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Wildlife Census Methods: A Resume

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Abstract

Wildlife census problems and sampling schemes are discussed. Basic census methods are presented. Examples of inventory techniques utilized for various wildlife species are mentioned.

Introduction

This is a brief overview of census techniques considered useful for inventorying wildlife populations. It is presented primarily for persons without training in wildlife census methods or statistics. Discussions of methods will be brief. They are only meant to acquaint the reader with some basic techniques. I used the terminology of the excellent work by Overton and Davis.[18]

Wildlife Census Problems

Some of the problems inherent in wildlife census work are obvious. Generally we are dealing with animals that must be secretive to survive. Many live in thick undergrowth or at least make good use of vegetation for hiding their movements. During some seasons they are more active and more visible than at other seasons. The peak of their daily activity patterns may not correspond with ours. We are often dealing with species that are fossorial, nocturnal or crepuscular. Activity patterns that differ from ours and secretiveness tend to make them more difficult to census.

Typically they are distributed in a non-random manner because they favor some specific type of habitat which is not distributed in a random manner. Others exhibit a clumped distribution due to gregarious behavior. This type of distribution makes sampling more difficult than a systematic distribution.

Most wild animals are fairly mobile; which means that we must either conduct our inventories in a short period or in some manner account for movement into and out of the study area.

Obviously populations of wild animals are not static. Some animals have a very short life span and high rate of reproduction and these characteristics must be considered in the technique used.

With the above mentioned problems in mind, we can turn to the basic assumptions which must be satisfied in any census technique. First, all mortality and recruitment should be negligible or correction should be made for these effects. The survey is therefore conducted at a season when recruitment and mortality are minimal or over a short period of time so recruitment and mortality can be ignored.

The simplest solution is to conduct the inventory in a short period, but sometimes this is not possible. For example, in Tennessee there were only two periods when we were able to trap deer on the Catoosa Wildlife Management Area. Food

was plentiful and deer would not enter traps for corn, apples, or other bait; however, they were attracted to salt between early spring and mid-fall. We would not trap in late spring when does were heavy with fawns nor during the high temperatures of the summer when mortality would be high. Thus our trapping was limited to cooler periods in the fall and early spring. By censusing in these two periods we were able to use the Lincoln or Peterson Index method, one of the mark-recapture techniques I will describe later. We made allowance for mortality and recruitment, during the intervening summer period, by collecting data on herd productivity, fawn survival and mortality factors. With this data we could make corrections for the problem of mortality and recruitment.

Another basic assumption of inventory techniques is that all members of the population should have an equal probability of being included in the census. This means there should be no grouping or clumping by sex or age. Actually varying probabilities of capture or visibility are the common situation. Bailey[3] studied trap response in wild cottontails. Rabbits were most trappable at the age of 4-5 months and thereafter became less trappable. Sex, age and month accounted for about 20 percent of the variation in susceptibility to trapping. Sub-adult animals are typically easier to observe or capture. Behavioral traits sometimes make one sex easier to capture and certain individuals may be trap-happy. These differential probabilities must be considered and the appropriate correction made before using a model which assumes equal probability of sampling.

Sampling Schemes

If the population being studied dwells in an area too large for a complete inventory then sampling becomes necessary. There are several types of sample census. Basically they are censuses conducted on only a part of the space or time dimension of the population. The portion sampled is assumed to be representative of the total population and a statistical estimate of the entire population can be made from the sample.

Five basic sampling schemes are possible. Simple Random Sampling requires that the space or time component of the population be subdivided into equal units. Each subunit should have an equal probability of being selected for sampling. A table of random numbers, sampling dice or other means may be used to select the sample units.

Stratified Random Sampling requires some prior knowledge of the population so it will be possible to subdivide the study area into separate homogenous subpopulations. For example, one might know from previous experience that rats were extremely abundant in slum areas, moderately abundant in industrial areas, and low populations were present in the suburbs. With this meager information it is possible to define three strata or levels of rat populations within a city. Now we can take random subsamples of each strata, selecting our sampling units just as we did in the Simple Random Sampling Method. Stratified Random Sampling has the advantage of providing data on subdivisions of the population. It generally means greater precision for the entire population estimate. For a given degree of accuracy it requires less sampling than the Simple Random Sample Method.

Systematic sampling is simply a situation where sampling units are spaced at regular intervals. As an example, the study area might be marked off in grids and every fourth or fifth grid sampled. This method is appropriate where distribution of the population is homogenous.

Two-stage sampling is commonly used where very large populations are to be censused such as the statewide raccoon population. The Simple Random Sample Method could be used to determine which counties would be sampled. Within the

chosen counties a random sample would then be taken of a certain number of smaller land units. Two-stage sampling is basically a means of working down to a sampling unit of manageable size.

Double sampling is a modification of the Two-stage Method whereby on the county level one might count the number of raccoons seen along the road as roadkills. This extensive sample would then be strengthened by intensive sampling on smaller land units to determine what type of population density contributed to the associated count of roadkilled raccoon.

Basic Census Methods

Overton and Davis[18] recognize five categories of basic census methods.

Direct Count: The term direct refers to counting the animal itself rather than some related object such as tracks. This is the most obvious way to determine the number of individuals in a population. An attempt is made to count all individuals and this type of complete count is called a *census.* Two types of census are generally recognized: (1) spatial and (2) temporal censuses. By definition "A *spatial census* is one in which a count is made of all the animals in a *specified area* at a specified "point" in time."[18]

Included in the spatial census are drive counts and territory mapping methods. Territory mapping has been used for wild turkey, quail, song birds and ruffed grouse. In some cases this is the mapping of a true territory, which in the definition of behaviorists means a defended area. In other situations it involves mapping something intermediate between a home range and a territory. For example, among wild turkeys the individual flocks are distinguished by flock size, sex and age composition, special track or body-color characteristics. These separate flocks are plotted on maps in an attempt to avoid duplicate counting of some groups. The investigator makes use of his own observations as well as those of cooperators (persons working or living in the area of interest). Modern radio telemetry equipment has permitted considerable refinement in territorial mapping methods.

Drive counts have been used for deer, pheasants, and for prairie chicken on booming grounds. They are used to survey deer within enclosures and to sample habitat with well-defined boundaries. In states where road systems are laid out on the square mile this unit is used as the boundary of the area to be surveyed. This technique requires considerable manpower but inexperiencd groups such as scouts, prison labor, and school classes are normally used. Observers are stationed on three sides of the square mile and count all deer passing to their right between them and the next observer. Other observers line up on the fourth side of the square mile and walk through it driving the deer past the counters. The "drivers" count all deer which run back through the drive line.

"A *temporal* census is one in which the spatial dimension is a "point" and the count is made of all animals passing the point during some interval of time.[18] Examples of this type of census would be counts of migrating deer passing a given point, sandhill cranes leaving a roost or salmon moving up a fish ladder.

Another type of direct count is the Extermination or Total Capture Method. For big game it has rather restricted use and is expensive. It is a useful technique for censusing rodents in small areas. This method refers to censusing the trappable portion of the population.

Some direct counts are called "pseudo-sample" censuses. A pseudo-sample refers to census over portions of a study area for which the boundaries have not been delineated. The King Method for censusing grouse and the Hahn Method for deer are examples of this type of pseudo-sample. The acreage sampled has been determined in several ways. Using the Hahn census method the observer walks or rides a horse

along a transect line and records all the deer he sees.[7] The acreage surveyed is the area in which the observer feels deer would have been visible from the transect line. In the King Method the sample width is twice the distance from either the observer or a point on the transect line to the point where the grouse was flushed.

Roadside counts are commonly used census methods for rabbits, pheasants, turkey, deer and other species. They can be applied to a statewide population and normally are used only to detect population trends. These figures could be expanded to provide estimates of the entire population if the observer knew how the roadside populations related to the populations of the remainder of the habitat. Some states enlist the assistance of rural mail carriers to inventory their pheasants. These mailmen record all pheasants seen on their route during a particular season of year. This survey is repeated annually and provides information on trends that is useful for setting hunting seasons.

A study by Shaw[21] indicates the amount of effort necessary for a given accuracy. He used roadside counts to measure trends in the turkey population on a 500-square-mile study area. By driving 3,400 miles of survey each year he was able to detect changes of 25 percent in trend figures which were significant at the 90 percent confidence level.

Roadside counts are influenced by factors such as season, food supply, weather and condition of roadside cover. To minimize the influence of these variables the inventory is standardized so it will be comparable from year to year. The same routes are used each year, during the same time interval and at the same driving speed. Adjustments may be made for weather and other factors that would influence the count. Overton and Davis[18] refer to these corrections as "calibration." For example, if doves are likely to be seen three times as frequently during a wind velocity of 5 miles per hour than they are at a velocity of 15 miles per hour, then an appropriate correction could be made so census figures would be comparable from year to year. Frye's Strip Census for quail and Time-Area Counts for squirrel are other pseudo-sample censuses.

Methods Relying On Animal Signs and Related Objects: These are the methods most widely used by State Game Departments. They have varying utility. Some indicate only the presence or absence of a species. Methods relying on animal sign are normally used to indicate trends in the population but there are situations where they provide estimates of the total population.

Auditory indices, track counts, and pellet counts are examples of these methods. Auditory counts are used to survey birds that are highly vocal during courting behavior or that sing a territorial song. They are commonly used for woodcock, grouse, quail, dove, turkey and pheasant. Again there are many factors influencing these counts and they are standardized and calibrated.

Pellet counts are used to inventory deer, other hooved big game animals and rabbits. Considerable research has been conducted on pellet group counts for deer. Michigan[1] and other northern and western states now rely heavily on this census technique. The observer counts the number of pellet groups on stratified random sample areas. Generally the counts are made in winter or spring and only those pellets deposited since leaf fall are counted. The average date of leaf fall has previously been determined so it is possible to estimate the period during which the pellets were deposited. The average deer deposits about 13 pellet groups per day. From this information it is fairly easy to estimate the total herd size. This type of inventory is not suitable in the south because dung beetles remove the pellets.

Methods Involving Marked Animals: Variations of this approach can involve fairly complex mathematical modeling. These methods also fit into the category of pseudo-samples because the observer does not know initially what part of the study area he is sampling. There are many variations of these methods and the Petersen or Lincoln Index is probably the best known example.

Most of these methods involve trapping, marking and releasing a sample of the population and then some type of resampling. Information on mortality and movement can also be collected on the marked animals. One problem frequently encountered with this method is that of trap-happy animals that are captured repeatedly. Sometimes the multiple-capture individual is treated in the data as though he was taken only once. Another means of avoiding this problem is to use different sampling devices during the two sampling periods. For example, one might use an automatic tagging device for deer which utilizes snares set along deer runways and automatically places a colored collar on the deer's neck.[21] The second sampling method could involve recording obesrvations of the marked and unmarked deer or sampling during the regular hunting season. One census method actually capitalizes on the problem of animals which are recaptured repeatedly and uses frequency of recapture to estimate total population.

The Lincoln or Petersen Index method has been used for everything from mice and rabbits to elk. In this case the word "Index" is a misnomer because this technique provides estimates of the entire population. A brief example will serve to convey the general idea of this method. We are interested in the number of foxes residing in a 10,000-acre study area. Padded steel traps are used to capture 12 foxes which are ear clipped and the pelage is marked with Nyanzol black dye. Two weeks later we resample the population using a predator call and spotlight at night and calling foxes close enough to observe them for color marking. Fifteen foxes are observed in five evenings of calling and seven of these are marked. We assume that our first sample of 12 has the same relationship to the total population as our second sample of 7 marked animals had to the 15 in the total sample. We then solve for the unknown total population and the answer is 26. The Lincoln Index technique can be stratified to allow for different sampling probabilities in different sex and age groupings or in areas of varying population density.

Accuracy of the Lincoln estimate is dependent on the proportion of the population sampled. Strangaard[23] studied roe deer populations and concluded that trap-recapture procedures seldom provide acceptable population estimates unless 66 percent or more of the calculated population was handled. Mosby[16] studied gray squirrels and found that population estimates based on trap-recapture techniques were lower than the actual numbers known, from time-specific data, to be present. Mosby suggested that more than one-half of the squirrel population should probably be sampled to ensure an accurate inventory.

The Lincoln Index Method has been used to census rabbits in Michigan.[6] It was apparently not valid because tagged rabbits were more vulnerable to recovery by hunting than rabbits that were not tagged.

The Schnabel Method is a variation of the Lincoln Index. In this situation samples are taken on a series of occasions in the same manner one would use a Lincoln Index and on each occasion it is possible to calculate a Lincoln Index estimate. In each sample period all of the captured animals would be marked. The model permits an averaging of the estimates.

Methods Involving "Reduction" of Population Size & Rate of Capture: These methods are based on the principle that rate of capture or observation decreases as the population decreases. Several models have been used including the Graphical Solution, the Leslie Method and DeLury's Method. All of these methods assume that the only change in the population is due to those animals removed by trapping or some other removal method. Animals which are captured and marked need not be removed from the study area but if they are recaptured they are treated as if they did not exist. If the sample period is lengthy it is best to make some allowance for emigration, immigration, reproduction and mortality. These reduction methods also assume that the probability of capture remains constant throughout the study. This is probably the greatest weakness of these methods.

Probability of capture will often vary seasonally as well as among individuals. In some circumstances it may be possible to add correction factors for these problems. Traps with a fixed location throughout the study will make certain individuals more vulnerable to capture simply because the trap is close to their center of activity. Moving the traps several times during the sampling period will reduce this chance for error.

We used the Leslie Method to estimate the size of a deer herd within a 2,500-acre enclosure.[18] Over a nine year period 1,554 deer were removed from this enclosure for use in a deer stocking program. An average of one deer per 14.4 acres was removed annually from the study area. This methods involves plotting trapping success against cumulative removal and extrapolating to the number that will be removed when trapping success becomes zero. In this situation we underestimated herd size because we were unable to meet one of the conditions for use of this method: that the vulnerability of the population should not change during the census period. Salt was the only bait used for trapping and apparently the deer's physiological desire for salt increased in the spring and decreased in the fall. This problem could have been overcome by monitoring the intensity of use of open salt licks throughout the spring and fall. The Lincoln Index method was also used on this herd, and gave what seemed reasonable estimates considering the number of deer removed annually and the herd's ability to produce replacements.

The Method of Selective Reduction or Increase: Kelker[11] was the first to make use of this method and he used it to estimate deer herd size. It could be used with any species in which two or more sex and age groups are distinguishable. There are two sampling periods and an intervening period when the population decreases or increases by some known amount.

As a simplified example, suppose the pre-hunt buck-to-doe ratio was 100 bucks to 200 does. Checking station information indicated 350 bucks were harvested during the regular season. The post-hunt sex ratio was 75 bucks to 200 does. What was the total herd size prior to hunting? We know that for every 300 deer present prior to hunting, 25 were harvested. A total of 350 bucks were harvested, or 14 groups of 25. Forty-two hundred deer were present prior to the hunt (14 x 300).

Inventory Methods Used for Some Animal Groupings

I have mentioned some basic inventory techniques. Let's look briefly at some animal groupings and see what inventory techniques have been used for them.

Bats: Mist nets may be set up around a pond in a form of trap effort-success indice.[17] Visual estimates may be made as bats leave the cave entrance at dusk. Some colonies contain over a million bats and visual estimates become difficult. A more refined method has included systematic-timed photographs of the column of bats as they leave the caves and counting of individuals in the print.[10]

For roosting bats the entire surface area of the roost may be determined and portions of the surface photographed and individuals counted. The photographic method is suitable for bats that hang from the ceiling in a single layer. Some species of bats hang in clusters composed of several layers and for these it is necessary to take samples of the surface area with a net and actually count the number of bats involved. Constantine[4] used four inventory methods. He counted bat pellets in trays, estimated numbers of roosting bats, used recapture ratios and the number of bats trapped.

Carnivores: Wolves have been censused from aircraft[15]. Auditory counts of howling packs or individuals have been used to establish the presence of wolves or wolf packs. General observations, including locating dens, studying tracks and other signs, have been used to inventory foxes on small areas.[20]

Wood[26] used a scent post method to estimate relative numbers of foxes in the southeast. This type of inventory appears to be the most practical for detecting population densities conducive to rabies epizootics. Bounty records, fur harvest records and reports of rabid animals have been used as indices to trends or relative densities in foxes and other carnivores. The validity of these indices are questionable because factors other than the abundance of the organism may become predominant.

A variety of methods were used by Verts[23] to inventory skunks. Illinois and Iowa state policemen and rural mail carriers made statewide counts of striped skunks along the highway. These counts were made during a 24-hour period and were used as relative indices to abundance. Verts[25] measured population trends on 516 square miles using steel traps for a capture-effort index. He also used the Petersen Index on a smaller study area.

Miscellaneous Small Mammals: Workers in New Zealand determined an index of abundance for opossums based on catch per trap effort.[3] On smaller sample areas (Double Sampling) they determined the total population by trapping until the population was exterminated. They estimated absolute density of opossums by comparing the index of abundance with the same index on other areas where total population had been determined.

Live-trapping of small rodents like deer mice has been a suitable method for determining population levels. Live traps are placed at 50-foot intervals to saturate a study area. Trapping continues until nearly all the unmarked animals have been marked. The distances of their movements are determined and then divided by 2. This figure was used to determine the acreage which was sampled.[22]

Birds: Many of the techniques used by wildlife managers to survey birds have already been mentioned. Most of these provide information on relative abundance rather than a true census. Hickey[9] indicated ". . . the statistical design for many of these indices have rarely been described; and the reliability of most of the results remains to be determined."

Kendeigh[12] felt that territorial mapping was the most practical method of censusing the total breeding population of birds in a given area. The Bureau of Sport Fisheries and Wildlife currently coordinates the breeding bird survey of North America. Each one-degree block of longitude and latitude (about 70 by 55 miles) is sampled by one or more routes. Each route direction and starting point is permanently established and was originally selected at random. They are standarized with 50, three-minute stops, at one-half mile intervals. Birds heard and seen are counted. These routes provide an index to trends.

Deer: Because of the wide distribution and economic importance of deer, census techniques for them have received more attention than for any other game animal. Almost all survey techniques have been tried on deer. Some of those which have not been previously mentioned will be discussed now.

Aerial surveys have been used as a census approximating a total count in terrain of moderate relief in prairie areas[19] and coastal marshes.[14] Winter surveys and counting in early morning and late evening seem best. In New York state, aerial surveys were tested in deciduous forest habitat on a herd of known size within an enclosure. Surveys were made during the winter, generally with snow on the ground. In only three of the 13 surveys did the observer succeed in seeing as many as half of the deer known to be present.[8]

A recent addition to aerial survey techniques has been the development of infra-red scanning devices. Croon[5] used infra-red scanning devices from an airplane to census deer in the George Reserve enclosure in Michigan. By this method 98 deer were located as compared to 101 counted in a drive census. "Under the right conditions, infra-red scanning will probably give better results over large areas than any

other technique available at present. However, the inability of infra-red to penetrate green leafy canopy, variability of animal and background apparent temperatures depending upon weather and other factors, difficulty in distinguishing between species of animals, and high initial cost of the scanning device are substantial limitations to the use of this technique."

Cost of Inventory Work

It is difficult to say anything profound about the cost of wildlife inventory work. The general statements I am about to make seem self-evident. The greater the accuracy desired the more expensive the census. Those methods designed to show only population trends are less costly. Techniques providing good censuses with a 90 or 95 percent probability of accuracy are expensive. In some cases their cost makes them prohibitive for the research purpose in mind and the researcher is forced to use a less accurate and less expensive method. Associated with the cost of some of the more accurate methods is the great amount of time required for their execution. Investigators in disease ecology and epidemiology soon realize that population inventory can become a full-time research project by itself.

Choosing the Proper Census Technique

To choose the proper census technique requires considerable information. The project leader should read Chapters 21 and 22 of the Wildlife Management Techniques Book,[18] counsel with an experienced wildlife biologist and a biostatistician and jointly they can decide what inventory method would be most appropriate and what it will cost. The research goal will be of prime importance. Suppose we are studying incidence of rabies in skunks in a county with an endemic skunk rabies problem and in another county with a rabies epizootic underway. Will it be sufficient if we can say that county A has a skunk population density three times that in county B? Or do we need actual numbers of skunks per square mile? Other decisive factors also include behavioral traits of the species of interest, abundance of the subject animal, size of the study area, number of personnel and type of equipment available for the inventory, topography, seasonal work loads of project personnel, and a multitude of other factors. With this type of information it will then be possible to develop cost figures of alternative inventory techniques and make a choice of the appropriate technique(s). In some cases it will be desirable to try two inventory techniques, especially when pioneering census with a relatively unstudied species. Cross checks provide some reassurance that the researcher may be somewhere near the true number of animals present.

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