels of effort five times each. The students repeat the estimate five times to see how precise the estimate is. The students begin by choosing random sample units from a hat. It is easy to label your grid 1-10 rows and A – J columns and have 100 pieces of paper in a hat labeled 1A – 10J. Each group will fill out the random number sheet (see attached) prior to collecting samples. If time is an issue, the teacher can save time by supplying the random numbers, but if time permits it is an important lesson to see what random means.

Then the students will go to the grid and count the number of animals in each subsampled unit and fill this in on the datasheet. First, they will use five subsamples to estimate population size. Next, they will use ten subsamples to estimate population size. Population size is estimated by summing the animals counted in all the subsamples and using the scaling factor to calculate population size. The scaling factor is based on the idea that the density of animals in the area of interest is stable. So you can use the number of animals you counted in a small area and scale it up to a larger area. Population estimates are obtained from samples by assuming the density of individuals in the sample is the same as in the entire landscape. That is:

$$\frac{N_{sample}}{A_{sample}} = \frac{N_{total}}{A_{total}}$$

N = number of individuals

A = area

So, N_{sample} is the number of animals you count in your sample, A_{sample} is the area covered by your sample, N_{total} is the population estimate and A_{total} is the total area occupied by the population of interest.

To estimate population size, you solve the equation for $N_{total} = N_{sample}(\frac{A_{total}}{A_{sample}})$

For example, let's say you are trying to estimate the population size of frogs in a 10m x 10m area ($100m^2$). You take subsamples from 5 1x1m quadrats (squares) and find a total of 10 frogs.

$N_{sample} = 10$

$A_{total} = 100\ m^2$

$A_{sample} = 5\ m^2$

Therefore N_{total} = 10 (100/5) = 10 (20) = 200, our population estimate = 200

$(\frac{A_{total}}{A_{sample}})$ is also referred to as the **scaling factor**, which in this case was 20.

This will be done for both levels of effort so students can compare both the accuracy and precision of estimates for two levels of effort with two different species' distribution.

The students will graph the results which will help with interpretation. The students can draw a line across the true population size (i.e. 50) and accuracy can be assessed by looking at how close the estimate is to true population size. Precision can be assessed by looking at how variable the 5 different estimates are (do the estimates bounce around alot or are they pretty similar?)

A good class discussion can include the students coming to the board and drawing the results on the board and comparing among groups.

A helpful task is to have students make predictions about which species distribution would take more effort to accurately count. Predictions should be that evenly distributed animals will take less effort to accurately estimate the population size

10. ASSESSMENT:

The students are asked to graph their results and interpret the graphs. This is a good exercise in transferring tabular data to a graphed format, understanding axes, and overall graph interpretation. Additional questions are:

This activity includes questions for the kids to take home and answer

1) Briefly summarize your findings. Examine your graphs for the two species comparing the two different sampling efforts. How are they different? Is there a point in which increasing the sampling area (number of subsamples) seems to make little difference in increasing accuracy. Does this point depend on the distribution of the species? (Adapted from Ecobeaker)

2) Pick a species that you are interested in and describe how you think it is distributed on the landscape. Describe the amount of sampling effort you would use to accurately estimate the population size.

Quiz/Test questions are a good follow up to this exercise to ensure the scaling factor is understood, as well as what high vs. low levels of variation implicate.

11. EXTENSION IDEAS:

Good ways to extend this exercise are to include other sampling designs

Such as stratification or cluster sampling and to consider other species distributions such as random. Other extensions could include an addition on species distributions and reality of even vs. clumped vs. random.

For more advanced classes, a great extension would be having the students present the graphed results in a presentation that expanded to include recommendations on sampling designs for a local species that was detailed in how the results from sampling safari would inform the specific sampling design.

12. SCALABILITY

This lesson can be scaled down by simplifying the lesson to counting one type of animal, not considering distribution. Focus on estimating numbers in a big area from a small area. This could be scaled up by incorporating more advanced topics in sampling design and having the students do more work with the scaling factor and design of own sampling scheme.

13. REFERENCES: Manly BFJ. 1992. The design and analysis of research studies. New York: Cambridge University Press.

14. LIST OF EXPERTS AND CONSULTANTS

15. EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT:

Overall, sampling safari was a very successful exercise. The introduction and conclusion discussions are a very important part of this exercise. Students need to have a clear picture of why they are outside counting animals in little squares to make it a meaningful exercise. This can be accomplished by a good introduction that has links to local population monitoring efforts and how they are conducted. A good review of the scaling factor, amount of effort, and variation is helpful in clarifying the exercise as well. Additional exercises involving the scaling factor and graph interpretation may be helpful in really bringing the points home.