More Design Issues

The NOREMARK framework for estimation of population size under closure is very effective in many situations. Here, a number of animals is caught and uniquely marked (M) at occasion 1 (e.g., baited traps or drop nets). The cost of such initial capture and marking is typically high. Then resighting surveys are conducted, often using aircraft or ground vehicles (or boats?). These surveys are often less expensive and focus on getting either (1) just counts of marked and unmarked animals seen at each occasion, or (2) recording sighting of individual marked animals as well as the count of the unmarked animals seen at each occasion.

In the first case (above) the joint hypergeometric estimator can be used; this provides a likelihood basis for inference with all of the associated advantages. However, this method assumes homogeneity of initial capture and resightings (often this is a good approximation). In the second case, Bowden and Kufeld's estimator can be used. This allows heterogeneity in the resigning process, but requires additional data (the individual tagged animals seen at each occasion must be recorded). Their estimator is not based on a likelihood and thus several limitations are imposed (these are not severe and this is also a very useful method). Both methods require a “representative" sample of captured animals at occasion 1.

Three variables can affect the precision of the estimator of population size $\hat{N}$. In the case of the joint hypergeometric model, we can consider the number of resighting surveys (k), the number of animals initially tagged (M), and the probability of being resighted (p_i) on occasion i in designing an effective survey. First, consider the coefficient of variation (cv) as a handy measure of precision,

$$\text{cv} = \frac{\widehat{\text{se}}(\hat{N})}{\hat{N}} .$$

Another measures of precision is the expected confidence interval width. We will focus on the simple cv here. Then, one can see that the **cv *decreases***

(1) as k increases,

(2) as M increases, and

(3) as p_i increases.

Thus, an optimal survey would have a large number of animals initially captured and marked, a large number of resighting surveys and a very high resighting probability. Opps, at some point costs of these activities must enter into consideration. It turns out that **costs *increase***

(1) as k increases,

(2) as M increases, and

(3) as p_i increases!

This suggests some trade-offs must be considered in designing these C-R surveys.

Often, the cost of initial capture and marking is relatively expensive. Thus, this is an important design variable. Increasing k soon leads to diminishing returns and in some cases closure may begin to fail as k gets large. As in all C-R surveys, p_i is a big design factor; you would always like to have

p_i be as high as possible (note, however, there are diminishing returns as the effort to get $p_i \rightarrow 1$ becomes excessive). Program *NOREMARK* provides options to help explore the trade-offs between k, *M*, and p_i for a fixed level of precision. What might Babler have done to make his deer survey at the Air Force Academy more efficient?