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An evaluation of ground census methods for the whitetailed deer on the George Reserve, Michigan.

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AN EVALUATION OF GROUND CENSUS METHODS FOR THE WHITETAILED DEER ON THE GEORGE RESERVE, MICHIGAN

by Wayne H. Tody

This thesis is submitted to the faculty of the School of Forestry and Conservation of the University of Michigan in partial fulfillment of the degree of Master of Forestry.

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AN EVALUATION OF GROUND CENSUS METHODS FOR THE WHITETAILED DEER ON THE GEORGE RESERVE, MICHIGAN

Introduction

In the past two decades of intensified research in wildlife management census methods have received much attention. Many techniques have been developed and described for population appraisals of the whitetailed deer. These census methods vary greatly in the techniques used and in accuracy. But also they vary in the objectives sought for the management of the species. This study on the ground census methods for the whitetailed deer is an attempt to evaluate them as to accuracy and economy of use, and to suggest new methods for use in future management. This evaluation is based on the biology of the species, rather than on the mathematical problems entailed in census work. In time the mathematical foundations of the techniques will be examined and improved, but in the present stage of management greater progress will be attained in biological studies on the behavior of the species in relation to the census methods.

The present status of the whitetailed deer in the United States creates a pressing need for efficient and reliable census methods. There is no animal on the North American continent that can rival the position of the whitetail in importance to the sportsman as a big game animal. Fortunately this foremost big game animal has fared well with the development of our economy and today exists in numbers even near densely settled industrial areas. In some states, especially in Michigan and Indiana, the whitetail has in recent years extended its range into hitherto unpopulated agricultural areas where it creates a conflict with farm crops. Over large sections of whitetail range irruptions are now old stories. It is here that the greatest management problem arises. It is now generally recognized that the only solution to the problem of the deer irruption and the consequent destruction of habitat is to be had in the form of some sort of herd control, whereby sufficient numbers of the deer would be harvested to balance their numbers with the carrying capacity of the land. Basic in any herd control plan is the determination of population densities on which to base numbers for removal. It is thus that a sampling type of census, inexpensive and reliable, is a real and fundamental need in deer management.

Excellent opportunity is afforded by the Colonel Edwin S. George Reserve, Pinckney, Michigan, for a comparison of deer census methods. There 1268 acres of reverted farmland have been fenced and stocked with native Michigan deer which are allowed to lead a continued undomesticated existence in the fenced enclosure. Nearly all of the established census methods for this species are applicable in the Reserve, with the notable exception of intensive track counts. Track counts are undoubtedly influenced by the deer-proof fence surrounding the enclosure.

On the George Reserve, the direct drive type of census was found to be the most accurate of the census methods, but also the most expensive. A new type of census based on the recorded movements of deer was found in early experimental trials to show great promise as a less costly method for total enumerations on sample areas. The various methods of census through indices, and sight records, were found to be inaccurate, sometimes in the extreme, and usable only for the most extensive population appraisals.

Before a detailed discussion of the application of the census methods evaluated in this study, it is pertinent that the Reserve be described as to census conditions. As deer census work has been conducted on the Reserve as a basis for herd control, it would be well to review the history of this work. One other desirable item to review is a brief description of the trend in development of deer census methods in general.

Description of study area

The George Reserve is located in the southwestern corner of Livingston County. The land comprising the Reserve and large areas of the surrounding country is sub-marginal for agricultural crops and is well suited as habitat for whitetails. A deer population estimated at some 5,000 individuals is now found in the general Livingston County area outside the confines of the Reserve.

The area is best described geologically as a pitted outwash plain of glacial origin. The major land forms are kames, kettleholes, and level outwash plains. About one-third of the Reserve is lowland covered by marshes and bog swamps, the remainder is composed of sandy uplands. The relief of the Reserve is exceptionally rugged for southern Michigan, ranging in elevation from 890 to 990 feet. There is one natural bog lake and three artificial ponds on the area. Climatic conditions are the same as those that pertain to southern Michigan in general, fairly cold winters and mild to hot summers. The average snowfall of 29 inches is light compared to most of the other regions of the state.

Of especial importance in this census study was the diverse cover types found on the Reserve. A cover type map (Figure 1.) based on an ecological system (Graham, 1945) was prepared in 1948 by John G. Brasch, School of Forestry and Conservation, University of Michigan. This map was used throughout this study as a base map for all of the methods. The cover types are important from three points of view:

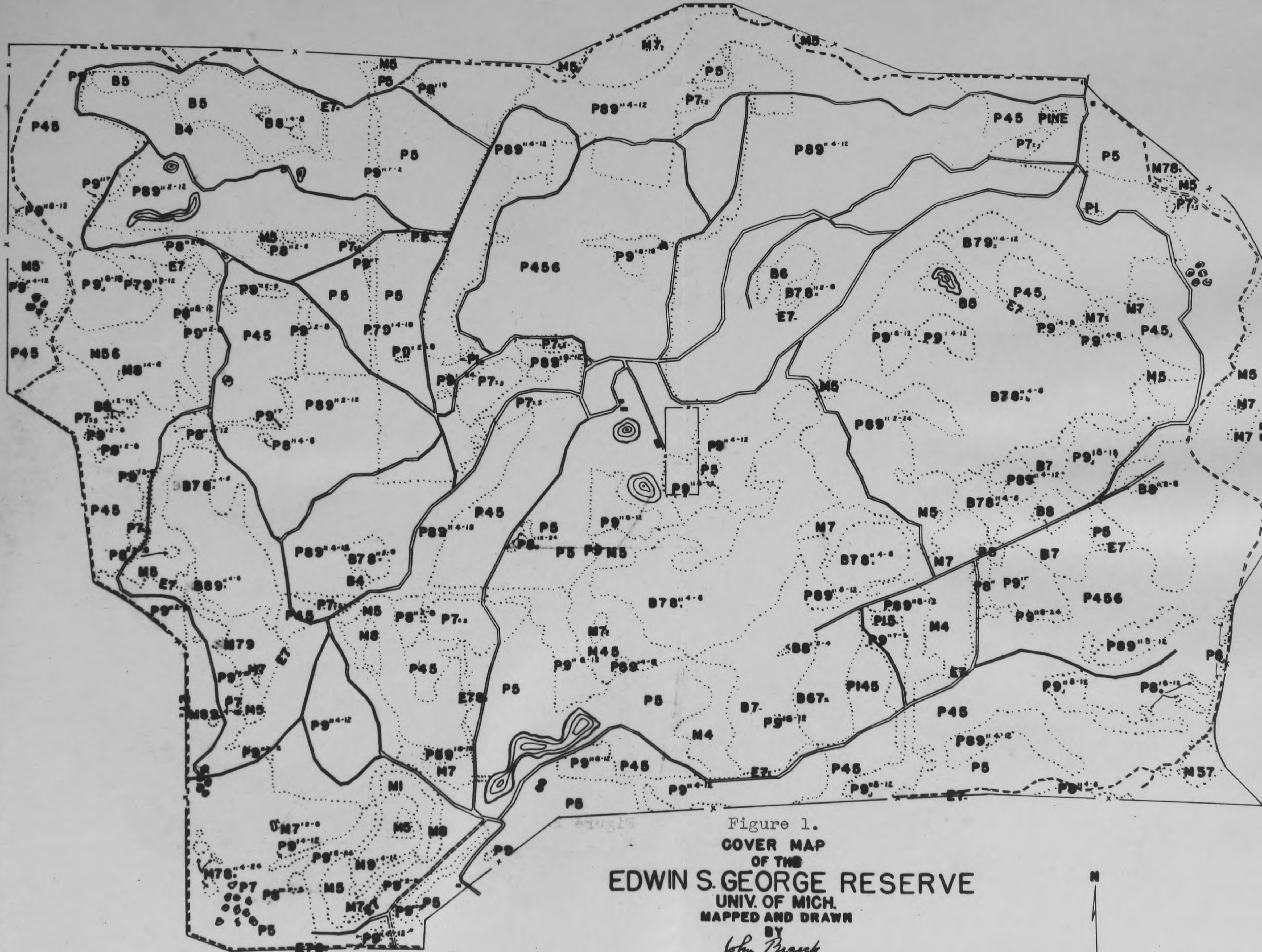


Figure 1.

COVER MAP
OF THE
EDWIN S. GEORGE RESERVE
UNIV. OF MICH.
MAPPED AND DRAWN
BY
John Braeck
MARCH 1948
SCALE
0 1000 ft.
LEGEND ATTACHED

Legend for Cover Map (Figure 1.)

	Upland Types - Terrestrial Origin			Lowland Types-Aquatic Origin				Transition Types	
				Bogs		Marshes			
	Porous Soils P	Nonporous Soils A	Rock Outcrops R	Seepage BS	Stagnant B	Seepage MS	Stagnant M	Floodplain F	Transition Belts E
1	Bare Soil	Bare Soil	Bare Rock	Saturated Soil or Water	Water	Saturated Soil or Water	Water	Bare Soil	Same as Corresponding Water or Dryland Type
2			Crustose Lichens		Submerged Vegetation		Same as B2		do.
3			Foliose Lichens and Moss						do.
4	Moss + Annuals	Same as P4	Same as P4	Sphagnum Sedge Mat	Same as BS4	Emergent Aquatics	Same as MS4	Annuals	do.
5	Grass + Other Perennials	Same as P5	Same as P5	Sphagnum Sedge + Heath	Same as BS5	Emergents + Sedge-Grass	Same as MS5	Same as A5	do.
6	Mixed Herbaceous	Same as P6	Same as P6		Same as P6	Same as P6	Same as P6	Same as P6	Same as P6
7	Shrubs	Shrubs	Shrubs	Swamp Shrubs	Same as BS7	Same as BS7	Same as BS7	Same as P7	Same as P7 or BS7
8	Intolerant Trees	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8
9	Mid-tolerent Trees	Same as P9	Same P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9
10	Tolerant Trees	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10

Physiographic Conditions-Exponential Letters

o - Outwash
d - Dunes
k - Kettle Hole
l - Calcareous
g - Igneous Rock
s - Shale
m - Glacial Drift
b - Loess

"Same as" = Ecological eqivalent not necessarily identical species.

Disturbance Effects - Sub Letters

d - Drained
P - Pastured
e - Eroded
c - Cropped
f - Flooded
y - Cutover
x - Burned
a - Wild Animal Grazing + Browsing
b - Blowdown

Timber Size and Stocking

I Scattered — 4" to 6" DBH
II Medium — 4" to 12" DBH
III Dense — Etc.

Shrub Density

— Scattered
= Medium
≡ Dense

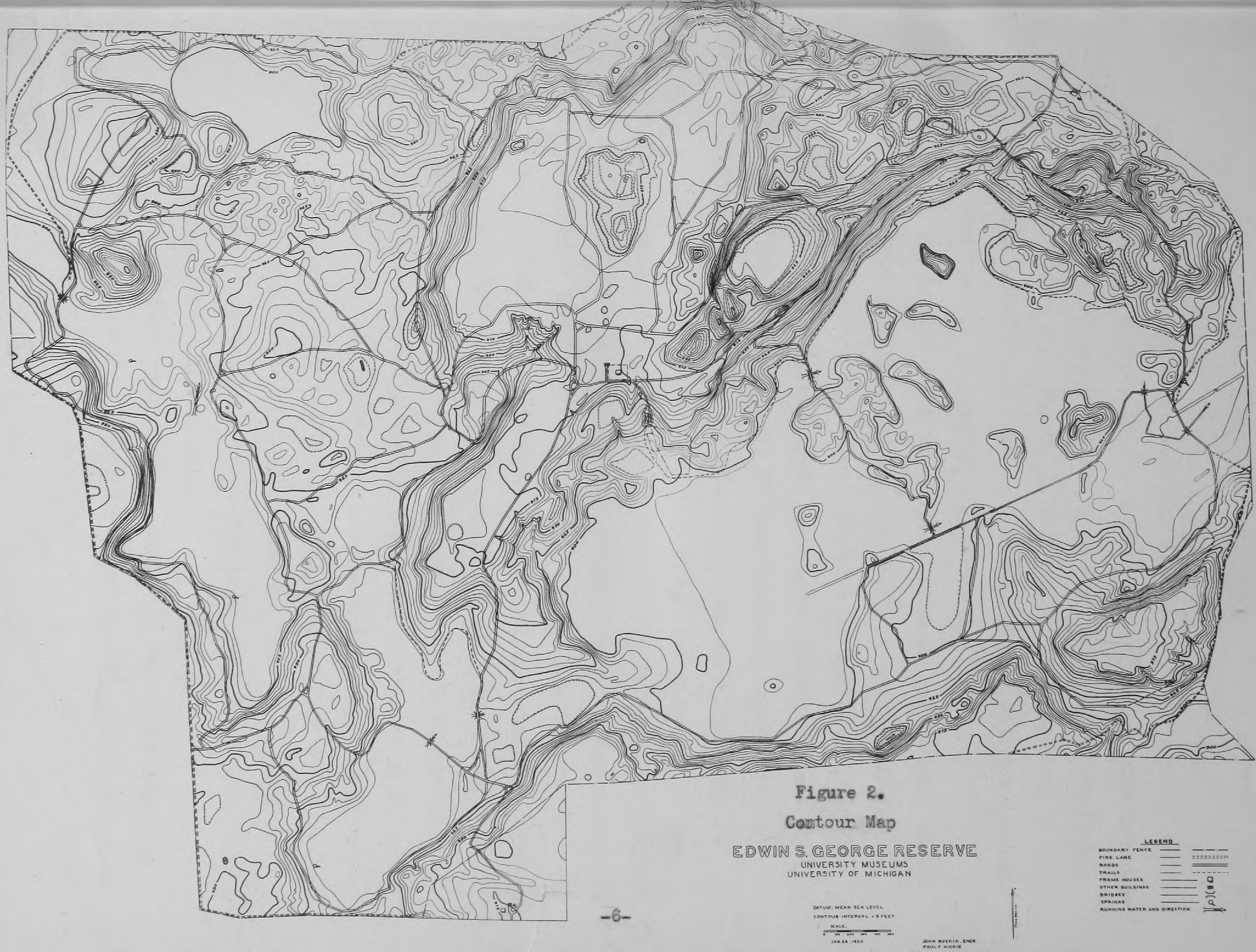


Figure 2.
Contour Map

first, as a basis for sampling in census methods based on deer signs; second, in the degree of visibility afforded the observer, or, conversely, in the escape cover available to the deer; and, third, in the use of the different daily weather conditions. The composition of the different types on the Reserve is presented in Table I.

The wooded areas are covered with an oak-hickory forest of medium density, with an understory of shrubs and reproduction varying from sparse to dense in different parts of the Reserve. Visibility is good to an average extent of about 150 feet over most of this hardwood type during the winter season. Some of the tracts are over 100 acres in size, and deer can easily slip around the observer unseen.

Grasslands comprise the largest single type. Visibility is good throughout the area. Although some of the grasslands are being invaded by shrubs, this succession is not far advanced due to the feeding pressure of the deer.

A large portion of the marsh types is in the "M-7" classification, or marsh-shrub type. This type furnishes excellent escape and bedding cover for the deer. Although running deer can be spotted immediately in this type, the the observer must practically walk over deer in the beds before they can be flushed and seen. This is especially true under certain weather conditions, such as bright, sunny days, or cold, windy weather.

The upland brush types are for the most part composed of the sumacs and a few other upland shrubs, which are over-

Plate 1.

View of large artificial pond, with open grassy meadow and hardwood forest in the background.

Plate 2.

View of terrain around southwest end of big swamp. These photographs illustrate the general types involved in census work on the George Reserve.

Table 1

Morphometry of the ecological cover types on the Col. Edwin S. George Reserve.*

Type	% of total area	Acres in type
Woodland	34.6	439
Grassland	39.7	503
Upland brush	1.7	22
Bog swamp	13.5	171
Marsh	10.0	127
Open water	.5	6

* Two methods were used in measuring the area. The first was by the weight-apportioning method, and the second by the use of a polar planimeter. The difference in the total area by these two methods was less than one percent (.59).

browsed by the deer and hence offer little obstruction to the visibility of the observer, and sparse cover for the deer.

The bog swamp is the greatest obstacle to the observer in making any census. In places visibility is cut down to only a few feet. Progress is greatly impeded by windfalls and thickets of shrubs. It is nearly impossible to move through such cover quietly, and thus many deer may be flushed that are not seen. Deer are notorious for their ability to skulk unseen within a short distance of the observer in this type of cover. Most of the low bog areas are covered with dense stands of poison sumac and tamarack, or swamp hardwoods (maple-birch-elm mixtures) and lowland shrubs. There are some leather-leaf bogs, but these are not much frequented by deer.

The objectives in study and management of the George Reserve is to control only the deer herd in numbers that will not be detrimental to the available browse. No control or harvest is exerted on the other species of wildlife found on the Reserve. The present plan is to so regulate the winter removals of deer that the early spring population will approximate 50 deer, or 25 per section. In the past, the removals necessary to reduce the herd to these numbers have been based on annual deer drives by students and faculty of the University of Michigan. A brief review of these drives will be presented in the next section.

Plate 3.

Inside one of the second-growth hardwood forests. Note the lack of an understory. This area was selected as a sample plot for studies on the accumulation of sign.

Plate 4.

Kames in the northeast corner of the Reserve. This photograph was taken on a foot sight index census. A large buck may be seen in the circle. This type of observation is characteristic of the majority of observations made by this method.

Previous censuses on the Reserve

The only reliable census work executed on the Reserve in the past has been of the direct drive type. The first census was conducted in 1933, followed by censuses in 1935 and 1936, and every year since 1939.

The land that now comprises the Reserve was purchased in the years 1927 and 1928 by Colonel Edwin S. George. Six deer were purchased in 1928 which constituted the original introduction of the present herd.

In the fall of 1933 it became apparent that the deer herd had increased greatly and that the vegetation on the Reserve was rapidly becoming overbrowsed. So in the fall of that year the first drive was conducted by Paul Hickie, the Resident Biologist. Many of the drives have been quite reliable counts, but some were considered little more than training exercises for the inexperienced personnel participating. (O'Roke and Hamerstrom, 1948.)

The reasons for the direct drive type of census on the Reserve for population appraisals is given by Hickie in the description of the first drive. He states: "Track counts could offer little since the deer were confined. Counts by a single person were proved to be of little value, since the number of deer counted seldom came up to the number that had been seen at one time on previous occasions. It was decided that a drive with a number of persons participating would give the best results." (Hickie, 1934 Ms.) Hickie's decision was doubtlessly influenced by the number of interested persons available at the University for use in the drive type of census.

Regarding the efficiency of the drive type of census previously used on the Reserve, O'Roke and Hammerstrom state: "To get good results the men must be good observers who understand how the drive is b eing conducted, and who will follow instructions and do team work. Long experience with deer drives on the area shows that massed manpower drives are unnecessarily expensive, and that better methods must be worked out."

The direct drive type of census was used as the control method in this investigation. It was assumed that this was the most accurate method available. Every effort was made to use only reliable, experienced men, and accuracy was sought above all else. Based on the experience of other drives on the area, it is believed that this drive was entirely reliable in the results obtained, and satisfactory as a basic check for an evaluation of the other ground census methods.

While the field work by the writer was being conducted, a similar study on the aerial census methods for deer was conducted by James W. Wheeler, also of the School of Forestry and Conservation. Wheeler and the writer worked in the closest of cooperation at all times.

While the census work on the Reserve since the early 1930's has been concerned primarily only with the direct drive type of census, the development of census methods by other workers in various parts of the country have shown much change in applied techniques.

Development of deer census techniques

A complete review of the development of census techniques for population appraisals of the whitetailed deer would necessarily be a long discussion and is beyond the scope of this paper. However, the trend in this development is important in an evaluation of present census techniques. The past trend in development is also important in the determination of improvements or refinements for the existing methods. An excellent review of the literature on this subject covering the period up until 1947 is presented in the master's thesis of Harold W. Steinhoff of the New York State College of Forestry, Syracuse University. Steinhoff's work, titled White-tailed Deer Census Methods, is quite similar in scope to this evaluation. As the New York State College of Forestry was kind enough to provide the author with a copy of Steinhoff's work, every effort has been made to supplement that work rather than duplicate it.

The first phases of organized game management in North America brought population estimates into practice. At first, these population estimates were nothing more than guesses of the number of deer on the area in question. With the upswing in better management practices and with hunting controls in effect, these crude guesses as to the population density were replaced by field estimates by the game managers. These estimates were often far from correct as proved by later censuses on the same areas with improved methods.

In the 1930's, with the advent of intensified game management due to the increased hunting pressure, more accurate appraisals of deer population densities became a real need.

The first census method devised to accurately enumerate the numbers of deer on a given area was the mass-manpower drive. It was realized early that adequate man-power could seldom be relied upon for drives to census deer over large areas. The trend thus turned to census methods with reduced manpower in the form of variations of the drive, and in sampling techniques. By this time, game management had been placed on a more scientific basis, so further census methods were generally arrived at through scientific means.

As deer leave many traces of their daily and seasonal activities in the environment in the form of "sign", attention was turned to this indirect type of censusing early in the development of sampling techniques. The strip census was applied to deer as well as to the smaller game animals. The mass-manpower drive has also found a continuous use, due to its high accuracy, even in the censusing of large areas as it can be used as a sampling technique in enumerations on small sections of large areas.

At the present time we are in the stage of attempting to refine our sampling techniques. The deer census in general does not readily lend itself to statistical analysis and thus is somewhat handicapped in its development. While some direct research on census methods is being conducted, good progress is to be had by the many workers using sampling techniques in deer herd enumeration when they attempt to evaluate the methods in actual use. Steinhoff (1947 Ms) has contributed one of the first evaluations of deer census methods wherein nearly all of the established techniques were tried on the same area and supposedly the same population of deer.

On the Reserve most of the established ground census methods applicable under winter conditions were tried. Briefly, the methods evaluated by actual field trial were:

1. Direct drive method.
2. Census through movements.
3. Strip cruise.
4. Foot sight index.
5. Horseback sight index.
6. Automobile sight index.
7. Spotlight sight index.
8. Census through deer sign.
    a. By 2.5 acre plots.
    b. By half-chain square plots in transects.

Methods considered in this investigation, but which for various reasons were not tried in the field, were:

1. Trapping, marking, and release with later recapture.
2. Pellet group count index method.*
3. Track count index.*
4. Track and bed count.*
5. Bait spot counts.

---

* These methods were not ignored but were used in the census through deer sign studies.

In the following sections of this paper the census methods used on the study area will be described in conjunction with the results obtained.

Field comparison of deer census methods for accuracy

One definite advantage was enjoyed on the Reserve that has not always been available to other investigators. The number of deer present, once determined, was not subject to the fluctuations that would be expected in an uncontrolled deer habitat. Thus in this study the variable of the fluctuations in population numbers, either daily or seasonal, was entirely eliminated. Although the annual removals of deer for herd control were made during the period of study, complete kill records were made available by Lawrence Camburn, custodian of the Reserve, and so do not influence the accuracy of the census results.

All field work was executed with the plan that each of the census methods would be applied one or more times and the results checked against the known number of deer present on the area at the time of census. This known number was established through the direct drive type of census. All methods employed more than once were executed in a standardized manner. If change in the method was deemed necessary for more accurate results, due consideration was given in the subsequent evaluation.

The scope of this paper does not allow a complete, detailed description of each of the census methods and its variations. All of the techniques used on the George

Reserve for the established census methods were similar to the methods described in the literature by the originators of the methods. Where deviations from the established methods were used, explanations will be made. New census methods will be described in detail, especially the census by movements method.

All field work was completed in the period from November, 1948, to April, 1949. Most of the work was centered in the winter season. Unfortunately, this winter was one of the lightest in recent years in the southern part of Michigan. At no time was there an accumulation of snow, and only at scattered intervals throughout the winter was there good tracking snow. Consequently the methods that were dependent on tracking snow did not receive as much trial in the field as was desired. It is believed that enough information was collected for an adequate evaluation of the census methods used despite the poor snow conditions.

Deer census methods

For convenience the deer census methods are best grouped by purpose and relationship for clarity of discussion. In the following discourse the methods will be discussed in this order: 1) total enumeration methods on whole areas or samples of them; 2) total enumeration through trapping, marking, and later recapture; and 3) determination of population densities or trends through index methods of sampling. The determination of population densities through index sampling methods may be further subdivided into: 1) sight index methods; 2) census through deer sign; and 3) spot counts with bait.

Total enumeration census methods

Two methods were tried on the Reserve that aimed at a total count of all deer present. The first of these, the direct drive, is the old standby in deer census work. The second method is quite new and had previously received only one trial on the Reserve. It has been termed "census through movements" by the author. As these two methods are entirely different in the field procedure, it is best to discuss them individually.

Direct drive method

Several variations of the direct drive census method have been employed by various workers. All are similar in that a line of drivers moves across the designated area, surrounded by counters, routing all deer present and tallying them as they leave the decreasing contained area. As the George Reserve is completely fenced and roughly rectangular in shape, all that was necessary for the count in this study was for the line of drivers to form along one of the narrow sides and then move completely across the area counting all deer as they were forced back through the counting line.

The direct drive was assumed to be the most

Plate 5.

Orientation of the participants before the direct drive census. Here each man is assigned his number and position in the driving line.

Plate 6.

Start of the direct drive. The drivers are keeping themselves aligned with the foreman who is the second man from the left.

accurate census method and so was used as the check on the other methods of census evaluated. It was necessary, therefore, that the drive be as accurate as possible. Only persons experienced in biological work were used in the census. The more experienced persons were spaced between the less experienced in the line. In addition, six foremen were instructed to follow familiar assigned lines to keep the drivers aligned properly. To maintain a driving line free from the usual bulges, time checks by the foremen were adhered to across the Reserve. All that was necessary for these checks was that the foreman so regulate his forward progress that he reach the designated points at the stated time, and keep his group of drivers aligned with him.

Other improvements in this drive over some of the previous ones on the Reserve were: 1) an orientation meeting of all the personnel participating in the drive; 2) a slower speed through regulation of the line; and 3) a centralized direction of the drive.

The drive was considered by most of the experienced participants as <u>one of the most accurate drives ever held on the Reserve</u>. The resulting totals of deer were therefore assumed to be correct to within one or two individuals, and no error was considered in the comparison of the other census methods. A total of 67 deer were counted during the drive. Sex and age determinations are not entirely reliable due to the late date of the census

Plate 7.

Foreman stopping momentarily at a time check. Note close interval of men, and good alignment.

Plate 8.

Line moving through a stand of small hardwoods. As may be seen, with the close spacing of the drivers a good liaison between them was possible.

(January 8, 1949). The composition of the herd as tallied was 12 antlered bucks, 41 antlerless adults, and 14 fawns.

The census, including arrangements, took one forenoon with 54 men participating to complete. Obviously, if the personnel had been paid for their contribution, the drive would have been a very costly venture. Such drives as this are practical only in such special instances.

Census through movements

The census through movements idea was first devised by Dr. Samuel A. Graham, School of Forestry and Conservation. With his guidance the author worked out the procedure here presented. No claim is made that this is a finished procedure for widespread use in deer census work, but experimental trials on the George Reserve show great promise for this method.

The basic technique in this census is to disturb the deer until they move freely about the census area. Observations are made on the movements of the deer which are recorded on maps of the area. Other pertinent data is also recorded on separate data sheets. The total population is computed on the basis of these observations. The experimental trials indicate that the best application of this method is not strictly a ground one, but that the observations are greatly facilitated through aerial techniques.

In the first application of this method, the area was divided into eleven districts on the basis of

Plate 9.

Deer moving back through the driving line at finish of the direct drive census. Most of the deer are easily tallied.

Plate 10.

Deer passing observer in first census by movements. Note the wide reach of the observer's vision to the distant horizon at this point.

cover types. One man was assigned to each of these districts. While the census was in progress, the man stationed in each of these districts acted as a driver, his function being to keep the deer moving and to flush as many deer as possible that were bedded down. The census was one hour in duration so each driver moved about his area for that length of time. All of the areas were not covered by the drivers to the same extent because of the difference in size of the individual areas. As may be seen from the map of this census (Figure 3.), areas such as Number 4 are several times larger than the small areas such as Number 8. This division of the areas allowed the heavy cover to be driven more thoroughly to rout the deer.

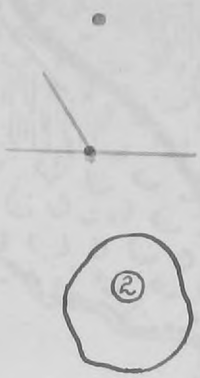
In addition to the eleven drivers, ten men were designated as observers and stationed at key points which afforded maximum visibility. The location of the observers is also indicated on the map in Figure 3.

All persons, both drivers and observers, recorded data in the following manner. On a cover map (Figure 1.) each observation was plotted by a long arrow to indicate the route of travel of the deer. A number was placed at the head of the arrow to indicate the number of the observation, and to correspond to the additional information on the data sheet. The supplementary data recorded consisted of: 1) the exact time at which the deer were first sighted; 2) the exact time they were last seen; 3) the composition and exact number of deer in the flock; and 4) any additional information on the observation possible. The instructions

Legend

First census through movements map

(Figure 3.)



Observer station

Lines of vision of observers

Driver district and number

Symbols on map represent the swampy areas and hardwood forests. Open grassy areas show on map as clear areas. The main road across the area is indicated by a double line. The secondary roads by a black dash line.

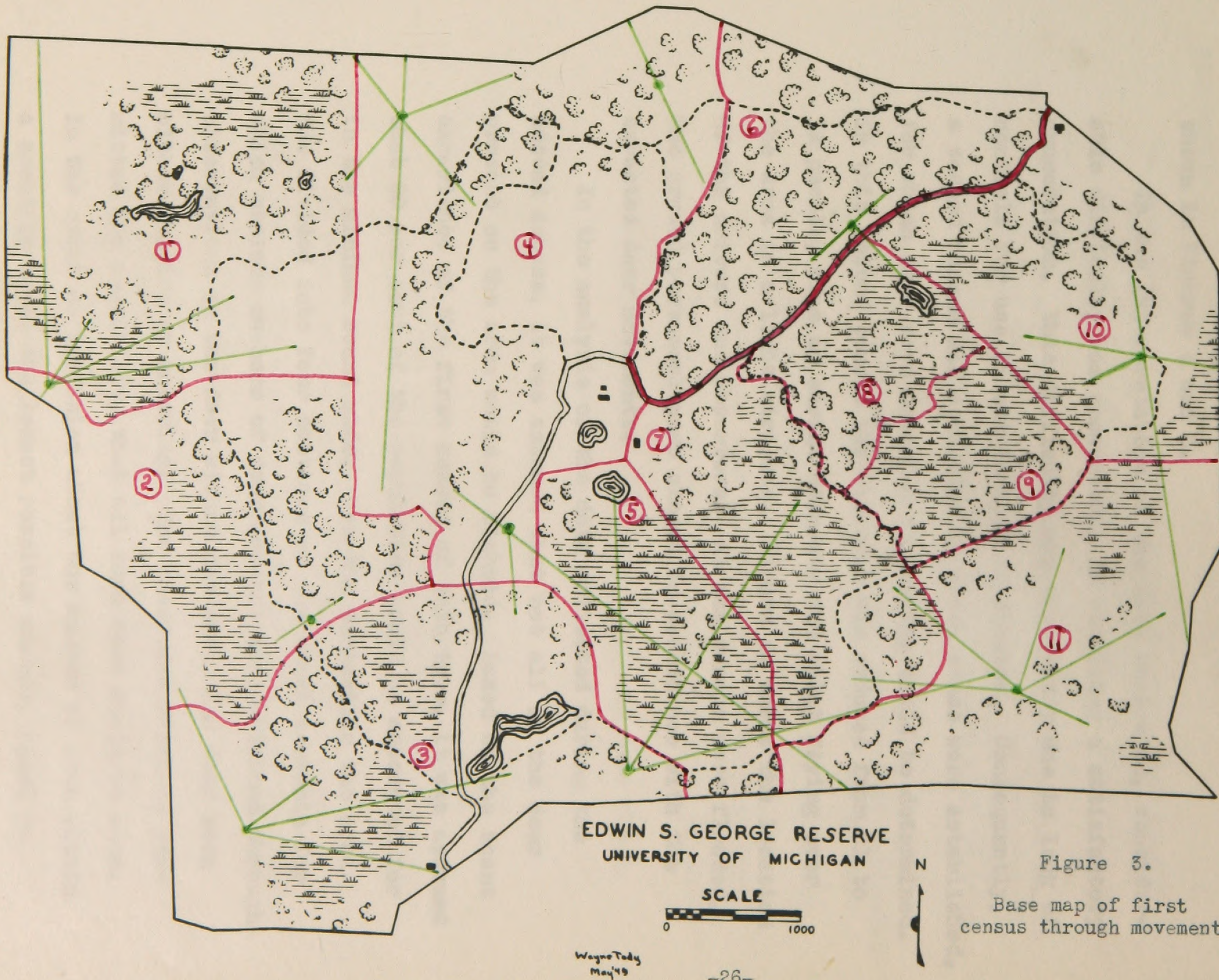


Figure 3.

Base map of first census through movements and data sheet used in the field for this census are shown in Figures 4 and 5.

In the interpretation of the data collected, considerable difficulty was encountered in obtaining a satisfactory enumeration. This difficulty was apparently due to lack of controls for use in eliminating duplicates. Consequently, a second census was conducted in which zones were established, for which deer seen entering or leaving could be determined. In this second census the manpower was reduced from 21 to 12 people, plus an aerial observer and pilot flying over the area in a light airplane. Figure 6. shows the location of the drivers and observers. As the swamps were flooded, the ground personnel were placed in accordance with the expected deer movements.

In the analysis of the data collected during the second census, it was assumed that not all of the deer present on the area would be sighted. Based on the scant experience of the first census of this type, it was assumed that 90 per cent of the population would be accounted for in the minimum count made. For the tabluation the area was divided into four sections as the zonal controls for which minimum numbers of deer present were obtained through observations on the deer within the area, and deer seen either leaving or entering. The observers stations permitted the possibility that all such deer could be seen. In the event of confusion about the number of deer within a specific area, the lowest possible number, based on

DEER CENSUS BY MOVEMENTS

PROCEDURE:

1. The theory of the method is to keep the deer moving about the area. Each person will record deer when seen, and from this data, the number of deer will be computed.

2. The Reserve has been divided into ten districts on the basis of cover types. One driver will be assigned to each of these districts. The driver will move about the district in such a way that all deer will be kept constantly on the move.

3. Observers will be posted about the Reserve on key spots. The observers will remain on the spot indicated on the maps provided at all times during the census.

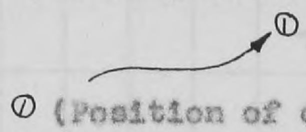
4. Both drivers and observers will follow the following procedure in recording observations:

   a. On the map, draw a long arrow to indicate route.

   b. Place a number at the head of the arrow to indicate number of observation.

   c. Fill in additional information on data sheet.

   d. Example of plotting observation on map:



(Position of driver)

   e. Drivers will also indicate their position at the time the observation is made by a corresponding number enclosed by a circle.

5. The actual census will last for one hour. A signal will be given at the start and finish of this hour.

6. Hand in the maps and data sheets, and make remarks on your opinion of this type of census on the back of the data sheets.

Figure 4.

A sample copy of the instructions passed out to all participating members of the census.

DEER CENSUS BY MOVEMENTS

Name John Doe DATA SHEET Position Observer # 4

No.	Time first seen	Time last seen	Bucks	Does	Fawns	Misc.	Total	Remarks
1	10:35	10:37	1			3	4	Jumped by driver # 3
2	10:40	10:41		2	3		5	Ronning Area 3 to 4
3	10:47	10:50	1	1	2		4	Large rock on buck.

Figure 5.

A sample copy of the data sheets used by all participant members of the census.

Legend

Second census through movements map

(Figure 6.)

Observer station

Lines of vision of observers

Driver district and number

Route of track count

Boundary of zonal control

Number of zone

Symbols on map represent the swampy areas and hardwood forests. Open grassy areas show on map as clear areas. The main road across the area is indicated by a double line. The secondary roads by a black dash line.

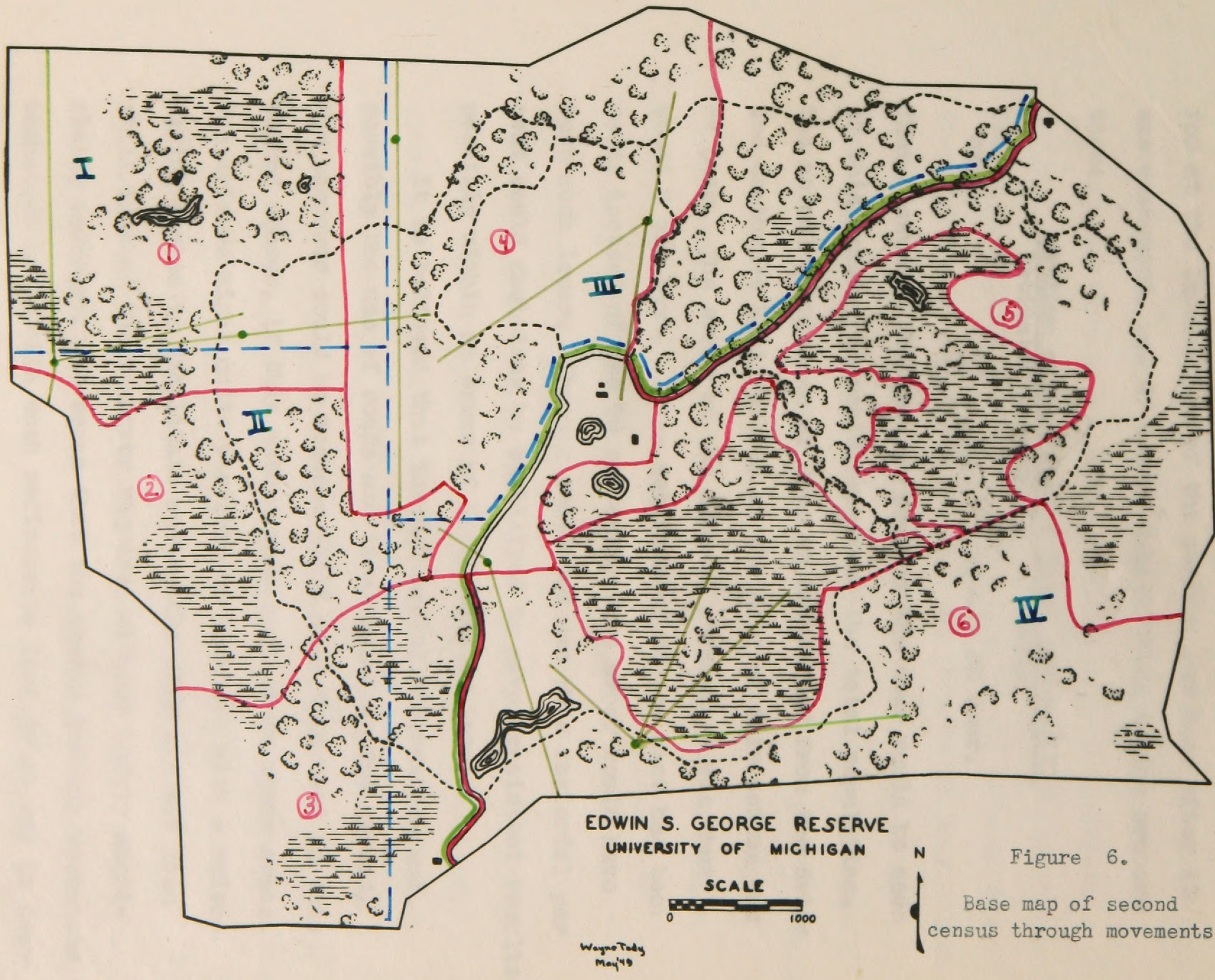


Figure 6.

Base map of second census through movements observation, was used. The minimum number thus accounted for at the termination of the census, one hour after it was commenced, was 47 deer. Substituting in the proportion:

$$\frac{\text{Minimum number seen}}{\text{Estimated \% seen}} : \frac{\text{Total number (X)}}{100\%}$$

or: $\frac{47}{90} : \frac{X}{100}$ equals 52 deer.

Thus, assuming that 90 per cent of the deer would be seen in this census, 52 would represent the total population. The actual population of deer as determined from the drive and Camburn's kill records at the date of this census was 57 deer. The error on the assumed percentage was thus about 9 per cent. If an estimate of 80 per cent had been used, instead of the 90 per cent, this error would have been much lower. Through continued use this factorial per cent could doubtless be stabilized to give consistent results possibly within an error of 5 per cent or less.

It is believed that through aerial observation and possibly the use of roads and fire trails on the ground, the manpower could be reduced still more than used in this second census, if this method were applied on other areas. The drivers might quite possibly be equipped with a noise-making device to facilitate moving the deer and cut down still further the manpower required without unduly sacrificing accuracy. It seems that the census through movements technique could with such refinements find great use in deer population studies.

Trapping, marking, and later recapture

This census method was not tried in the field on the George Reserve, as equipment available, time, and the already wide scope of the problem were prohibitive.

Deer are readily captured in areas of high population densities, where food shortages exist, such as the deer yards of northern Michigan. The results of this method if it were used in such areas would not be particularly valuable in total enumeration, as the deer dispersal from such areas is so erratic that it would cancel any possibility of correct population enumerations. (Ilo Bartlett, oral communication.) In regions other than such concentration areas, the cost of the trapping is probably prohibitive for use of this method over large areas.

Index methods of sampling

Several index sampling methods were tried on the Reserve. The strip cruise, sight index methods -- foot, automobile, and spotlight -- and deer sign plots were each tried several times. It was impossible under the light winter weather conditions to use the bait spot index method, due to conflicting needs for the limited tracking snow.

Strip cruise method

Usually the strip cruise census method is not considered an index method because it is used to determine the total enumeration of the population. In this study, however, the results obtained by this method were so erratic that it seems best to group it with the index methods. The field procedure followed was similar to the first description of the method by Erickson, 1940. More recently, variations of the method have been described that bring the mean of the results of this method up to a level with the real mean of the population. In this study the author was not concerned so much with the low results as with the consistency of such results, hence Erickson's techniques were as usable as others. Two lines were marked across the area, the long way from east to west, and followed each time this method was used. Seven censuses by the strip cruise method were made.

The population enumerations by this method varied from 28 to 94 deer. The mean of the estimates was 54 23.3 as compared to the real mean of 59 deer. The range in which 95.44 per cent of the estimates would fall was thus 5.7 to 98.9 deer as determined from the standard deviation of this data. The method as applied in this study thus appears to be much too variable for reliable enumerations. If the sample were increased to several thousands of acres, the range of variation would be considerably reduced, but the indication is that the results would be incomparable in the extreme for different sections of the total deer habitat thus considered.

Many of the reasons for the fluctuations in this method are discussed in a recent publication (Hayne, 1949), which are concerned with the mathematical nature of of the method. Reasons for the wide fluctuation is also to be had in the biological nature of the whitetail. These biological discrepancies will be discussed later in this paper.

The comparison of this method with the actual population is shown graphically in Figure 7.

<u>Sight index methods</u>

The sight index methods are merely estimates of the total population as determined from the number of deer seen per hour by a well trained observer.

The theory of the method is that the greater the population density the greater the number of deer that will be seen per hour of observation on any given area, providing that the observer restricts his observations to the twilight periods of greatest activity of the deer. As ability to see deer varies with the observer, the same man must conduct all estimates by the sight index methods. One advantage of the sight index over the strip cruise is that the observer can travel freely in the localities where the deer are most apt to be seen and thus can usually see more deer in a shorter period of time. No area control such as that used in the strip cruise method can be exerted.

Four variations of the sight index method were used on the Reserve in this evaluation. Seven trials were given each of the automobile counts, daylight and spotlight, eight to the foot count, and one to the horseback count. The horseback variation was found to be unsatisfactory due to purely local conditions. The mount used was too

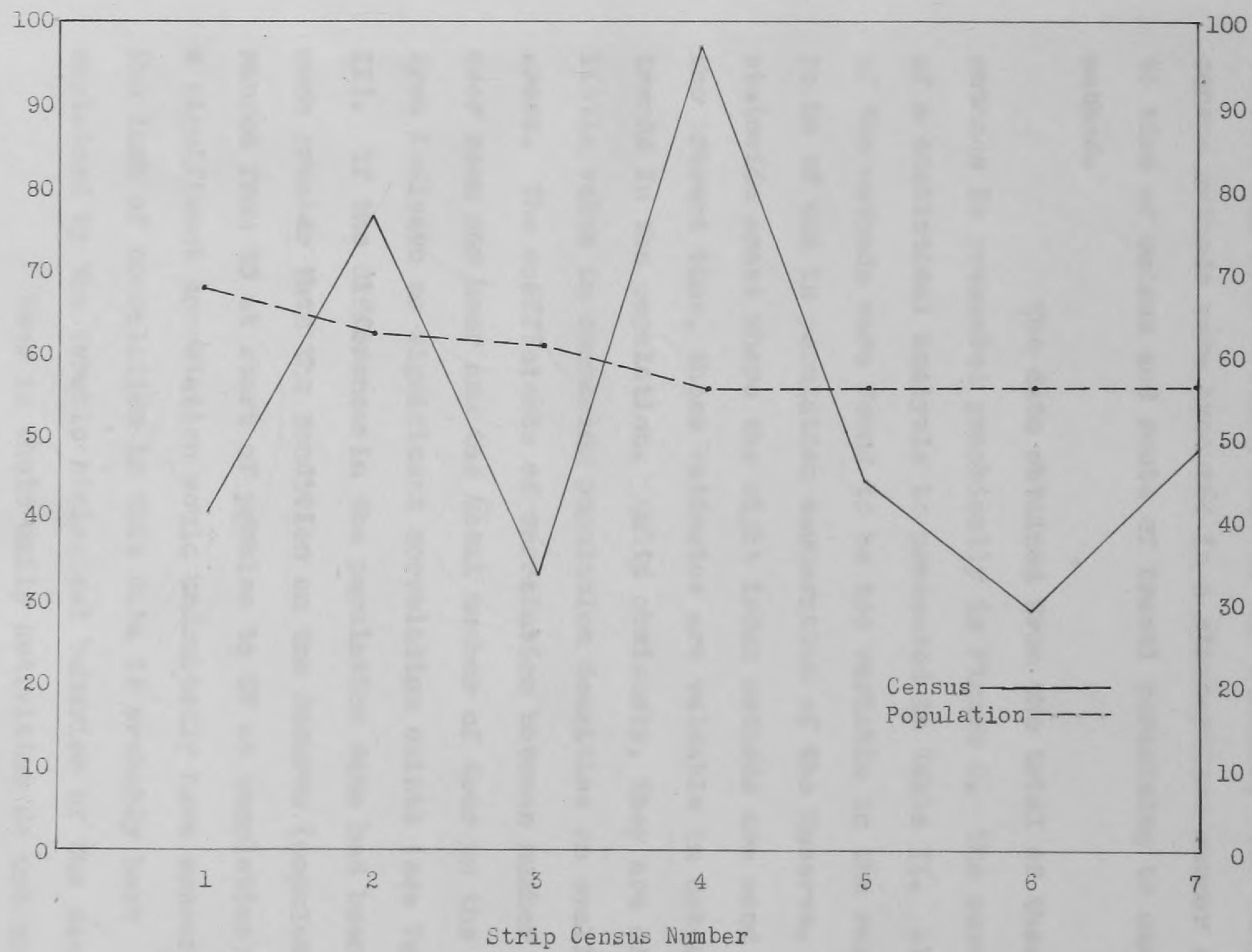


Figure 7. Comparison of the strip cruise census method results with the known deer population at the date of the census.

familiar with the Reserve, and constant control was necessary to keep him from bolting back to the stables. The other census methods were executed in a standardized manner as to time of census and route of travel pertaining to each method.

The data obtained from the trial of these methods is presented graphically in Figure 8. The results of a statistical analysis is presented in Table II. All of the methods were found to be too variable in the results to be of use in population enumeration of the Reserve. On statewide areas where the sight index methods are used at the present time, these estimates are valuable in detecting trends in the population. Quite obviously, they are of little value in comparing population densities on small areas. The coefficients of correlation between number of deer seen per hour and the total number of deer on the area indicate no significant correlation exists (see Table II). If the differences in the population data had been much greater than the condition on the Reserve (population ranged from 83 at start of problem to 57 at completion), a significant correlation would undoubtedly have appeared. The lack of correlation in this data is probably best explained by the erratic biological behavior of the deer.

Deer in their daily activities do not move about to the same degree every day. On clear and bright days, they may not move all day. On dark, overcast or rainy days, they may move throughout the day. The number

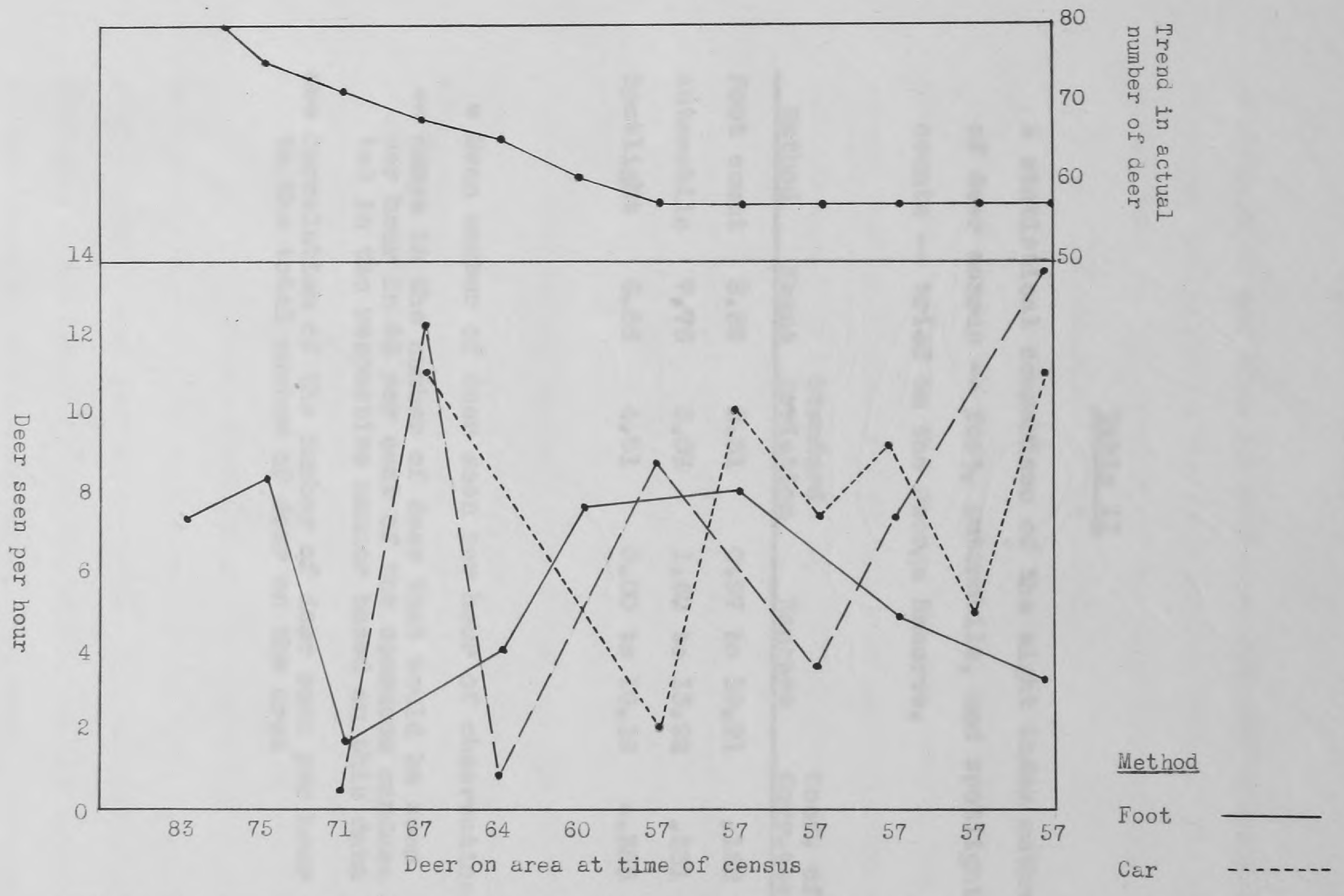


Figure 8. Comparison of sight index methods - number of deer seen per hour to known population of deer. The censuses grouped together were not necessarily executed on the same date.

Table II

A statistical comparison of the sight index methods of deer census -- foot, automobile, and spotlight counts -- tried on the George Reserve.

Method	Mean*	Standard Deviation	Range**	Coef. of Corr.***
Foot count	5.59	2.31	0.97 to 10.21	.162
Automobile	7.76	3.08	1.60 to 13.92	.531
Spotlight	6.56	4.81	0.00 to 16.18	-.385

* Mean number of deer seen per hour of observation

** Range in the number of deer that would be seen per hour in 95 per cent of the censuses conducted in the respective manner based on this data

*** Correlation of the number of deer seen per hour to the total number of deer on the area of deer seen per hour is thus more closely related to the movement exhibited by the deer at the time of the observation than to the density of the deer population.

Census through deer sign

Since deer sign once formed is not subject to the great variable of mobility exhibited by the parent animal, many authors have suggested the possibility of a census medium. Notable work has been accomplished on census methods based on track, bed, and pellet group counts.

Through field observations, it was found by the author that such methods as have been described in the literature for these counts were not applicable on the Reserve. Track counts were influenced by the confining fence. Bed counts as such were ruled out due to the error introduced by chance distribution, and the necessarily small sample allowed by the counting method. Pellet group counts presented a more greatly diversified situation. Consequently an intensive study of pellet group occurance was made by cover types on the Reserve during the winter.

It was found that the distribution of pellet groups was very spotty when considering them as an accumulation over a long period of time. The groups were very numerous about the edges of the swamp, in the swamps, and in the edges of the upland types. In some places the pellet groups were numerous but hard to find. In the hardwood types they were easily covered up by drifting leaves, in tall grass they were almost entirely obscured, and in any

Plate 11.

Method of marking plot corner in deer "sign" studies.

Plate 12.

Method used for marking cruise lines. These methods were used in place of axe blazes or stakes which would subtract from the esthetic value of the area. These marks were found to be quite satisfactory.

type they were buried with the first snow. Another important factor in the accumulation of the pellet groups was that the deer tended to yard in the big swamps to the exclusion of the other types during severe weather. The floor of the big swamps was covered with one or two feet of water, hence with a thaw the large accumulation of pellet groups in the swamp disappeared from further view. In addition to the distribution of pellet groups in accumulations other factors seemed apparent that would lead to discrepancies in census methods. Most important of these were the size of the groups, and the age of the groups. The pellets comprising one group were found to vary in number from one to over two hundred. Some pellets were four times as large as others. The determination of age from the moisture content of the pellets was very unreliable. All in all it seemed apparent that census through the accumulation of pellets on the George Reserve was a physical impossibility in the winter season. No census by pellet group count alone was attempted. It must be mentioned, however, that the Reserve is very heterogeneous as far as cover types are concerned. In an area where cover types are faily homogeneous the conditions mentioned here might not exist, and census through pellet group counts might be feasible.

In order to explore the possibilities of census through the accumulation of fresh deer sign, two types of plots were established on the Reserve. As snow

Plate 13.

Well worn path leading to the concentrated bedding area in the big swamp during the winter. The numbers of paths similar to this one present on the Reserve alone indicate that a large number of deer are present.

Plate 14.

Winter pellet groups in grassy meadow near edge of big swamp. The groups in this region remain visible for long periods of time. In this area such groups are so numerous that confusion is unavoidable in counts made of them.

Plate 15.

Winter pellet group in the woods. Groups such as this one are difficult to spot especially if partially buried by strong winds.

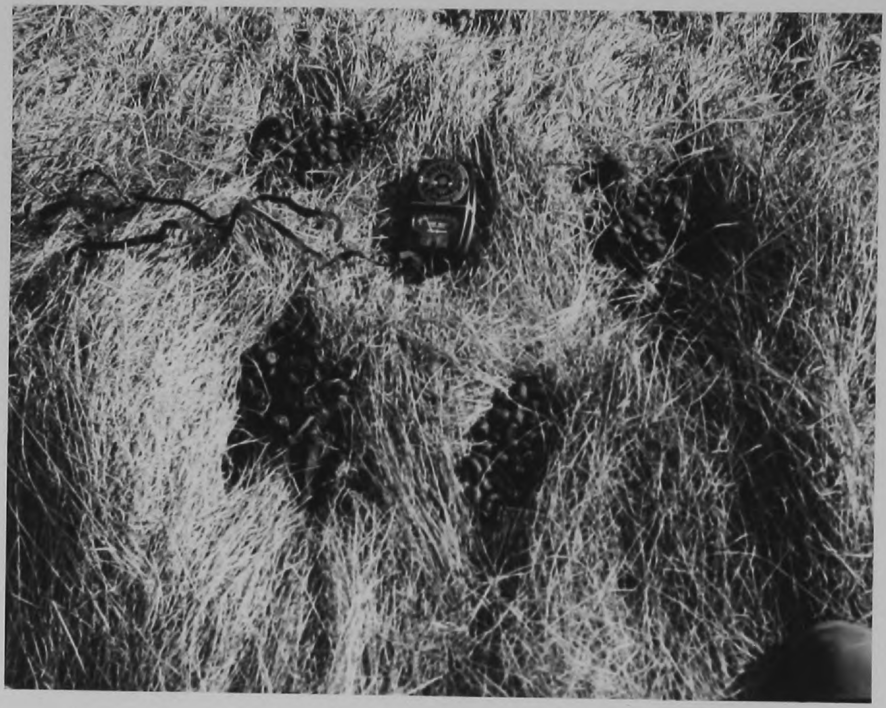


Plate 16.

Apple tree showing both deer and cottontail rabbit browse. The deer browse is apparent only at the nipped-off ends of the branches.

Plate 17

Antler scrape on poplar tree. Such deer sign as this is spectacular, once seen, but is not usable in census work due to the rare occurrence.

was the limiting factor in the use of these plots, adequate data on which to base conclusions could not be had. Five plots were laid out five chains square (2.5 acres) and all fresh sign present was tallied 24 hours after each fresh snow. One of these plots was located in each of the following types: grassland, tamarack swamp, hardwood, and marshland. In addition one plot was placed in an ecotone so that it contained equal portions of each of the above mentioned types. It was thought that the sign left by a known number of deer in twenty-four hours after a fresh snow on the Reserve might be used as a guide to population densities on other areas. Thus the results of the four counts made on the plots are presented in Table III. Certainly there is a good use for such plots in determining the use of different cover types by deer at different intervals throughout the winter.

In the other study of deer sign by use of plots, transects of one-half chain plots (adjacent as in dominoes laid in a row) were run through various cover types. All beds, pellet groups, and tracks found on each plot were recorded. It was found that the number of pellet groups and beds was negligible but that the number of tracks so intercepted was quite high. Here is another useful tool in deer movements studies, and possibly in census work. One advantage of plots of this type is that the results so obtained can be subjected to statistical analysis. Only two counts were made in this manner, so no comparison of of the data was made.

Table III

Deer sign accumulated on the two and one-half acre sample plots in different cover types on the George Reserve, twenty-four hours after each tracking snow, with a known number of 28 deer per section.

Number of count	I	II	III	IV
Grassland	9- 0- 1**	14- 0- 1	6- 0- -	31- 0- 2
Bog swamp	50- 5- 2	29- 1- 4	38-10-12	27- 4- 6
Marshland	19- 0- 1	12- 5- 1	4- 0- 1	8- 0- 0
Hardwoods	10- 0- 2	10- 0- 3	7- 0- 1	14- 0- 1
Composite (all 4 types)	12- 0- - .	7- 0- 0	13- 1- 2	25- 7- 5

** The first number in each series designates number of tracks, the second number of beds, and the third the number of pellet groups

Bait spot counts

It was originally planned in this study to try a bait spot count as an index method of census, but the rare occurence of tracking snow was prohibitive. The method of census as proposed by the author was to put out bait that would be palatable to the deer, and would attract them, then to count the tracks of the deer around each bait set. Apples or corn were the proposed baits. Around the bait a ring in the snow would be brushed out in the evening of the set followed by a track count in the early morning. These baits were to be set out at intervals of one-half or one-fourth mile over the entire area. Counts at salt-licks were tried and discarded by Bartlett (1938).

Evaluation of the census methods

In a total analysis of the data collected in this study certain facts become apparent on the individual deer census methods and on the problem of censusing deer in general. In this discussion the individual methods will be reviewed in regard to accuracy and value in census work, followed by a theoretical explanation of the variance of the methods in accuracy based on the biology of the species.

The direct drive census method when executed by a sufficiently large group of experienced men was found to be the most accurate, but also the most expensive, of the census methods.

The census through movements shows great promise for use in accurate census work. It is also relatively inexpensive when compared to the drive method.

The trapping, marking, and release with later recapture census method was not tried on the Reserve but is generally considered to be mathematically sound if the variable of selectivity in trapping can be eliminated.

The strip cruise method based on Erickson's technique (1940) was found to be unreliable for use on a small sample area.

Sight index methods were found to be inaccurate in the extreme and usable for only the most extensive population survey work where the other methods of census are not feasible in use.

Census through deer sign was not investigated adequately in this study. Pellet group counts, however, were not found to be applicable in a region of such diverse cover types as the George Reserve, especially in the winter season. Census through fresh accumulation of deer sign is a possibility to be further explored. Bait spot counts may be a simple method of relative population density determination.

The outstanding fallacy in the deer census methods considered, then, was to be found in the methods based on sighting of deer by one or two men. All such methods were found to be unreliable. The reason for the failure of these methods may be found in the basic technique followed in conducting the census. The observer simply tries to count the deer with the advantage in their favor. He is dealing with them at their level which he is not biologically equipped to do. The deer have a great advantage in mobility. They can hear and smell much better than any observer, and can probably optically detect motion at least as well. Other factors too are in favor of the deer. They do not have to move about during the census as does the observer; rather, they can skulk in heavy escape cover and remain perfectly motionless. Undoubtedly many deer slink away from the observer unseen. The observer has certain factors in his favor, but in comparison they are of minor importance. Man has greater power of reasoning than deer, and is thus able to anticipate many of their movements. He is also probably superior in the sense of color perception. In any summary of these advantages and disadvantages, however, it must be stated that the deer has a greater chance of escaping the observer unseen, under favorable circumstances, than the observer has of seeing the deer. He is thus at a disadvantage from the very beginning in the sight index census methods.

There is one other factor which contributes even more to the erratic results obtained by these census methods than does the disadvantage in observation. This factor is the movements of deer. Deer are definitely known to be sporadic in their movements from day to day and from season to season. We do not know enough about these movements, however, to predict the behavior of the animal while we are in the field on any given day in a definite enough manner to be of value in census work. If coefficients of correlation could be set up between weather, physiology of the animal, and all other factors influencing his movements, we could eliminate much of the variance in the results of these index census methods. Such factors will have to be determined if further progress in census work is to be made with these methods, a difficult task indeed.

Much work remains to be done on developing reliable techniques to ascertain population densities through deer sign. Methods based on the accumulation of sign are logical and show promise of success in this line. It seems that the greatest progress could be made in studies concerning fresh sign rather than old sign. The environment shows a remarkable ability to absorb sign rather quickly after it is formed. Tracks last only a few days at most. Even pellet groups are by no means as stable as sometimes believed. On the Reserve some pellet groups in tall grass and leaves were obscured immediately. The thawing of the ice in the big swamps with the consequent disappearance of the large accumulations of pellet groups on it is the perfect example of this condition.

In the census methods designed for total enumeration, we must deal primarily with the animals alone. The factors of mobility and variations in behavior must be eliminated. In the direct drive through the use of mass-manpower this is accomplished. It matters little in the drive how fast the deer can move, and little in how well they can see or hear. Nor does it matter what the inclination of the deer is to move on the day of the census. The method alone forces the deer to move in such a way that they can be counted. The census through movements similarly gives the advantage in census to the census takers rather than to the deer. In this method the deer are forced to move about, and this alone subjects them to a count or tally. Consideration, however, must be given to topography and vegetative types. Hence through the improvements suggested earlier in this paper it seems that through further development of the census through movements method, accuracy can be had in deer census work to a high degree without the high expense heretofore assumed necessary.

One final point should be considered in the development of deer census methods. That is in the use of machines in census work to cut down the cost of expensive manpower. We are no longer in the stage of hand tilling of the soil or in strictly manual labor in industry. Machines have been used in census work with notable success, especially the airplane. Aerial observation in the census through movements reduced the cost of the census considerably, and greatly facilitated the method. Undoubtedly other uses of machines to eliminate mass-manpower can be devised as well.

Further refinement of the deer census techniques must come through the following channels: 1) use of methods designed to give the advantage in census to the observers and not to the animal, 2) derivation of further mechanical means to eliminate costly man-power, and 3) in the extensive index methods of determining population densities through deer sign by the quantitative analysis of fresh sign only. These channels will lead to better census methods for the whitetailed deer.

Summary

Nearly all of the ground census methods for the whitetailed deer applicable under winter conditions were tried in this study conducted on the Colonel Edwin S. George Reserve of the University of Michigan. As conditions were not favorable for a thorough study of all methods due to the light winter weather conditions, and limitations on the length of time of study, all existing methods could not be tried.

1. The direct drive census was found to be the most accurate method and was used as a control for the evaluation of all the other methods. The drive, using 54 men, was also the most costly of the census methods tried.

2. The census through movements method was found to exhibit good accuracy with much less cost then the direct drive. This method is new in deer census work.

3. The strip cruise census, and all other sight index methods, were extremely variable in results. Evidently they are unsatisfactory for population enumerations on small sample areas.

4. Census through deer sign could not be investigated adequately due to the light winter conditions. It was found that greatest promise through use of sign in the determination of population densities is contained in studies of a quantitative nature involving the accumulation of *fresh* deer sign.

5. Bait spot counts, and census through trapping, marking, and release with later recapture, were not tried on the Reserve.

6. The fallacy in accuracy of the strip cruise census and sight index methods is best attributed to the fact that these methods do not compensate for the biological factors of the species. These factors present unsurmountable variables in these census methods. It is unwise to attempt to census deer by methods which allow them a biological advantage in escaping attention. Usable census techniques must give the advantage in census to the observers.

7. Improvements in total enumeration census work seem to be most promising in the direction of the census through movements idea, or in some phase of it. Census work can also be greatly facilitated through the use of machines to eliminate costly manpower.

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