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# Estimating Mobile, Rare and Clustered Population Size Using Two Stage Sampling When Capture Probabilities Vary Among Animals

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Abstract

In real-world situations, researchers would like to estimate a characteristic of a population by observing and collecting information from only a part of the population. In recent years, many studies have been done in nature in an attempt to estimate the population total or population density. In most of the studies the population area is divided into small plots of the same size and a random sample of these smaller plots is selected. The numbers of animals or plant species are counted on each selected plot.

There are many situations where the variable of interest tends to be at or near zero for many of the counts and distinctly different from zero for a few counts. Simple random sampling or cluster sampling techniques are not applicable since there is a chance that the selected sample might not have any unit having the particular characteristic. For example, some biologists want to estimate the total number of a rare species of trees in a forest, the total forest area could be partitioned into equal size plots and a random sample of plots might be selected to observe the existence of the rare trees. It is fairly likely that the selected sample may not carry that specific tree. In that scenario, the biologists might follow adaptive cluster sampling. This is where the initial simple random sample of square plots from a grid of plots will be selected. If a plant is found in one of these plots, then all the plots in its neighborhood are also sampled. If further plants are found on an adjacent plot, its neighborhood is also searched. Finally the researchers will end up with a group of plots each containing particular plants but surrounded by a boundary of empty plots for collecting information.

In many ecological or biological studies, investigators might be interested in estimating the total number of animals in a huge study area where the animals live in clusters by nature and are rare in terms of huge territory and moving together for finding food or getting shelters from extreme weather. For example, scientists might be interested in estimating the total number of Grant's zebra in savanna forest in Africa. Savanna in Africa is rolling grassland dotted with trees. The zebra lives in close-knit groups called families or harems. To estimate the total number of zebra population, we will apply two stage sampling technique.

The capture recapture technique has been widely used by field biologists to estimate the population size. They use it in single stage sampling, but if the study area is vast, like, savanna

forest, only following this method will provide the population size in a small selected area. To overcome this problem and obtain an estimate of the total animal population in the huge study area, we will consider adaptive cluster sampling in the first stage and in the second stage we will follow capture recapture sampling to obtain an estimate of the total of the population. In this proposed multistage sampling technique, the researchers must be familiar with the "hot spots" where the concentration of that particular species is high in an environmental population study. For this zebra example, the scientists might consider the habitat of that animal, such as, water reserves in savanna forest. Zebras drink at least once daily and during the dry season, the zebras dig to the table water level holes which are 50 cm (1.6 ft) deep, 1 m (3.3 ft) wide and through which water is filtered by sand. Water reserves might be one of the characteristics near which the investigators observe a high abundance of that animal population. After defining the characteristic, a simple random sample of *n* plots will be selected, if a selected plot satisfies the specified condition, neighboring units are added to the sample. This process is continued until a cluster of units is obtained that contains a boundary of units that do not satisfy that certain condition. The final sample then consists of *n* clusters, one for each unit selected in the initial sample.

Next the investigators will follow capture-recapture technique with unequal catchability to all units in a selected network to find the population abundance or the density. Most of the works are based on the assumption that all individuals have the same capture probability. But ecological studies show that equal-capture- probability assumption is not often valid. In this stage we consider unequal probabilities of captures. This method will be applied to all *n* clusters and finally the estimate of the total or the density of the population will be obtained. In this research work, the purpose is to present an appropriate estimate of the total of a mobile, clustered and rare population using two stage sampling considering variability of capture probabilities among animals.

We used Grant's zebra example to provide an essence of the problem we are going to solve; there are numerous examples in real world; estimating the total number of HIV patients in a large community, estimating the number of a particular STD patients; or in ecological study, marine biologists might be interested in the density of commercially important fish.