TECHNIQUES FOR ESTIMATING QUAIL POPULATION TRENDS

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Abstract: Quail managers need estimates of bobwhite populations, and their changes from place to place - or time to time - to support management decisions. For population surveys to be useful, the estimates they yield must be as reliable as possible. A reliable estimate is repeatable and has minimal bias. While some techniques for estimating bobwhite population trends have advanced in recent decades, other techniques (i.e., whistle counts) have been used for over 70 years. Bobwhites may be surveyed by whistle counts, several types of direct counts, mark-recapture techniques, and productivity ratios. Each technique has its own set of sampling considerations and potential for bias. The application of several of these procedures is reviewed with an emphasis implementing a monitoring system that provides reliable estimates of bobwhite population trends.

Reliable estimates of bobwhite abundance and productivity may be the best currency for judging the ultimate success of your management program. However, almost all population survey techniques remain biased (i.e., they do not represent an accurate accounting of the true population), and choosing the right survey technique for your needs requires some knowledge of what you are actually measuring.

The ideal set of population information for making bobwhite management decisions is well-summarized by Rosene (1969):

> The fact that quail live short lives is important to know, but this is only part of the picture. One needs to find out what is continually taking place in a population of bobwhites on a given area and for this, annual records on the following are necessary: total population in the fall and spring, broken down by sexes and ages, loss due to hunting, hatching dates in summer, and whistling cock numbers at their summer peak. Each year these records can be compared with those of the preceding year and changes in population can be related to weather, drainage, predators, and management of the environment.

Rosene challenges serious quail managers with quite a difficult task. Thirty years have passed since he published these words in his classic, The Bobwhite Quail: Its Life and Management. Even 40 years prior to that, many of these same data needs were considered by Herbert Stoddard in his 1931 landmark, The Bobwhite Quail: Its Habits, Preservation and Increase. By now, given our efforts at research and management, you would think we might have developed methods for easily and accurately monitoring all of these bobwhite population parameters. Even though we have made suitable progress in sampling theory, statistical analyses, and the development and refinement of survey procedures, quail managers still struggle with acquiring reliable basic population information.

In this paper, I will not provide any easy solutions to these challenges - but will attempt to provide some guidance for bobwhite managers to gain the most possible information at the least possible expense. I will review some practical uses of several methods for gaining an estimate of population trends. Other papers presented at this Symposium will consider population dynamics (F. Guthery) and the interpretation of harvest records (W. Cohen). Those topics complement this work, as estimates of population trends are necessary for making practical use of your knowledge of population dynamics, and harvest records are often used to monitor population trends.

Concepts and Terminology

As a point of review, we need to clarify concepts and terms. The following are based on White et al. (1982), but I specifically consider them here within the context of managing bobwhites - these are our operational definitions.

* A population is a collection of individual bobwhites that occupy a defined area at a certain time.

* Abundance refers to the number of individual bobwhites in a population. This is also referred to as population size.

* Population density is the number of individual

bobwhites per unit area, for example, 0.8 birds per acre (or the equivalent, 1 bird per 1.25 acres). Estimates of population density require reliable estimates of both population size and the land area that the population effectively occupies. As a result, population density estimates can be difficult to obtain.

* Relative abundance and relative density are rankings of bobwhite populations according to their size or density, respectively.

* A population index is a statistic used to rank bobwhite populations according to their size. An index does not result in a direct estimate of bobwhite numbers or population density - but it is related - thus, it is a measure of relative abundance or relative density. As bobwhite density increases over time, a reliable index of relative abundance should increase. Likewise, when comparing bobwhite populations on different areas at the same time, the area with the higher density would have a higher index of relative density. Ideally, a change in a relative density index would be proportional to the difference in population (for example, area A has a relative density estimate 40% higher than that on area B, so the difference in absolute density is assumed 40%). This, however, is not always the case (e.g., see Whistle Counts).

* A bobwhite population trend is simply the pattern of change in abundance or density among several time periods or land areas. In the short term (i.e., over successive seasons), a population trend can indicate changes due to productivity or survival - or even movements in or out of the area of interest (immigration and emmigration). In the long term (over successive years), a population trend can indicate population increase/decrease or even a fluctuating cycle. A population trend can be estimated with careful application of survey methods designed to gain estimates of absolute population density, indexes of relative density, or productivity.

Survey Methods

Over time, managers and researchers have grappled with the development of practical, accurate, repeatable and reliable survey methods for determining bobwhite populations. Despite over 70 years of development, there is no one method that serves all needs. To reliably determine population trends, you should consider use of several methods, in combination with accurate harvest records and applied common sense. If the results of one properly performed method contradict those of another, you should probably continue to consistently apply both methods, always bearing in mind that your ultimate goal is to generate information to support your habitat management and harvest decisions.

Whistle counts

> *The number of persistently whistling cock quail in early summer furnishes a key to the breeding population where the sex ratio is known, since such calling is largely from the unmated, or surplus, cocks.* - H. L. Stoddard (1931)

Indeed, bobwhite populations in the fall may be related to the numbers of males that give breeding calls during late spring. Call-count surveys (whistle counts) of males giving calls during the peak of the breeding season may also be useful in making judgments about the relative quality of habitats in different areas (e.g., Reid et al. 1977). Over time, and in different parts of the bobwhite's range, workers have adopted variations in the method (for examples see Rosene 1969, Reid et al. 1977, and Guthery 1986). The design considerations and procedures presented below are adapted from those cited sources. The most important part of the process, however, is consistency.

* Whistle counts are usually conducted during the spring and early summer (March to July). In most parts of Texas, the peak calling period is likely to be during May or June - and this is the best time to conduct your surveys.

* The normal routine includes establishing permanent listening stations spaced at 1/2 to 1 mile intervals along a quiet road running through the area of interest. For a practical matter, the smaller the area the closer the listening stations will need to be. Because most observers can hear a bob-white whistle for a distance of up to 1/4 mile, it is important you avoid duplicate counts by spacing listening stations at least 1/2 mile apart. This means that each survey station could cover approximately 125 acres - but this will vary with terrain and vegetation.

* You should establish between 10 and 20 listening stations per survey route, upon constraints of property size and

You should prearrange survey stations to maximize the amount of your area of interest that is audible, but without overlap. On larger ranches, you may chose to subdivide the area into management units of 3,000-5,000 acres, each with a stand-alone survey.

* Begin whistle count surveys at the same time relative to sunrise each time you survey. Begin your survey route sometime between 1/2 hour prior to sunrise and sunrise. Complete your survey route no later than 2 hours after sunrise. Suspend surveys during rain and winds > 5 mph.

* At each survey station, count the numbers of males calling "bob-white" during a 3 to 5 minute period, but always use the same time period. Note that this is the number of different calling males, not the number of calls heard.

* Each time you conduct surveys, do so on two consecutive days, reversing the order of the route on the second day. The data for these two days should be combined to calculate the overall average number of calling males per station per day.

* Conduct your 2-day surveys 2-3 times per month during May and June, maintaining as consistent a schedule as is possible among years. The highest overall average among these survey periods during any one year is the calling peak and may be used for comparison purposes among years. You may also compare the relative changes in calling males among your stations over time to gain insight into longterm changes in habitat quality among sites.

Whistle count survey results do not actually estimate abundance, but they may be correlated with abundance. Some biologist's observations suggest that it is usually unmated males that do most of this calling. During spring, areas with greater numbers of bobwhites are likely to have more unmated males in the population - therefore, more males are likely to give breeding calls. Likewise, relative densities during the following fall are likely to be highest on those areas with the highest numbers of breeding calls in the previous spring.

Whistle counts probably do not vary at a constant proportion with abundance. Just because you have twice the number of calling males in one area versus another, for example, does not necessarily mean that there are twice as many birds. Because of this shortcoming, whistle counts are not the best information for making harvest decisions - but they may be reliable for ranking habitat quality.

Direct Counts

Complete Counts. - One appealing method of attempting to determine bobwhite populations is to simply conduct a complete count. This method has several variations, at times involving the use of dogs, and various estimating procedures involving covey mapping and calculating average covey size. In general, the method includes the use of several workers traversing an area walking abreast at a predetermined interval. As coveys are flushed by the workers, individuals are counted - with some systematic method to avoid duplicate counts and assign count values to coveys of unknown size. The method assumes that all coveys and individuals in the area traversed are flushed and counted.

At best, "complete counts" are an accounting of the minimum population. Dimmick et al. (1982) found that a direct drive-count method using 5-10 observers spaced at 66 ft intervals failed to account for about 1/2 of the bobwhite population as estimated by a more rigorous capture-recapture method. Roseberry and Klimstra (1984), while using a 24-30 ft spacing interval between workers in Illinois, believed they underestimated their population densities by only 10-15%. Thus, the proportion of the population that is detected by these methods varies somewhat according to the spacing interval of the workers. This increased accuracy, however, comes at cost. Dimmick et al. (1982) reported that the method took a crew of 6-10 approximately 8-12 hours to traverse study areas slightly greater than 500 acres - about 1/2 of the time/work investment using the more intensive methods of Roseberry and Klimstra (1984).

Drive counts. - In his practical guide for quail management in cattle country, Guthery (1986) describes a "drive count" that can also be used as a sampling method:

With drive counts, a crew walks abreast and records the number of birds flushed. Space members of the crew at 60-foot intervals. Each counter, except those on the ends, records the number of birds that pass to his right up to the next member of the drive line. The left-end member counts birds that pass to his left and right; the right-end member counts birds that leave the counting area to the right without passing through the drive line. End members do not count

birds that flush outside the area being counted, i.e., those that flush to the left of the left end or to the right of the right end. The drive crew must maintain even spacing and stay in line from right to left while counting.

Guthery suggests performing this drive count during the 3 hour period following sunrise or prior to sunset, in strips covering 15-25% of the area. You may estimate in the field the actual area covered; or, if you have adequate mapping materials available you may calculate area covered more accurately. You then estimate quail density by dividing the total number of birds counted by the area covered (acres). If the areas surveyed are representative of the entire area of interest (i.e., the ranch), you may also divide the total numbers of birds counted by the proportion of the area surveyed to estimate absolute population size for the ranch - keeping in mind that this is likely a minimum estimate. As an example, suppose you count 13 coveys totaling 141 birds in a survey of 363 acres across a 2186 acre ranch. Your density estimate is 141/363 = 0.39 quail per acre (about 1 bird per 2 1/2 acres); proportion surveyed is 363/2186 = 0.166; and your estimated population size is 141/0.166 = 849 birds.

Line Transects. - Line transect sampling methods are similar to direct count methods in that birds (or coveys) are flushed and counted, but only along a single line. A characteristic that distinguishes the two methods, is that line transects do not make the assumption of a complete count within any specified area. In other words the probability of flushing a covey decreases with increasing distance from a sampling line (Burnham et al. 1980). The method requires measurements of the perpendicular distances of each covey flushe from the line of travel. The perpendicular measurements are ultimately used to determine the likelihood of detecting a covey flush as a function of the distance away from the transect line. A computer program TRANSECT, developed by Laake et al. (1979), can compute these distance functions and aid in the analysis of line transect data. The exact calculations and fitting of curves are somewhat involved.

Using the line transect method, Ratti et al. (1983) estimated density of gray partridges in South Dakota. However, the lack of the method's published use for bobwhites suggests that it may have limited use as a pure density estimator (for bobwhites). This probably results from the rigid assumptions that must be met for reliable density estimates. These are (from Burnham et al. 1980): (1) all coveys on the line will be observed, (2) coveys are fixed in their initial position and none is counted twice, (3) measurements are exact, (4) observations are independent events, and (5) the probability of detecting a covey is independent of covey size. In any one situation, one or more of these assumptions are likely to be violated.

The above does not mean that the line transect method is without some use for gaining valuable information for determining bobwhite population trends. If line transects are permanently marked and repeatedly sampled, they may provide managers with a suitable index of relative changes in bobwhite abundance over time. If line transects are thoughtfully established across a management area in a representative set of habitats, the resulting count data can be compared among habitats and between seasons and years to index the change in bobwhite numbers.

Your objective in conducting line transects should be to gain a reliable index of relative abundance as it changes through time - from season to season and year to year - as well as a comparison across space - for example, from one pasture to another. Guthery (1986) suggests a practical procedure for gaining line transect (i.e., "walking counts") data useful for these purposes:

* Per square mile of habitat (640 acres), establish four(4) 1-mile straight-line transects.

* A worker walks a line during the first 3 hours of daylight, recording all bobwhites flushed - including only those birds actually flushed by the observer (e.g., exclude sightings of birds flushed by cattle or other disturbance).

* Each line should be sampled 3-5 times (but the same for each line).

Guthery (1986:144) also suggests a set of habitat specific factors that might be useful for gaining a rough estimate of density depending upon habitat structure. Using these may be particularly useful for adjusting counts for comparisons of line transect data collected from portions of a ranch with different habitat structures.

Covey Call Counts. - By counting and mapping the numbers of coveys calling early in the morning prior to leaving their roosts, it is possible to gain an estimate of density or abundance. Guthery (1986:138-139) describes a procedure for recording covey calls from established listening posts for 20 minutes during the 45 minutes following sunrise.

Using this method, one listening post is used per 2000 acres of habitat. The audible area is assumed to be 500 acres. The average covey size is separately determined by flush counts following the survey. The number of coveys recorded per listening post is then multiplied by the average covey size resulting in the estimated number of birds per 500 acres, and then converted to a density estimate (birds/acre). This method can be highly biased by variations in the actual listening radius and individual covey behavior. Guthery (1986:138-139) supplies several guidelines for improving the reliability of covey call counts.

When to Survey. - For comparison purposes, you should consider conducting direct counts (complete counts, drive counts, and line transects) during approximately the same times each year, maintaining consistency among years. For example, determining relative abundance during the fall (immediately prior to hunting season), and during the early spring (prior to breeding) provides an estimate of the proportion of the fall population surviving into the next breeding season. Covey call counts should also be accomplished during the same times each year - but only during the season in which birds are actually in coveys (e.g., September through February).

Mark-Recapture Methods

Abundance estimates are also possible by capturing, marking, and then recapturing bobwhites. These mark-recapture methods rely on the ratio of marked (usually banded) to unmarked birds in the recaptured population to calculate an estimate of abundance. Mark-recapture methods require substantial expense and labor in trapping and marking a subset of the population. Because of some limiting constraints of the method, it is used primarily for intensive research studies where the recapture methods are controlled. After initial marking, birds are "recaptured" either by re-trapping or by harvest. The proper application of the method assumes a "closed" population in between these events. In other words, no new individuals can enter the population through ingress or production and no individuals can leave the population through egress or death. Also, the calculations for determining population size can vary if there are differences in individual capture probabilities due to behavior, or time, or sex and age. For a practical matter, Mark-recapture methods are rarely appropriate for operational monitoring outside of research. For detailed information on the methods and constraints of these methods, see White et al. (1982).

Productivity Ratios

Under almost any set of management objective for bobwhites, the incremental increase to the population due to breeding productivity becomes an important indicator of management success and the influence of other environmental factors. Thus, annual records of the numbers of new birds in the fall and winter population (juveniles) compared to the numbers of adults (the previous breeding population) become an important measure of the combined influence of habitat quality and other environmental factors (e.g., weather and predation) since the previous hunting season.

Given an adequate sample size from the hunting bag, you can use a ratio of juveniles per adult to provide an index of this breeding production. Over a 15-year period in the rolling plains of north Texas, Jackson (1969) found an average of about 3.8 juveniles per adult in the annual harvest. This is slightly higher than the ratio of 2.6 juveniles per adult found over a 5-year period by Gore (1970) in north-central Texas. Rarely is this average realized in any one year given the boom-and-bust that quail populations experience throughout much of Texas. Kiel (1976), for example found juvenile to adult ratios to vary from 0.6 to 7.0 over a 6-year period in south Texas (average = 3.7). The ratios in Kiel's work were highly correlated with early summer rainfall - a limiting factor in that portion of the bird's range.

The fact that this productivity index is highly correlated with a known limiting environmental factor suggests that that ratio is useful as a yardstick for monitoring population trends. Furthermore, the required data are easily acquired by simply collecting wings from birds harvested during the hunting season. The characteristics distinguishing adult from juvenile birds are easy to identify by inspecting the upper primary coverts (these are the small feathers above the primary flight feathers). Juvenile bobwhites have a buff-colored tip on these coverts, while the coverts of adult bobwhites are uniformly gray (for aging methods see Koerth et al. 1991). By collecting wings and keeping records of the numbers of juveniles versus the numbers of adults, you can document changes in productivity over time. Further details for interpreting harvest records are presented elsewhere in these proceedings (W. Cohen, Interpreting Harvest Records).

Designing a Monitoring System

Using survey data from the methods described

above can provide you with insight into the effectiveness of your quail management program. However, few methods will stand alone in providing you with reliable information. Likewise, these methods will provide you little information if not repeated annually and/or seasonally with consistency in your procedures. In fact, within reason, you may modify any of the methods described here to meet your particular situation provided you pay close attention to repeating the procedures under fairly uniform circumstances. Always keep in mind that you are not as much interested in any one result of a method as you are in the relative changes in your results over time, and sometimes space. The following guidelines may help:

Use more than one method of monitoring population trends. - For example, whistle counts, combined with line transects and productivity ratios will provide three indexes of population trends. You can then compare the conclusions of one method to another to verify trends. For example, if results from line transect data suggest lower population when compared to the previous year, the results of productivity ratios might confirm that trend with corresponding lower ratios.

Divide your area into management units. - If monitoring population trends across a relatively large ranch, you may be able to take a more "surgical approach" to your management and monitoring efforts by dividing the area into 500+ acre management units (or, alternatively, the minimum area required for obtaining an estimate with your selected procedure). Your population monitoring can be implemented independently on each management unit. Ideally, these management units should be divided along ecological or operational boundaries.

Maintain permanent markers along all survey routes. - Even with good maps, the exact survey stations for whistle counts, and the strips and transects surveyed for direct counts can become overgrown and lost. Steel stakes with permanent labels are a good investment for avoiding loss of your survey areas. Also, annual photos at these spots can help visually document changes in habitats over time, adding relevance to your population trend results.

Maintain detailed records. - Annual summaries of your survey efforts provide you with immediately useful information. However, you should also retain the detailed records of individual survey efforts, accompanying these with information on precipitation patterns, livestock grazing, and habitat manipulations. The most valued information from population monitoring is often the careful detective work that occurs after several years of these management records.

Be consistent. - Although you should not be afraid to experiment with different survey techniques, you should consistently use one or more techniques. Even though any one technique may be biased, any technique when used with consistency should provide at least a relative index of population change.

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