A COMPARISON OF THE DELURY AND PELLET GROUP METHODS IN CENSUSING WHITE-TAILED DEER

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
PAUL ALAN KOOIKER
1972

ABSTRACT

A COMPARISON OF THE DELURY AND PELLET GROUP METHODS IN CENSUSING WHITE-TAILED DEER

By

Paul Alan Kooiker

The DeLury census method enables an estimation of population size through analysis of data on catch per unit of hunter effort. This study was established to test the DeLury method against the deer pellet count census method. The effectiveness of the DeLury method in estimating pre-hunting season sex and age proportions, and in appraising the behavior of the herd throughout the hunting season also was studied. In addition, sources of hunter biases which would affect the deer population estimate were reviewed. Hunter observations as reported by questionnaire were collected at Mid Forest Lodge in Roscommon County, Michigan, during the autumn hunting seasons of 1969 and 1970. A pellet count survey conducted during the spring of 1970 provided a standard of reference.

The DeLury population estimates of 5.0 males per square mile based on buck kills and buck sightings appeared to be accurate, while estimates based on data for total deer or antlerless deer were generally inaccurate and imprecise, primarily due to hunter biases in shooting deer.

A sex proportion of 8.9 percent legal bucks, calculated by comparing the initial rates of sightings of bucks and antlerless deer, appeared to be reasonable, though perhaps slightly low. The total population estimate, based on the estimated sex proportion and legal buck population, was 55.7 deer per square mile; considerably higher than the estimate yielded by the pellet count of 34.3 deer per square mile. It was not possible to calculate age ratios because of the hunters' inability to distinguish fawns from yearling does.

A disproportionately high number of successful hunters responded. A hunter preference for bucks over antlerless deer was established. It was also demonstrated that the vulnerability of the deer herd decreased throughout the season. The relative importance of these factors in influencing the DeLury population estimates was not known, although the first two tended to raise, and the latter to lower, the estimates.

Advantages of the DeLury method over the pellet count are the reduced biologist effort required and the greater amount of information gathered.

A COMPARISON OF THE DELURY AND PELLET GROUP METHODS IN CENSUSING WHITE-TAILED DEER

By

Paul Alan Kooiker

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1972

ACKNOWLEDGMENTS

I wish to extend special thanks to Dr. George A. Petrides, my major professor, for his advice and guidance during this study. I am also grateful to Dr. Wayne Myers, Dr. Leslie W. Gysel, and Dr. Rollin H. Baker for their suggestions and editorial assistance. I express my gratitude to Dr. Walter Conley for his valuable aid in setting up the linear regression computer programs. Further thanks are given to Dr. Ralph I. Blouch of the Michigan Department of Natural Resources, for his initial assistance and for affording me the use of personal data dealing with his earlier pellet count survey.

I would also like to express my sincere thanks to all members of Mid Forest Lodge, especially Mr. H. Delos Nicholie and Dr. John C. Porter, without whose aid and cooperation this study would have been impossible.

Finally, I am deeply grateful to my wife, Marilyn, for her help in typing the final copy of this manuscript, as well as all preliminary drafts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The DeLury method involves the application of regression analysis to "catch per unit effort" data, for the purpose of computing estimates of absolute population sizes. As a population is depleted through harvest removals, the rate of capture of individuals from that population decreases. DeLury (1947) first applied this analysis to fish populations, utilizing records which indicated the number of individuals caught daily and the amount of effort expended in capturing them. More recently, DeLury (1951) elaborated on the calculations employed in this method. Application of the DeLury method to wildlife populations, however, has been limited. Hayne (1949) tested this method on a meadow vole (Microtus pennsylvanicus) population in Michigan. Later studies in Michigan (Howe 1954, Eberhardt 1960) discussed the method in comparisons of various white-tailed deer (Odocoileus virginianus) census techniques, but intensive studies are lacking.

One objective of this study was to obtain a comprehensive comparison of the DeLury method and the pellet group count method. The latter is considered to be a reliable technique, and is probably the best single deer census method in use today (Eberhardt and Van Etten 1956, Ryel and Hawn 1962). For this reason it was chosen as a standard of reference for the DeLury method. Another objective was to determine

the effectiveness of the DeLury method in estimating various parameters of the deer population, especially sex and age ratios. It was felt that this method should also provide information regarding the behavior of the deer herd throughout the open hunting season. A final objective was to appraise the reliability of hunter observations, on which the DeLury studies are most conveniently based.

STUDY AREA

Mid Forest Lodge

The study area was Mid Forest Lodge, a large private hunting club of 18,080 acres located in T21N, R2W, Roscommon County, Michigan. The northeastern Lower Peninsula of Michigan, in which the study area is situated, has long been, and still is, one of the heaviest deer-producing regions in the state. Mid Forest Lodge is bordered on three sides by public lands open to hunting.

Cabins are concentrated around two of the lakes, with the intent of keeping most of the Club land undeveloped. However, approximately 50 miles of dirt roads and trails provide access to all portions of Club lands (Figure A-1).

The number of members is maintained at 400. Hunting is limited to members, their wives, and their minor children. Shareholders who own plural memberships may invite guests on those extra memberships, but no other guests are allowed. The maximum number of registered hunters is normally about 550, although the number actually hunting at any given time is considerably less.

The Club has always been very cooperative in donating the use of their land and facilities to wildlife and fisheries researchers. Two of the most recent wildlife studies on Mid Forest Lodge were those of Blouch (1963) and McNeill (1971).

Topography and Soils

The area is characterized by level glacial-outwash plains and rolling to hilly moraines (Michigan Department of Conservation 1924). Dry, sandy soils of the Roselawn, Grayling, Rubicon, and Saugatuck types predominate (Figure A-2) and cover nearly 80 percent of the area (Blouch 1963). These soil types are characterized by low moisture content, low natural fertility, and high acidity. The moderately fertile sandy loams of the Roselawn and Ottawa series are the next most common. Scattered throughout the Club are swamps and marshes.

Vegetation

The vegetation is predominately of aspen and oak forest types (Figure A-3) which invaded following the disappearance of the original white pine through logging and fires. The oak type occupies 43 percent of Club property (Westell 1958). Most is low-quality pole-size red oak (Quercus rubra). The aspen type comprises 39.5 percent of the area. Trembling aspen (Populus tremuloides) and bigtooth aspen (Populus grandidentata) are both present. Openings occupy 10.4 percent of the acreage. Most are less than 10 acres in size, but there are at least a dozen openings of 40 to 200 acres (Blouch 1963). Coniferous swamps, so important as winter habitat for deer, comprise only 1.5 percent of the Club land (Westell 1958). The principal conifer is balsam fir (Abies balsamea), though white cedar (Thuja occidentalis) and black spruce (Picea mariana) are also present.

METHODS

Pellet Group Count

For the purposes of this study, the population estimates resulting from the pellet group counts were assumed to indicate the average size of the winter deer herd. The various estimates from the DeLury method were judged for accuracy against this standard.

The techniques used for the pellet group survey were similar to those used annually in Michigan, and included a sampling modification developed by Blouch (1961). To insure that the areas with the highest deer populations were sampled most intensively (Eberhardt 1957), the Club was divided into five strata based on expected deer densities (Figure 1) derived from earlier pellet group surveys (Blouch 1963). The number of course lines assigned to each stratum was proportional to the product of the relative estimated deer density and the relative area of each stratum (Table 1). A sixth stratum was composed of 25 feeding sites dispersed throughout the Club. It was not feasible to determine the relative estimated deer density for these sites, so sampling frequency could not be determined by normal procedures. Twenty percent of the feeding sites were sampled, since this closely approximated the average sampling rate of course lines over the entire Club. Consequently, one plot was randomly located on each of the five feeding sites (Table 1).

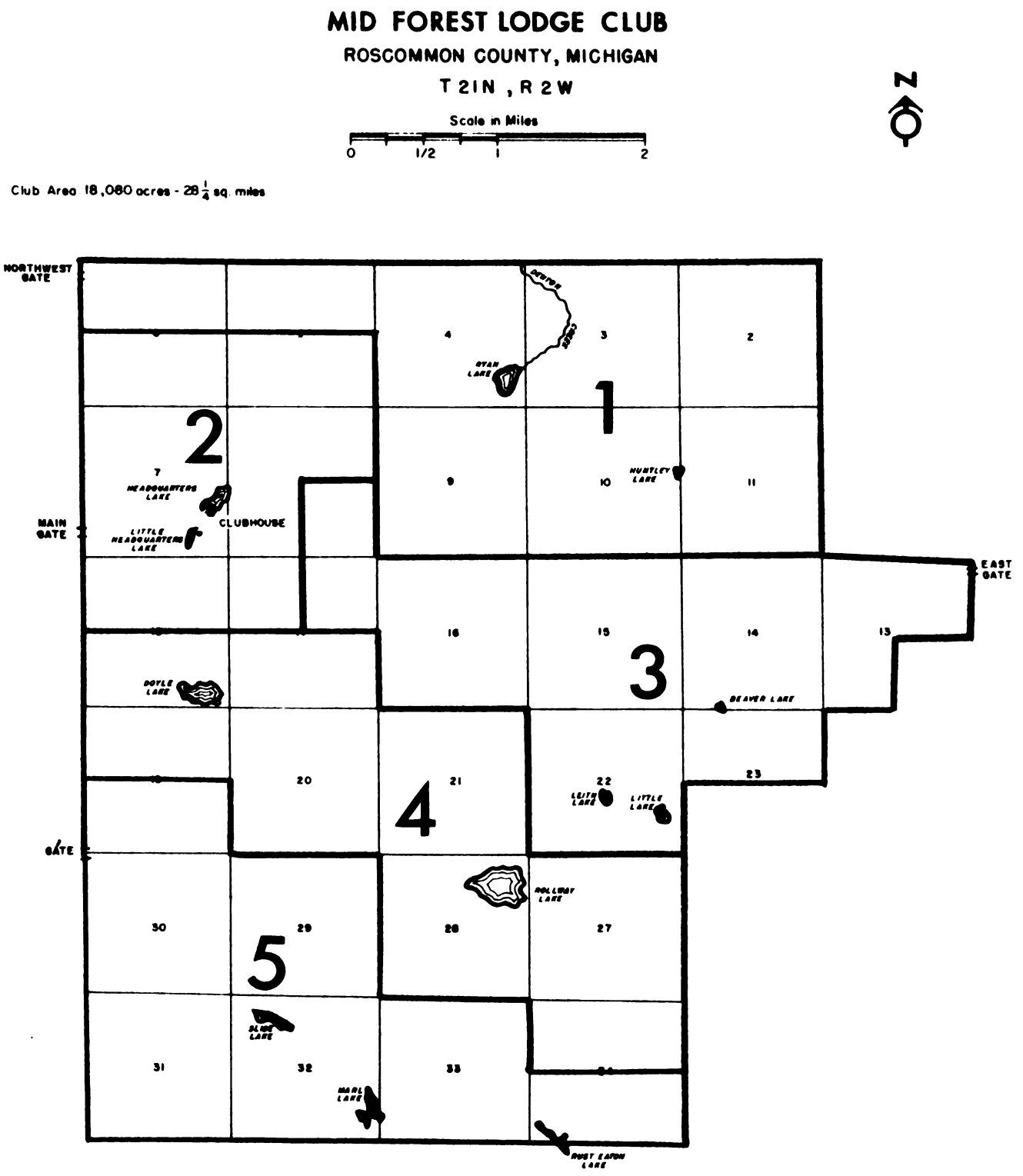


Figure 1. Stratification employed in 1970 pellet group survey, Mid Forest Lodge.

Table 1. Number of sample plots per stratum for deer pellet group survey on Mid Forest Lodge, spring of 1970, Roscommon County, Michigan.

Stratum	Relative* Estimated Deer Density	Relative** Area	Relative*** Sampling Frequency	Number of Quarter-Sections	Number of Plots
1	3.90	2.00	7.8	9	72
2	2.80	1.00	2.8	3	24
3	3.20	1.65	5.3	6	48
4	3.00	1.70	5.1	6	48
5	1.00	1.70	1.7	2	16
6****	---	.00	---	---	5

* Product of relative estimated deer density and relative area.

** Relative to Stratum 5, that with the lowest estimated deer density.

*** Relative to Stratum 2, that with the least area.

**** Stratum 6 was composed of 25 feeding sites. Relative estimated deer density could not be determined. Twenty percent of the sites were sampled with one plot in each for a total of five plots.

Each square mile section was divided into four quarter-sections extending east-west across the section. Within each stratum, quarter-sections were numbered consecutively and then chosen to the intensity previously determined, using a table of random numbers (Figure 2). Two course lines, each with 4 plots spaced 20 chains apart, were randomly placed within the quarter-section. The location of the first plot of each course line was selected randomly within 20 chains of the east or west edge of the quarter section. The area of each plot was 1/50 acre (12' x 72.6').

Blouch (1963) determined that 30 quarter-sections would be statistically adequate for an unstratified sample. Since stratification results in a more efficient use of time and manpower, it was concluded that 26 quarter-sections (208 plots) would be adequate for this survey.

The field work was begun in the spring of 1970 before any new vegetative growth had arisen to obscure pellet groups. Pellet groups within each plot were counted and recorded as "old" or "new", depending on whether deposition was judged to have occurred before or after the date of leaf fall, October 22, 1969. The forest cover type of each sample plot was also recorded. Sixty-five man-hours of work were required to run the 26 quarter-sections.

Population estimates were calculated for each stratum and summed to give an estimate of the total deer population on Mid Forest Lodge. Standard errors of the mean were calculated for each stratum and 95 percent confidence limits were established. Confidence limits at the 95 percent level for the total population estimate were computed using the method suggested by Cochran (1953) for stratified

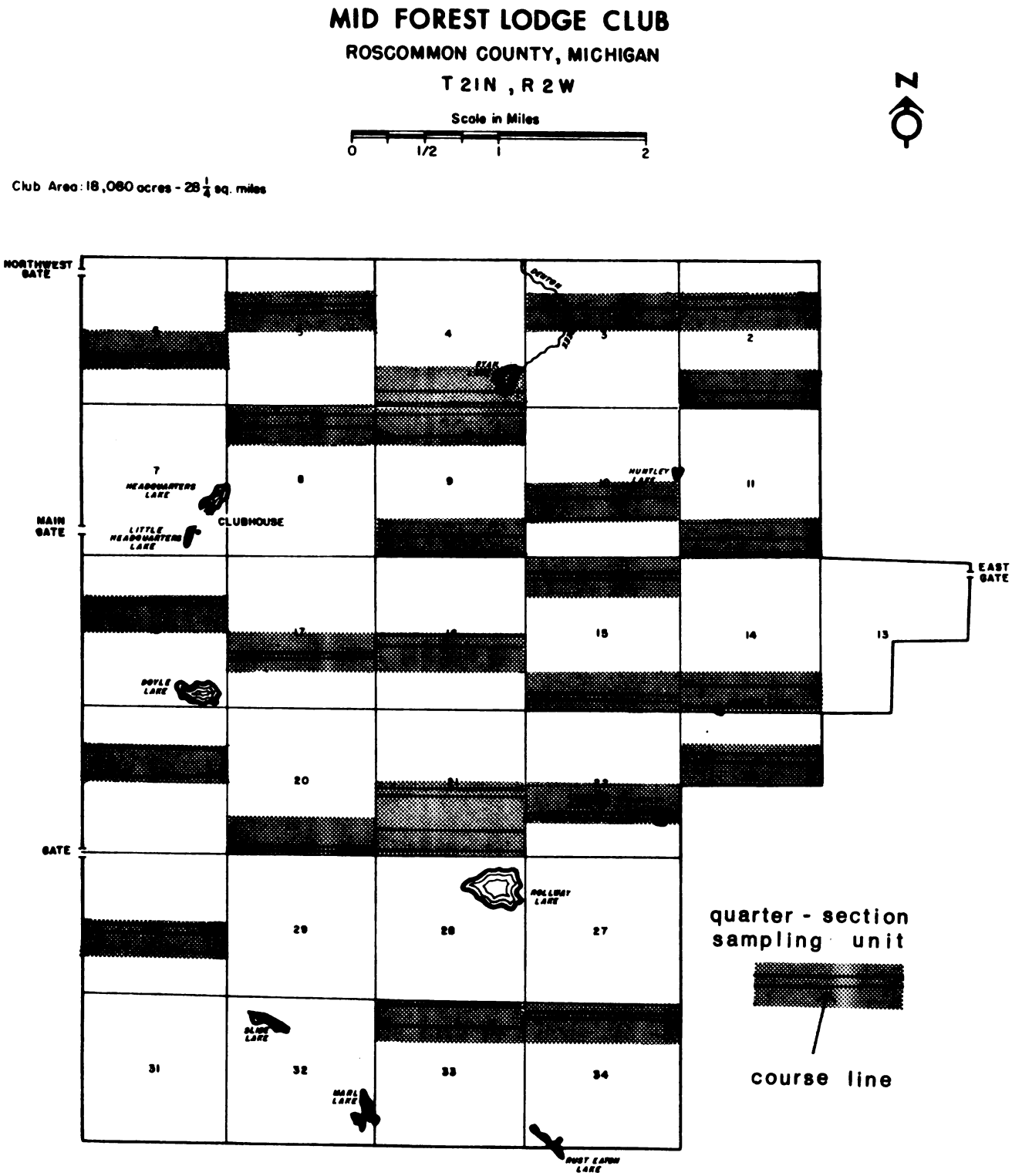


Figure 2. Deer pellet count courses, 1970 survey, Mid Forest Lodge.

samples, as used by the state of Michigan in analysis of the annual pellet group survey.

A deer defecation rate of 12.7 groups/deer/day was used (McCain 1948, Eberhardt and Van Etten 1956, Ryel 1959, Eberhardt 1960). Corrections made for deer removals after leaf fall included the 1969 deer kill and an assumed crippling loss of 10 percent of the kill (Blouch 1961). Since the pellet groups tallied were accumulated over the entire period between leaf fall and the spring survey, the population estimate which resulted applies to that entire period and reflects the average deer density then. No allowance was made for starvation or other winter losses because data were lacking.

DeLury Census Method

Catch-effort data obtained from hunter observations allowed calculation of the following values:

$C(t)$ = catch per unit effort for time interval t

$K(t)$ = total catch up to and including the tth interval

$E(t)$ = total effort up to and including the tth interval

DeLury (1947) demonstrated that the values of $C(t)$, $K(t)$ and $E(t)$ were theoretically related as indicated in the two equations:

(1) $C(t) = kN(o) - kK(t)$

(2) $\log C(t) = \log (kN(o)) - k \log e\, E(t)$

Where:

$N(o)$ = initial population

k = the proportion of the population taken per unit of effort

$\log e$ = 0.4342945, transforms log values from base 10 to base e

$\log$ = logarithm to base 10

Equation (1) involves plotting $C(t)$ against $K(t)$, while Equation (2) corresponds to the graph of $log\ C(t)$ against $E(t)$. The appropriate method of fitting a line to these points which adequately describes the behavior of the population must be decided. DeLury (1947) argues that if the graphs were reasonably straight, then Equations (1) and (2) could be fitted as if they were linear regression equations. In this case $K(t)$ and $E(t)$ are treated as independent variables and $C(t)$ and $log\ C(t)$ as dependent variables. Regression analysis would then yield a straight line with y intercept $kN(o)$ and slope $-k$, or intercept $log\ kN(o)$ and slope $-k$, for Equations (1) and (2) respectively. With the regression equations constructed, it follows that the estimates of k and $N(o)$ for Equation (1) are $-b$ and $-a/b$, and for Equation (2) are $-\frac{b}{.4342945}$ and $-\frac{antilog\ a}{b/.4342945}$. Equation (1) provides a graphical estimate of $N(o)$, given by the intercept of the regression line on the abscissa.

Theoretically, these equations cannot be put in the form of a linear regression equation, but are more accurately described by non-linear regression analysis (Myers, in conversation). In both of the DeLury equations the y intercepts $kN(o)$ and $log\ kN(o)$ are complex terms which include the value of the slope, k. In linear regression, the values of a and b are independent of each other, and are fixed values. Therefore, DeLury (1947) applied linear regression analysis only to obtain estimates of these complex terms, which could then be used to estimate the parameters desired, k and $N(o)$.

If the following assumptions are met, a straight line graph is insured, and linear regression analysis can be applied with reasonable confidence.

1) The population is closed; i.e., the effects of emigration, immigration, and natural birth and mortality during the sampling period are negligible.
2) The units of effort employed during interval t do not compete with or enhance each other.
3) Each unit of effort takes a constant proportion of the population; i.e., k = a constant.

DeLury (1947) states that any departure of the graph from complete linearity indicates a lack of one or more of these assumptions. Unfortunately, however, straight-line slopes may still occur if there is a regular percentage change in the number of animals on the area or if there is a similarly regular change in the vulnerability of the species to being seen or shot (Petrides, unpublished).

The fisheries term "catch" as applied to deer, can refer to either deer "kills" or "sightings" (Howe 1954). The most obvious difference between the two is that kills represent captures without replacement, while sightings are captures with likely replacements (resightings). However, both the decreasing rates of kill and rates of sighting may be plotted throughout the season against the cumulative kill as deer are removed from the herd.

Catch-effort data were collected by surveying the hunters on Mid Forest Lodge during the November firearms deer seasons of 1969 and 1970. Questionnaires were distributed to the members and their guests as they arrived at Mid Forest. Each hunter was required to register with gate keepers at either of the two entrances to the Club. Whenever possible, a brief oral explanation of the research study accompanied

the distribution of the questionnaires. Questionnaires were also placed at strategic locations within the Club for those hunters who did not receive one at the gates.

Two types of questionnaires were used. The questionnaire distributed to most members asked for the number of deer seen daily, differentiated by sex (adults only) and age (fawn vs. adult), and the number of hours hunted each day. The first two days of the hunting season were split into half days, due to the large number of observations expected during this period. The sex and age of any deer killed were also requested, as well as the date and location of the kill. A second type of questionnaire was distributed to a small group of cooperating hunters, who recorded the above data by half-days throughout the season. The questionnaire also requested daily information on weather conditions.

To reduce errors of memory, hunters were requested to fill in the forms after each day of hunting, and were reminded continuously throughout the season to do so. The questionnaires were collected when members were through hunting for the season. Reminders were later mailed to members who had not returned their questionnaires.

It was felt that grouping the data into eight approximately equal units of effort would reduce the variance of the distribution, as well as simplify the analyses (Howe 1954). The catch per unit of effort, $C(t)$, was computed for each time interval. The paired values of $C(t)$ against $K(t)$, and $\log C(t)$ against $E(t)$, were then entered into a computer program of basic linear regression. It has been demonstrated (Petrides, unpublished) that the use of the summed kill

$K(t)$ interpolated to the midpoint of each time interval, rather than the summed kill at the beginning or end of the interval more accurately reflects the true situations in each time period. The computer printout included the regression equation, confidence limits of the slope, analysis of variance, and the actual graph of the regression equation. The values of k, $kN(o)$, or $log\ (kN(o))$, obtained from the regression equation, allowed immediate estimation of $N(o)$.

The 1969 catch-effort data were divided into the following six categories and analyzed as described above:

1. Buck kills
2. Antlerless kills
3. Total kills
4. Buck sightings
5. Antlerless sightings
6. Total sightings

"Bucks" included legal males only, those with 3-inch spikes or longer. These were generally yearlings or older. "Antlerless" deer included sub-legal males and all females, i.e., "permit" deer. Both of the DeLury equations were applied to each of the above categories, resulting in 12 possible population estimates. For instance, the value "buck kills per hour" was plotted against the "summed buck kills at the midpoint of time interval t", and the value "log of buck kills per hour" was plotted against the "summed hours at the midpoint of time interval t". The 1970 data, however, allowed analyses of only buck kills and buck sightings, since no antlerless or total data could be obtained due to a moratorium on antlerless hunting in effect during that deer season.

Club Records

All members and guests had to register to hunt, and were required to report their success at the end of the season. All vehicles were checked for deer as they left the Club. These results were used as a check on the kill data obtained from the questionnaires. The actual daily kill was provided by the Club, while other data, such as past kill records and results of the annual track count, were made available by individual members. Blouch (1963) felt that the gate registration forms provided a very accurate record of hunting pressure and legal kill.

RESULTS AND DISCUSSION

Pellet Group Count

Population estimates, corrected for fall and winter deer removals (Blouch 1961), were calculated for each stratum individually (Tables A-1 - A-6) and then summed (Table 2). The estimated 1970 average winter-spring deer population on Mid Forest Lodge was 25.8 deer per square mile. The 1969 pre-hunting season population, calculated by adding fall deer removals to the estimated 1970 winter-spring population, was 34.3 deer per square mile.

The mean, $\bar{x}_{st.}$, and standard error for the stratified sample were computed according to Cochran (1953) as follows:

$$\bar{x}_{st.} = w_1\bar{x}_1 + w_2\bar{x}_2 \ldots . w_n\bar{x}_n$$

$$S.E. = \sqrt{\sum \frac{w_j{}^2 s_j{}^2}{n_j}}$$

Where:

w_n = proportion of the total area in each stratum

$\bar{x}_j$ = mean number of pellet groups per course for stratum j

$s_j{}^2$ = variance of stratum j

n_j = number of courses in each stratum

Confidence limits at the 95 percent level were ±21.2 percent of the population estimate (Table 2).

Table 2. Results of 1970 spring pellet group survey, Mid Forest Lodge, Roscommon County, Michigan.

Unit	Square Miles	Deer Removal*		Population Estimates				
				Winter-Spring 1970		Fall 1969		
		Deer Losses	Losses Per Sq. Mile	Total Deer	Deer Per Sq. Mile	Total Deer	Deer Per Sq. Mile	95 Percent Confidence Limits**
Stratum 1	7.0	73	10.4	308	44.0	381	54.4	± 32.4%
Stratum 2	3.5	9	2.5	44	12.6	53	15.1	± 40.0%
Stratum 3	5.75	67	11.7	183	31.8	250	43.5	± 47.7%
Stratum 4	6.0	62	10.3	87	14.4	149	24.7	± 20.6%
Stratum 5	6.0	30	5.0	94	15.6	124	20.6	± 66.7%
Stratum 6	.013	---***	---	13	985.6	13	985.6	± 14.5%
Total	28.26	241	8.5	729	25.8	970	34.3	± 21.2%

* 1969 fall hunting kill plus 10 percent crippling loss.

** Expressed as a percentage of the estimate.

*** Deer removals for Stratum 6, the feeding sites, could not be determined reliably.

DeLury Census Method

Hunter Response

In 1969, 20.0 percent of registered hunters returned a completed questionnaire. This figure rose to 33.2 percent in 1970, probably because considerably more hours were spent in contact with hunters during that deer season. It was found that hunters had to be constantly reminded to fill in and return their questionnaires.

A comparison of actual and reported hunter response indicated that the percentage of successful hunters returning questionnaires was greater than the actual percentage of successful hunters (Table 3). The percentage of unsuccessful hunters reporting was less than the true percentage of hunters who failed to shoot a deer. These trends were apparent for both 1969 and 1970. It was also noticed that of the successful hunters, those who shot bucks were more likely to reply than those who shot antlerless deer.

The above observations were not surprising. It is obvious that a successful hunter, especially one who shot a buck, would be more inclined to publicize his hunting exploits than would an unsuccessful hunter. In addition, many hunters assumed that their reports were useless if they did not kill a deer. Consequently, the sample was not completely random. The higher proportion of successful hunters reporting resulted in an overestimate, since the entire regression line was shifted to the right. This agrees with earlier findings that population estimates based on voluntary reports tend to be biased in the direction of overestimation (Hayne and Eberhardt 1954). It is likely that buck sightings, as well as buck kills, were "over-reported",

Table 3. Hunter response to questionnaires distributed on Mid Forest Lodge during the November firearms deer seasons of 1969 and 1970, Roscommon County, Michigan.

1969 Percentage of Registered Hunters Returning Questionnaires		20.0%
	Actual	Reported
Percentage of Hunter Success	38.9	52.4
Percentage of Buck Success	17.4	26.7
Percentage of Antlerless Success	21.5	25.7
Percentage of Unsuccessful Hunters	61.1	47.6

1970 Percentage of Registered Hunters Returning Questionnaires		32.2%
	Actual	Reported
Percentage of Hunter Success	11.9	18.2
Percentage of Buck Success	11.9	18.2
Percentage of Antlerless Success	0.0	0.0
Percentage of Unsuccessful Hunters	88.1	81.8

since successful buck hunters tend to see more bucks than unsuccessful hunters.

Population Estimates

Population estimates based on Equation 1

$$C(t) = kN(o) - kK(t)$$

exhibited more consistency and a greater degree of statistical significance than did the estimates derived from Equation 2

$$\log C(t) = \log (kN(o)) - k \log e \, E(t)$$

(Tables 4 and 5). These results agreed with previous findings that Equation 1 is a more reliable estimator of the deer population (Howe 1954). In addition, less information is available by Equation 2 since no theory has been developed to supply confidence limits to estimates based on this equation (DeLury 1951). Furthermore, any zero values of $C(t)$ in the data render the estimates based on Equation 2 indeterminable, since $\log 0$ is meaningless (Table 5).

The consistency of the buck data in particular, for both 1969 and 1970, was demonstrated by the fact that estimates of the legal buck population based on buck sightings and on buck kills were nearly identical (Table 4). Statistically those population figures were very significant; i.e., there was little deviation of the points from the fitted regression line. However, estimates based on antlerless data were in all cases inconsistent and statistically non-significant.

The disparities between buck and antlerless data were primarily due to hunter bias. Many hunters on Mid Forest Lodge apparently passed up antlerless deer early in the season and waited for a shot at a buck.

Table 4. Deer population estimates based on DeLury Equation 1: $C(t) = kN(o) - kK(t)$, Mid Forest Lodge, Roscommon County, Michigan, November 1969 and 1970.

Source*	$kN(o)$	k	F value**	$N(o)$***	95% Conf. Limits of $N(o)$		$N(f)$****
					L_1	L_2	
			1969				
Total Kills	.04235	-.00070	72.7 s.	302	225	460	64
Buck Kills	.04156	-.00149	58.6 s.	140	102	219	30
Antlerless Kills	.01087	-.00019	1.0 n.s.	286	86	---*****	157
Total Sightings	1.29866	-.00957	3.3 n.s.	678	288	---	442
Buck Sightings	.10681	-.00380	39.8 s.	141	91	229	31
Antlerless Sightings	1.09210	-.01151	1.5 n.s.	474	159	---	347
			1970				
Buck Kills	.03783	-.00127	322.3 s.	90	78	105	25
Buck Sightings	.08631	-.00271	76.4 s.	94	78	118	29

* Graph of rate of kills or sightings plotted against corresponding cumulative kill; data grouped.

** s = significant; n.s. = non-significant.

*** Population estimate, $N(o)$, is based on the source, buck, antlerless or total kills or sightings. (1969 corrected for 20.0% return; 1970 corrected for 33.2% return.)

**** $N(f) = N(o)$ - (kills + 10% crippling loss), where $N(o)$ = pre-season population and $N(f)$ = post-season population.

***** The population estimate is undetermined, since the slope is positive at the upper confidence limit.

Table 5. Deer population estimates based on DeLury Equation 2: *log C(t) = log (kN(o)) - k log e E(t)*, Mid Forest Lodge, Roscommon County, Michigan, November 1969 and 1970.

Source*	*kN(o)*	*k*	*F value***	*N(o)****	*N(f)*****
			1969		
Total Kills	-1.36795	-.00074	45.54 s.	176	<0
Buck Kills	11.59651	-.12489	1.04 n.s.	---*****	---
Antlerless Kills	-1.99411	-.00023	.98 n.s.	132	3
Total Sightings	.03219	-.00009	1.06 n.s.	32,254	35,216
Buck Sightings	-1.20190	-.00094	16.70 s.	201	91
Antlerless Sightings	.01167	-.00007	.77 n.s.	45,840	45,711
			1970		
Buck Kills	102.54383	-.18344	15.88 s.	---	---
Buck Sightings	-1.33040	-.00055	13.09 s.	256	191

* Graph of the log of rate of kills or sightings plotted against the sum of gun-hours; data grouped.

** s = significant; n.s. = non-significant.

*** Population estimate, *N(o)*, is based on, and applies to, the source, buck, antlerless or total kills or sightings. (1969 corrected for 2010% return; 1970 corrected for 33.2% return.)

**** *N(f) = N(o)* - (kills + 10% crippling loss), where *N(o)* = pre-season population and *N(f)* = post-season population.

***** Zero values of *C(t)* render estimate indeterminable, since *log* 0 is meaningless.

If still unsuccessful late in the season, they settled for an antlerless deer. Therefore, antlerless deer were not killed at a constant rate throughout the season. Furthermore, bucks and antlerless deer were not killed proportionately throughout the season (Figure 3); therefore, the corresponding kill rates (or sighting rates) did not decline proportionately. If all assumptions were met, it would be expected that the sum of the estimated legal buck and antlerless populations would equal the estimated total population. This was not the case (Table 4), and was a reflection of the error in the antlerless data. The relatively large number of late-season antlerless kills would be expected to result in an overestimate of the antlerless, and therefore of the total, population.

Contrary to expectations, the antlerless and total population estimates appeared to be too low (Table 4). The underestimate of the antlerless population was likely due to a gradual decrease in vulnerability of the deer throughout the season. During the 1970 hunting season, only legal bucks were killed due to a moratorium on antlerless hunting. Yet the rate of sightings of antlerless deer declined throughout the season (Table 6), even though no antlerless deer were harvested. Emigration of deer from Mid Forest Lodge also would lower the sighting rates. However, emigration during the hunting season was unlikely since hunting pressure was lighter on the Club than on the surrounding public lands. It seems reasonable that the cause of lower sighting rates was an increased wariness of the deer due to human disturbance during the hunting season. A similar situation is being documented for pheasants on a heavily hunted area (Petrides,

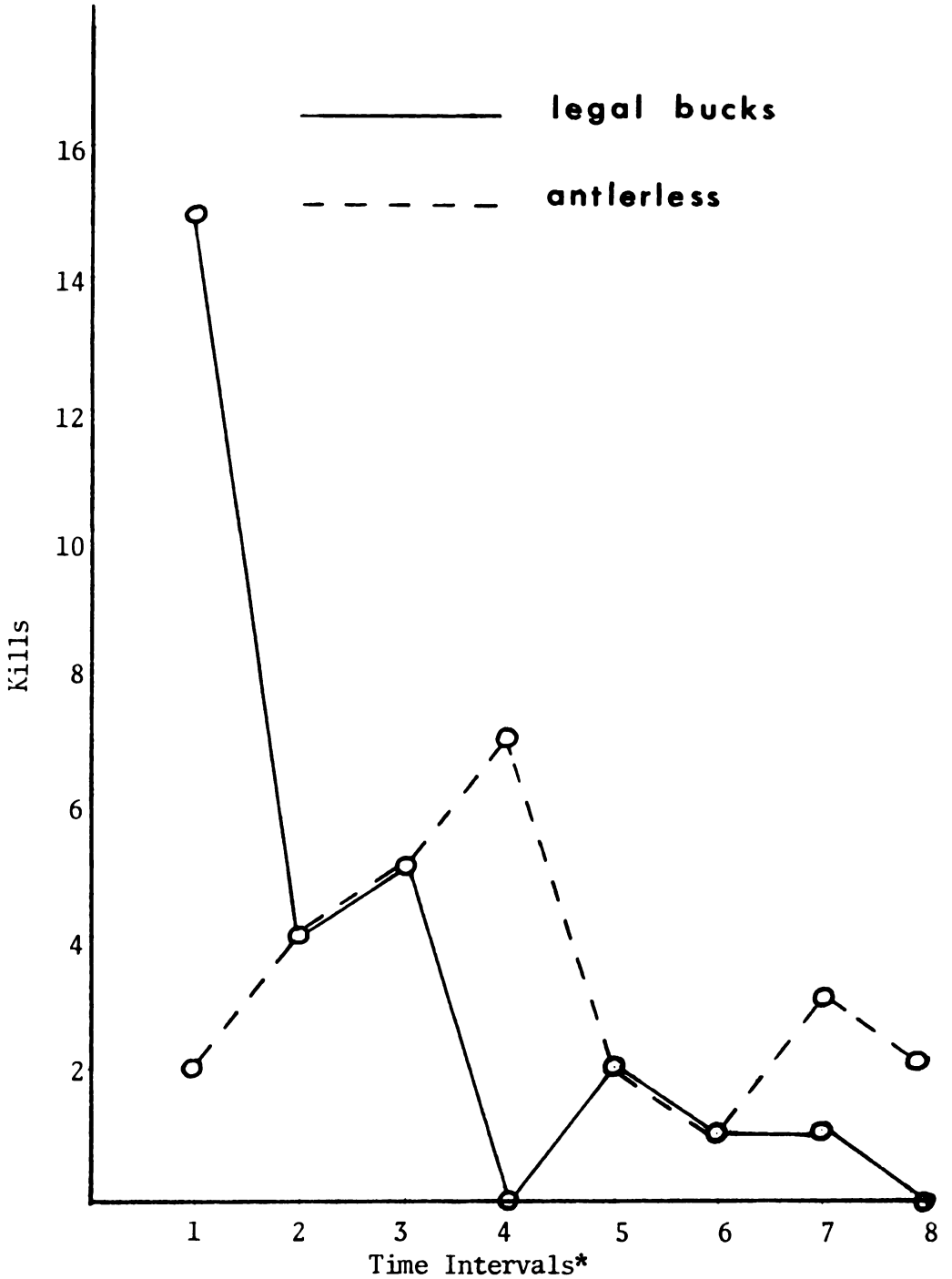


Figure 3. Number of reported kills in each time period for legal bucks and antlerless deer throughout 1969 fall hunting season, Mid Forest Lodge, Roscommon County, Michigan

* Intervals contain approximately equal numbers of hunter hours.

Table 6. Decreasing rates of sightings for antlerless deer during the November 1970 hunting season even though no antlerless deer were killed, Mid Forest Lodge, Roscommon County, Michigan.

Time Intervals*	Number of Antlerless Deer Seen per Hour
November 15 a.m.	.995
November 15 p.m.	.604
November 16 a.m.	.588
November 16 p.m.	.392
November 17	.473
November 18-19	.348
November 20-22	.478
November 23-30	.517

* Intervals contain approximately equal numbers of hunting hours.

in conversation). In accordance with this reasoning, the initial rates of sightings and kills were high as the youngest and most susceptible deer were seen and killed first. The survivors likely were those which were most adept at evading hunters; hence vulnerability of the deer herd as a whole decreased.

The buck data were less subject to hunter bias, since most hunters tended to shoot bucks as they were encountered. As a result, the decline in the rate of kill or rate of sightings throughout the season was constant, as indicated by straight line graphs (Figures 4 and 5). The estimate of 140 bucks (5.0 bucks per square mile), based on either buck kills or sightings, was considered reliable because of this evident lack of bias as well as the consistency of the two estimates (Table 4). The reliability of this estimate was further substantiated by an examination of kill data. As the estimated legal buck population decreased by 36 percent from 1969 to 1970, the actual kill of legal bucks dropped by 41 percent. The hunting pressure in both years was almost identical. However, it would be dangerous to conclude that this consistency in kill trends insured accuracy of the actual buck estimate. If it was assumed that bucks, as well as antlerless deer, decreased in vulnerability throughout the season, then the buck population also may have been underestimated somewhat.

Sex and Age Proportions

If it can be assumed that all segments of the deer herd were equally susceptible to being seen prior to the hunting season, then since the number of legal bucks was known fairly accurately, the total population size could be calculated. The comparison of initial

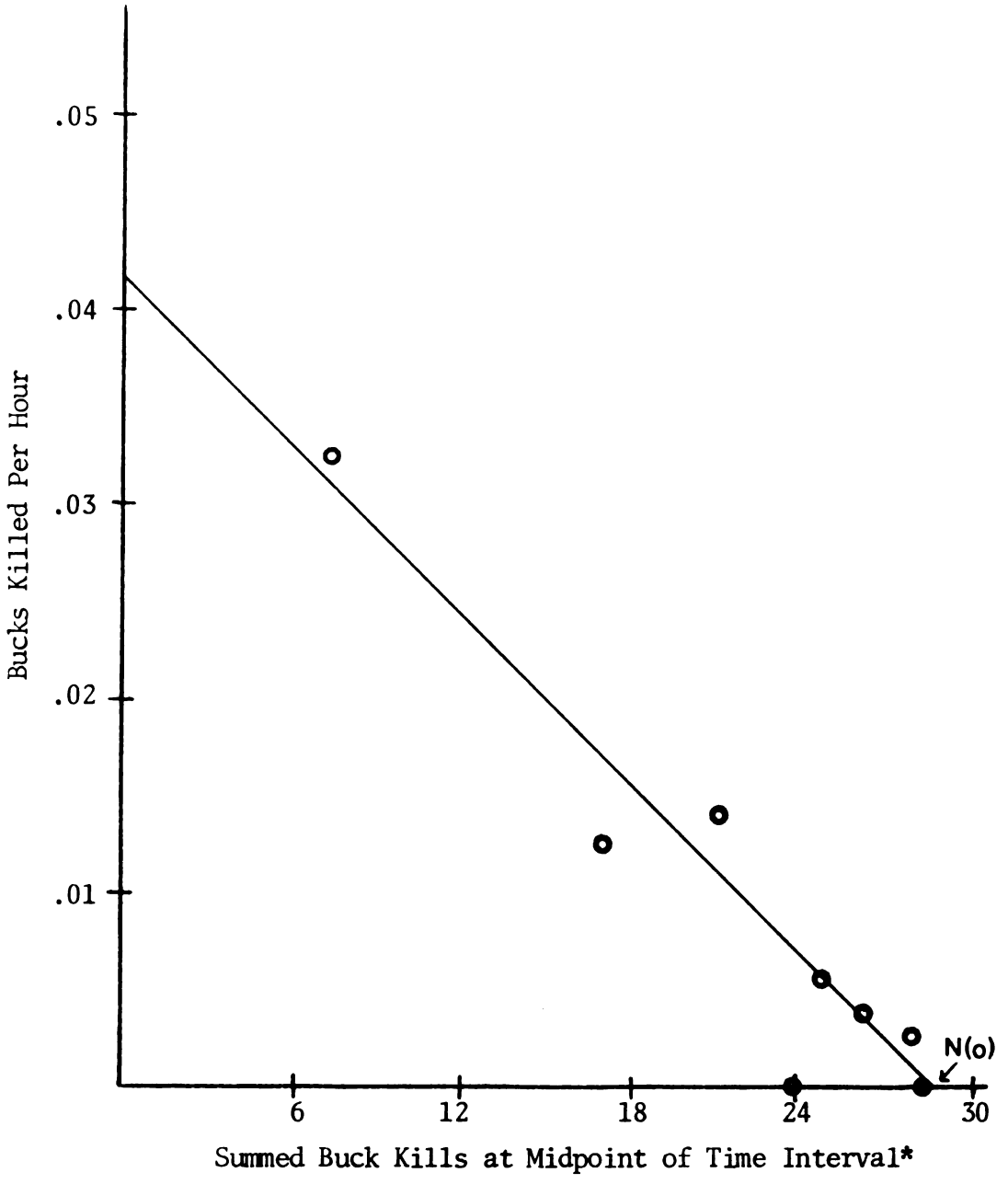


Figure 4. Rate of decline of buck kills during 1969 deer hunting season, Mid Forest Lodge, Roscommon County, Michigan.

* Values represent a 20.0 percent sample, so $N(o)$ = 28.0/.200 = 140 bucks.

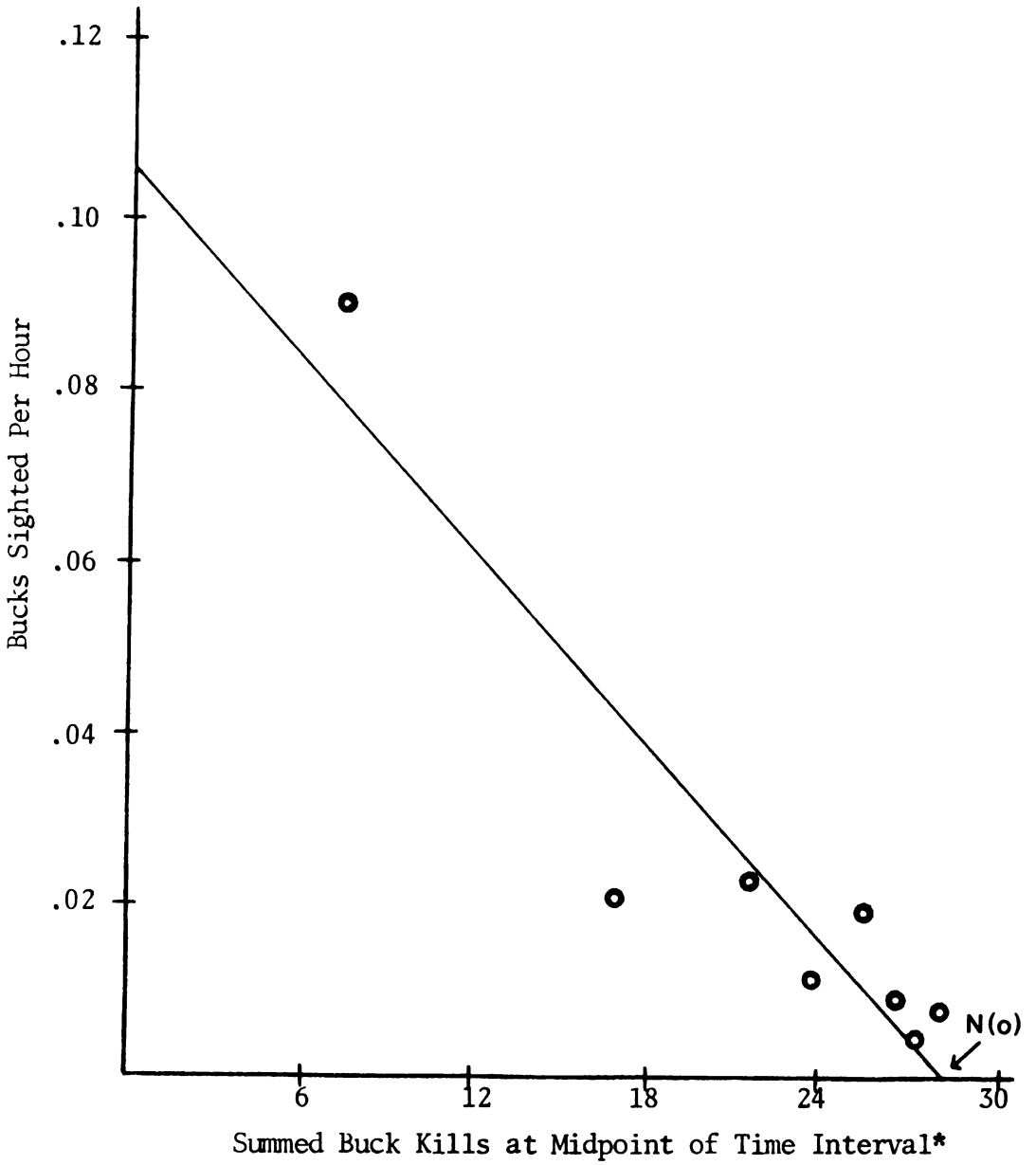


Figure 5. Rate of decline of buck sightings during 1969 deer hunting season, Mid Forest Lodge, Roscommon County, Michigan.

* Values represent a 20.0 percent sample, so $N(o)$ = 28.1/.200 = 141 bucks.

sighting rates for legal bucks and antlerless deer should provide a valid sex proportion. These original rates are indicated by a, the calculated intersections of the regression lines on the ordinate (Figure 6).

The percentage of legal bucks in the pre-season population, m_1, was computed using the formula

$$m_1 = \frac{a_M}{a_M + a_F} \times 100$$

and was found to be 8.9 percent. Eberhardt (1960) reported that the percentage of legal bucks in Roscommon County over the period 1952-1958, based on Michigan Department of Natural Resources' random summer counts, ranged from 14 to 18 percent with an average of 15.2. Blouch (1963) found that over the four year period from 1958 to 1961, the average percentage of legal bucks on Mid Forest Lodge was 13.2 percent, based on summer-fall road counts. By 1969, the estimated proportion of legal bucks in Roscommon County, again based on random D.N.R. summer counts, had dropped to 9.4 percent (Michigan Department of Natural Resources 1969). This value agrees very well with the present estimate of 8.9 percent legal bucks and increases the credibility of the DeLury method as an estimator of sex proportions. Evidently, the percentage of legal bucks in Roscommon County, and on Mid Forest Lodge, has undergone a marked decline in the last 20 years.

On the basis that 140 legal bucks, as determined by the DeLury regression of buck kill or sighting rates on the sum of buck kills, comprised 8.9 percent of the population, the entire 1969 fall population must have been 55.7 deer per square mile. This is considerably higher than the pellet count population estimate which,

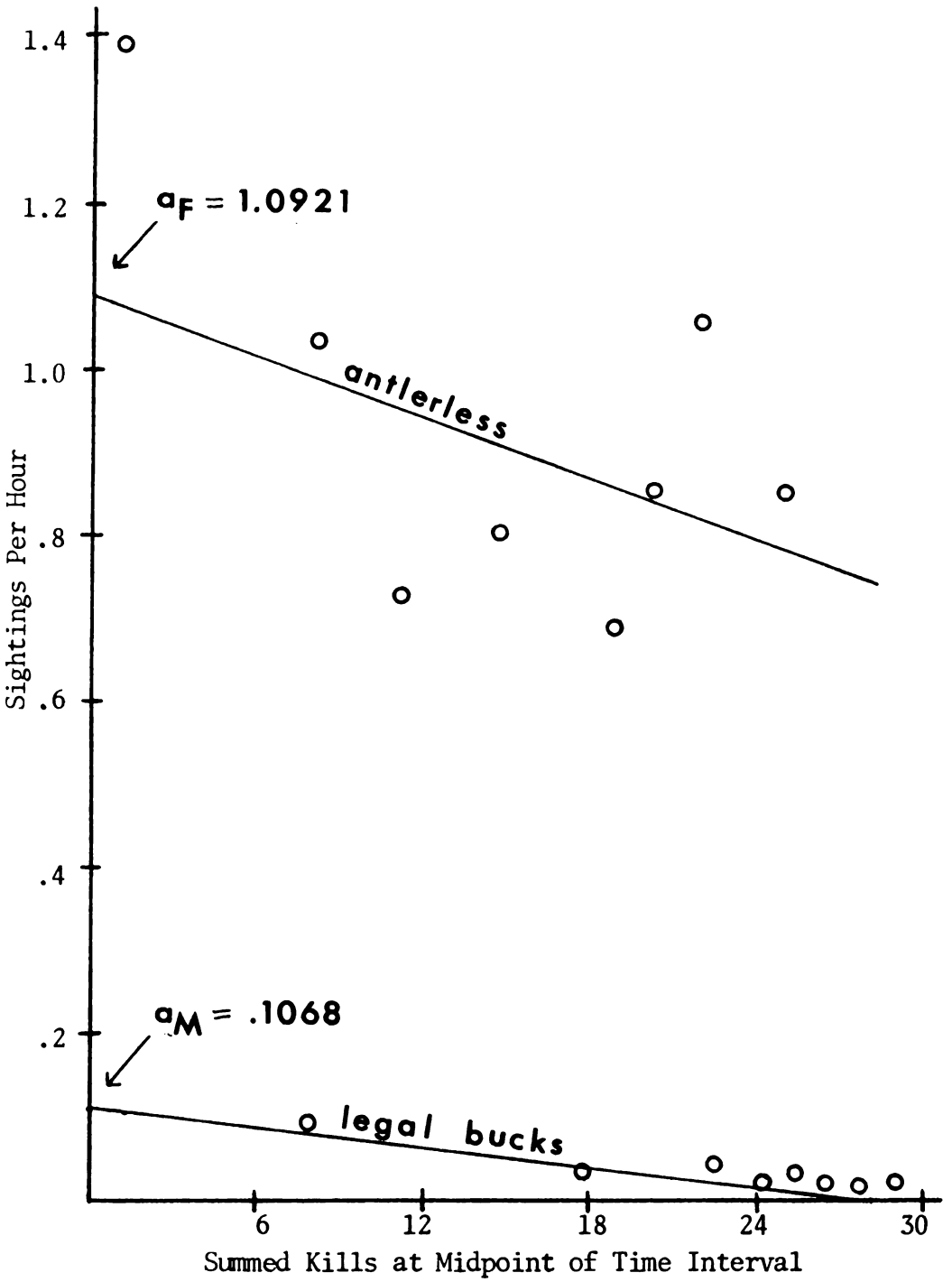


Figure 6. Determination of sex proportions by comparison of calculated initial rates of sightings, November 1969, Mid Forest Lodge, Roscommon County, Michigan.

corrected to pre-season levels, was 34.3 deer per square mile. Several possibilities exist which might account for this discrepancy. (1) It is possible, but not probable, that the pellet group census is in error. (2) An underestimate of a_M due to a greater wariness of bucks over antlerless deer, however, would lead to an underestimate of m_1, and result in an overestimate of the total fall population by the DeLury method. Such greater wariness in male deer agrees with McNeill's observations (1971) that antlerless deer react more slowly to hunter disturbance than do bucks. (3) Emigration of deer from Mid Forest Lodge after the hunting season could result in an underestimate of the winter-spring (and hence, by correction, the fall) population by the pellet count method. Deer may emigrate during early winter in order to reach traditional yarding areas outside of the Club, or to find better browse conditions before yarding occurs. The extent to which each of these factors contributes to the discrepancy between the two population estimates is not known, but it appears that the DeLury sex proportion estimate of 8.9 percent legal bucks is reliable and the higher figure for the fall population may be correct.

The decision to hunt "bucks only" during the 1970 hunting season precluded collection of data on antlerless deer at that time. Calculation of sex proportions, therefore, was not possible in 1970.

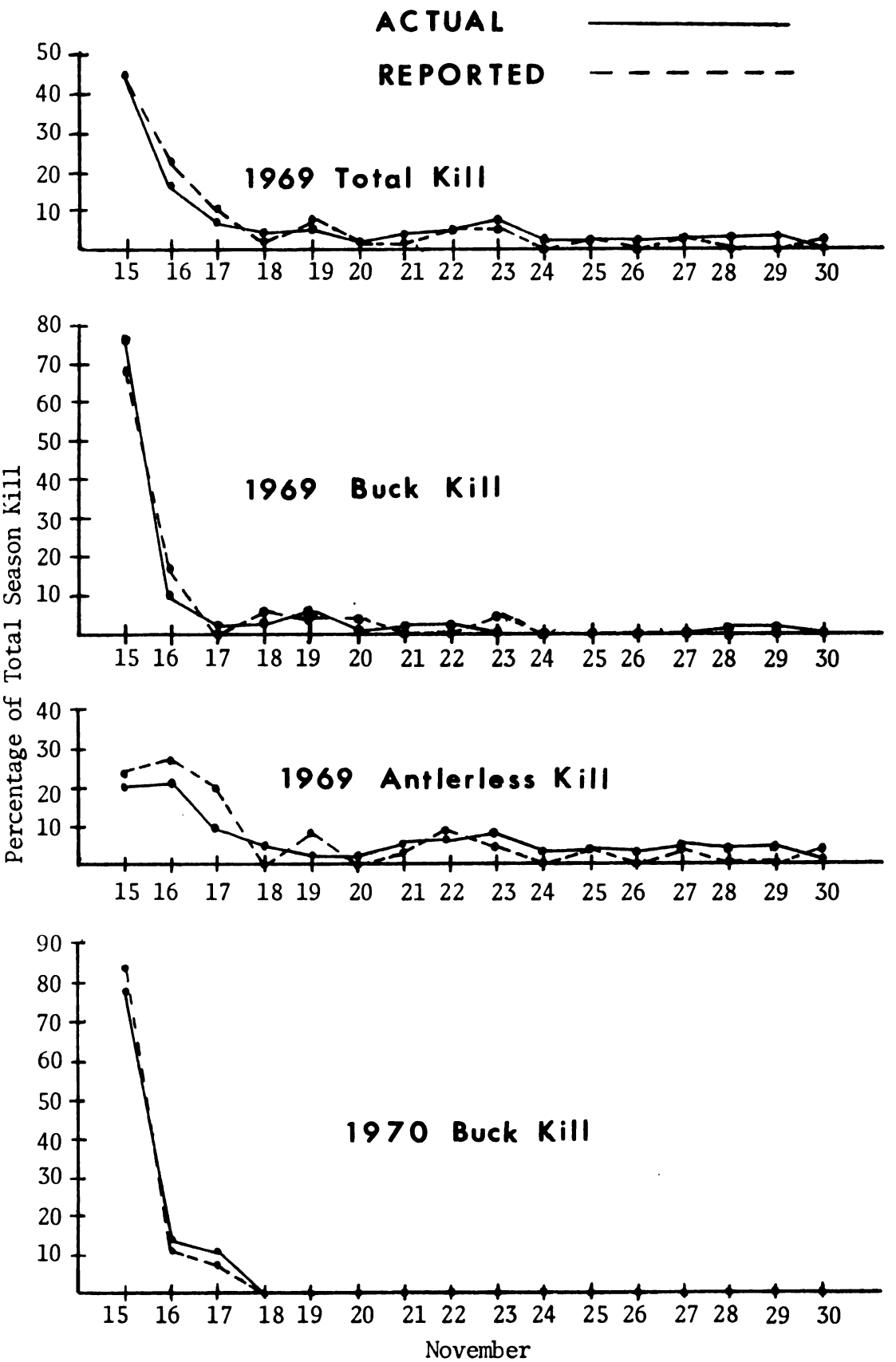
Data on the age distribution of deer sighted could not be tabulated because of the hunters' inability to consistently distinguish fawns from yearling does. As a result, no age proportions were calculated for either 1969 or 1970. It was evident that age data in deer were poorly suited for collection by the DeLury method, at least

for average hunters. Useful age data could perhaps be obtained from a select group of experienced sportsmen, but this concept must be tested further. The volunteers on Mid Forest Lodge who completed the more detailed questionnaire were too few in number to be used as a source of age data, or as a valid comparison with the average hunter report.

Distribution of Kill

The reported daily kill was precise in describing the actual distribution of the kill throughout the season (Figure 7). In both 1969 and 1970, nearly 90 percent of the bucks killed were shot during the first two days of the season. However, only 41 percent of all antlerless deer shot during the 1969 season were taken in the first two days. The data clearly illustrated that hunters selected bucks over antlerless deer. This agrees well with McNeill's findings(1971) that over the period 1963-1967, an average of 87 percent of the total buck kill occurred the first two days of the hunting season. Blouch (1963) reported that the buck kill during the first two days averaged 70 percent of the total buck kill for the four year period from 1959 to 1962.

Figure 7. Daily percentage of deer kill for actual and reported data, November 1969, Mid Forest Lodge, Roscommon County, Michigan.


ACTUAL
REPORTED
1969 Total Kill
1969 Buck Kill
1969 Antlerless Kill
1970 Buck Kill
Percentage of Total Season Kill
November
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

CONCLUSIONS AND RECOMMENDATIONS

It seems reasonable to conclude that the DeLury method could be a valuable addition to present methods of obtaining deer kill estimates, population estimates, and sex proportions. A distinct advantage of the DeLury method over the pellet group survey is that it yields information on several parameters of the deer herd, rather than only a seasonal population estimate.

The DeLury method would probably be most useful on relatively small areas, such as hunting clubs or public game lands. A mail survey of hunters recruited to cooperate on such areas would be inexpensive. Hunting clubs could utilize the DeLury method to gain valuable information about their own deer herds. Club members should be motivated to report their hunting observations accurately. In all cases, it is critical that cooperation with the group or organization involved be arranged well in advance of the hunting season, and that close supervision and encouragement be provided throughout the season, to insure regular daily reports.

On a state-wide basis, the cost of a hunter mail survey would be small in comparison to the outlay in funds and manpower sustained by the annual pellet count. On selected areas, the DeLury method could provide a useful check on population estimates obtained by the pellet count or other methods. A corps of cooperating trained hunters would be essential on public areas or over wide areas, in order to provide a

standard of reference to the general hunter sample. If hunters can be sufficiently motivated to report their observations accurately, the DeLury method may yield dependable estimates.

This study indicated that the effects of hunter response on DeLury estimates need to be investigated further. It is probable that those questionnaires which were returned after the hunting season were less reliable than those submitted earlier. Especially if hunters did not record observations daily, but instead tried to reconstruct their hunts after a considerable length of time had elapsed, some errors may have occurred. In another study, it would be advisable to have hunters return their reports daily, even though this would require a considerable effort to contact hunters throughout the season. Also, a sample of non-respondents should be taken to determine the extent to which their observations differed from those of cooperators (Table 3).

The great majority of the members of Mid Forest Lodge were conscientious sportsmen who would make no attempt at deception. A small percentage of the questionnaires returned, however, seemed to involve attempts to misrepresent the true situation by including fallacious data. The planned application of techniques to detect the extent of misrepresentation would help determine the importance of this factor.

An attempt was made to obtain the services of a small group of experienced sportsmen, whose deer observations were to be used as a standard of reference for the average hunter. Unfortunately, only six were recruited and these were too few to give significant results.

Probably more intensive efforts should have been made to obtain a larger number of such volunteers.

DeLury procedures may well be an important source of biological data, but it is critical that hunters be motivated to keep accurate records of their observations. This might be initiated with a brief explanation of the project at one of the periodic meetings of hunting clubs or sportsmen's groups, though this could not be arranged in this instance. Small inducements, such as a promise to report final results of the study to all respondents, undoubtedly increase hunter participation. Hunter motivation would also be enhanced if the hunters themselves could see the results, perhaps daily through the season. For example, the kill and rate of kill, along with a graph of these values, could be recorded daily on a large sign, and could form an eye-catching display when placed in a conspicuous location. This would emphasize to the hunter that he is personally involved in deer management. By hindsight, efforts to undertake these steps would certainly be helpful.

SUMMARY

The DeLury census method yields a population estimate through regression analysis of catch per unit of effort data. A major objective of this study was to test the DeLury method against the deer pellet count census method. Additional objectives were to determine the effectiveness of the DeLury method in estimating various parameters of the deer population, such as sex and age proportions at various times, and in quantifying the behavior of the deer herd throughout the hunting season. It was also desired to appraise any sources of hunter biases which would affect the deer population estimate.

The study was conducted at Mid Forest Lodge in Roscommon County, Michigan during the autumn hunting seasons of 1969 and 1970. The method utilized hunter observations reported by questionnaire. The pellet group survey was conducted during the spring of 1970 to provide a standard of reference for the 1969 DeLury population estimates.

Results of the hunter survey indicated that the reported sample was not truly random, but was biased in the direction of successful hunters, tending to increase the deer population estimate. At the same time, a hunter preference for bucks resulted in a high late-season antlerless kill, which would also cause an overestimate of the deer herd size. Declining rates of sightings of antlerless deer in 1970, even in the absence of antlerless kills, suggested that vulnerability

of the deer to sighting decreased throughout the season. The effect of this change in behavior would be to lower the population estimate.

The relative importance of these three components in influencing the accuracy of the DeLury population estimate could not be determined. Only if these factors balance each other, can the DeLury estimate be considered accurate.

It appeared that the DeLury population estimates of males based on buck sightings and buck kills were accurate. Estimates based on data for total deer or antlerless deer were generally both inaccurate and imprecise. This appeared to be a result of hunter biases in shooting deer.

The proportion of legal bucks in the population was determined by comparing the initial rates of sightings of bucks and antlerless deer. This allowed computation of the total deer population, since the legal buck population had been previously estimated by the DeLury method. When compared to past estimates of sex proportions, this ratio was found to be quite reasonable, although, if biased, then perhaps slightly low. It was not possible to calculate valid age ratios from hunter-collected data, because of the sportsmen's inability to distinguish fawns from yearling does.

Kill data gathered by the DeLury method provided an accurate assay of the distribution of the kill throughout the hunting season. The DeLury method provided information on population size, sex proportions, and patterns of kill regarding the deer herd. The pellet group survey gave only an average seasonal population estimate of the herd.

An important advantage of the DeLury method is that it utilizes hunter observations with little or no biologist effort required. Consequently, data could be collected by a cooperating corps of sportsmen and the overall cost would be considerably less than that required for other census methods. In addition, the diversity of information learned would be greater. The DeLury method is most useful on relatively small areas, such as hunting clubs, or as a check on the pellet group survey in particular areas, but it also could be useful on a state- or region-wide basis.

LITERATURE CITED

LITERATURE CITED

Blouch, R. I. 1961. Spring deer population surveys (pellet counts). Job. Compl. Rep. No. A-2. Michigan Department of Conservation, Lansing. 7pp.

_____. 1963. The response of deer to a forest-wildlife management program on Mid Forest Lodge. Ph.D. thesis, University of Michigan. 233pp.

Cochran, W. G. 1953. Sampling techniques. John Wiley and Sons, Inc. New York, New York. 330pp.

DeLury, D. B. 1947. On the estimation of biological populations. Biometrics. 3(4): 145-167.

_____. 1951. On the planning of experiments for the estimation of fish populations. Jour. Fish. Res. Bd. Can. 8(4): 281-307.

Eberhardt, L. 1957. Some uses of stratified sampling in wildlife investigations. Game Div. Rep. No. 2158. Michigan Department of Conservation, Lansing. 5pp. (mult.).

_____. 1960. Estimation of vital characteristics of Michigan deer herds. Game Div. Rep. No. 2282. Michigan Department of Conservation, Lansing. 192pp. (mult.).

_____, and R. C. Van Etten. 1956. Evaluation of the pellet group count as a deer census method. J. Wildl. Mgmt. 20(1): 70-74.

Hayne, D. W. 1949. Two methods for estimating population from trapping records. Jour. Mam. 30: 399-411.

_____, and L. Eberhardt. 1954. Nature of the bias of estimates computed from voluntary reports. Game Div. Rep. No. 2825. Michigan Department of Conservation, Lansing. 8pp. Presented at the 16th Midwest Wildlife Conference, St. Louis, Missouri, December 1-3, 1954.

Howe, D. L. 1954. A comparison of deer census methods in the Rifle River area. M.S. thesis, Michigan State University. 46pp.

McCain, R. 1948. A method for measuring deer range use. Trans N. Amer. Wildl. Conf. 13: 431-441.

McNeill, R. E. 1971. Interactions of deer and vegetation on the Mid Forest Lodge and Gladwin Game Refuge. Ph.D. thesis, University of Michigan. 198pp.

Michigan Department of Conservation. Land Econ. Survey. 1924. Soil and lay of the land map of Roscommon County. (map).

Michigan Department of Natural Resources. Wildlife Division. 1969. Deer herd composition. Compiled from reports of deer observed by Department personnel, April 1 to October 1, inclusive. 1pp. (mimeo.).

Petrides, G. A. Unpublished. Rate of kill as an index to population level. Paper presented to Michigan Academy of Science, Arts and Letters, East Lansing, Michigan, March 23-25, 1959. (Supplemented by class notes, Michigan State University, 1960-1972.).

Ryel, L. A. 1959. Deer pellet group surveys on an area of known herd size. Game Div. Rep. No. 2252. Michigan Department of Conservation, Lansing. 26pp. (mult.).

_____, and L. J. Hawn. 1962. Recent deer population indices. Game Div. Rep. No. 2389. Michigan Department of Conservation, Lansing. 23pp. (mimeo.).

Westell, C. E. 1958. A forest and wildlife management plan for the Mid Forest Lodge Club. Unpublished report. Packaging Corp. of Amer., Amer. Boxboard Div., Filer City, Michigan. 67pp. (mimeo.).

APPENDIX

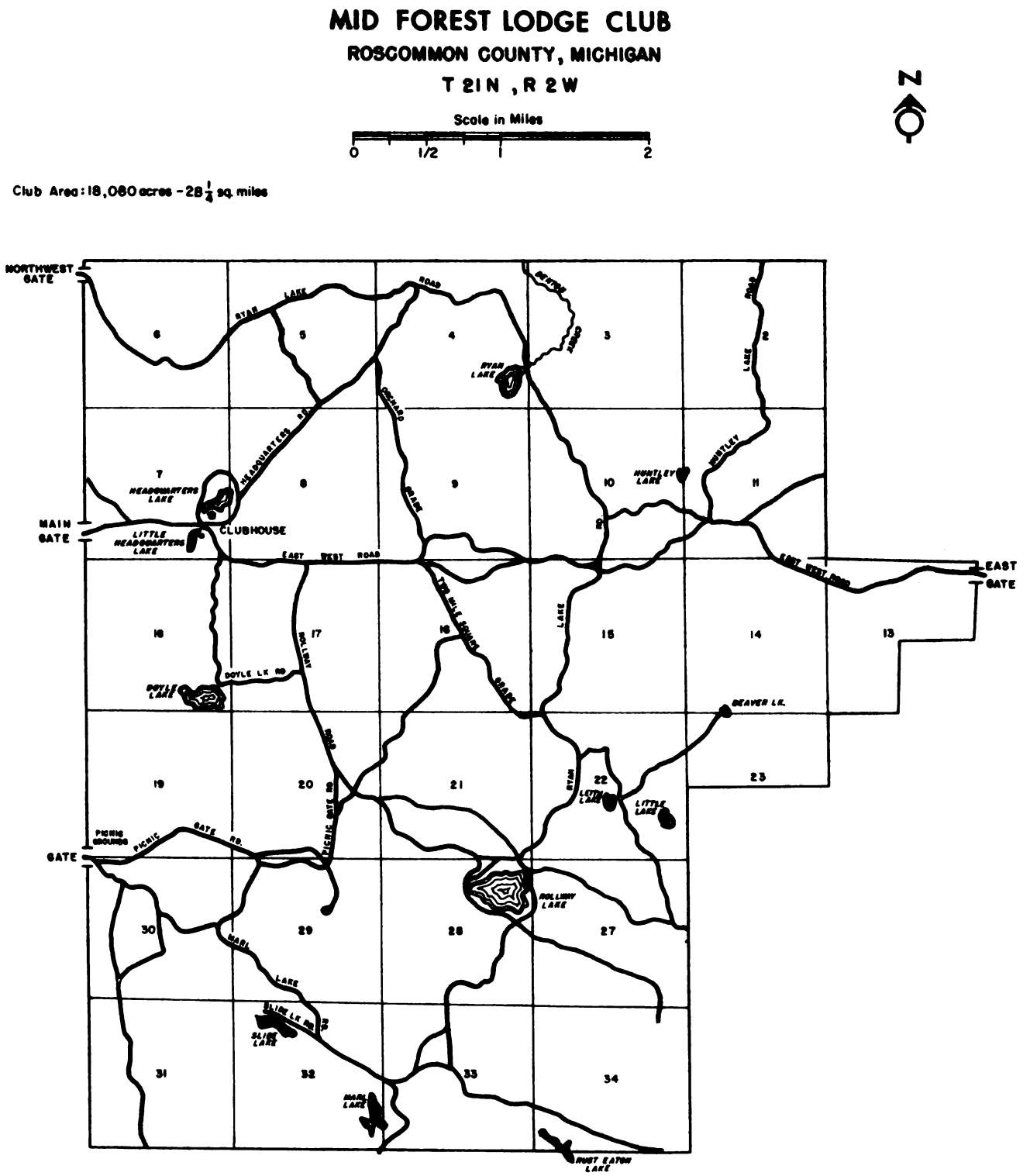


Figure A-1. Road and trail system on Mid Forest Lodge (Blouch 1963).

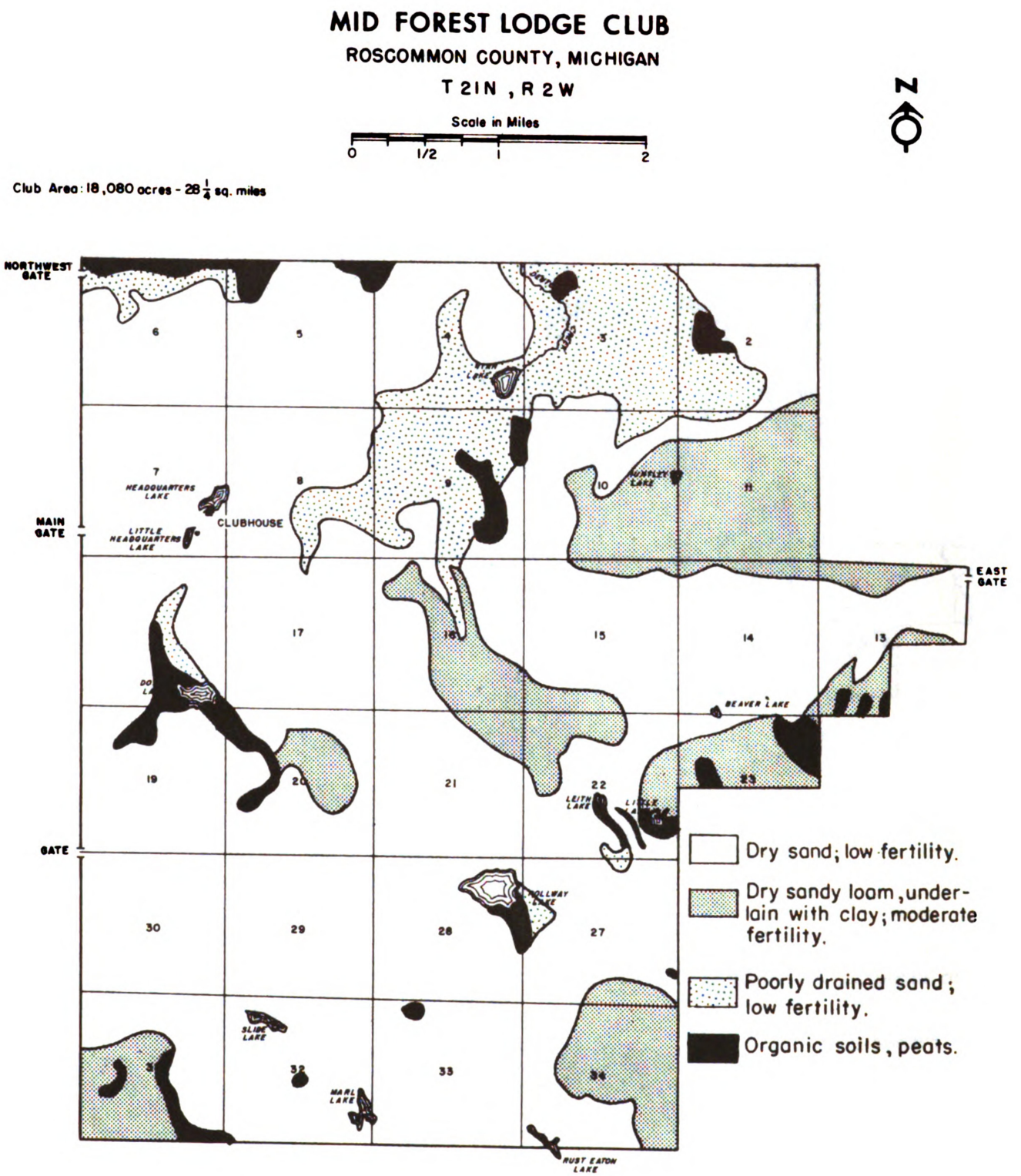


Figure A-2. Generalized soils map of Mid Forest Lodge (Blouch 1963).

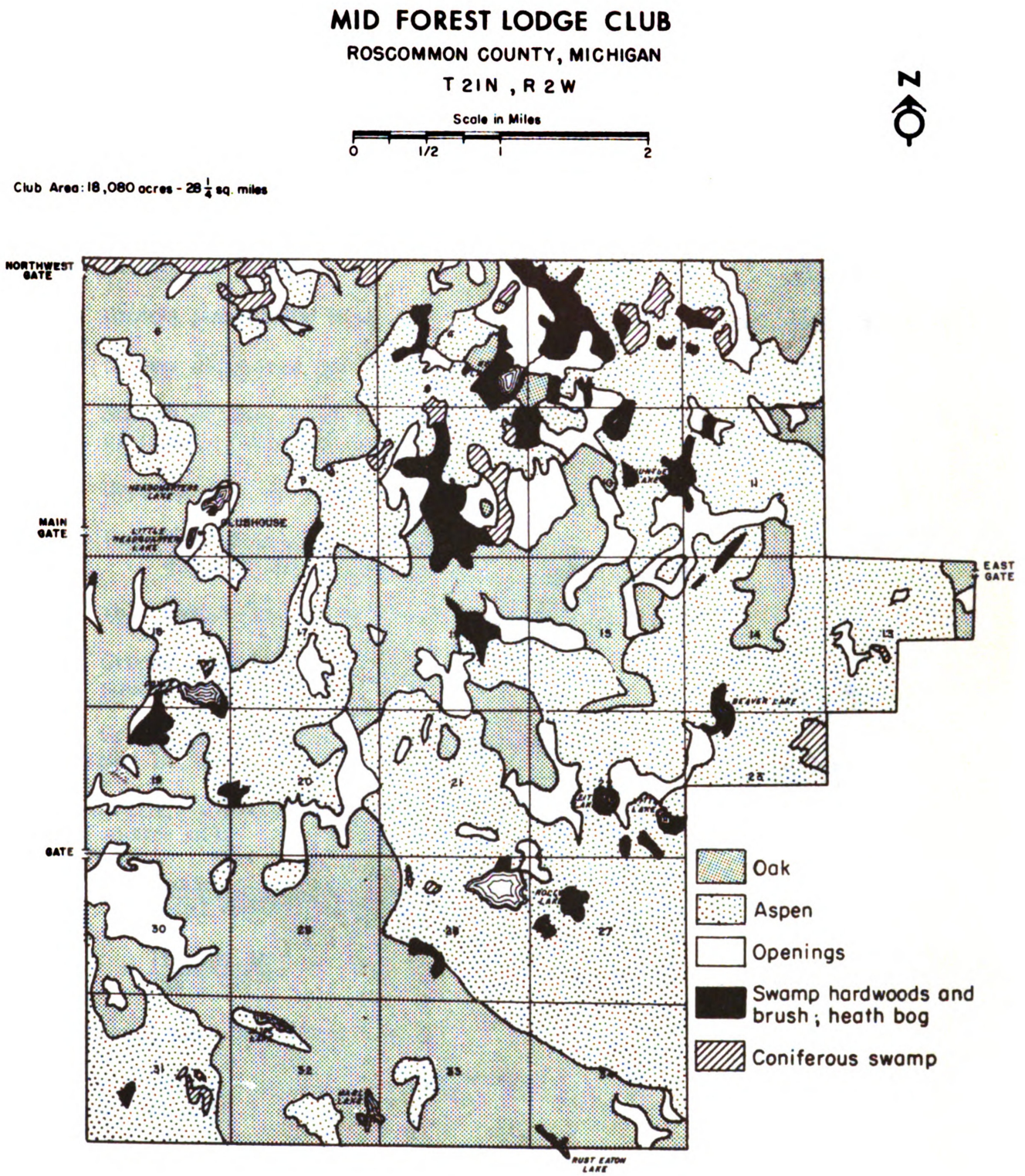


Figure A-3. Generalized cover types (Blouch 1963).

Table A-1. Results of 1970 pellet group survey, Stratum 1, Mid Forest Lodge, Roscommon County, Michigan.

1.	Mean number pellet groups per course:		29.3333
2.	Area of each course:	8 x 1/50 acre	= .16 acre
3.	Groups per acre:		183.3331
4.	Groups per square mile:		117,333.1840
5.	Groups deposited per deer per day:		12.7
6.	Number of days from leaf fall to middle of count, (10/22/69 - 5/14/70):		204
7.	Deer removal per square mile:		
	(a) 1969 hunting season kill: 9.43 assumed 10% crippling loss: .94 10.37		
	(b) Number days leaf fall to hunting season:		25
8.	Groups deposited by hunting removal per square mile, (10.37 x 12.7 x 25):		2695.58
9.	Groups per square mile from deer alive on May 14, (117,333.1840 - 3292.5000):		114,040.684
10.	Average winter-spring population, deer per square mile:		44.01

$$P = \frac{\text{Groups per square mile}}{\text{Total days X groups per deer per day}}$$

$$= \frac{114,040.684}{204 \times 12.7} = 44.01$$

11.	Total area in square miles:	7.0
12.	Confidence limits at 95% level as percentage of estimate:	±32.36%
13.	Total deer on Stratum 1, (7.0 x 44.0176):	308.12
14.	Range of estimate:	208 to 408

Table A-2. Results of 1970 pellet group survey, Stratum 2, Mid Forest Lodge, Roscommon County, Michigan.

1.	Mean number pellet groups per course:	8.3333
2.	Area of each course: 8 x 1/50 acre	= .16 acre
3.	Groups per acre:	52.0831
4.	Groups per square mile:	33,333.184
5.	Groups deposited per deer per day:	12.7
6.	Number of days from leaf fall to middle of count, (10/22/69 - 5/14/70):	204
7.	Deer removal per square mile:	
	(a) 1969 hunting season kill: 2.28 assumed 10% crippling loss: .23 2.51	
	(b) Number days leaf fall to hunting season:	25
8.	Groups deposited by hunting removal per square mile, (2.51 x 12.7 x 25):	796.925
9.	Groups per square mile by deer alive on May 14, (33,333.184 - 796.925):	32,536.26
10.	Average winter-spring population, deer per square mile:	12.55
	$P = \frac{\text{Groups per square mile}}{\text{Total days X groups per deer per day}}$	
	$= \frac{32,536.26}{204 \times 12.7} = 12.55$	
11.	Total area in square miles:	3.5
12.	Confidence limits at 95% level as percentage of estimate:	±39.98%
13.	Total deer on Stratum 2, (3.5 x 12.5583):	43.95
14.	Range of estimate:	26 to 62

Table A-3. Results of 1970 pellet group survey, Stratum 3, Mid Forest Lodge, Roscommon County, Michigan.

1.	Mean number pellet groups per course:		21.5000
2.	Area of each course:	8 x 1/50 acre	= .16 acre
3.	Groups per acre:		134.3750
4.	Groups per square mile:		86,000.0000
5.	Groups deposited per deer per day:		12.7
6.	Number of days from leaf fall to middle of count, (10/22/69 - 5/14/70):		204
7.	Deer removal per square mile:		
	(a) 1969 hunting season kill: 10.61 assumed 10% crippling loss: 1.06 11.67		
	(b) Number days leaf fall to hunting season:		25
8.	Groups deposited by hunting removal per square mile, (11.67 x 12.7 x 25):		3705.225
9.	Groups per square mile by deer alive on May 14, (86,000.0000 - 3705.225):		82,294.77
10.	Average winter-spring population, deer per square mile:		31.76
	$P = \frac{\text{Groups per square mile}}{\text{Total days X groups per deer per day}}$		
	$= \frac{82,294.77}{204 \times 12.7} = 31.76$		
11.	Total area in square miles:		5.75
12.	Confidence limits at 95% level as percentage of estimate:		±47.73%
13.	Total deer on Stratum 3, (5.75 x 31.7642):		182.64
14.	Range of estimate:		95 to 270

Table A-4. Results of 1970 pellet group survey, Stratum 4, Mid Forest Lodge, Roscommon County, Michigan.

1.	Mean number pellet groups per course:		10.1666
2.	Area of each course:	8 x 1/50 acre	= .16 acre
3.	Groups per acre:		63.5412
4.	Groups per square mile:		40,666.3680
5.	Groups deposited per deer per day:		12.7
6.	Number of days from leaf fall to middle of count, (10/22/69 - 5/14/70):		204
7.	Deer removal per square mile:		
	(a) 1969 hunting season kill: 9.33 assumed 10% crippling loss: .93 10.26		
	(b) Number days leaf fall to hunting season:		25
8.	Groups deposited by hunting removal per square mile, (10.26 x 12.7 x 25):		3257.5500
9.	Groups per square mile by deer alive on May 14, (40,666.3680 - 3257.5500):		37,408.82
10.	Average winter-spring population, deer per square mile:		14.43
	$P = \frac{\text{Groups per square mile}}{\text{Total days X groups per deer per day}}$		
	$= \frac{37,408.82}{204 \times 12.7} = 14.43$		
11.	Total area in square miles:		6.0
12.	Confidence limits at 95% level as percentage of estimate:		±20.58%
13.	Total deer on Stratum 4, (6.0 x 14.439):		86.63
14.	Range of estimate:		69 to 104

Table A-5. Results of 1970 pellet group survey, Stratum 5, Mid Forest Lodge, Roscommon County, Michigan.

1.	Mean number pellet groups per course:	10.5000
2.	Area of each course:	8 x 1/50 acre = .16 acre
3.	Groups per acre:	75.6250
4.	Groups per square mile:	42,000.0000
5.	Groups deposited per deer per day:	12.7
6.	Number of days from leaf fall to middle of count, (10/22/69 - 5/14/70):	204
7.	Deer removal per square mile:	
	(a) 1969 hunting season kill: 4.50 assumed 10% crippling loss: .45 4.95	
	(b) Number days leaf fall to hunting season:	25
8.	Groups deposited by hunting removal per square mile, (4.95 x 12.7 x 25):	1571.6250
9.	Groups per square mile by deer alive on May 14, (42,000.0000 - 1571.6250):	40,428.38
10.	Average winter-spring population, deer per square mile:	15.60

$$P = \frac{\text{Groups per square mile}}{\text{Total days X groups per deer per day}}$$

$$= \frac{40,428.38}{204 \times 12.7} = 15.60$$

11.	Total area in square miles:	6.0
12.	Confidence limits at 95% level as percentage of estimate:	±66.69%
13.	Total deer on Stratum 5, (6.0 x 15.6045):	93.62
14.	Range of estimate:	31 to 156

Table A-6. Results of 1970 pellet group survey, Stratum 6, Mid Forest Lodge, Roscommon County, Michigan.

1.	Mean number pellet groups per plot:	79.8000
2.	Area of each plot:	.02 acre
3.	Groups per acre:	3990.0000
4.	Groups per square mile:	2553.6000
5.	Groups deposited per deer per day:	12.7
6.	Number of days from leaf fall to middle of count, (10/22/69 - 5/14/70):	204
7.	Deer removal per square mile:	0*
8.	Groups deposited by hunting removal per square mile:	0
9.	Groups per square mile by deer alive on May 14:	2553.6000
10.	Average winter-spring population, deer per square mile:	985.60

$$P = \frac{\text{Groups per square mile}}{\text{Total days X groups per deer per day}}$$

$$= \frac{2553.6000}{204 \times 12.7} = 985.60$$

11.	Total area in square miles:	.013
12.	Confidence limits at 95% level as percentage of estimate:	±14.47%
13.	Total deer on Stratum 6, (.013 x 985.60):	12.81
14.	Range of estimate:	11 to 15

* Zero deer removals were assigned to this stratum since no data was available to indicate how many deer, if any, were killed on this small area.