# A COMPARISON OF DEER CENSUS METHODS IN THE RIFLE RIVER GAME AREA

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# A COMPARISON OF DEER CENSUS METHODS IN THE RIFLE RIVER GAME AREA

By

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# A COMPARISON OF DEER CENSUS METHODS IN THE RIFLE RIVER GAME AREA

## INTRODUCTION

### Review of the Methods

Some of the important deer census methods that have been employed in the past are the strip method, the drive, sex and age ratios, track counts, pellet counts, and aerial surveys.

The strip census.

The strip, or King (1937), census method was initiated by Erickson (1940) in Minnesota and was used successfully by Krefting and Fletcher (1941) in Oklahoma. In the latter study, it was found that ideal weather conditions were a cloudy day with low wind and moist ground cover and that the most effective cruising technique was a slow, cautious, stalking method.

A variation of the strip method was used by Hahn (1949) in censusing deer in the Edwards Plateau region of Texas. Hahn found that counts made during the last hour of daylight were ninety-six per cent higher than those taken during full daylight and sixty-one per cent higher than counts taken during the first hour of daylight. He also found that counts varied inversely with relative humidity. Other factors, such as temperature, wind velocity and direction, and atmospheric pressure did not seem to affect the counts.

Cronemiller and Fischer (1946), using variations of the method to census deer in California, found that the car method worked best because the deer tended to scent a person afoot or on horseback and retreat without being seen. The effect of time of day on the number of deer seen was found to be similar to that described by Hahn (1949).

Deer drives.

In a report on deer drives in Minnesota (Olson, 1936), the average drive area was 560 acres, drives on larger areas being less successful and more difficult to manage. According to Adams (1938) the main disadvantages of the drive method are:

1. Disorganized drive lines.
2. Exaggeration of number of deer seen (incompetent help).
3. Heavy cover hindering observation.
4. Weather -- more men required on a wet day.

It was also found that drive areas of one square mile obtained the best results.

A technique described by Morse (1943) greatly reduces the manpower required in the drive by using tracks in the snow instead of watchers to tally the number of deer leaving the drive area.

Ratios.

Kelker (1940) explains how the population may be computed if the sex ratio before and after the season and the kill of bucks and does is known. Equations for computing the number of bucks, does, and fawns in the population are also given by Kelker (1945). Kelker (no date) explains equations for computing the population when both does and bucks are killed.

Petrides (1949) presents equations which differ from Kelker's in using ratios of bucks, does, and fawns to the total population rather than to each other. Petrides also suggests the use of ratios of deer seen per unit distance of travel before and after the season to calculate the population when the kill is known.

Lauckhart (1950) explains how postseason sex ratios may be computed from the age classes in the kill. Guettinger (1951) developed a method for correcting preseason sex ratio data, but its use is limited considerably by requiring bucks and does to be killed at random.

Pellet counts.

Pellet group counts as used by Bennett, English, and McCain (1940) consisted of one-tenth acre quadrats and eleven-foot-wide strips established at random within different cover types. The plots were generally cleared in May and checked monthly through September. Rasmussen and Doman (1943) used 123 circular one-hundredth acre plots established at regular intervals along transect lines to obtain a population estimate on 740 acres.

DeGarmo et al. (1949) used transect lines eleven feet wide and six feet wide to obtain a pellet-group census of white-tailed deer in West Virginia. The six-foot-wide lines were found to produce estimates more nearly comparable to those obtained by other techniques. It was also found that the value of the pellet counts was much greater when the distribution of the plots was correlated with the cover types.

Aerial counts.

Hahn (1949) found that in spite of the absence of foliage on deciduous trees, aerial counts revealed only about fifty per cent of the number of deer observed in cruise counts in the same area. According to Petrides (1953, unpublished) less than twenty per cent of the known population on the George Reserve could be counted at an altitude of two-hundred feet.

Other methods.

Other possible methods for censusing are the Delury method, shining, and the time-area count. Delury (1947) proposes the use of a mathematical relation between effort and success during the open season to estimate animal populations. Shining counts have been used in Michigan with some success; however, no literature on the method is available at present. The time-area count, as employed by Chiavetta (1952), records the number of deer seen from a series of watching posts during a given length of time to obtain a population index.

## Objectives

The purpose of the study is to apply various census techniques and to test and compare the results. The Rifle River Area was chosen as the site for the research because it is enclosed, thus allowing the compiling of a complete record of all hunting and all game taken on the area. This is an important aspect of the problem because the determination of the accuracy of the different census methods is aided considerably if the kill during the hunting season is known.

## Methods and Techniques

### The strip census.

The cover types in the area were estimated by establishing a grid of sixty dots per section on a cover map and from these calculating the proportion of each cover type present. By blazing trees, the census lines were then located so that they would sample each cover type in proportion to its occurrence in the area.

The census was taken by walking along the census lines cautiously, as though stalking a deer, and recording the number of deer seen and the distance from the observer to each deer.

The Delury method.

Data were collected for the Delury method by recording the number of hours spent afield by each hunter and the time at which each buck was killed during the regular season.

Deer drives.

The drives were carried out according to the plan described by Trippensee (1948, pp.214-219). Counters were stationed along the boundary of the area to be counted. The drivers lined up along the fourth side and proceeded abreast across the sample area, driving the deer ahead of them. Deer crossing the boundary were recorded by the posted counters and deer cutting back through the drive line were counted by the drivers. As the drive line moved along, the counters posted along the boundary joined the drive line to prevent recounts of deer doubling back.

Mileage count.

The mileage count was taken by recording the number of deer seen per mile of car travel in the study area before and after the open season.

Sex and age ratios.

Sex and age ratios were collected from four different sources:

1. Incidental observations by conservation department personnel.
2. Observations taken during strip censusing.
3. Shining observations.
4. Deer observed in the mileage count.

The shining count.

Preseason shining counts were made between September 15 and November 13, and postseason counts were made between December 3 and 11.

Before the hunting season the counts were made from a Willys pick-up truck with one person driving and recording data, one person shining through the right hand window, and the author shining the left side of the road from the rear of the vehicle. The persons assisting in the counts were employees of the Fish Division working in the study area on fisheries research, who donated their own time to help.

After the hunting season, when no help was available, all the counts were made alone from a Willys Universal. This was done by removing the canvas top and standing in the vehicle, and shining with one hand while driving with the other. The jeep was throttled to about ten miles per hour in second gear. At this speed both sides of the road could be shined in one trip.

Distances to the deer were estimates to the nearest ten yards with an occasional check by pacing. All distances were measured perpendicularly from the road to the animals.

<u>Track counts</u>.

The roads in the Rifle River Area and in the adjacent private area were divided into four track-count routes totaling 9.5 miles. Counts were made by first cleaning the roads of all tracks with a pine tree or an ordinary drag just before dark and then counting all crossings the following morning. Any trail crossing or following in the road was counted as a crossing.

<u>Time-area counts</u>.

Time-area counts were made by locating sites at random and observing from each site for a given length of time. In this way an index of deer seen per unit area per hour was to be calculated.

Pellet counts, aerial surveys, and tagged-untagged ratios.

Pellet counts were not included in this study because of the limited time available in which plots would be open to the deposition of pellets before hunting season.

Aerial counts were not attempted because of the difficulty in securing a plane and because the usefulness of such a method in Michigan has already been largely determined.

Marking of animals was also not attempted because of the difficulty of trapping deer during the fall of the year.

## DISCUSSION

### The Strip Census

Explanation and presentation of data.

From 71.5 miles of strip census data, collected from August 7 to October 21, 1953, three population estimates have been made using three different techniques. The simplest method is the one described by King (1937), which uses the doubled average of all flushing distances and the total length of strips to calculate the area populated by the deer seen. Another variation is to use the King method to calculate a population in each cover type, adding them to get a population for the area. The third method is the application of the Hayne (1949) modification.

Calculating the preseason population.

(A) Using the King method, from equation

$$(1)\quad N_t = \frac{CF}{\bar{d}2L} = \frac{(640)(4840)(155)}{(49.5)2(71.5)(1760)} = 38.5 \text{ deer/mi.}^2$$

where $N_t$ = deer per square mile

$F$ = total number of deer flushed

$\bar{d}$ = average flushing distance in yards

$L$ = length of census line

C = conversion factor to put $\bar{d}2L$ and $N_t$ in the same units

(B) Using the King method by cover types:

The reasoning behind computing a population for each cover type is that flushing distances differ significantly between different cover types, as is shown by analysis of variance in Table 2, page 9. Table 1 shown the estimates made for each cover type, computed from equation (1).

TABLE 1

Populations of the different cover types

| Cover Type | Per cent in Area | Pop. per Mi.$^2$ | No. in a Pop. of 1 Mi.$^2$ |
|---|---|---|---|
| P & Pb* | 32 | 56 | 18 |
| Upland H | 17 | 17 | 3 |
| Upland Open | 3 | 65 | 2 |
| Lowland H | 7 | 178 | 12 |
| Swamp | 26 | 28 | 7 |
| Cleared | 13 | 30 | 4 |
| Li. & Gs. | 2 | 8 | 0 |
| | 100 | | Total = 46/mi.$^2$ |

*Abbreviations are explained on map (inside of back cover).

(C) Applying the Hayne modification:

The third technique involves the use of a modification devised by Hayne (1949) which corrects for a faulty estimate of the true flushing distance due to a certain behavior of some animal populations. Whether this behavior is present in the population being studied here may be determined by reasoning as to whether Hayne's method obtains more logical estimates than other methods. The population is calculated from equation

(2) $N_t = \frac{C}{2L}\left(\frac{F_1}{d_1} + \frac{F_2}{d_2} - - - \frac{F_n}{d_n}\right) = \frac{(640)(4840)}{2(71.5)}\ (4.55) = 56/\text{mi.}^2$

where d = flushing distance observed in yards and F = number of deer flushing at the corresponding distance.

TABLE 2

Analysis of variance of flushing distances between cover types.

| Cover Type | N | SX | $\frac{(SX)^2}{N}$ |
|---|---|---|---|
| P & Pb | 77 | 3908 | 198,344 |
| Upland Open | 6 | 177 | 5,222 |
| Lowland H | 13 | 380 | 11,108 |
| Cleared | 9 | 589 | 38,547 |
| Swamp | 33 | 1548 | 72,615 |
| Upland H | 15 | 989 | 65,208 |
| Li & Gs | 2 | 83 | 3,444 |
| | 155 | 7674 | 394,488 |

The F test

| Source | d.f. | S.S. | M.S. | F |
|---|---|---|---|---|
| Total | 154 | 80,143 | - | - |
| Cover types | 6 | 14,551 | 2,425 | 5.5 |
| Error | 148 | 65,592 | 443 | - |

Computing preseason confidence limits. Confidence limits are computed from the information in the following table:

TABLE 3

Population estimates by the King method for each trip over the 6.5 miles of census lines.

| Trip | No. Deer | Av. Dis. | Pop. Est. |
|---|---|---|---|
| 1 | 11 | 48.8 | 30.5 |
| 2 | 7 | 33.0 | 28.7 |
| 3 | 20 | 52.4 | 51.7 |
| 4 | 23 | 52.5 | 59.3 |
| 5 | 16 | 52.5 | 41.3 |
| 6 | 9 | 52.1 | 23.4 |
| 7 | 13 | 44.7 | 39.4 |
| 8 | 12 | 45.2 | 35.9 |
| 9 | 9 | 32.7 | 37.2 |
| 10 | 17 | 57.3 | 40.2 |
| 11 | 18 | 52.9 | 46.0 |
| Mean population estimate = 39.4/mi.$^2$ | | | 433.6 |

$$SX^2 = 18153.6$$

$$C = 17091.7$$

$$Sx^2 = \overline{1061.9}$$

$$s^2 = \frac{Sx^2}{N-1} = \frac{1061.9}{10} = 106.19$$

$$S\bar{x} = \sqrt{\frac{s^2}{N}} = \sqrt{\frac{106.19}{11}} = 3.1$$

$$\text{Upper Limit} = 39.4 + 2(3.1) = 45.6$$

$$\text{Lower Limit} = 39.4 - 2(3.1) = 33.2$$

Error = $\pm$ 15.7% at 95% level of significance

Since it would be useful to know how many 6.5 mile strips should be used to obtain certain degrees of accuracy, a graphic representation of the narrowing of the confidence limits with the number of trips over the census lines has been worked out.

Following is the method used for computing the standard error (d) expressed as a fraction of the mean:

$$(3) \quad d = \frac{s}{\bar{y}\sqrt{N}}$$

where N = number of trips made over the census lines

$\bar{y}$ = mean population estimate in deer/mi.$^2$

s = computed standard deviation

Example: for N = 11 trips,

$$d = \frac{10.30}{39.4\sqrt{11}} = .079$$

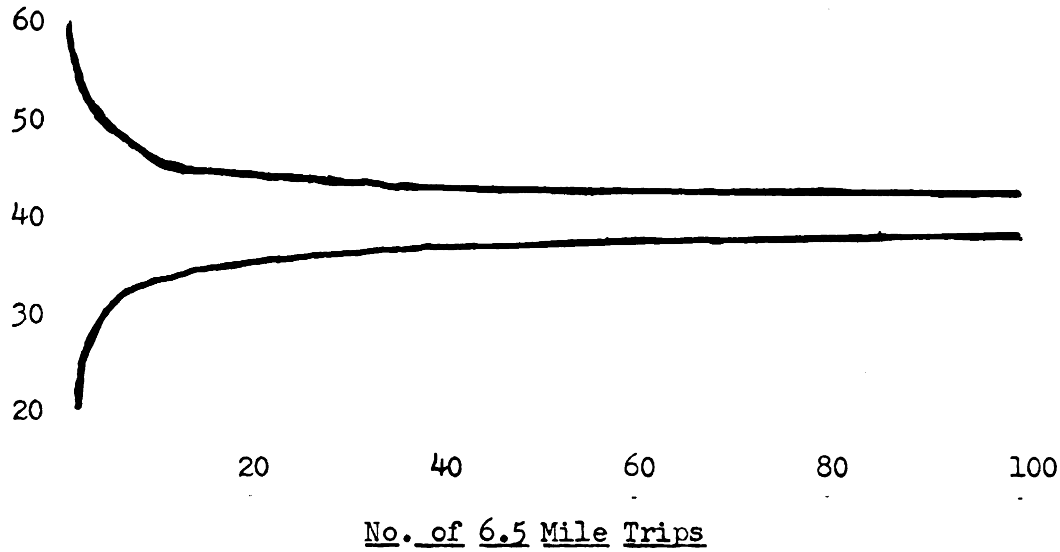
$$\text{Upper Limit} = 39.4 + 2(.079)(39.4) = 45.6$$

$$\text{Lower Limit} = 39.4 - 2(.079)(39.4) = 33.2$$

It is seen in Figure 1 that the accuracy increases very rapidly to about five trips (32.5 mi.), then increases less rapidly to about ten trips, where the increase becomes comparatively small for each succeeding trip.

FIGURE 1

Correlation of confidence limits and sample size




Calculating the postseason population.

(A) Using an over-all average flushing distance:

from equation (1) $N_t = \frac{cF}{d2L} = \frac{(640)(4840)(20)}{(44.6)2(32.5)(1760)} = 12.1$ deer/mi.$^2$

(B) By cover types:

TABLE 4

Population by cover types, calculated from equation (1).

| Cover Type | Pop. Per mi.$^2$ | No. in a Pop. of 1 mi.$^2$ |
|---|---|---|
| Upland P & Pb | 19.2 | 6.1 |
| Swamp | 43.2 | 11.2 |
| Lowland H | 6.6 | .5 |
| | | 17.8 |

(C) Applying the Hayne modification:

from equation (2) $N_t = \frac{C}{2L}\left(\frac{F1}{d_1} + \frac{F2}{d_2} --- \frac{F_n}{d_n}\right) = \frac{(640)(4840)}{2(32.5)}(.563) = 15.4$ deer/mi.[2]

Estimates of the kill follow directly:

TABLE 5

Estimates of the kill from preseason and postseason estimates.

| Method of Handling Flushing Distances | Preseason | Postseason | Kill | % of Known Kill of 30 per mi.[2] |
|---|---|---|---|---|
| King method | 39 | 12 | 27 | 90 |
| By Cover Types | 46 | 18 | 28 | 93 |
| Hayne Modification | 56 | 15 | 41 | 137 |

From this comparison it appears that the Hayne modification does not apply to the population being studied since its estimate of the kill seems to be too high. However, the postseason confidence limits are considerably wider than the preseason limits and this should be taken into consideration when analyzing the results.

Computing postseason confidence limits.

TABLE 6

Population estimates by the King method

for each trip over the census lines.

| Trip | No. Deer | Av. Dis. | Pop. Est. |
|---|---|---|---|
| 1 | 4 | 65 | 8.4 |
| 2 | 5 | 52 | 13.0 |
| 3 | 3 | 24 | 16.9 |
| 4 | 1 | 75 | 1.8 |
| 5 | 7 | 32 | 29.6 |

Mean population estimate = 13.9/mi.[2]

Confidence limits for postseason estimates are calculated as follows:

$$SX^2 = 1404.6$$

$$C = 971.6$$

$$Sx^2 = 433.0$$

$$s^2 = \frac{Sx^2}{N-1} = \frac{433}{4} = 108.2$$

$$S_{\bar{x}} = \sqrt{\frac{s^2}{N}} = \sqrt{\frac{108.2}{5}} = 4.6$$

Upper limits = 13.9 + 2(4.6) = 23.1

Lower limits = 13.9 - 2(4.6) = 4.7

Error = ± 67% at 95% level of significance

With such wide limits it is conceivable that the Hayne method could give a postseason estimate as high as twenty-five, indicating a kill of thirty-one per square mile, which is very close to the known kill.

Conclusions.

1. It appears that the Hayne method gives too high an estimate, but it may be correct because of wide confidence limits on the postseason estimate.

2. Evaluation of the other two techniques will depend on a comparison of their preseason population estimates with estimates by other methods.

## The Delury Method

Explanation of method.

Using hunting success information to compute a population requires the fitting of the data into a regression equation of the general form

$$\hat{Y} = a + bX$$

where Y is a dependent variable, X is an independent variable, a is the ordinate value at which the regression line crosses the Y axis (X = 0), and b is the slope of the line (Snedecor, 1950, Pg. 108).

The accuracy of the Delury method depends, in part, on the extent to which the population being studied fulfills two important assumptions:

1. Recruitment remains negligible during the period of study.
2. Catchability is equal between animals and constant throughout the open season.

According to Delury (1947), if the above qualities are present in a population, the plotting of the logarithm of the catch per unit of effort, C(t), against cumulative effort, E(t), will yield a number of points which fall about a linear regression line. The absence of one or more of the assumptions may be indicated by the departure of the line from complete linearity.

Presentation of data.

Kill data were collected by recording the hours of the day during which each hunter was afield and the time to the nearest half hour that each buck was killed. Each day from November 15 to 22 was then divided into three equal parts of three and one-half hours each, from 7:00 A.M. to 5:30 P.M. This was done to separate the data into a number of parts so that more points would be available for determining a regression line.

Plotting the regression line. The plotting of log C(t) on E(t) in Graph II, page 15, results in a scattered group of points which vaguely describe a straight line. An alternative to this method, substituting bucks seen for bucks killed, is represented in Graph I on

GRAPH I Regression of Bucks Seen and Killed on Cumulative Effort



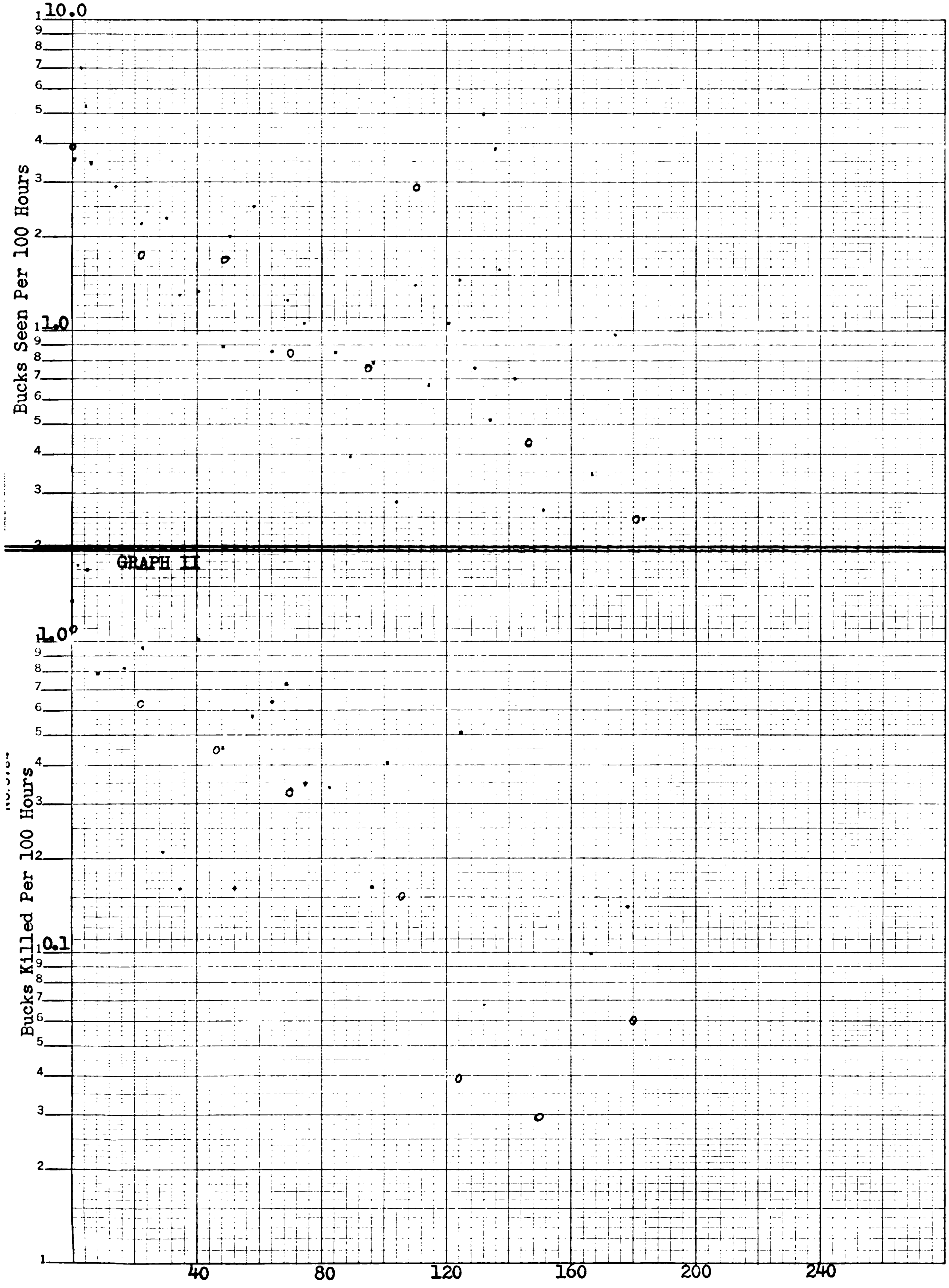


TABLE 7

Catch-Effort Data, November 15 to December 1.

| Day | Hours Hunted | Bucks Seen | Bucks Killed | Kill Per 100 Hours | Cumulative Kill | Log Kill Per 100 Hours + 2 | Cumulative 100 Hour Periods |
|---|---|---|---|---|---|---|---|
| Nov. | | | | | | | |
| 15 | 785 | 42 | 13 | 1.66 | 13 | 2.22 | 7.8 |
| | 750 | 26 | 6 | .80 | 19 | 1.90 | 15.4 |
| | 715 | 21 | 6 | .84 | 25 | 1.92 | 22.5 |
| 16 | 730 | 16 | 7 | .96 | 32 | 1.98 | 29.8 |
| | 485 | 11 | 1 | .21 | 33 | 1.32 | 34.6 |
| | 610 | 8 | 1 | .16 | 34 | 1.20 | 40.8 |
| 17 | 680 | 9 | 7 | 1.03 | 41 | 2.01 | 47.6 |
| | 440 | 4 | 2 | .45 | 43 | 1.65 | 52.0 |
| | 635 | 13 | 1 | .16 | 44 | 1.20 | 58.3 |
| 18 | 630 | 16 | 4 | .58 | 48 | 1.76 | 64.6 |
| | 460 | 4 | 3 | .65 | 51 | 1.81 | 69.2 |
| | 550 | 7 | 4 | .73 | 55 | 1.86 | 74.7 |
| 19 | 835 | 9 | 3 | .36 | 58 | 1.56 | 83.0 |
| | 580 | 5 | 2 | .34 | 60 | 1.53 | 88.8 |
| | 775 | 3 | 0 | - | 60 | - | 96.6 |
| 20 | 640 | 5 | 1 | .16 | 61 | 1.20 | 103.0 |
| | 350 | 1 | 0 | - | 61 | - | 106.5 |
| | 370 | 0 | 0 | - | 61 | - | 110.2 |
| 21 | 490 | 7 | 2 | .41 | 63 | 1.61 | 115.1 |
| | 450 | 3 | 0 | - | 63 | - | 119.6 |
| | 465 | 5 | 0 | - | 63 | - | 124.2 |
| 22 | 475 | 7 | 0 | - | 63 | - | 129.0 |
| | 260 | 2 | 0 | - | 63 | - | 131.6 |
| | 80 | 4 | 0 | - | 63 | - | 132.4 |
| 23 | 170 | 0 | 0 | - | 63 | - | 134.1 |
| 24 | 195 | 1 | 1 | .51 | 64 | 1.71 | 136.0 |
| 25 | 180 | 7 | 0 | - | 64 | - | 137.8 |
| 26 | 510 | 8 | 0 | - | 64 | - | 143.0 |
| 27 | 855 | 6 | 0 | - | 64 | - | 151.5 |
| 28 | 1545 | 4 | 0 | - | 64 | - | 167.0 |
| 29 | 1145 | 4 | 0 | - | 64 | - | 178.4 |
| 30 | 715 | 7 | 1 | .14 | 65 | 1.15 | 185.6 |
| Dec. 1 | 3325 | 8 | 2 | .06 | 67 | .78 | 218.8 |
| | 21880 | 273 | 67 | 10.21 | | 30.37 | 3309.5 |

the same page. This distribution has a definite tendency toward linearity. The data grouped into eight approximately equal units of effort, represented in the graphs by o's, follows the same trends and is as definite as the ungrouped data, if not more so, in describing a straight line.

The standard deviations from regression, calculated as described by Snedecor (1950, pp. 108-118), are as follows:

| | |
|---|---|
| Ungrouped, killed | $s = .60$ |
| Grouped, killed | $s = .23$ |
| Ungrouped, seen | $s = .37$ |
| Grouped, seen | $s = .34$ |

This seems to indicate that the grouped data are more precise in determining the regression in either case, and that the substitution of bucks seen for bucks killed increases the precision of the technique for ungrouped data, but not for grouped data.

It is on the assumption that a straight line regression is represented by the data that further analysis is attempted.

Calculating the population. Delury (1947) presents two equations that utilize catch-effort records to estimate the population:

$$(4) \quad \log C(t) = \log \ kN(o) - kE(t)$$

$$(5) \qquad C(t) = kN(o) - kK(t)$$

in which k is the proportion of the population captured by one unit of effort, N(o) is the population before the first capture, and K(t) is the total catch up to time (t).

Equations (4) and (5) are applied to the data as follows:

Using the ungrouped data we obtain from

equation (4) $\log C(t) = .02531 - .01102\ E(t),$

therefore $k = .025$

$N(o) = 42$

equation (5) $C(t) = 1.42177 - .02090\ K(t),$

therefore $k = .021$

$N(o) = 68$

Using the grouped data we obtain from

$$\text{equation (4)} \quad \log C(t) = .16315 - .00805\, E(t),$$

$$\text{therefore } k = .018$$

$$N(o) = 78$$

$$\text{equation (5)} \quad C(t) = 1.73502 - .02546\, K(t),$$

$$\text{therefore } k = .025$$

$$N(o) = 68$$

Equation (4) with the ungrouped kill data estimates the preseason buck population at 42, which, since there was a known kill of 67, is obviously too low. Estimates of 68, however, obtained from equation (4) with the ungrouped data and from equation (5) with the grouped data, seem reasonable but possibly somewhat low. Equation (4), using the grouped data, estimates a preseason population of 78, which appears reasonable with a known kill of 67.

However, if the postseason population is calculated from k and N(o) in each case, it is seen that with a preseason population of 78 bucks and with $k = .018$, N(t) (the postseason population) is 1.5. This indicates a kill of 77 bucks, which is 10 more than the known kill of 67. On the other hand, if $N(o) = 68$ and $k = .025$ or $.021$, then $N(t) = .3$ and $.7$ respectively. The estimated kill is then within one deer of the known kill in either case. It should be noted here that any unrecorded kills or deer driven from the study area by high hunting pressure would tend to lower the population estimates.

The procedure for obtaining the above population is as follows:

$$\text{if } N(o) = 78$$

$$\text{and } k = .018$$

$$\text{from the equation } N(t) = N(o)\, e^{-kE(t)} \quad \text{(Delury, 1947)}$$

$$= (78)(2.71828)(-.018)(218)$$

$$= 1.5$$

The other estimates of k and N(o) may be handled in the same manner.

Conclusions.

1. Since equation (5) obtains practically the same estimates using either grouped or ungrouped data, it appears that grouped data can be used without affecting the results.

2. Equation (4) is inconsistent in its estimate of N(o), thereby casting suspicion on its applicability in this situation, and questioning the basis for grouping the data.

3. The estimates N(o) = 68, although seemingly too low for a kill of 67, may not be unreasonable since the hunting pressure was extremely high.

## The Deer Drive Census

Execution of the drives.

The drives were carried out by male students of ages fifteen to eighteen from a local high school. Before the first drive the boys were given pamphlets outlining the procedure followed in making a deer drive, and on-the-spot instructions were given to be sure that each person knew his job. In spite of the previous instruction, however, the drive lines became disorganized and had to be reassembled at least once during each drive.

Because of the great enthusiasm expressed by the boys, it was feared that some exaggeration of the number of deer seen would result, but in collecting the information from them after each drive it was evident that they were aware of the correct technique and refrained from reporting more than the correct number.

The study area, in general, does not lend itself well to the drive type of census because of the lack of a regular road system and the occurrence of swamps and heavy lowland cover throughout the area. As a result of these factors, the drives were limited in size to less than a quarter-section each.

Presentation of the data.

The populations on a square mile basis indicated by the two drives were fifty-six on drive-area A, and sixty-two on drive area B. Drive-area A, as shown on the map is primarily upland poplar and poplar-birch cover types. Looking back at Table 1, page 8, it is seen that the strip census estimate for upland poplar and poplar-birch is fifty-six deer per square mile. Similarly, the cover types of drive-area B, in which the drive count netted an equivalent population of sixty-four deer per square mile, are approximately seventy per cent upland poplar, fifteen per cent swamp, ten per cent lowland hardwood, and five per cent leatherleaf. Taking the correct proportions of the corresponding populations from Table 1, a population of sixty-two is computed for the area.

Conclusions.

The apparent agreement of the drive and strip census methods lends considerable support to the accuracy of each. The efficiency of the drive count should be more evident than that of other methods, since an actual count is being made on an area of known size. The sample size for the drive count was rather small (six per cent of the study area), but it is the author's opinion that the results obtained were quite accurate, and are therefore valid in determining the accuracy of other methods.

## The Mileage Count

### Collection of data.

All the data for the mileage count were taken while driving in the study area for other purposes, thus allowing the method to be included in the study without incurring added expense or inconvenience.

### Presentation of the data.

Preseason counts were made from August 7 to November 2, and registered 166 deer in 771 miles of travel. However, if the data are divided into two parts, before and after the opening of the grouse and bow-and-arrow deer seasons, it is seen that the two resulting population estimates differ significantly. It is suspected that this difference is an effect of the presence of numerous hunters after October 1, which tends to make the deer more seclusive during the daylight hours.

TABLE 8

Effect of small game and bow-and-arrow deer seasons on mileage count.

| Period | Car Miles | Deer Seen | Pop. Est. |
|---|---|---|---|
| Aug. 7 - Sept. 30 | 357 | 108 | 225 |
| Oct. 1*- Nov. 2 | 414 | 58 | 297 |

*Opening of small game and bow-and-arrow deer seasons.

The preseason population estimates shown in Table 8 are calculated from a postseason mileage count of nine deer in 172 miles as follows:

equation (6) $$P_1 = \frac{C_1K}{C_1-C_2} = \frac{(.140)(186)}{.140 - .052} = 297$$ (Petrides, 1949)

where $P_1$ = preseason population

$K$ = kill

$C_1$ = preseason mileage count

$C_2$ = postseason mileage count

It seems reasonable that the postseason count would be comparable to the preseason count after October 1 rather than to the count before October 1 because:

1. The regular deer season tends to cause the deer to remain in seclusion temporarily following the season, as do the grouse and bow-and-arrow deer seasons before the regular season.
2. The small game season is still in effect after the deer season.

Conclusions.

1. The preseason mileage count is affected by the opening of the small game and bow-and-arrow deer seasons.
2. The mileage count may be inaccurate because of its dependence on the behavior of the deer, which is easily affected by environmental influences.

## Sex and Age Ratios

Explanation of method.

According to Kelker (1940, 1945, no date) and Petrides (1949) population estimates may be calculated if sex and age ratios are known before and after an open season if the kill is also known. Similar equations are given by the two authors and are represented in the one given by Petrides as follows:

$$P_1 = \frac{f_2 K - K_F}{f_2 - f_1} \quad \text{and}$$

$$P_1 = \frac{j_2 K - K_J}{j_2 - j_1}$$

where $f$ = proportion of females in population

$P$ = number in total population

$K$ = kill

$j$ = proportion of juveniles in population

and subscripts 1 & 2 = before and after the season respectively

$F$ & $J$ = females and juveniles respectively

Presentation of the data.

Sex and age data collected before the open season are presented in Table 9.

TABLE 9

Preseason sex and age data collected by four different methods.

| Method | Does | Fawns | Bucks | Bucks: Other Deer |
|---|---|---|---|---|
| Mileage count | 51 | 75 | 7 | 1: 18.0 |
| Strip census | 50 | 48 | 14 | 1: 7.0 |
| Shining | 72 | 66 | 7 | 1: 19.7 |
| Incidental obs. | 47 | 29 | 12 | 1: 6.3 |
| Total | 220 | 218 | 40 | 1: 11.0 |

A test of the agreement of the four methods by Chi-square in Table 10 shows that the ratios obtained differ significantly.

TABLE 10

Interaction Chi-square

| | ♀ | F | ♂ | $\chi^2$ |
|---|---|---|---|---|
| Mileage count | 51 | 75 | 7 | 6.63 |
| Strip census | 50 | 48 | 14 | 2.47 |
| Shine count | 72 | 66 | 7 | 2.57 |
| Incidental obs. | 47 | 29 | 12 | 6.97 |

Interaction $\chi^2$ = 18.64**; d.f. = 6

No sex and age ratios were obtained after the open season because it was impossible to observe enough deer to get valid data. Because of this lack of data no population estimate can be made by this method.

Conclusions.

Two conclusions may be drawn from the available information:

1. The method used in collecting sex and age data has a considerable influence on the results.

2. Since it has been shown previously that there was a preseason population of approximately forty to fifty deer per square mile, and since there was a known kill of sixty-seven legal bucks, the preseason sex ratio must have been between 1: 2.6 and 1: 3.5 (bucks: other deer) using a preseason buck population of seventy. Therefore, the most nearly correct (but still inaccurate) of the methods of collecting sex ratios were the strip census and incidental observation methods, which indicated ratios of 1: 7.0 and 1: 6.3 respectively.

## The Shining Count

Presentation of the data.

The roads in the Rifle River Area and in the private area adjacent to the west were divided into four shining routes, totaling 13.6 miles. The private area, about 3,000 acres in size, was included in the track and shining counts because of the general belief that deer tend to move into it from the Rifle River Area during the general deer season. If this were true, it would seriously affect the results of this study unless it was taken into consideration. The reason for such a migration might be a result of the extremely high hunting pressure in the game area, which was not experienced in the private area.

Pertinent shining data are presented in Table 12.

TABLE 12

Shining count data.

PRESEASON

| DEER SEEN | | | | | | | | AVE. DIS. TO DEER (YARDS) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Route, Miles | Observation: 1 | 2 | 3 | 4 | 5 | 6 | Total | Observation: 1 | 2 | 3 | 4 | 5 | 6 | Ave. of all Flushing Distances |
| 3.3 | 10 | 6 | 8 | 18 | 5 | 7 | 54 | 28 | 64 | 46 | 36 | 35 | 51 | 41 |
| 4.0 | 24 | 16 | 25 | 18 | 21 | 22 | 126 | 61 | 124 | 58 | 74 | 59 | 49 | 68 |
| 2.8 | 4 | 10 | 3 | 5 | 11 | 5 | 38 | 48 | 59 | 120 | 86 | 70 | 120 | 77 |
| 3.5* | 23 | 20 | 16 | 11 | 33 | 22 | 125 | 100 | 94 | 99 | 64 | 77 | 71 | 85 |
| POSTSEASON | | | | | | | | | | | | | | |
| 3.3 | 4 | 1 | 3 | 3 | - | - | 11 | 10 | 100 | 52 | 13 | - | - | 30 |
| 4.0 | 8 | 5 | 11 | 4 | - | - | 28 | 40 | 25 | 65 | 15 | - | - | 44 |
| 2.8 | 5 | 1 | 0 | 1 | - | - | 7 | 51 | 45 | - | 40 | - | - | 49 |
| 3.5* | 34 | 35 | 23 | - | - | - | 92 | 60 | 43 | 74 | - | - | - | 57 |

*in private area

Analysis of variance.

Analysis of variance indicates no significant differences between routes or between counts in the preseason data. An average of all the counts may therefore be used to calculate the population. The post-season counts were not subjected to the F-test because Bartlett's test (Bartlett, 1937) indicates that the variances in the different samples differ significantly. It will be necessary, however, to average the postseason counts in order to obtain a population estimate.

Bartlett's test, preseason data:

$$X^2 = 2.3026(k-1)(n \log \bar{s}^{\,2} - S \log s^2)$$

$$= 2.3026(6-1)(11.81696 - 11.51321)$$

$$= 3.50, \text{ insig.; d.f.} = 3$$

Analysis of variance, preseason data:

TABLE 13

Population estimates for each trip over the shining routes

Routes

| | | $T_1$ | $T_2$ | $T_3$ | $T_4$ | M.S. |
|---|---|---|---|---|---|---|
| Replications | R1 | 96 | 86 | 25 | 58 | 265 |
| | $R_2$ | 24 | 29 | 53 | 53 | 159 |
| | $R_3$ | 45 | 95 | 9 | 40 | 189 |
| | $R_4$ | 133 | 53 | 19 | 43 | 248 |
| | $R_5$ | 37 | 79 | 50 | 108 | 274 |
| | $R_6$ | 37 | 99 | 12 | 78 | 226 |
| | M.S. | 372 | 441 | 168 | 380 | 1361 |

The F test

| Source | Deg. F. | S.S. | M.S. | F |
|---|---|---|---|---|
| Total | 23 | 25,067 | 1090 | - |
| Replications | 5 | 2,541 | 508 | .59 (Insig.) |
| Routes | 3 | 7,068 | 2356 | 2.57 (Insig.) |
| Error | 18 | 15,485 | 859 | - |

Bartlett's test, postseason:

$$X^2 = 2.3026(k-1)(n \log \bar{s}^2 - S \log s^2)$$

$$= (2.3026)(4-1)(8.76663 - 7.56175)$$

$$= 8.32^*;\ \text{d.f.} = 2$$

Calculating the population.

Calculating the preseason population using equation

$$(1) \quad N(t) = \frac{CF}{\bar{d}(2L)} = 50.3/\text{mi.}^2$$

The postseason population calculated in the same manner = $24.2/\text{mi.}^2$

Further analysis of the data shows that when deer observed at distances greater than 105 yards from the census route are included in the calculations, the resulting population estimate is reduced. Table 14 shows the effect of distance classes on the population estimate.

TABLE 14

Effect of distance from shining route on population estimate.

| | Preseason | | | | Postseason | | | |
|---|---|---|---|---|---|---|---|---|
| | Rifle River Area | | Private Area | | Rifle River Area | | Private Area | |
| Distance to Deer (yards) | Cum. Deer Seen | Cum. Pop. Est. | Cum. Deer Seen | Cum. Pop. Est. | Cum. Deer Seen | Cum. Pop. Est. | Cum. Deer Seen | Cum. Pop. Est. |
| 5 - 15 | 12 | 17 | 0 | - | 10 | 20 | 2 | 17 |
| 16 - 25 | 20 | 21 | 9 | 19 | 16 | 23 | 14 | 62 |
| 26 - 35 | 54 | 32 | 17 | 29 | 22 | 24 | 41 | 132 |
| 36 - 45 | 101 | 47 | 24 | 34 | 35 | 26 | 54 | 153 |
| 46 - 55 | 134 | 54 | 37 | 42 | 38 | 26 | 58 | 157 |
| 56 - 65 | 154 | 57 | 57 | 53 | 44 | 26 | 65 | 159 |
| 66 - 75 | 169 | 58 | 63 | 56 | 45 | 26 | 68 | 159 |
| 76 - 85 | 177 | 59 | 67 | 57 | 45 | 26 | 70 | 158 |
| 86 - 95 | 181 | 59 | 69 | 57 | 45 | 26 | 77 | 154 |
| 96 - 105 | 182 | 59 | 81 | 58 | 46 | 26 | 77 | 154 |
| over 105 | 218 | 50 | 125 | 62 | 49 | 24 | 92 | 137 |

If the apparent population density is decreased when deer observed at distances greater than 105 yards from the shining route are included in the estimate, it is probably because the deer present at these distances are observed only when they occur in open areas. This tends to raise the average distance without proportionately adding to the total number of observations. The preseason estimate in the private area did not follow this trend, probably because a large number of deer were seen at extreme distances in the open areas. The openings in the private area represent a greater proportion of the roadside cover than of the cover in the area as a whole. The cover types in the Rifle River Area, however, are represented fairly proportionately along the shining routes, as Table 15 indicates.

TABLE 15

Comparison of the cover types represented by the shining routes with their occurrence in the areas.

| | Rifle River Area | | Private Area | |
|---|---|---|---|---|
| Type | % in Area | % on Routes | % in Area | % on Routes |
| Upland P & Pb | 32 | 38 | - | - |
| Upland H | 17 | 23 | - | - |
| Swamp | 26 | 25 | 19 | 12 |
| Lowland H | 7 | 3 | - | - |
| Open & Cl | 16 | 9 | 7 | 37 |
| Li & Gs | 2 | 5 | - | - |
| Upland P & O | - | - | 45 | 32 |
| O - J | - | - | 27 | 19 |

The occurrence of the cover types in the private area was estimated from aerial photos and the percentages in the Rifle River Area were obtained from a cover map as explained in the Introduction. The cover on the shining routes was measured from speedometer readings of the distance that each occurred adjacent to the roads.

Using the maximum population estimates given in Table 14, the kill is computed at (59 - 26) = 33 deer per square mile, which compares favorably with the known kill of 30 per square mile. These population estimates, however, are considerably higher than those computed by some of the other methods. This may be explained by the fact that the distances to the deer were measured perpendicularly from the road, rather than from the observer to the deer. This results in recording a shorter distance than is actually observed, because animals seen ahead of the observer are not recorded until the observer has proceeded along the road to the point where the animal is at a minimum distance from the line of travel.

The above method was also found to give high estimates by Robinnette (1954, unpublished) in his experiment with dead deer in Colorado.

A population estimate may also be made by comparing the number of deer shined per mile before and after the season. This is done by applying equation

$$(6) \quad P_1 = \frac{C_1 K}{C_1 - C_2} = 43/\text{mi.}^2$$

This estimate is considerably lower than the ones obtained previously and is in better agreement with the estimates of some of the other census methods.

Confidence Limits.

Preseason limits of 42 and 62 deer per square mile may be expected with 95 per cent confidence, to include the true mean population estimate. Postseason confidence limits at the 95 per cent level are 16 and 42.

Computing confidence limits for the preseason data:

TABLE 16

Preseason population estimates for each shining count on the 10.1 miles of census routes.

| Census | No. Deer | Ave. Dis. (Yards) | Pop./mi.$^2$ |
|---|---|---|---|
| 1 | 38 | 50.9 | 65 |
| 2 | 32 | 92.6 | 30 |
| 3 | 38 | 58.9 | 56 |
| 4 | 39 | 60.1 | 56 |
| 5 | 37 | 58.9 | 55 |
| 6 | 34 | 59.7 | 50 |

Mean population estimate = 52/mi.$^2$

$$S\,X^2 = 16{,}922$$

$$C = \underline{16{,}224}$$

$$Sx^2 = 698$$

$$s^2 = \frac{Sx^2}{N-1} = \frac{698}{5} = 139.6$$

$$S\bar{x} = \sqrt{\frac{s^2}{N}} = \sqrt{\frac{139.6}{6}} = 4.83$$

Upper limit = 52 + 2(4.83) = 62/mi.$^2$

Lower limit = 52 - 2(4.83) = 42/mi.$^2$

Error = ± 19% at 95% level of significance

Computing confidence limits for the postseason data:

TABLE 17

Postseason population estimates for each shining count on the 10.1 miles of census routes.

| Census | No. Deer | Ave. Dis. (Yards) | Pop./mi.$^2$ |
|---|---|---|---|
| 1 | 17 | 36.2 | 41 |
| 2 | 7 | 38.6 | 16 |
| 3 | 14 | 62.2 | 20 |
| 4 | 8 | 17.4 | 40 |

Mean population estimate = 29/mi.$^2$

$$S\,X^2 = 3937$$

$$C = \underline{3422}$$

$$Sx^2 = 515$$

$$s^2 = \frac{Sx^2}{N-1} = \frac{515}{3} = 171.7$$

$$S\bar{x} = \sqrt{\frac{s^2}{N}} = \sqrt{\frac{171.7}{4}} = 6.55$$

Upper limit = 29 + 2(6.55) = 42/mi.$^2$

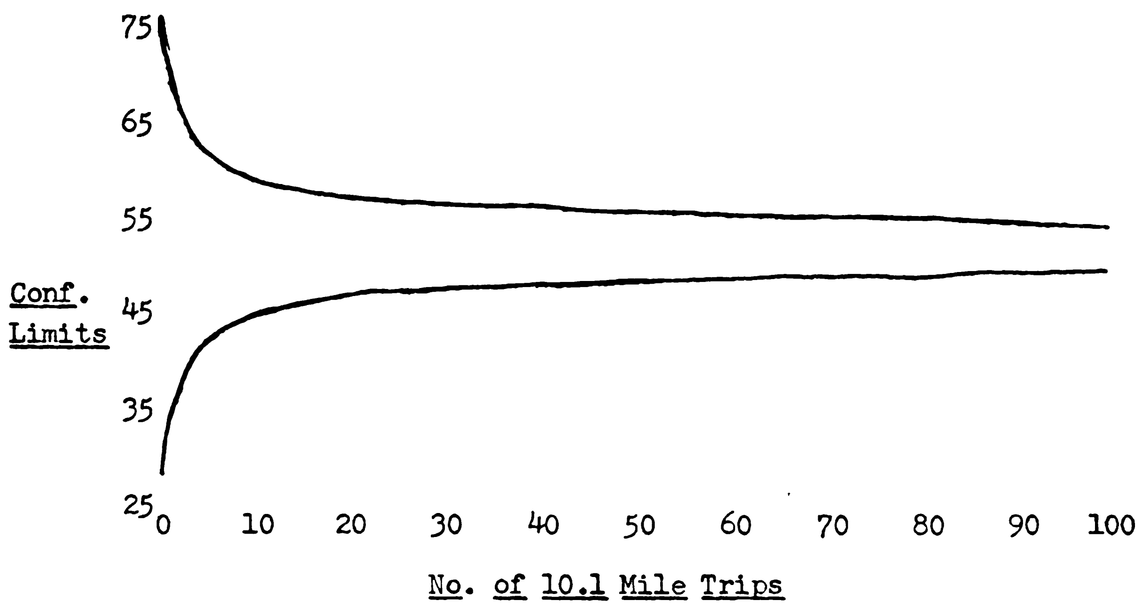
Lower limit = 29 - 2(6.55) = 16/mi.$^2$

Error = ± 45% at 95% level of significance

Figure 2 represents the narrowing of the confidence limits at the 95 per cent level as the length of the shining route increases.

FIGURE 2

Correlation of confidence limits and sample size




It is seen that after about five trips considerably more effort is required to close the limits a given amount and that after twenty trips the increase in precision becomes negligible.

Conclusions.

1. A smaller percentage of the deer at distances greater than 105 yards from the line of travel are seen than are those at distances less than 105 yards.
2. Shining count population estimates using perpendicular distances from the road to the deer are considerably higher than estimates by other methods.
3. Reliable counts can be obtained from a minimum of about

fifty miles of shining when deer are seen at the rate of approximately 36 per mile.

## Track Counts

### Presentation of data.

Each of the four track-count routes was dragged five times before the open season for a total of 47.5 miles, tallying an average of forty crossings per mile. Postseason counts on 26 miles were much lower, averaging 8.7 crossings per mile.

The raw data are summarized in Table 18.

TABLE 18

Track count data, crossings per mile.

Preseason

| Route, miles | Observation: 1 | 2 | 3 | 4 | 5 | Ave. |
|---|---|---|---|---|---|---|
| 2.2 | 53 | 30 | 42 | 44 | 51 | 44 |
| 1.8 | 60 | 65 | 82 | 30 | 30 | 53 |
| 2.5 | 24 | 45 | 57 | 37 | 13 | 35 |
| 3.0* | 30 | 33 | 25 | 43 | 39 | 34 |

Postseason

| Route, miles | 1 | 2 | 3 | 4 | 5 | Ave. |
|---|---|---|---|---|---|---|
| 2.2 | 11 | 15 | 17 | 12 | - | 14 |
| 1.8 | 4 | 13 | 5 | 3 | - | 6 |
| 2.5 | 10 | 4 | 5 | 4 | - | 6 |
| 3.0* | 18 | 35 | 42 | - | - | 32 |

*Private area included in preseason, not in postseason computations.

### Analysis of variance.

Bartlett's test is first applied to the data to test for homogeneity of variance.

Bartlett's test, preseason:

$$X^2 = 2.3026(k-1)(n \log \bar{s}^2 - S \log s^2)$$

$$= 2.3026(5-1)(9.51068-8.81689)$$

$$= 5.786, \text{ Insig.} \quad d.f. = 3$$

Bartlett's test, postseason:

$$X^2 = 2.3026(k-1)(n \log \bar{s}^2 - S \log s^2)$$

$$= 2.3026(4-1)(3.26973 - 3.12779)$$

$$= .981, \text{ Insig.} \quad \text{d.f.} = 2$$

Since Chi-square is insignificant, analysis of variance may be applied to the data. Following are the values of F obtained for the preseason data:

Analysis of Variance

| Source | Deg. F. | S.S. | M.S. | F |
|---|---|---|---|---|
| Total | 19 | 5037 | 265 | - |
| Replicates | 4 | 720 | 180 | .70 (Insig.) |
| Routes | 3 | 1219 | 406 | 1.57 (Insig.) |
| Error | 12 | 3098 | 258 | |

The postseason data yield F values as follows:

Analysis of Variance

| Source | Deg. F. | S.S. | M.S. | F |
|---|---|---|---|---|
| Total | 11 | 271 | 24.6 | - |
| Replicates | 2 | 29 | 14.5 | 1.07 (Insig.) |
| Routes | 3 | 161 | 53.6 | 3.95 (Insig.) |
| Error | 6 | 81 | 13.6 | |

The F tests show no significant variation between routes or between individual counts. The different observations may, therefore, be averaged in order to complete necessary computations.

Calculating the preseason population.

The preseason population may be calculated by equation

$$(6) \quad P_1 = \frac{C_1 K}{C_1 - C_2} = 37/\text{mi.}^2$$

It is seen that in the private area the preseason index is essentially the same as the postseason index.

Confidence limits.

The standard error expressed as a fraction of the mean may be computed from equation

$$(3) \quad d = \frac{s}{y\sqrt{N}} = .057$$

Confidence limits for the preseason counts are

Upper limit = 40 + 2(2.28) = 44.6 crossings per mile

Lower limit = 40 - 2(2.28) = 37.4 crossings per mile

Error = ± 11% at 95% level of significance

For the postseason counts the standard error,

$d = .084$

Confidence limits are computed as

Upper limit = 9 + 2(.76) = 11 crossings per mile

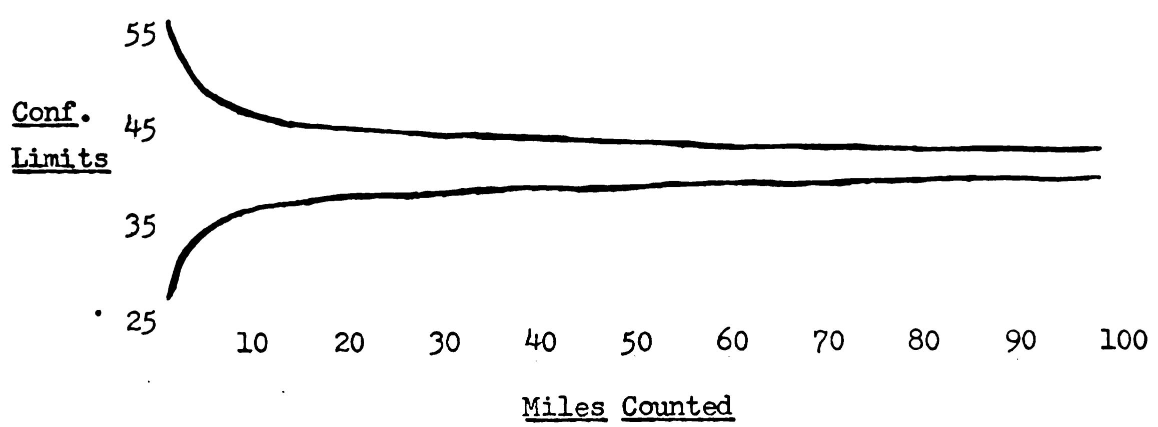
Lower limit = 9 - 2(.76) = 7 crossings per mile

Error = ± 17% at 95% level of significance

By applying equation (3), a series of values of d have been computed at the 95 per cent level of confidence and presented as a curve in Figure 3 showing the decrease in the per cent error with an increase in sample size (from preseason data).

FIGURE 3

Correlation of confidence limits and sample size.




Comparison of data with counts on known populations.

Track counts made on known population densities at the Cusino Wildlife Experiment Station, Shingleton, Michigan, and at the George

Reserve, Pinckney, Michigan, indicate crossings at the rate of 1.1 and 0.1 per deer per mile respectively. If the population for the Rifle River Area is calculated using the rates observed at Cusino on a population of thirty per square mile, the following estimate is obtained:

$$\frac{30}{x} = \frac{33.4}{40.2}$$

$$33.4\,x = 1206$$

$$x = 36/\text{mi.}^2$$

This estimate is almost the same as the estimate obtained from equation (6), page 33 ($37/\text{mi.}^2$). The George Reserve data do not seem to compare with either the Cusino or Rifle River Area data.

Conclusions.

Track counts give a conservative estimate of the population. Confidence limits of 37 and 45 may be expected to include the true mean preseason count 95 per cent of the time. In 95 out of 100 trials the postseason count would be expected to be between 7 and 11 crossings per mile.

The private area counts are essentially the same after as before the season, reflecting the very light kill on the heavy population there.

Track counts in the Rifle River Area and in the adjoining private area show that crossings are made at about the same rate on a per deer basis as has been observed in the Cusino deer herd.

## Time-Area Counts

Explanation of method.

In order to obtain random samples of the study area, the center of each quarter-section was selected as a site at which to make a count. Each site used was approached in a manner that would least arouse any deer in the vicinity and an arbitrary period of one hour was spent at the site watching for deer within visible range.

The object of the census method was to obtain an index of the number of deer seen in a given length of time in a known area.

Presentation of data.

Data collected in the time-area counts are presented in Table 19.

TABLE 19

Deer seen in time-area counts.

| Site Location | No. Deer Seen |
|---|---|
| NE $\frac{1}{4}$ sec. 2 | 0 |
| SE $\frac{1}{4}$ sec. 2 | 0 |
| SE $\frac{1}{4}$ sec. 11 | 0 |
| NE $\frac{1}{4}$ sec. 12 | 0 |
| SE $\frac{1}{4}$ sec. 12 | 0 |
| NE $\frac{1}{4}$ sec. 14 | 0 |
| SE $\frac{1}{4}$ sec. 14 | 1 |
| NE $\frac{1}{4}$ sec. 23 | 1 |

After eight different sites had been tested and only two deer were observed, it became apparent that the method would not yield enough observations to warrant the expenditure of the time required. The time-area count was therefore discontinued in favor of further development of the other methods.

Conclusions.

In the time-area counts carried out, deer were observed at the rate of one every four hours. The method requires a considerable amount of time for the number of observations that result (about eight times that required in the strip method).

EVALUATION OF THE RESULTS

Results of the different census methods are summarized in Table 20.

TABLE 20

Population estimates and confidence limits of the different techniques.

| Method | Preseason Estimate | % Error | Postseason Estimate | % Error | Kill Estimate |
|---|---|---|---|---|---|
| Strip (King) | 39 | 16 | 12 | 67 | 27 Per mi.$^2$ |
| Strip (cover types) | 46 | 16 | 18 | 67 | 28 Per mi.$^2$ |
| Strip (Hayne) | 56 | 16 | 15 | 67 | 41 Per mi.$^2$ |
| Mileage | 47 | | 17 | | 30 Per mi.$^2$ (Known) |
| Shining | 59 | 19 | 26 | 45 | 33 Per mi.$^2$ |
| Shining (index) | 43 | 19 | 13 | 45 | 30 Per mi.$^2$ (Known) |
| Track | 37 | 11 | 7 | 17 | 30 Per mi.$^2$ (Known) |
| Drive | (Agrees closely with strip method by cover types.) | | | | |
| Delury (Eq. 4, gr.) | 78 | - | 1 | - | 77 (Total |
| Delury (Eq. 4, ungr.) | 42 | - | 0 | - | 42 Legal |
| Delury (Eq. 5, gr.) | 68 | - | 0 | - | 68 Bucks) |
| Delury (Eq. 5, ungr.) | 68 | - | 1 | - | 67 |

## The Strip Census

Of the three variations of the strip census method, it has been shown that the King method consistently derives the lowest estimates and that the Hayne method yields the highest estimates. These numbers seem to be respectively too low and too high when compared with estimates by other methods. When the King method is applied by cover types, however, an estimate results which agrees reasonably well with the mileage count and very well with the drive count. It is also in fair agreement with the shining count index estimate.

It is to be recognized that the per cent error stated for the strip method is the maximum, since it was computed from the King type data. Grouping the data by cover types would, of course, decrease the error in the population estimate. Because of the wide confidence limits on the postseason data, however, not enough reliance can be placed on the estimates of the kill to evaluate the techniques. It may be said, though, that since the best estimate is the one midway between the limits, the cover type method is probably the most accurate because it agrees best with other estimates and it gives the closest estimate of the kill.

## The Delury Method

The variation of the Delury method which is most consistent in its estimate is the one applying the regression of C(t) on K(t), giving a preseason estimate of sixty-eight bucks in the Area. This means a buck population of eleven per square mile. This seems to be a rather high ratio for bucks, since about half of the "other deer" are fawns and about thirty per cent of the does are yearlings (from special season kill) leaving a buck to breeding doe ratio of 1: 1.1, assuming that no yearling does breed.

If this ratio is too high for bucks, any of the following factors may be implied:

1. The buck kill was close to one hundred per cent.
2. Bucks migrated into the study area during the hunting season.
3. The preseason population estimate is too low.

Since there was no postseason decrease in the population or buck ratio in the private area which could not be attributed to the known kill in the private area, the high kill of bucks was probably due to the first or third of the above factors rather than the second.

According to the shining counts the sex ratio in the private area was 1: 8 before the season and 1: 14 after the season. Since the preseason population was probably about fifty deer per square mile, giving a ratio for entire area of approximately 26 bucks: 209 other deer, and the known kill was twelve bucks and six does, the postseason ratio would be near 14:203 or 1: 14, as was already computed from the shining data.

Since an increase of ten deer per square mile in the Rifle River Area preseason estimate would change the buck: breeding doe ratio to only 1: 1.4, this (factor no. 3) does not seem to provide an explanation for the seemingly high buck ratio. A contributing factor for this may be that in 1952 the special season kill included thirty does and twelve fawns per buck while the Region II kill was in the ratio of 2.1 does and fawns per buck, where the sex ratio was 1 buck: 3 does $1\frac{1}{2}$ years and older.

In view of the above analysis it seems that a preseason estimate of 68 bucks may not be unreasonable, since a higher buck population would proportionately increase the buck ratio, which is extremely high already.

## Deer Drives

The agreement shown between the drives and the strip census by cover types was brought out on page 20. It is not possible to place confidence limits on the drive data, but if it were, it is likely that they would be as good as those for any of the other methods. This statement is based merely on observations of the drives and noting the efficiency with which they were carried out.

## The Mileage Count

The mileage count seems to give a fairly good estimate of the population when certain biased data are excluded from the computations.

Such a bias is to be expected when counts are made along road-ways, because the presence of the roads introduces a variable which must be treated carefully if the information obtained is to be representative. It seems likely that the mileage count could be employed with reasonable accuracy if the influencing factors are taken into consideration.

## Sex and Age Ratios

The probable preseason sex ratio was discussed under the Delury method and was computed at 1 buck: 1.6 does $1\frac{1}{2}$ years and older. The observed ratios most nearly resembling this were the random and strip methods with ratios of 1:3.9 and 1:3.6 respectively. The results of the other methods indicated buck ratios much lower than the first two mentioned and were probably incorrect.

Doe-fawn ratios observed were as inconsistent as the sex ratios, ranging from 2.1 fawns/breeding doe to .86 fawns/breeding doe, both of which are very improbable. The ratios obtained by the shining and strip methods (1.3 and 1.4 fawns/breeding doe respectively) are comparable to the ratios calculated for Region II (Game Division, Michigan Department of Conservation, unpublished) and may be assumed to be a reasonable estimate of the correct ratio.

Of the four methods used to obtain sex and age ratios the only one that provided a reasonably accurate estimate of both was the strip method.

## Shining Count

The shining technique used in this study to estimate populations from a modified King method resulted in an overestimation of the population. If the average distance to deer as shown in Table 14 for the maximum population estimate is corrected by substituting for it the hypotenuse of a 45 degree right triangle of which the recorded distance is one leg, the population estimate becomes 41 per square mile, which is probably more nearly correct than the original estimate of 59. Since the 45 degrees is only an arbitrary correction figure, the true average angle may more nearly correct the estimate.

The shining counts of deer seen per mile before and after the season also gave a reasonable population estimate (43/mi.$^2$).

## Track Counts

The significance of the almost exact agreement of the track counts on the Rifle River Area and at Cusino may be questioned with some degree of confidence because of the great variability that would be expected from place to place. The difference observed in the George Reserve seems to amplify this viewpoint. The apparent agreement of the former may, however, lend some mutual support to the accuracy of the two counts.

The track counts in the Rifle River Area appear to somewhat underestimate the population. This estimate, however, is subject to an error equal to the sum of the preseason and postseason confidence limits, and therefore cannot be very reliable. Such wide confidence limits will usually apply to any method using both preseason and postseason counts.

## The Time-area Count

The time-area count may be thought of as a modified strip census because it records populations on random sample areas. The main disadvantage of the method is that it requires much more time than the strip method and obtains essentially the same results. If the average area observed in the time-area counts were five acres, the resulting population estimate would be 32 deer per square mile. The two deer seen by this method required eight hours of observation, while in the strip method an average of only one hour was needed to observe two deer.

## Summary

The strip census, which can be carried out on an intensive basis by a small number of workers, was found to give good results when the King variation by cover types was employed. Theoretically, one man could adequately census an area similar to the Rifle River Area by walking sixty-five miles of census strips. This would require a maximum of sixty-five hours of labor, or a minimum of about forty hours under ideal weather conditions.

Delury's regression equation of kill per unit effort and total kill gives a fairly good estimate of the buck population. Grouped data seem to be as good as ungrouped data for this technique. The method can be applied with relatively little effort, but is limited to areas where hunting success can be accurately recorded.

Deer drives were found to give accurate population estimates, but require considerable man power and are limited to areas of relatively easily penetrable cover traversed by frequent roads or openings.

The mileage count gives a reasonably good population estimate, but is affected by an uncontrolable variable-people. An advantage of the mileage count is that it may be applied wherever roads are present and that it requires very little man power.

Accurate sex and age ratios were found to be very difficult to obtain, especially immediately following the open season. For this reason, their usefullness as a census technique is limited.

Shining counts, although consistent, were found to overestimate the population by the King variation when distances were measured perpendicularly from the census route to the animals. However, if distances from the observer to the deer were substituted for the above, the estimates were much more reasonable. Shining counts of deer seen per mile before and after the season also gave a good estimate of the population. The disadvantages of this technique is that the kill must be known in order to obtain an absolute population estimate. The shining method is advantageous, however, in that it may be used wherever roads are located and that it requires very little man power.

Track counts gave a somewhat low population estimate. Individual counts were sometimes extremely variable, making it difficult to determine when a representative count had been made. Track counts are limited to easily dragged roads and require much more work than do shining or mileage counts.

The time area method was found to be rather impractical because of the large amount of time required to obtain results.

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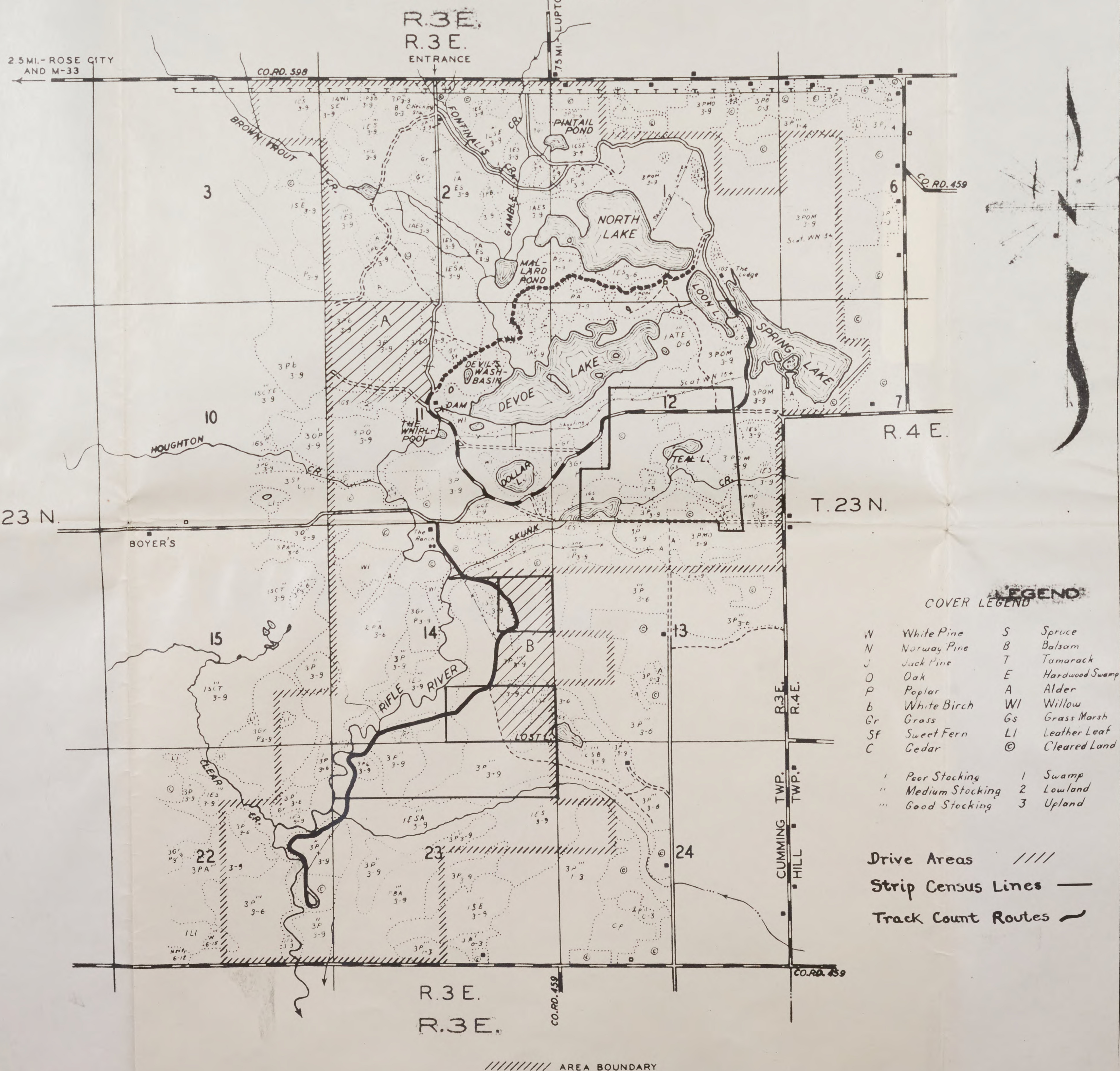
MICHIGAN DEPARTMENT OF CONSERVATION
GAME DIVISION

# RIFLE RIVER AREA

COVER

OGEMAW COUNTY

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