NuMBerS
numerical methods for biosciences students

Introduction to functions and models: MARK-RELEASE-RECAPTURE METHOD FOR ESTIMATING POPULATION SIZE

1. Introduction

Mark-release-recapture is a technique for estimating the size of a population of mobile animals where it is likely to be impossible to count all individuals from a given piece of habitat. A number of animals are captured within a habitat, and are marked in a way that makes them easily recognized when they are encountered again. The marked animals are released into the same habitat, and it is assumed that they will mix back into the rest of the local population. The same habitat is then resampled, and the number of marked and unmarked animals caught in the second sampling is noted. The proportion of animals marked in the first sampling that is recaptured in the second sampling can then be used to calculate an estimate of the overall population size, if certain assumptions are satisfied.

2. The calculation

The initial batch of marked animals has a chance to mix with unmarked animals when they are released, and have the same chance of being recaptured during the second sampling as the unmarked animals. The second sampling yields marked and unmarked animals. The marked animals are assumed to be a random selection from the population, so that we can calculate a proportion, P_r, of the original marked animals that have been recaptured.

$$P_r = \frac{M_2}{M_1}$$

where M_1 and M_2 are the numbers of marked animals captured on the first and second samplings respectively. P_r is, in effect, an estimate of the probability that an animal will be recaptured.

If the marked animals released back into the habitat had mixed randomly with the rest of the population, then the total number captured on the second sampling should represent the same proportion of the total population as P_r. So

$$P_r = \frac{M_2}{M_1} = \frac{(U_2 + M_2)}{Pop_{total}}$$

where U_2 is the number of unmarked animals captured in the second sampling, so that the total number of animals captured in the second sampling is ($U_2 + M_2$).

It is easy to rearrange the equation to give the estimated total population, N:

$$N = \frac{(U_2 + M_2)}{P_r} = M_1 \frac{(U_2 + M_2)}{M_2}$$

3. Assumptions

In describing this method, we have already noted several assumptions. Most importantly, the marked and unmarked animals must have equal chances of being captured, and after capture the marked animals must intermix with the rest of the population. Strongly territorial animals might not be suitable candidates for this method if the sampling method made it more likely that marked animals would be recaptured than unmarked.

Further assumptions include a closed population (no immigration or emigration within the period of study) and a stable population (no births or deaths within the period of study). The marking applied to the animals must remain in place over the period of the experiment, and must not adversely affect the survival of the marked animals.

4. Example calculation

Mark-release-recapture is used to estimate the population of turtles in a small lake. In the first sampling, 23 turtles are captured and the backs of their shells are marked with paint. The turtles are released into the lake. In the second sampling, 28 turtles are captured, of which nine carry paint markings. Using the notation in Section 2:

$$M_1 = 23$$

$$M_2 = 9$$

$$U_2 + M_2 = 28$$

We can insert these values into the expression in Section 2, so that:

$$N = M_1 \frac{(U_2 + M_2)}{M_2} = \frac{23 \times 28}{9} \approx 72$$

5. Low rates of recapture

In addition to the assumptions set out in Section 3, the method is vulnerable to low rates of recapture of marked animals. Imagine that 100 animals are captured and marked before release. On the second sampling, a further 100 animals are captured, only one of which is marked. Using the equation above, this suggests a population size of 10 000. If two marked animals had been caught in the second sampling, this would halve the population estimate, whilst three animals would reduce the estimate to 3333. So if the rate of recapture is low, small variations in the number of marked animals in the second sampling will have a profound impact on the estimate of population size.