Population Estimation Protocol

This is a useful way to estimate the size of a large population. Use if you believe there are more than 250 individuals present. If plants in the population are in separate areas surrounded by a large gap, you may repeat this protocol in each area to arrive at two or more estimates that can be added for the total. If the population stretches over tens of thousands of square meters and time is limited a visual estimation to the nearest 500 individuals may be preferable. The estimation protocol is broken into two levels, depending on time constraints, volunteer skill level, and survey objectives. Both levels are similar in that 1 meter x 1 meter quadrats are used to estimate the population size.

<u>Level one protocol</u>: simpler, less time consuming, but cannot be used for most statistical analysis.

<u>Level two protocol</u>: more involved. Intended for volunteers looking for a more rigorous way to detect change in a population through annual or semi-annual monitoring.

Level One

Sampling objective: Obtain estimates of the population size.

1. Flag the perimeter or outside edge of the plant population.

2. Measure the length and width of the plant population.

3. Meander through the population and periodically count all the plants in a 1 meter x 1 meter area. Use a 1m x 1m quadrat to be more accurate. The more quadrats that are sampled, the better the chances your estimate will reflect the true size of the population. For each quadrat, record separately the total number of seedlings, flowering individuals, fruiting individuals, vegetative individuals, and total number of individuals. Try to place your quadrat in areas that represent the plant population best. Avoid placing quadrats in only the densest portions of the population or only the sparsest. This will overestimate or underestimate the population, respectively.

4. Calculate the average number of seedlings, flowering, fruiting, vegetative, and total number of individuals per quadrat. Add up all the plants in each category you counted across all your quadrats and divide by the total number of quadrats. This is the average number of plants per meter squared.

5. Multiply the average number of seedlings calculated in step 4 by the total area of the population (length x width measured in step 2). Repeat for flowering, fruiting, and total number of individuals.

6. Record on your data sheet the estimates of seedlings, flowering, fruiting, vegetative, and total number of individuals.

Level Two

Sampling objective: Obtain estimates of the population size with 95% confidence intervals that are within 20% of the estimated true value.

1. Flag the perimeter or outside edge of the plant population.

2. Pilot sampling. Do some preliminary trials to determine the correct number of quadrats to sample from.

   2.1 Meander through the population, and sample a few 1 meter x 1 meter quadrats. Count all the plants in each quadrat and record them on a sheet of paper.

   2.2 Calculate the mean and standard deviation for these quadrats.

      2.2.1 The mean is the average number of plants per quadrat. Add up all the plants you counted across all your pilot quadrats and divide by the number of quadrats.

      2.2.2 The standard deviation is a measure of how much your counts varied across the pilot quadrats.

         1) Subtract the mean calculated in step 2.2.1 from the number of plants you counted in each quadrat during your pilot study. Then square this number. You should have one number for each quadrat in your pilot study. For example, if you counted 5 plants in quadrat 1 during your pilot study and the mean number of plants per quadrat was 10 plants, then $(10-5)^2=25$. Do this for each quadrat.

         2) Calculate the mean of all the squared differences you calculated in step 1.

         3) Take the square root of the mean calculated in step 2. This is the standard deviation.

   2.3 Use the following equation and the results from your pilot sampling to determine how many quadrats to sample during the final study:

$$n = \frac{(1.96)^2 (s)^2}{(B)^2}$$

   Where:
   n = The number of quadrats you should sample during your final study.
   s = The standard deviation.
   B = 0.2 x the sample mean. For example, if your sample mean = 10 plants/quadrat then B = (0.20 x 10) = 2

3. Determine where to locate your quadrats. Quadrats should be located randomly within the plant population.

   3.1. Measure the width of the population at its widest point.
   3.2. Measure the length of the population at its longest point.

   3.3. Whichever number is longer between 3.1 and 3.2 is your baseline. The shorter side is your sideline.

   3.4. Select a random number between 1 and however long your baseline is. For example, if the width of the population is 10 meters and the length is 20 meters, your baseline is 20 meters long. Select a random number between 1 and 20.

3.5. Select a random number between 1 and however long your sideline is. For example, if the width of the population is 10 meters and the length is 20 meters, you sideline is 10 meters long. Select a random number between 1 and 10.

3.6. Starting from one end of the baseline, walk to the number selected in step 3.4. Then walk perpendicular the baseline the distance selected in 3.5. Set your first quadrat here.

3.7. Count all the plants within the 1 meter by 1 meter quadrat. Tally separately flowering, fruiting, vegetative adult plants, and seedlings if they can be confidently identified.

3.8. Repeat steps 3.4 through 3.7 to set up the remaining quadrats.

4. Calculate the average number of plants per quadrat in each category (flowering, fruiting, vegetative adults, seedlings, and total) in the population.

4.1 Add the number of seedlings found in each quadrat and divide this sum by the total number of quadrats sampled. For example, if you counted 4 seedlings in quadrat 1, 10 in quadrat 2, 6 in quadrat 3, and 7 in quadrat 4. Then your mean is $(4+10+6+7)/4 = 6.75$. Repeat this for each category of plant counted, including total number of plants per quadrat.

5. Calculate the estimate of the total number of plants in the population in each category.

5.1. Multiply the average number of plants in each category (flowering, fruiting, vegetative adults, seedlings, and total) by the area occupied by the plant population. Round to the nearest whole number. Record the estimated number of plants in each category in the data collection form. For example, you calculated an average of 6.75 seedlings per 1m x 1m quadrat in step 6. The total area of the population is $200m^2$ based on measurements in steps 3.1 and 3.2 (10 x 20 =200). The estimate of the total number of seedlings in the population, therefore, is 1,350.

Example:

1. A pilot study of 4 quadrats showed the following results:
- Mean = 4 plants per quadrat
- Standard deviation = 1.2
- Using the equation for determining sample size from step 2.3 above, approximately 9 plots should be sampled.

2. Using a measuring tape, I see that the plant population measures 7 meters by 11 meters. Therefore, the baseline is 11 and the sideline is 7. Keep the measuring tape laid out to help with the next step.

3. A random number between 1 and 11 (i.e., the length of the baseline) is selected. It is 9. From the junction of the baseline and the sideline I walk along the baseline 9 meters.

4. A second random number between 1 and 7 (i.e., the length of the sideline) is selected. It is 3. From the 9th meter point on the baseline, I walk 3 meters perpendicular to the baseline (use a compass if necessary) and set up my 1m x 1m quadrat. I set up the quadrat with one corner at my foot, one corner closest to the start of the baseline and the other two corners toward the start of the sideline. In other words, the quadrat should be between the 8th and 9th meters on the baseline and the 2nd and 3rd meters on the sideline.

5. All the individuals of the target rare plant population are counted. I make separate tallies for seedlings, flowering individuals, fruiting individuals, and vegetative individuals.

6. After finishing counting all the individuals of the target species in quadrat 1, I head back to the junction of the baseline and the sideline and repeat steps 3-5 8 more times. Figure 1 shows the final location of all quadrats.

7. Results from sampling

- Quadrat 1: 1 seedling, 3 flowering individuals, 0 fruiting individuals, 0 vegetative individuals
- Quadrat 2: 0 seedling, 0 flowering individuals, 0 fruiting individuals, 0 vegetative individuals
- Quadrat 3: 0 seedling, 2 flowering individuals, 2 fruiting individuals, 0 vegetative individuals
- Quadrat 4: 3 seedling, 1 flowering individuals, 1 fruiting individuals, 1 vegetative individual
- Quadrat 5: 2 seedling, 3 flowering individuals, 1 fruiting individuals, 3 vegetative individuals
- Quadrat 6: 1 seedling, 1 flowering individuals, 0 fruiting individuals, 0 vegetative individuals
- Quadrat 7: 1 seedling, 3 flowering individuals, 1 fruiting individuals, 2 vegetative individuals
- Quadrat 8: 6 seedling, 6 flowering individuals, 0 fruiting individuals, 1 vegetative individual
- Quadrat 9: 2 seedling, 2 flowering individuals, 0 fruiting individuals, 2 vegetative individuals

8. Estimate of means

- Mean number of seedlings per quadrat = (1+0+0+3+2+1+1+6+2)/9 = 1.8
- Mean number of flowering individuals per quadrat = (3+0+2+1+3+1+3+6+2)/9 = 2.3
- Mean number of fruiting individuals per quadrat = (0+0+2+1+1+0+1+0+0)/9 = 0.6
- Mean number of vegetative individuals per quadrat = (0+0+0+1+3+0+2+1+2)/9 = 1
- Mean total number of individuals per quadrat = (4+0+4+6+9+2+7+13+6)/9=5.7

9. Estimate of population totals = (mean/quadrat) x total area:

- Total number of seedlings in population: 1.8 x 77 = 138.6 = 139
- Total number of flowering individuals in population: 2.3 x 77 = 177.1 = 177
- Total number of fruiting individuals in population: 0.6 x 77 = 46.2 = 46
- Total number of vegetative individuals in population: 1 x 77 = 77
- Total number of total individuals in population: 5.7 x 77 = 438.9 = 439

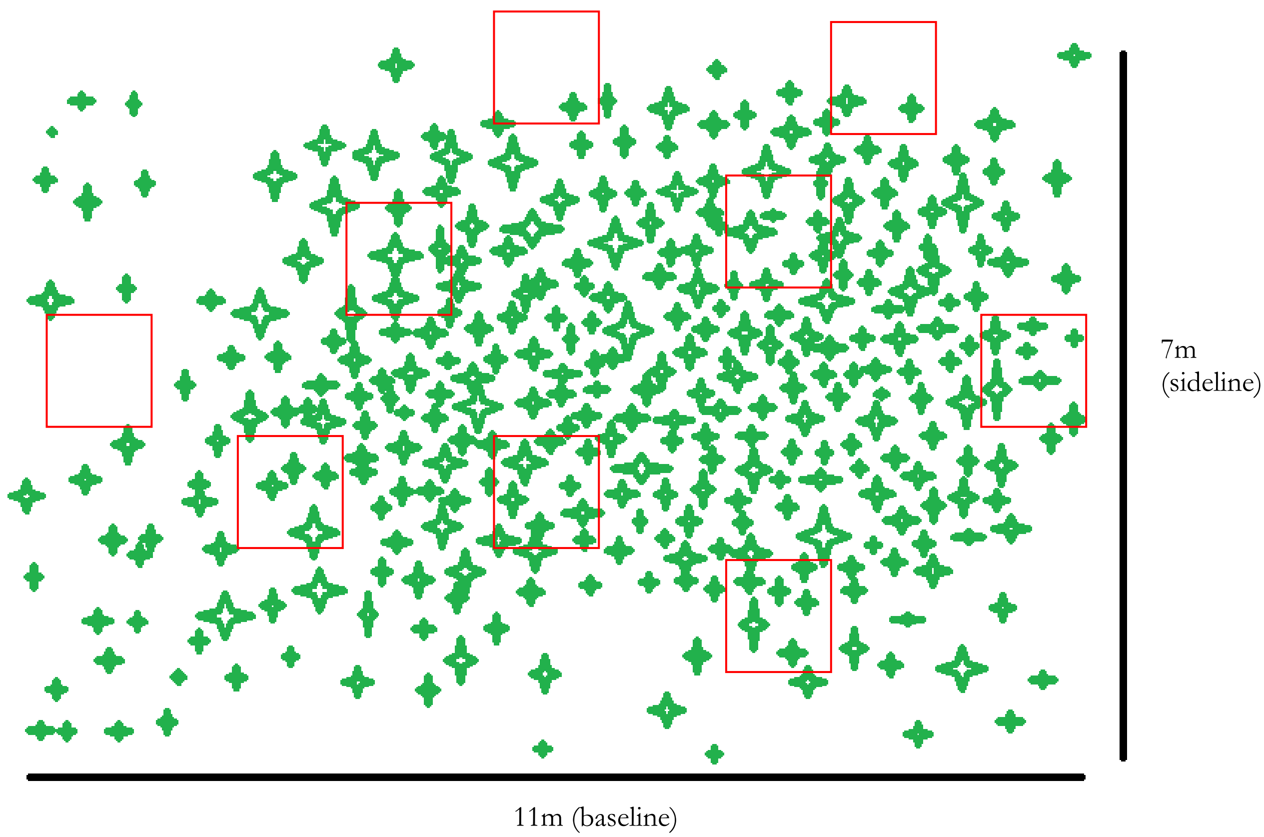

Figure 1. Layout of 1m x 1m quadrats. Each quadrat was randomly located, and all the seedlings, flowering, fruiting, and vegetative individuals of the target rare plant population were tallied separately.