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A COMPARISON OF SOME DEER CENSUS METHODS IN TENNESSEE

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ABSTRACT

Five deer census methods are compared on the Central Peninsula deer herd in Eastern Tennessee. This insular herd is intensively managed and has several characteristics which make it worthy of population analysis. All census methods indicated similar population trends and differed only in magnitude. The Lincoln Index and Percent Kill Methods provided the most reliable estimates. The latter is the easiest to calculate,

The Sex-age Kill Method will apparently give good herd estimates, if the percent of non-hunting losses can be approximated and allowance made for other problems. It shows promise of greater accuracy when existing biases and unknowns can be omitted. For the present time the Percent Kill Method seems to be the most practical for use on the typical management area in Tennessee.

Identification of accurate and practical deer census methods continues to challenge herd managers in most of North America. A study of a confined deer herd, of known population, has not yet been possible in Tennessee. However, we have one deer herd with characteristics which make it worthy of population analysis. This herd is located in eastern Tennessee on the Central Peninsula Wildlife Management Area.

This area is a 24,831-acre peninsula located between the Clinch and Powell Rivers in the upper portion of Norris Lake. It has been in public ownership since 1934. In 1937 eleven whitetail deer were stocked there. Deer hunting began in 1950 and has always been closely regulated by the Tennessee Game and Fish Commission.

Since this deer herd is an insular population, ingress and egress of deer and humans are limited. The area manager's home is located on the only access road where it enters the wildlife area. Less than six interior holdings are present and they no longer have persons residing on them. The deer receive better protection from free-running dogs and poaching than most Tennessee herds.

Limited access has also made the collection of harvest data easier and more uniform. The hunting data collected in the past 16 years provides an opportunity to use hindsight in checking past deer populations.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of the many Commission biologists and management area personnel that collected data from harvested deer. Past personnel of the Deer Restoration Project trapped the deer used in the Lincoln Index estimates. Mr. Sumner Dow was responsible for placing many years of hunt data on punch cards. Mr. Roy Anderson, Chief of Game Management, has always taken a special interest in this herd, assisted in collection of hunt data, and encouraged its compilation in this report. Mr. Harold Armstrong has been area manager since 1956 and has done an excellent job of hunt management. The assistance of all these persons is deeply appreciated.

CENSUS METHODS

"There are only three basic population estimation methods — direct count, change in a ratio, and survival — and the first is difficult and the last is rarely useful" (Davis, 1960:5:27). This paper compares several population estimate methods based on changes in ratios.

The methods being compared are not independant in the normal sense of the word. In this paper these methods will be referred to as the Lincoln Index, Sex-age-kill, Percent Kill, Minimum Standing Crop, and Minimum Fawn Crop Methods. They are all interrelated by the basic harvest data collection method. Our objective was to compare these methods and to determine if they gave similar herd trend indices, and see which gave the most practical, economical, up-to-date estimate.

Lincoln Index

The Lincoln Index estimate (Table 1) is calculated by marking trapped deer and checking their recovery during the managed hunts. To insure an accurate estimate, both the hunting and trapping must be representative samples of the same population. This method requires considerably more effort in time, money, and manpower than the other census methods.

Previous studies (Lewis, 1963; Leopold, *et. al.*, 1951) have shown that deer trapping does not always give a representative sample of the total population because fawns are not adequately sampled. In our computations the ratio tagged adult deer harvested/total adults tagged is assumed equal to the ratio total adult deer harvested/total adult population and we solve for the unknown total adult population. Adult to fawn ratios are then used to expand the adult population figure to the total population estimate. The probability is 19 to 1 that the true population occurs within the limits shown by the 95 percent confidence limits (Adams, 1951). In this case we have assumed that our correction from adult to total herd estimates did not change the accuracy of the total estimate and its confidence limits. The confidence limits have been corrected for bias caused when the ratio of trapped sample/total population is small.

Sex - age - kill Method

This estimate requires knowledge of numbers harvested and age structure (McNeil, 1962). One of the principal problems in formation of population estimates by this method is mortality from causes other than hunting. Losses from these causes, as previously noted, were thought to be slight for the Central Peninsula herd, particularly during the years of intensive either-sex harvest. This method does make allowance for a non-hunting mortality rate of 10 percent.

Another problem is the variation in mortality rates between deer age classes. An age class is composed of all deer of similar age. Maguire

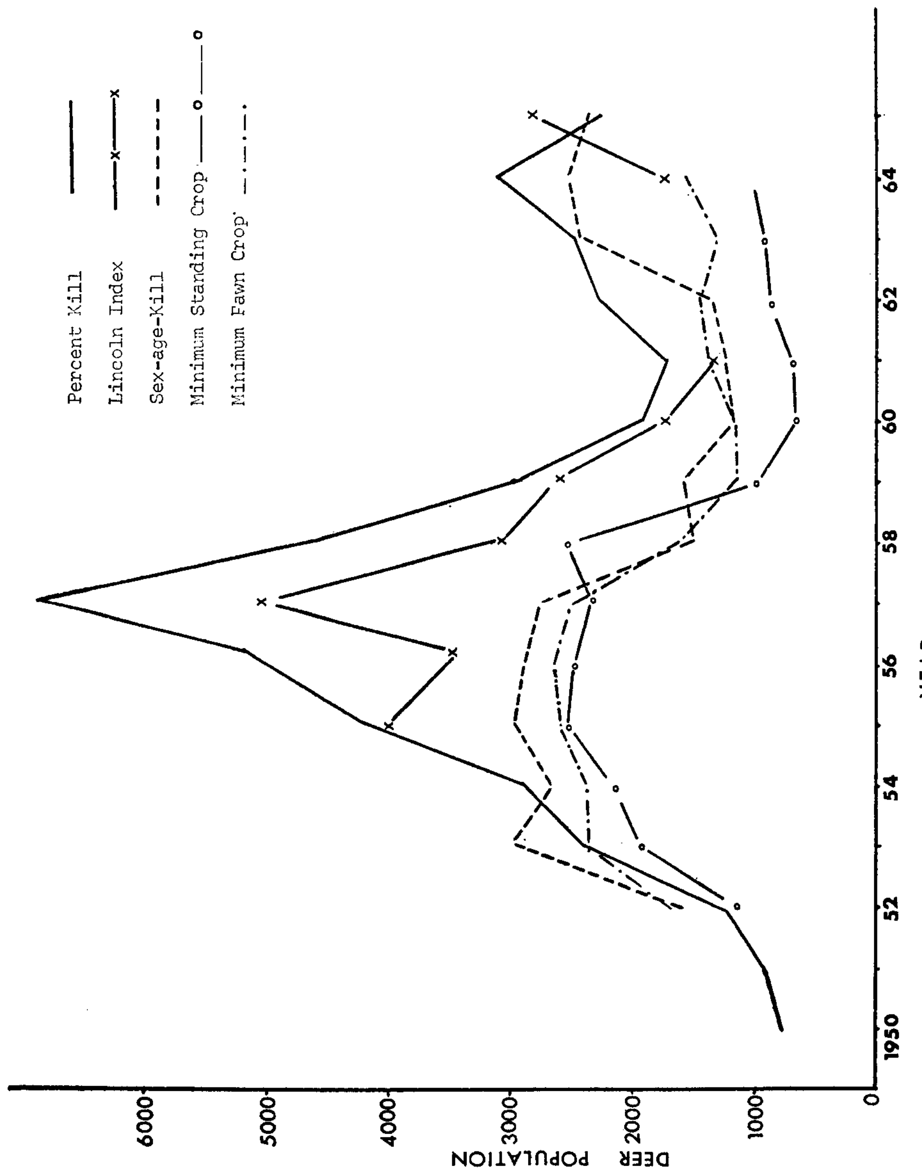

Figure 1. Deer population estimates for the Central Peninsula W.M.A., 1950-65

and Severinghaus (1954) reported a higher rate of kill among 1½-year-old deer in New York. Michigan studies of an enclosed herd (VanEtten, *et. al.*, 1965) indicated that fawns were most vulnerable and adult bucks least vulnerable to hunting. Our analysis of the Central Peninsula data indicates that fawn and 1½-year-old bucks suffer heavier losses, early in the hunting season, than 3½-year-old and older bucks. There appears to be less distinct differences between mortality rates for doe age classes (Lewis and Safley, 1966).

The varying mortality rates among deer age classes imply that sampled age composition may not be representative of the total population. A basic assumption of the Sex-age-kill Method is that sampled age composition be representative of actual age composition. Other problems of bias we considered are possible tendencies to misage some two-year-old deer and class them as older deer, and sampling errors based on deer jawbone collecting techniques formerly in use (Lewis and Safley, 1966).

These problems, (1) misaging, (2) differential vulnerability, and (3) biased jawbone collecting techniques, may be self-compensating to some extent. However, the latter two problems would tend to weight the younger age groups; thus, the tendency would be to reduce herd estimates. The bias would therefore be in a conservative direction.

The method may be described as follows:

$$P_i = \frac{1\tfrac{1}{2}_{i} + (a)\, 2\tfrac{1}{2}_{i+1} + (a^2)\, 3\tfrac{1}{2}_{i+2} + (a^3)\, 4\tfrac{1}{2}_{i+3} + (a^4)\, 4\tfrac{1}{2}^{+}_{i+3+}}{P\,1\tfrac{1}{2}}$$

"where P = buck population
1½, 2½, 3½, 4½ and 4½+ = numbers of individuals killed in each age class in the years of interest.
i = the year of interest
a = non - hunting season survival rate (assumed to be 0.90)
P 1½ = the proportion of bucks 1½ - year - old in year i.
This formula provides estimates of the 1½ - year - old class from the year i, tracing its harvest as the survivors become 2½, 3½, 4½ and older, and allowing for non-hunting mortality each year. The estimated population of 1½-year-olds is then expanded by the proportion, P 1½, to produce total population estimates for each year." (McNeil, 1962:37).

Age and sex ratios were used to correct the figures when only buck hunting was permitted. In those years when either-sex hunting was permitted the formula was modified to include all age classes and both sexes and we solved for the total population. Because the method depends on following a year class to its extinction, data for the older age classes are not available in more recent years. For these more recent years we used average age structures to calculate year classes not adequately represented. These estimates from the Sex-age-kill Method are listed in Table 2.

Percent of Kill

This method is based on a rule-of-thumb that the total legal buck kill multiplied by 10 (Davy, 1957) gives the total deer population size. When either-sex deer hunting prevails the total kill is multiplied by 5 to acquire the total herd estimate. Our estimates using this method are shown in Table 2.

Obviously this technique is not highly accurate under varying conditions of topography and hunting pressure where herd vulnerability can vary considerably. Under light hunting pressure, buck harvest will represent less than 10 percent of a herd. Under heavy hunting pressure more than 20 percent of the herd can be removed by either-sex hunts.

Minimum Standing Crop

This method is suitable for hindsight and permits a manager to compare his annual herd estimates with the known minimum standing crop. This standing crop is determined by placing all deer removed by hunters or other known losses, in age classes, and determining how many of these deer were present on the management area in a given year (Table 2). For example, the minimum standing crop in 1956 is comprised of all the deer harvested in the period 1956-1965 which were born in 1956 or earlier years. This method depends on following a year class to its extinction. A year class contains all deer born in a certain fawning season. The more recent estimates, 1962-1964, are lower because no correction has been made for those older members of a year class which will appear in future harvests.

Minimum Fawn Crop

This is a modification of the previous method and has the same hindsight values. All deer harvested from the management area were placed in year classes representing deer born in a certain fawning season. This minimum fawn crop is expanded, using fawn:adult ratios, to give a total population estimate (Table 2). This method also depends on following a year class to its extinction. The more recent estimates, 1962-1964, are lower because correction has not been made for those members of a year class which will appear in future harvests.

COMPARISON BETWEEN METHODS

Results

The five estimation methods indicate similar population trends and differ basically only in magnitude (Figure 1). All the biological indices; deer physical and physiological condition (body weights, antler size, reproductive capability), deer range conditions and survival curves, indicate similar population dynamics (Lewis and Safley, 1966). The Minimum Standing Crop provides a known population estimate which is an underestimate because it does not include non-hunting mortality or deer removed by trapping (their ages were not determined). The Minimum Fawn Crop Method is also known to provide a population underestimate for the same reason.

The true population apparently lies nearer the other three estimates. One other method of "second guessing" the true population is related to the percent of the herd that can be harvested annually without halting herd growth or causing a population decrease.

Van Etten (*et. al.*, 1965) found that limitation to a one-third harvest would have maintained original herd numbers in a square-mile enclosure in northern Michigan. Chase and Jenkins (1962) reported on the ability of a confined herd to sustain an annual yield of 39 percent. Eberhardt (1960:184) indicated "A maximum possible sustained annual mortality rate for adult female deer in northern Michigan was estimated to be about .30, while the much higher reproductive rates observed in the two youngest adult female age classes in southern Michigan apparently would sustain a mortality coefficient approaching .40."

Annual removal of 30-40 percent of the herd should stabilize the population. Based on the Sex-age-kill Method, which already assumes a 10 percent non-hunting mortality, the known annual deer removal varied from 33 to 72 percent between 1955 and 1959 (Table 3). Rapid herd growth continued from 1955 to 1957, indicating that the Sex-age-kill Method gave a considerable population underestimate. We earlier stated reasons why we thought this method would lead to conservative herd estimates. The true population appears to lie near the estimate of the Lincoln Index and Percent Kill Methods and they are considered our most accurate population estimate.

Herd growth continued rapidly until 1957 when the known removal of 1,535 deer was sufficient to cause a sharp population drop. This known removal was equal to 31 percent of our best population estimate (Table 4). Apparently, in that year other herd losses approximated an additional 10 - 20 percent of the herd. The known annual harvest removed an average of 24.9 percent of our best herd estimates for the period 1952-1965 (Table 4).

The standing crop estimate plus the annual number of trapped deer removed permits us to account for 20,098 deer (Table 2) during the same period (1952-1964) that our best population estimates indicate we should have data on 33,609 deer. Therefore, we can account for 60 percent of the deer herd and the remaining 40 percent represents losses other than legal hunting and trapping and deer still surviving on the area. These losses (disease, accidental death, crippling losses, gun harvest on interior holdings, dogs, poaching, and natural death) totaled one third of the deer produced on the area.

We have very little information on the importance of the various factors causing these losses. Losses to free-running dogs and poaching are reported occasionally. During the either-sex hunts substantial numbers of deer were reported wasted when a successful hunter shot a second deer, a better trophy, and left his first deer in the woods. Some crippling losses and other illegal kills are also observed in the woods following the hunting season. Crippling losses amounted to 10 - 15 percent, even where they were held to a minimum, by closely regulated hunting in an enclosure (VanEtten, *et. al.*, 1965).

Other Studies

Several other studies have included some of the census methods compared here. Dasmann and Taber (1955) compared four deer census techniques; pellet-group counts, sample-area count, total count, and Lincoln Index. The latter three yielded population figures in close agreement.

Jeter (1965:190) used the Percent Kill Method and indicated it "checks well against other census techniques on herds experiencing heavy hunting. It tends to underestimate the deer population when the hunting pressure on the herd is light." Our data indicates that the Percent Kill Method gave a conservative herd estimate during the years 1950-1952 when hunting pressure was relatively light and an overestimate in the years 1955-1958 when both sexes were heavily harvested.

Eberhardt (1960) compared three independent methods of estimating deer population levels; pellet-group counts, the Sex-age-kill Method, and a combined index of field surveys. A high degree of correlation among the methods was demonstrated. However, he indicated that the pellet-group counts (*op. cit.*, 1960:182) "cannot as yet be accepted as a wholly reliable standard by which to judge other methods of estimating deer population. Population estimates based on sex, age, and kill data from the hunting harvest were found to be feasible on the assumption of a low rate of non-hunting mortality in adult deer." Our own data indicates that the Sex-age-kill method would give accurate herd estimates when non-hunting mortality can be estimated and adjustment made for other conservative tendencies.

CONCLUSIONS

Five deer census methods were compared on the Central Peninsula Wildlife Management Area. They indicated similar population trends and differed only in magnitude. The Lincoln Index and Percent Kill Methods provided the most reliable estimates. The Percent Kill Method is the easiest to calculate. The Lincoln Index requires the greatest effort in time and manpower but seems to be the most accurate at the present time. The Sex-age-kill Method will apparently give good herd estimates if the percent of non-hunting losses can be approximated and allowance made for other problems. This method shows promise of greater accuracy when existing biases and unknowns can be omitted. For the present time the Percent Kill Method seems to be the most practical for use on the typical management area in Tennessee.

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Table 1. Lincoln Index population estimates for the Central Peninsula Wildlife Management Area

1955 - 1961, 1964 - 65

	CENSUS YEAR								
	1955	1956	1957	1958	1959	1960	1961	1964	1965
Adults Tagged	101	36	33	52	31	52	9*	63	52
Tags Recovered	21	11	9	16	7	10	4*	24	8
Adults Harvested	535	721	892	603	418	234	185*	492	300
Adult Population	2,573	2,366	3,271	1,960	1,851	1,217	416*	1,291	1,950
Correction Factor	.645	.697	.653	.644	.708	.709	.315	. 74	. 69
Total Population	3,989	3,394	5,009	3,043	2,614	1,716	1,321	1,744	2,826
Corrected 95%	2,828-	2,184-	3,237-	2,012-	1,565-	1,253-	759-	1,253-	1,500-
Confidence Limits	6,526	6,063	10,644	5,358	5,705	2,673	2,887	2,673	6,488

* Adult buck figures.

Table 2. Population estimates for the Central Peninsula deer herd, 1950-1965

	Census Methods				
Year	Sex-age-Kill	Percent Harvest	Minimum Standing Crop	Minimum Fawn Crop	Standing Crop Plus Trapped Deer
1950		790			
1951		900			
1952	1,534	1,220	1,047	1,696	1,047
1953	2,989	2,390	1,930	2,389	2,024
1954	2,685	2,860	2,168	2,387	2,327
1955	2,986	4,150	2,525	2,580	2,685
1956	2,891	5,185	2,488	2,643	2,680
1957	2,795	6,825	2,327	2,503	2,497
1958	1,504	4,685	1,528	1,572	1,670
1959	1,583	2,950	923	1,145	1,024
1960	1,168	1,940	666	1,148	666
1961	1,203	1,740	674	1,348	674
1962	1,333	2,240	841	1,432	841
1963	2,420	2,470	921	1,304	921
1964	2,517	3,100	1,001	1,539	1,042
1965	2,395	2,300	— —	— —	— —
Total					20,098

Table 3. Known annual deer removal as a percent of various population estimate methods, Central Peninsula W.M.A. 1952-65

Year	Removal By Gun and Trap	Deer Removal As A Percent Of Census Methods: Sex-Age-Kill	Lincoln Index	Percent of Kill	Minimum Fawn Crop	Standing Crop Plus Trap Removal
1952	122	7.9		10.0	7.1	11.6
1953	572	19.1		23.9	23.9	28.2
1954	731	27.2		25.5	30.6	31.4
1955	990	33.1	24.8	23.8	38.3	36.8
1956	1,229	42.5	36.2	23.7	46.5	45.8
1957	1,535	54.9	30.6	22.4	61.3	61.4
1958	1,079	71.7	35.4	23.0	68.6	64.6
1959	691	43.6	26.4	23.4	60.3	67.4
1960	329	28.1	19.1	16.9	28.6	49.3
1961	191	15.8	14.4	10.9	14.1	28.3
1962	246	18.4		10.9	17.1	29.2
1963	274	11.3		11.0	21.0	29.7
1964	705	28.0	40.4	22.7	45.8	67.6
1965	384	16.0	13.5	16.6	—	—

Table 4. Known deer harvest as a percent of "best" census estimates, Central Peninsula W.M.A., 1952-65

Year	Best Herd Estimate	Known Annual Harvest: Number	Known Annual Harvest: Percent of Herd	10 Percent Non-hunting Mortality Plus Percent Known Harvest
1952	1,220**	122	10.0	20.0
1953	2,390**	572	23.9	33.9
1954	2,860**	731	25.5	35.5
1955	3,989*	990	24.8	34.8
1956	3,394*	1,229	36.2	46.2
1957	5,009*	1,535	30.6	40.6
1958	3,043*	1,079	35.4	45.4
1959	2,614*	691	26.4	36.4
1960	1,716*	329	19.1	29.1
1961	1,321*	191	14.4	24.4
1962	2,240**	246	10.9	20.9
1963	2,470**	274	11.0	21.0
1964	1,744*	705	40.4	50.4
1965	2,826*	384	13.5	23.5
Total	36,836	9,078		
Average			24.6	34.6

* Lincoln Index
** Percent Kill

DRIVE-TRAPPING WHITE-TAILED DEER[1]

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Most methods of trapping white-tailed deer (*Odocoileus virginianus*) are based on the idea of enticing deer into confined spaces, such as large wooden boxes, by baiting them with one of their preferred foods. Baited box traps have been used with some success in northwestern

[1] A Contribution of Federal Aid to Wildlife Restoration Program, Florida Pittman-Robertson Project W-41-R.