POPULATION DENSITY LAB

Although density is usually an important population characteristic in ecological studies, it is often difficult to accurately measure. There have been many techniques designed for estimating population density, each with their own particular strengths and weaknesses. In this lab, we will examine two techniques for density estimation: "mark and recapture" and quadrat sampling. These are most appropriately used for mobile animal populations and sessile animal or plant populations, respectively.

EXERCISE 1: Mark and recapture techniques

In these techniques, a sample of organisms, usually mobile animals, is captured from the population whose density we wish to estimate and an identifying mark is applied to them. In practice, these marks can be of many types, including radio collars in large mammals, leg bands in birds, fin clipping in fish, etc. The marked animals are released back into the original population, and after a period of time a second sample is captured. The size of the population is related to the fraction of individuals in the second sample which carry marks. Slightly different mark-recapture techniques must be applied to populations that are open (meaning that individuals may migrate into and out of the population, be born, or die) or closed (where the population does not change size during the study period). In this example, we will examine the use of the Petersen technique, which is the simplest mark-recapture technique and is used to study closed populations.

In the Petersen method, the size of the population at the time of marking N is related to three variables:

$N = (CM)/ R$

where: M = number of individuals marked in the first sample
C = total number of individuals captured in the second sample
R = number of individuals in the second sample which are marked

To illustrate this, do the following:

Part 1

1. Grab several handfuls of beans (at least 200) and place then into a paper bag.
2. Mark 10 of the beans with a marker so that you can clearly identify them as being "marked". This is your initial marked sample, so M = 10.
3. Shake the bag and then withdraw 10 beans. This is your second sample, so C = 10.
4. Count the number of beans in the sample that are marked (R) and record your answer in Table 1. Replace your beans into the bag.
5. Estimate the size of your bean population (N) by dividing M x C by the number of marked beans in your sample.
6. Repeat steps 3 through 5 nine more times and average the population estimates you obtained in each trial to get an overall population size estimate.

Part 2

Repeat part 1 with the exception of taking 20 beans from the bag with each sample instead of 10. Thus, C for each pop. size estimate here will be 20 instead of 10.

Part 3
Repeat part 2 after taking 10 unmarked beans from the bag and adding marks to them. In this set of estimates, M = 20 and C = 20.

After you are finished, count the beans in your bag to determine the actual bean population size.

TABLE 1: Petersen mark-recapture estimates for bean "population"

	C = 10 M = 10		C = 20 M = 10		C = 20 M = 20	
Trial	# of marked beans in sample (R)	Population size estimate (= 100/R)	# of marked beans in sample (R)	Population size estimate (= 200/R)	# of marked beans in sample (R)	Population size estimate (= 400/R)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average estimated pop size	----------		----------		----------	

Questions:

1. How did your various average estimated population sizes compare to the actual size? Which combination of C and M gave you the best estimate? Which gave you the worst?

2. If you were trying to estimate the population density of a real species why might you have to sacrifice some accuracy in your estimation?

3. What do you have to assume to be true in order to believe your estimates of population size? What might happen in a real population of animals that would affect your results? (Give at least two assumptions)

EXERCISE 2: Quadrat techniques

For immobile animals or plants, our job of estimating density is made somewhat easier. Here, we could simply count up the number of organisms within our known study area and directly calculate the actual population density. In practice, however, it is usually impractical to count an entire population, so we usually do counts in a number of replicated small areas known as quadrats and use the average density in these quadrats as our estimated (but not necessarily "real") density.

In deciding how to sample our population, we must make a couple of choices. Specifically, we must decide:

1. the number of quadrats we will sample
2. the size of the quadrats used
3. where we will put the quadrats

Before proceeding, answer the following questions:

1. What would be the advantage of increasing the number of quadrats sampled? What would be the disadvantage or cost of increasing this number?

2. What would be the advantage of increasing the size of quadrats sampled? What would be the disadvantage or cost of increasing the size?

3. How should you arrange your quadrats? What would be the best method for determining where they should be placed?

After finishing the test, answer the following questions.

1. Besides the time actually spent counting the quadrats and monetary expenses, what other "costs" might be involved in ecological studies that these calculations don't take into account? How important would these be in designing a study?

2. What problems did you run into when using quadrats? Why might this method be a less than perfect way of estimating population density?

3. Would you expect the dispersion pattern you see in a population to change with quadrat size? Why or why not? Give an example of how the dispersion pattern seen in a population might change with scale.