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

ECOS Inquiry Template

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2. NAME OF INQUIRY: Scratching Your Head Over Itchy Weeds: A Population Activity

3. GOALS AND OBJECTIVES:
    a. Inquiry Questions: What is a population of knapweed/cheatgrass? How can we estimate population size of a plant population?
    b. Ecological Theme(s): population ecology, species interactions, and sampling
    c. General Goal: To provide a semi-guided inquiry that builds on a previous sampling activity and has the students think how to define a population in a real ecological situation.
    d. Specific Objectives:
        1) To teach students about how to define population boundaries
        2) To communicate the reasons for monitoring population size over time
        3) To build on sampling knowledge to determine the appropriate sampling design to estimate population size based on population characteristics
        4) To determine factors that affect population based on field observations.
    e. Grade Level: This activity is currently geared toward high school, and is most appropriate for high school to lower division college students
    f. Duration/Time Required:
        → Prep time: the only preparation involved is finding an appropriate area in your schoolyard that has two different species with different characteristics for comparison. Species that have very different spatial patterns visually, such as obvious clumps versus ubiquitous or rare, are the best ones to choose for a good comparison. This can even be grass, which is often ubiquitous vs. dandelions, which are often clumped.
        → Implementing Exercise During Class: a 15-minute introductory lecture is followed by 45 minutes outside. This could easily be shortened to 30 minutes outside. The students just need enough time to make observations necessary to answer the questions. It is helpful to talk with the students individually while they are making observations and ask them leading questions to direct them towards understanding how individuals in the population are interacting. For example, one of the main questions to ask is: what are the population boundaries? If the students have grouped things into many small populations in close proximity, then ask: if the individuals can reproduce with each other, are they in a separate population? For plants, this often requires thinking about how the seeds disperse and how pollination is done. If a bee pollinates a plant, then plants connected by bee pollination could be in the same population. Also, thinking about resources the plants are using, such as soil moisture and sunlight, are good areas to direct students to think about.

        → Assessment: The students are asked 11 questions in this activity, the first 8 are best answered outside while doing the activity and the next 3 can be answered at the end of class or as a take-home exercise

4. ECOLOGICAL AND SCIENCE CONTEXT:
    a. Background (for Teachers):

Background Information:

We began this exercise with a short introduction on the definition of a population. This can be a difficult concept because many people mean different things when they say the word population. Therefore, it is helpful to begin by defining the term in a general manner. We define a population as a group of organisms of the same species occupying a particular space at a particular time, with the potential to breed with each other.

We then introduced students to concepts relating to interactions among individuals within a population. Individuals may interact with each other directly through territorial and reproductive behaviors or indirectly through use of common resources or occupation of common habitat. The area within which individuals are interacting often defines spatial boundaries of populations. Spatial boundaries can be easily defined or may be vague. An example of a situation where it is easy to define boundaries is when you have island, or an isolated patch of habitat. Large areas of continuous habitat or areas that have been somewhat fragmented but well connected by corridors are much more difficult. In this case, biologists often assume arbitrary boundaries for investigations, which may be appropriate under many circumstances.

An important parameter in population biology is population size (i.e. abundance) or density (# individuals/unit). Biologists are often interested in how and why a population size may change over time. For instance, we are interested in know if a population growing, shrinking or staying the same size. Population changes over time can be expressed in a way that incorporates gains and losses:

$N(t+1) = N(t) + B(t) + I(t) – D(t) – E(t)$

$N(t+1)$: population size at time t plus time step (month, season, year)

$N(t)$: current population size

$B(t)$: births

$I(t)$: immigrants

$D(t)$: deaths

$E(t)$: emigrants

Birth, death, immigration and emigration are the four primary processes that affect populations.

Factors affecting populations *or* affecting the four primary processes can be classified as abiotic and biotic. Abiotic factors include the physical and characteristics of an organism's environment. For terrestrial organisms, these factors include: soil type, water availability, temperature, and fire frequency. For aquatic organisms, these factors include: water salinity, pH, currents, light penetration, and dissolved oxygen. Biotic factors include interactions among members of the same species (intraspecific) or interactions involving another species (interspecific). Examples of these factors include: predation, competition, parasitism, and disease. Biotic factors can be further classified as direct (behavioral interactions such as excluding other individuals from food resources) and indirect (depletion of common resources and occupation of common habitat). There is almost always interaction between biotic and abiotic factors which often influence more than one primary process at once

b. Background (to present to Students):
    1) population definitions
    2) spatial boundaries
    3) interactions: direct and indirect
    4) importance of population size: abundance vs. density, how biologists track trends
    5) factors influencing populations: abiotic vs. biotic (direct and indirect within these categories. Abiotic and biotic usually interacting with each other

5. MOTIVATION AND INCENTIVE FOR LEARNING: Students get to go outside and use field observations to synthesize and implement classroom knowledge

6. VOCABULARY:
Population: group of organisms of the same species occupying a particular space at a particular time, with the potential to breed with each other.

Spatial boundary: outer edge of population, often defined by a landscape characteristic such as a mountain range or river. Can be easily identified such as island boundaries, or vaguely identified by subtle changes in habitat type.

Abundance: number
Density: number per unit area
Immigration: individuals entering population
Emigration: individuals leaving population
Interaction: mutual or reciprocal action or influence
Direct interaction: when individuals have direct contact through reproductive or territorial behaviors
Indirect interaction: when individuals affect each other indirectly often behaviorally, such as use of common resources
Abiotic: physical and characteristics of an organism's environment
Biotic: interactions among members of the same species (intraspecific) or interactions involving another species (interspecific)

7. SAFETY INFORMATION: SAFETY CONCERNS ARE LIMITED TO ONES INHERENT TO AREA VISITING FOR OUTDOOR PORTION OF ACTIVITY (I.E. HOLES IN GROUND, ETC)

8. MATERIALS LIST :
handouts, including local area map (see attached sample)
clipboards for outdoor questions
we recommend the following paper on Yellowstone National Park to talk about interactions: Smith, D.W., Peterson, R.O. and Houston, D.B. 2003. Yellowstone after wolves. Bioscience 53(4): 330-340.

9. METHODS/PROCEDURE FOR STUDENTS:
a. Pre-investigation work: teachers need to identify area in schoolyard that has two species of plant with two different distribution; background lecture ~15minutes
b. Investigation work:
1) Students go to area of interest and use field observations to define the population of interest.
2) Students draw the population boundaries of each species on supplied area map
3) Students use field observations to determine biotic and abiotic factor influencing both populations
4) Students describe the distribution of species and use this information to determine a sampling scheme * (only relevant to classes with a background in sampling)
5) Students present evidence through short answer questions and drawing?
6) See sample data sheets

10. ASSESSMENT: Students answer 11 questions, the first 8 are best answered in the field and the final three are good classroom exercises or take-home exercises. It is important to conduct a wrap-up of the exercise reviewing the main points. The second section of the exercise is only relevant if there is a background in sampling

11. EXTENSION IDEAS: a great extension would be to take another class period and have the students actually design and implement a sampling design to estimate the population size. If several groups estimate the population size in the same area, then a graph could be made of the variance with different methods

12. SCALABILITY: this exercise could be scaled down to upper middle school by simplifying to just a population activity without talking about interactions and factors affecting populations. Scaled up by asking tougher questions about populations and sampling design.

13. REFERENCES: Williams BK, Nichols JD, Conroy MJ. 2002. Analysis and management of animal populations. San Diego, California: Academic Press. 817 p.

14. LIST OF EXPERTS AND CONSULTANTS:

15. EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT: This exercise went well overall, the questions could be re-phrased to be more clear. We could have spent more time developing the sampling schemes with the students out in the field. It was good to get the students outside and deciding in a real situation how to define population boundaries, however our map reflected the boundaries too well and could have provided a more "open-ended" way for the students to decide boundaries. Requires an interaction with each group while outside to encourage thinking in the right direction, so having 2-3 "teachers" in the field is helpful.

Field Lab Scratching Your Head Over Itchy Weeds Fall 2004

Name: Period:

Date:

In this activity we are interested in assessing the population size of two different plant species, knapweed (*Centaurea maculosa*) and cheatgrass (*Bromus tectorum*) at the DNRC field next to Big Sky. To do so, the first thing we need to do is determine what a population is for each type of plant.

1) What is a population in general?

The rest of these questions you will answer while we are at the DNRC field. Take a look at the field.

2) Describe a population of knapweed at DNRC. Is there one or more than one population?

3) Describe a population of cheatgrass at DNRC. Is there one or more than one population?

Usually we use a physical barrier like a river or a mountain divide to help us draw boundaries around a population. What boundaries could you use to help define populations of knapweed and cheatgrass in the DNRC field? Draw these boundaries in the box on the front of the next page, make sure you clearly label the boundaries.

4) How did you decide where the boundaries are?

5) What are three factors influencing populations of each species? Label each factor as either biotic or abiotic.

6) Name two ways the cheatgrass and knapweed plants within your population boundaries might be interacting with each other (keep in mind that now we are just talking about biotic factors).

7) For each of the biotic factors you just listed, say whether it is a direct interaction or an indirect interaction and why.

We would like to estimate the population size of knapweed and cheatgrass so we can determine if the population is changing over time. Remember from sampling safari that plants and animals can be distributed across the landscape in different ways. To figure out how to estimate the number of cheatgrass and knapweed plants, the first thing we need to think about is the distribution of each species. Then we can think about how much effort we need to use to get a good estimate of population size.

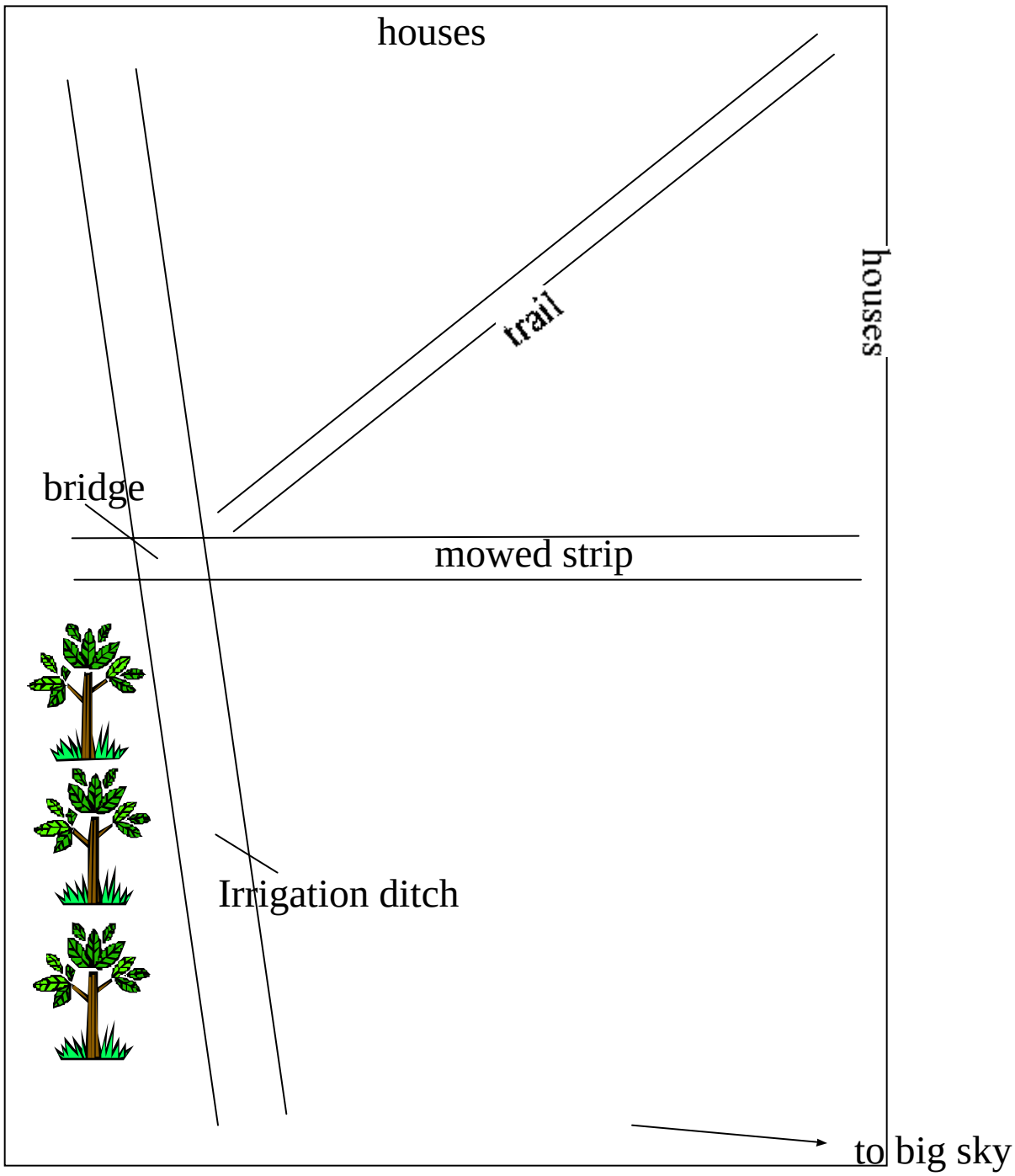
Draw the distribution of each species within the population boundaries in the box on the front of the next sheet. Use different symbols for each species and draw how each species is distributed.

8) What is the distribution of each species (clumped, random, or even)?

9) Based on their distribution, how would you sample each species (according to the kind of sampling we used in sampling safari)? Be specific, in your answer talk about how you would take subsamples in an organized way for each species and how much effort you would use for each species.

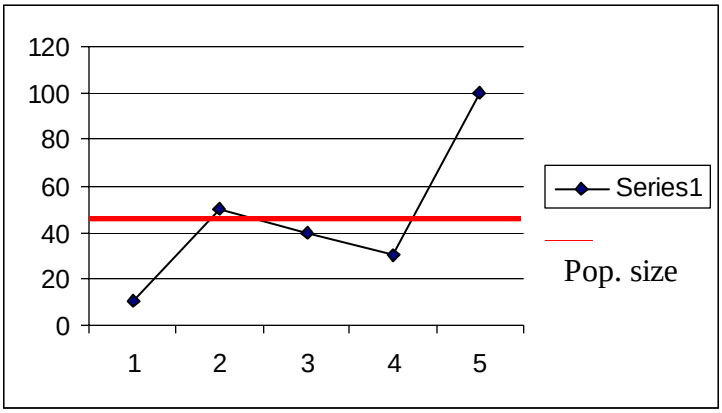
a. knapweed

b. cheatgrass

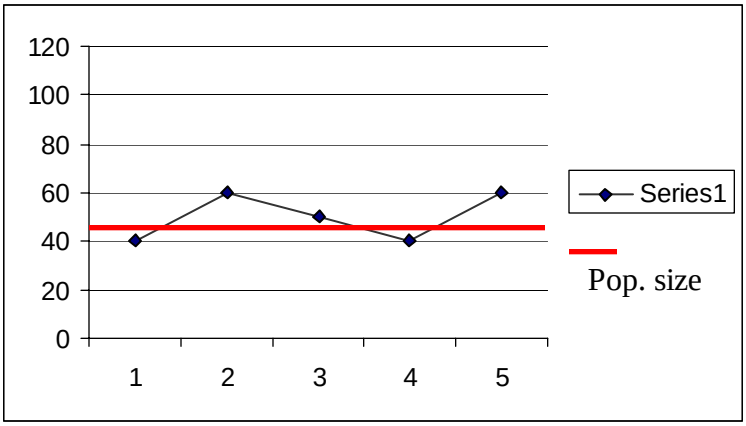

houses
trail
houses
bridge
mowed strip
Irrigation ditch
to big sky

10) When deciding how much effort we need to accurately estimate population size, our goal is to collect a certain number of subsamples and "scale up" to the correct population size. Remember in sampling safari we tested if 5 vs. 10 subsamples were enough to get an accurate population estimate. The graphs on this page are similar to the ones you made during sampling safari. On these graphs, each point on the graph represents the population estimate from 10 subsamples. If 10 subsamples is enough to accurately estimate the actual number of animals, what would the graph look like?

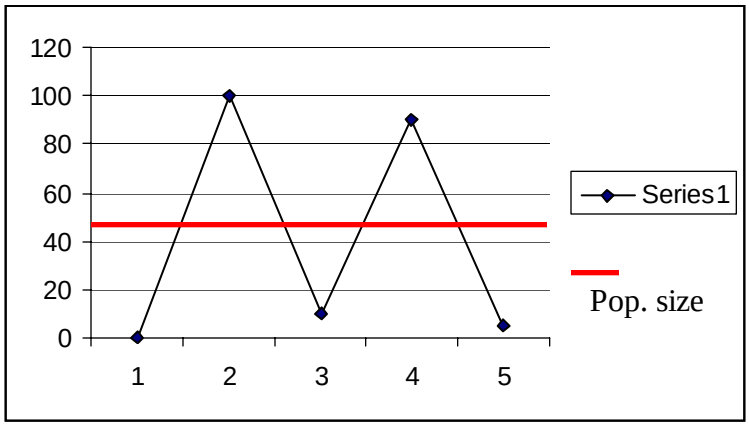
a



b



c



11) We know that we need to estimate population size accurately to be able to track populations over time. Give at least two reasons why we would want to track the population size of knapweed and cheatgrass over time.