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An analysis of aerial census methods of white-tailed deer.
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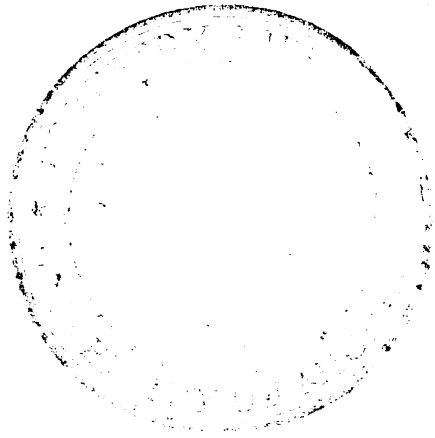

AN ANALYSIS OF AERIAL CENSUS METHODS OF WHITE-TAILED DEER

by

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Submitted in partial fulfillment of the requirements

for the degree of Master of Forestry,

University of Michigan

June 1949

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. Warren W. Chase and Dr. S. A. Graham of the School of Forestry and Conservation for their guidance and supervision.

I am grateful to Dr. J. Speed Rogers, Director of the Museum of Zoology, for permission to carry out this study on the George Reserve.

Mr. Wayne H. Tody, Graduate Student in Forestry, gave freely of his time and energies to act as aerial observer during the greater number of counts made for this problem and his help is gratefully acknowledged.

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INTRODUCTION

A knowledge of game populations is extremely important to the game manager. The harvest, as regulated by seasons, bag limits, and area restrictions, is controled by this knowledge. For this reason it is necessary that some means of determining numbers of game on specific areas, in an ideal and economical way, be discovered.

Attempts to obtain numbers of game present have included total counts, indices to trends in population, ratio counts, such as: the trapping, banding, releasing and retrapping technique and have met with varying degrees of success but a reliable method within reasonable limits of expense has yet to be perfected, especially when applied to big game species.

Successful uses of the airplane have been discovered with relation to forest surveys, aerial mapping, waterfowl surveys, soil surveys, fire detection and suppression and general reconnaissance of game areas and its value as a tool for use in big game censusing is debated in many states today.

Aerial censuses of several species of big game have been attempted in several states with spectecular success with animals that live in the open such as the elk, Dall sheep, antelope and to a lesser extent the mule deer.

Some investigators have experimented with censusing white-tailed deer from the air but due to the heavy cover in which whitetails are found, these have seldom produced consistent results.

The study reported in this thesis is an attempt to discover

whether or not white-tailed deer can be censused from the air economically and with consistent accuracy. The value of the study is primarily due to the fact that the field work was done over an area of known population and that the most promising, known methods of aerial censusing plus some new methods were compared by the same observers.

THE STUDY AREA

The Edwin S. George Reserve is an excellent proving ground for the testing of aerial counts of white-tailed deer. This is especially true because it is enclosed with a deer proof fence which is 7 feet high with an additional foot of barbed wire overhang. This fence prevents the egress or ingress of deer during the course of the problem and allows the population of the area to be known at all times.

The Reserve is a 1268 acre tract of land owned by the University of Michigan and administered by the Museum of Zoology. It is located in the southwest corner of Livingston County approximately 25 miles northwest of Ann Arbor. Previous to its purchase by Col. George in 1927 and 1928 it had been typical submarginal farming land with small portions under cultivation and the majority in woodlot and pasture. In 1928 it was stocked with six deer, four pregnant does and two bucks and in 1930 it was turned over to the University as a natural research area. The first reliable census was made in 1933 and showed a population of 160 deer and severe browsing damage. This was the start of the present managed deer herd.

Harvesting by shooting was started in 1934 and has continued to the present in an attempt to maintain the herd at a level of from 50 to 60 deer going into the new fawning season. The two sexes have been taken almost equally with some fawns being taken each year.

The Reserve is typical of the glacial outwash of southeastern Michigan with numerous kettleholes, kames, eskers and plains and its elevation is between 900 feet in the seepage bogs and 975 feet at the level of the plains and eskers. The vegetation is well interspersed and

is composed primarily of grasslands and hardwoods with scattered bogs, swamps and marshes. The percentage of types is shown by the following table:

Type	Percentage in Types	Acres
Grassland	39.7	503.396
Hardwood	34.6	438.728
Brush	1.7	21.556
Bog Swamp	13.5	171.180
Marsh	10.0	126.80
Open Water	0.5	6.340
	100.0	1268.00

Winter on the George Reserve is never severe enough to force the deer to yard, however, deer seeking food and shelter from the storms and cold winds make intensive use of the lowlands. This past winter has been less severe than usual but still there were high concentrations of population in the swamps, bogs and swales.

The known population of the George Reserve has varied from a high of 83 deer present in December when the field work on this problem was started to 57 deer at the end of April when the problem was completed. This reduction in population during the course of the work was due to the fact that it ran through the period of harvesting the crop and the annual increase was shot off. The populations shown here were determined by a manual drive of the enclosure which was believed to be nearly 100% accurate, plus or minus one or two deer, by the experienced men who observed it.

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

N

fig. 1


EDWIN S. GEORGE RESERVE
UNIVERSITY MUSEUMS
UNIVERSITY OF MICHIGAN
DATUM: MEAN SEA LEVEL
CONTOUR INTERVAL = 5 FEET
SCALE:
JAN 28, 1933
JOHN RUSKIN, ENGR.
PAUL F. HICKIE
LEGEND
BOUNDARY FENCE
FIRE LANE
ROADS
TRAILS
FRAME HOUSES
OTHER BUILDINGS
BRIDGES
SPRINGS
RUNNING WATER AND DIRECTION

Fig. 2

An airstrip suitable for light planes has been laid out on one of the level outwash plains which was available for emergency landings during censusing flights.

EQUIPMENT AND METHODS

The characteristics required of an airplane which is to be used in census work are principally safety, low cruising speed and maneuverability. Since most of the planes which satisfy these requirements are high-wing monoplanes, they have the visibility which makes them especially suited to this work, other desirable features will depend upon the methods of censusing to be used and the terrain to be flown over. Because all of the known methods of aerial censusing were to be used it was believed that a tandem seating arrangement would be desirable. This seating arrangement would enable each observer to scan the terrain on either side of the airplane.

The Piper Cub satisfied all of these requirements and so was used in the majority of cases, the only exceptions were to experiment with a side by side seating arrangement in the Luscomb Silvaire. It was found that in addition to the difficulty of observing from the same side, the planes with that seating arrangement usually have a higher cruising speed than the Cub and for this reason are less desirable over terrain such as that of the George Reserve. Over rough or mountainous terrain and where the strip method of censusing is to be used, the additional speed makes the plane safer and the side by side seating arrangement will make communication between the pilot and observer easier.

The landing gear may be wheels, skis or pontoons depending upon the time of year that the flying will be done and the place where the majority of landings will be made. Any of the popular planes of the type previously mentioned, are easily fitted with any of these kinds of gear. Wheels were used entirely on this problem because there was never sufficient snow to permit the use of skis and the landing field on the Reserve itself made it possible to land on the immediate area in case of emergency.

The tally sheet used on this problem was an abbreviated type map of the Reserve showing three principal types, the woodlands, the grasslands and the swamps (this included the seepage bogs, swales and the swamps). This map was constructed in colors so that the types would be distinguishable at a glance and was covered with a sheet of transparent astex paper upon which observations could be noted. The map itself could have been written on but since numerous counts were to be made using the same tally sheet and over the same area, the repeated erasures would have soon destroyed it. This type map is illustrated in Figure 5 of the paper. Counts over large areas could be made using a plat map of the township or road maps which will show road systems and the more conspicuous landmarks.

Upon returning to the office the data obtained was immediately transferred to a prepared data sheet (see Figure 6) and comments were made while the field work was fresh in mind. This data sheet was used so as to insure consistency in the notes and so that greater speed would be gained at the same time.

AIRPLANES USED

PIPER CUB
Tandem seating arrangement
Cruising speed approximately 80 MPH

Fig. 3

LUSCOMB SILVAIRE
Side by side seating arrangement
Cruising speed approximately 100 MPH

Fig. 4

Deer Tally Map
for
Edwin S. George Reserve

Fig. 5

Types

Green - Swamp
Yellow - Grassland
Blue - Hardwood

Roads

Date _____

AERIAL DEER CENSUS NOTES

WEATHER

Degree of Sunlight

1. Bright sun
2. Slight haze
3. Moderate haze
4. Overcast

Cloudcover

1. 0-25%
2. 25-50%
3. 50-75%
4. 75-100%

Temp. _____
Wind Direction _____
Wind Velocity _____

PRECIPITATION

Time since last:	Type of:	Degree of:	Duration of:
1. Within 24 hrs.	1. Rain	1. Violent	1. 24 hrs. plus
2. Within 48 hrs.	2. Snow	2. Moderate	2. 12-24 hrs.
3. Within 7 days	3. Sleet	3. Gentle	3. 2-12 hrs.
4. Not within 7 days.	4. Glaze		4. Under 2 hrs.

Census Method

1. Circling defined area
2. Strips 1/4 mile wide
3. Series of overlapping circles
4. Other _____

Number of Deer seen in:

1. Woodland _____
2. Grassland _____
3. Swamp _____

Condition of Vegetation

1. Snow covered
2. Ice covered
3. Bare
4. Persistant leaves
5. Green leaves
6. Undeveloped leaves

Activity of Deer Observed

1. Feeding _____
2. Traveling _____
3. Bedded _____
4. Other _____
   a.
   b.

Type of Airplane _____

Cost of Airplane _____

Time Taken _____

Altitude of Census _____

Observer _____

Ground Cover

1. Snow
2. Ice
3. Bare

Comments:

Fig. 6

Flight Patterns: Airplanes have been used in several different ways in attempts to census big game animals, those showing the greatest promise are: 1. A series of adjacent strips covering the area to be censused. 2. By circling one portion of the land to be censused until all the deer are counted and then moving to the next portion. This is continued until the entire area is censused. 3. By flying a series of overlapping, eliptical circles over a predetermined strip. Several of these strips are covered to census the entire area. These methods are illustrated in Figures 7, 8, and 9 respectively.

In addition to these methods, attempts were made to make counts from high altitude with binoculars, from three sets of complete aerial photographs of the Reserve from different altitudes and with different camera angles and the airplane providing supplimented data to that obtained by a ground census crew.

A discussion of each of these methods is made in the following pages of this paper.

TECHNIQUE AND RESULTS

Censusing by Strips:* The airplane was flown up the middle of each of eight strips laid off on the Reserve in a north-south direction. These strips were each approximately 1/4 mile wide and 1 mile long and were located by landmarks easily seen from the air. The length was determined by the distance across the reserve; the width was chosen because it was believed that 1/8 mile on each side of the plane was the maximum that could be scanned carefully. This system gave complete

* This method was used by Saugstad in North Dakota and by Erickson (unpublished) in Minnesota, with slight differences in technique.

coverage of the enclosure.

The censusing was done from 375 feet above the average terrain level. This elevation was recommended by Saugstad (1942) and seemed to be the point where the two limiting factors seemed to balance. These factors are the apparent speed of the plane over the ground and the apparent size of the object to be seen (the apparent speed is greater as the distance to the ground becomes less and the size of an object appears smaller as the distance to it increases). This height was used for all the low altitude methods used in this problem.

All of the counts made by this method were made on clear and relatively calm days during the last three hours before dark. This time was selected due to the increase in deer activity during these hours. Results: The counts obtained on eight censuses were low and extremely variable as shown by the following table:

Date	No. of Deer Present	No. of Deer Seen	Percentage
Dec. 4, 1948	83	33	39.8
Feb. 5, 1949**	60	0	0
Feb. 6, 1949	60	0	0
Feb. 8, 1949	60	0	0
Feb. 19, 1949	59	1	1.7
March 15, 1949	57	3	5.3
March 21, 1949	57	12	21.0
April 19, 1949	57	18	31.6

** This count was made when the air was windy and rough and the observer became airsick causing the census to be discontinued after four of the eight strips had been traversed.

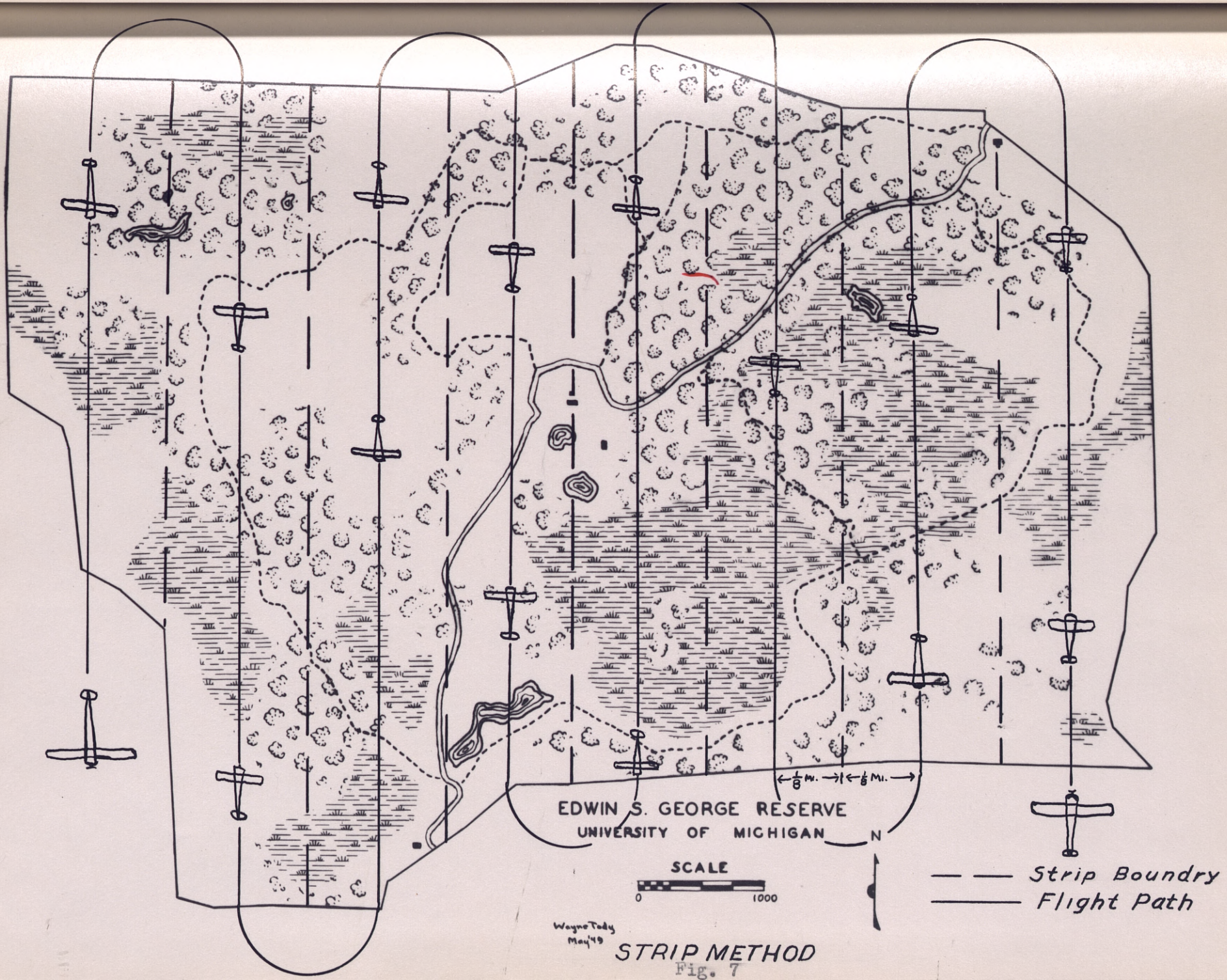
The counts made in the spring months seemed to produce better results due to the fact that the deer were coming out on the grasslands to feed. As shall be shown, this has proven to be true in each of the low altitude methods, where direct counts were used.

Of the 67 deer seen and tallied by this method only 13 or 19.4% were seen in the wooded or swamp areas. This is a very low number of deer seen in these areas because during the winter months, by far the majority of the population were found in areas of heavy cover.

The failure of this method to produce consistent results seemed to be caused by the speed of the plane over the ground and the fact that the observers did not have sufficient time to thoroughly scan the area though the slowest plane available was being used.

High Altitude with Binoculars: An attempt was made to scan the ground below from an altitude of 1000 feet using binoculars to aid the vision of the observer. It was found that even when the location of bedded down deer was known they could not be seen from this altitude. This was due primarily to the fact that the engine vibration prevented the observer from holding the binoculars still. It was also believed that much territory would be skipped because of the limited field of view through the glasses. This method was discontinued after one trial.

Circling a Defined Area: Nine rectangular plots were located on a map of the Reserve which were roughly 1/3 mile wide and 2/3 mile long. These were laid out so that conspicuous landmarks would serve to define them to the aerial observer. Continuous circles were made over these plots


EDWIN S. GEORGE RESERVE
UNIVERSITY OF MICHIGAN
N
SCALE
0
1000
Strip Boundry
Flight Path
Wayne Tody
May '49
STRIP METHOD
Fig. 7

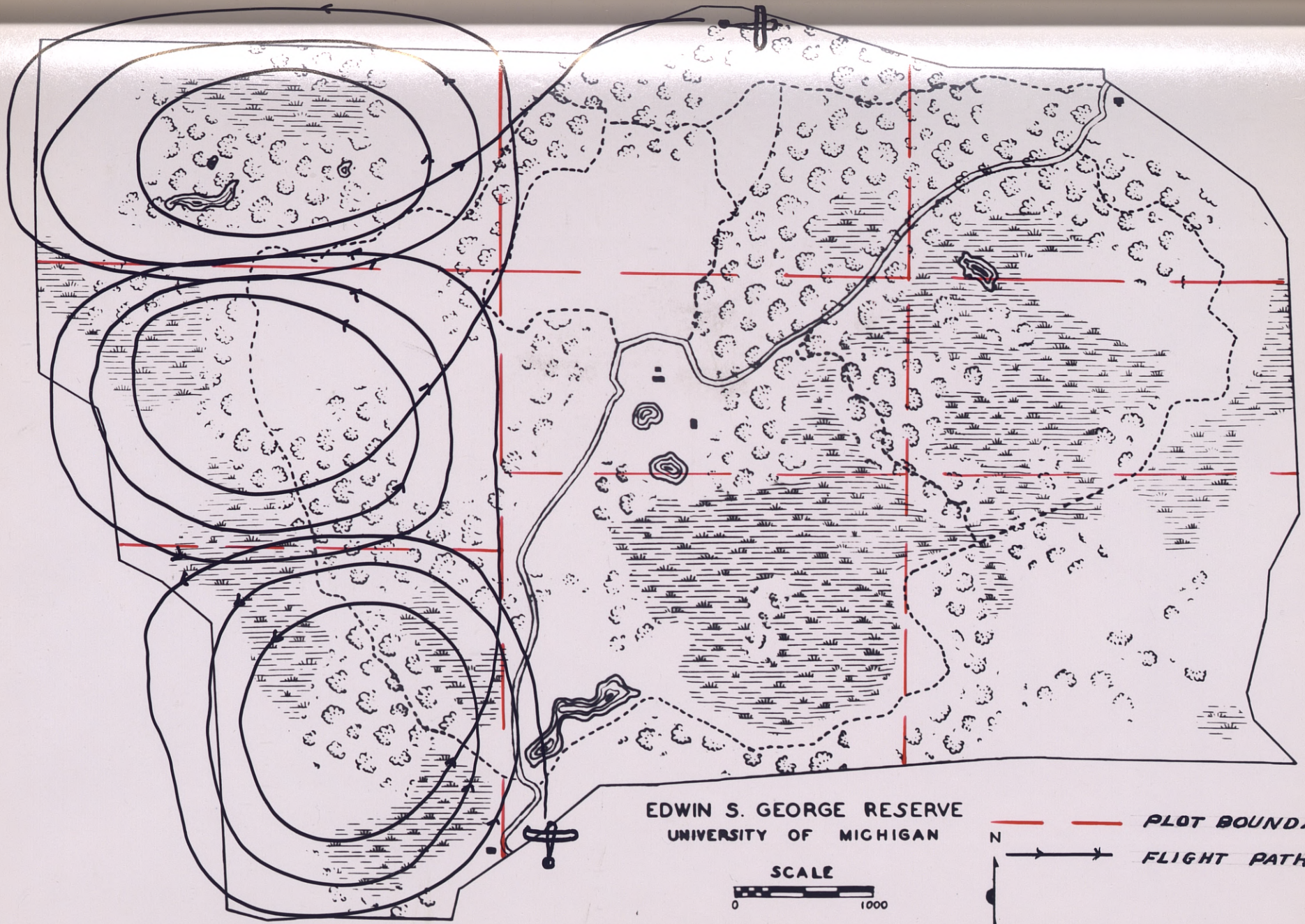
until it was believed that all deer present were seen and recorded, then the process was repeated with the next plot.

The technique used here was given in print in the Quarterly Progress Report, Wildlife Research for the period, January 1st to March 31, 1947, State of Illinois, and had been successfully used on the farmlands of that state where the deerherd was known to be located. The method was especially applicable to their state because each block or plot was defined with fence and hedgerows and could be censused with no danger of repetition in the counts.

Results: The particular advantage of this method was that each part of the plot was exposed to the observers from several different angles and several times when an observation was made it could be checked as many times as necessary to obtain a complete and accurate count.

This method gave good results in comparison with the strip method but resulted in loss of time because the plots were usually covered more thoroughly than the situation called for. The counts are very low but fairly consistent. This lack of numbers is believed to have been caused by the fact that the four counts made were during the coldest weather of the winter and the deer were mostly found in heavy cover which didn't permit good observation. This method was discontinued when the following method was started, however, the results of the censuses made are recorded in the following table.

Date	No. of deer present	No. of deer seen	Percentage
Feb. 5, 1949	60	9	15.0%
Feb. 6, 1949	60	6	10.0
Feb. 8, 1949	60	8	13.3
Feb. 19, 1949	59	11	18.4



Wayne Teddy
May '79

CIRCLING A DEFINED PLOT

Fig. 8

Series of Overlapping Circles over a Strip: This method is a refinement of the previous method and resulted in the most accurate and consistent results with the conditions of the census changing only in the time of year in which they were made.

A series of overlapping eliptical circles were flown moving across the Reserve in such a manner as to cover each part of the strip at least twice. These circles were confined to predetermined strips, 2/3 mile wide, which were established in a north-south direction across the Reserve. Each part of the terrain could be seen from several different angles with the plane steadily moving up the strip so that little additional time was wasted in repeated circles. If an observation was made which required checking, the same circle could be reflown without interrupting the census. In open areas where large amounts of ground could be clearly seen or in places where deer were not likely to be seen, such as extremely wet areas, the circles could be made larger so as to cover that section more rapidly. The circles could be made smaller and the area covered more slowly if the likelihood of seeing deer were increased.

This technique had been used in Colorado by L. E. Riordan and published in the transactions of the 13th North American Wildlife Conference. Riordan flew over rough terrain and his altitude varied with differences in the ground elevation. He counted only on the leading side of his circle which was over new terrain, however, in this problem it was used at a constant altitude and the deer were counted on the leading edge of the circle and checked or recounted and tallied on the last trip across that portion of the strip. No attempt was made to set a limit on the time taken to census the Reserve, instead the time varied with the number of

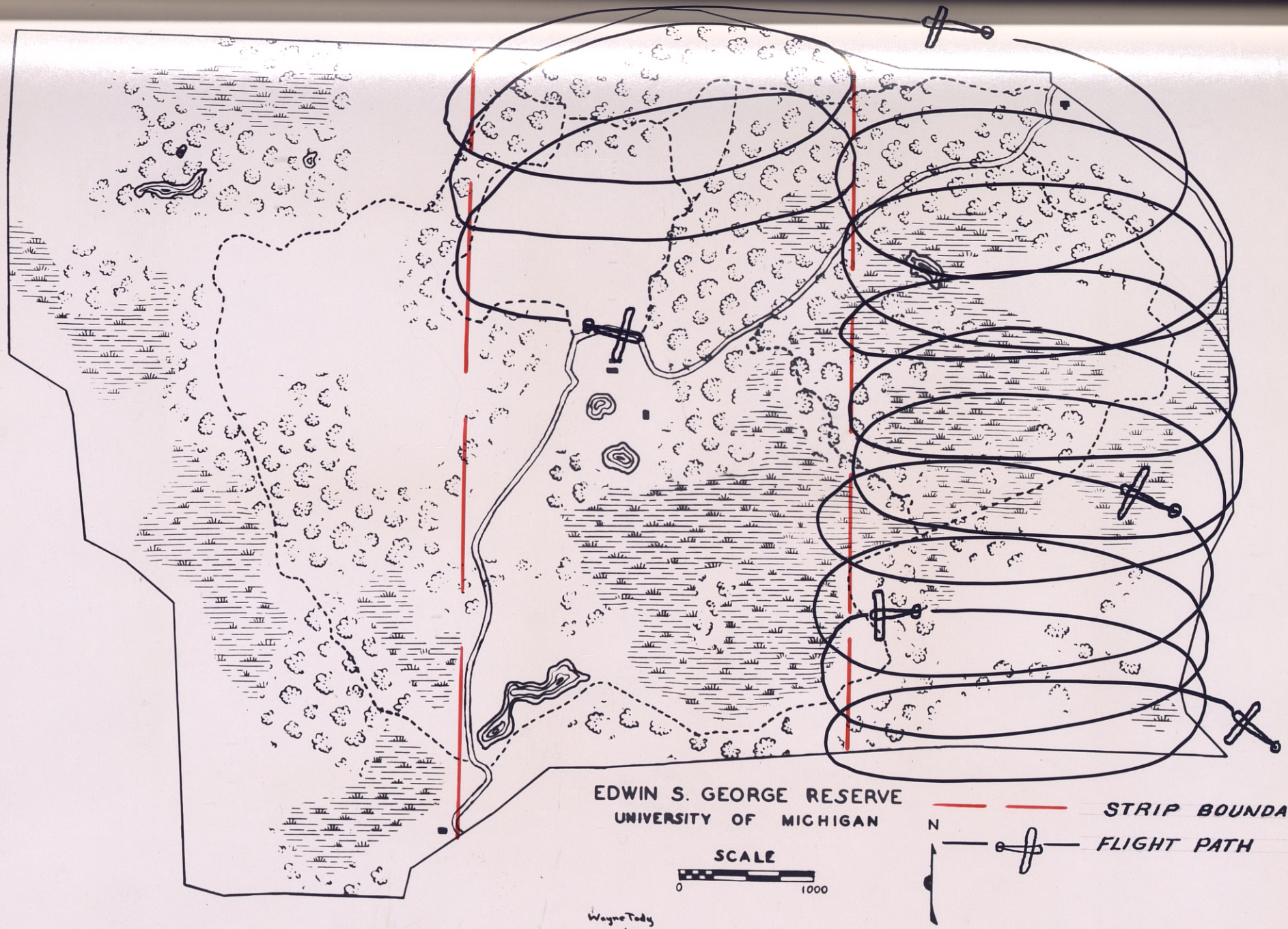
observations made, the time necessary to check those observations and the ease of spotting the deer.

Results: Because this method was derived from the circling method it was used in only the latter part of the field work and thus a small number of censuses were made. The results obtained were quite consistent and the counts much higher as is shown by the following table which shows the results obtained on each census made by this method.

Date	No. of deer present	No. of deer seen	Percentage
March 15, 1949	57	34	59%
March 21, 1949	57	29	51
April 19, 1949	57	31	54

It is the belief of the author that the improvement in technique was only one factor contributing to the improvement in results. The other being that these counts were made in the spring when better results are almost certain over this type of terrain. The deer move out into the openings early in spring which contributed to the ease of censusing them from the air. The influence of the spring season on aerial censusing will be discussed later in the paper.

Aerial Photographs: Three complete sets of full coverage aerial photographs were taken, obliques from 1800 feet, verticals from 3600 feet and another set of verticals from 7200 feet. They were taken on Tri-x pan film with a shutter speed of 1/220 of a second and a lens opening of f 22 on the verticals and f 16 on the obliques. The camera used was a Fairchild aerial camera mounted through the floor of the airplane and which took a negative 7 by 7 inches in size. The airplane was a 1932 Stinson, a



Wayne Tody
May '49

SERIES OF OVERLAPPING CIRCLES

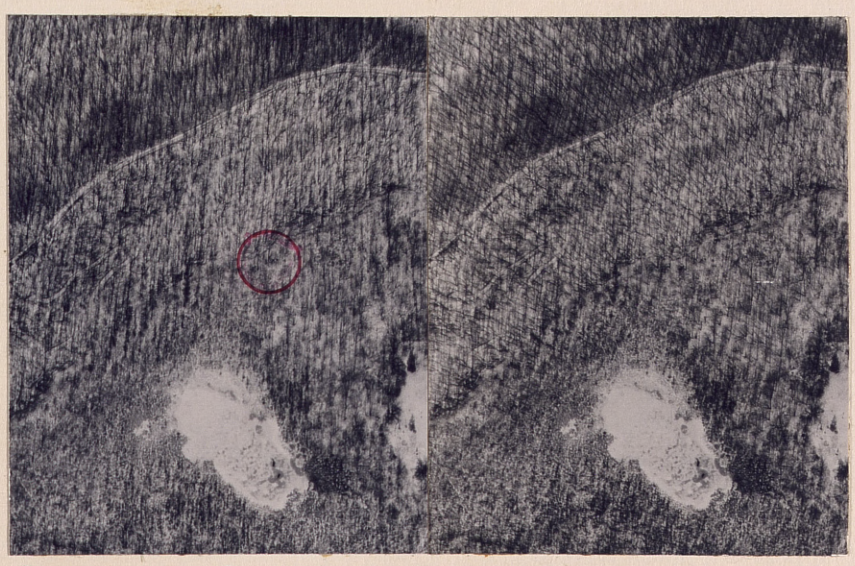
Fig. 9

four place, high wing monoplane which cruised at an airspeed of approximately 100 miles per hour.

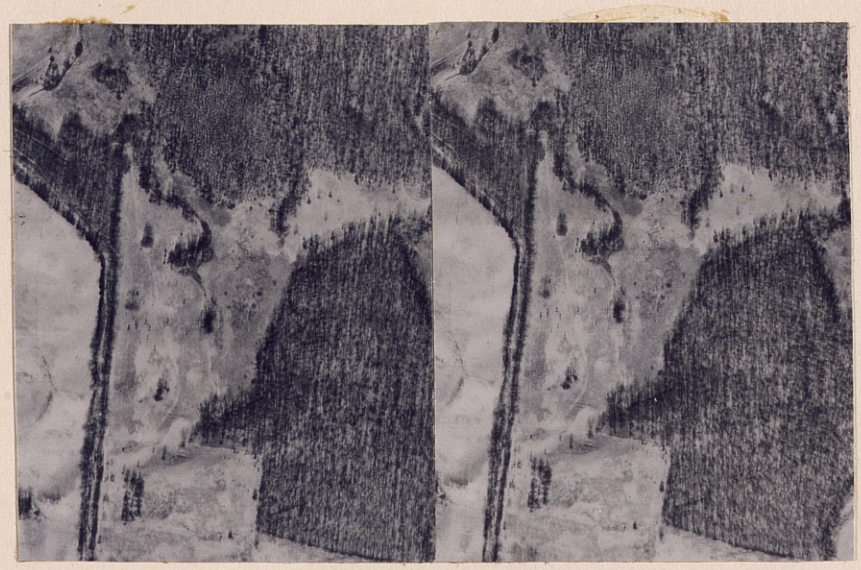
The scale of the obliques cannot be computed due to the fact that it will change as the distance from the camera changes, however the scale of the verticals was 1 to 5,236 on the pictures taken from the lower altitude and 1 to 10,472 on those taken from 7200 feet. The photos were taken between 11 o'clock A.M. and 2 o'clock P.M. on March 15, 1949, which was the day following a snow storm which left from 2 to 3 inches of snow on the ground. The verticals were taken with a 50% end overlap in order to provide stereoscopic coverage and were scanned under a 2 power lens stereoscope.

High Altitude Verticals: The small scale of the verticals taken from 7200 feet made an object 8.75 feet long, actual size, appear to be only .01 inch long on the photograph. This made any deer appearing on the photograph, only .005 inch long and made it unlikely that any deer would be seen and recognized except under the most perfect conditions. No deer were seen on these photos, in fact nothing was seen which even resembled a deer. The scale of photos from this altitude is to small for use in censusing. Figure 10 is a sterogram of pictures taken from this altitude.

Medium Altitude Verticals: The photographs taken from 3600 feet made an object 4.38 feet in size appear to be .01 inch in size, this when magnified twice or more times makes it much more likely that a deer will be seen. In several cases it was believed that small groups of deer were seen but since they were in the woodlands and the shadows dimmed their outlines,



Stereogram of vertical photos taken from 3600 ft.
Five deer easily seen in the circle.
Fig. 11



Stereogram of vertical photos taken from 7200 ft.
Scale too small to see any deer.
Fig. 10

positive identification could not be made. On two occasions groups were seen which left little doubt as to their identity, one of these is illustrated in a stereogram shown in Figure 11.

Low Altitude Obliques: The oblique photographs cannot be used stereoscopically and so were scanned under a 7 power binocular microscope. It was believed that 20 power might be used to make positive indentification but it was found that this magnification brought out the grain of the photo and made recognition impossible. The dark shadows under the trees seemed to completely black out detail in many places and these photographs failed to allow positive identification of any deer on the area.

Discussion of Possible Use of Aerial Photographs in Censusing: The detail obtained in aerial photographs seems to suggest their use in censusing, however, those used on this problem conclusively prove that a small scale and dense shadows will prevent close inspection of the surface of the ground. It is believed by the author that with deciduous vegetation and snow cover, aerial photos can be taken which will allow the close inspection required in such a census. Photos taken on bright days with a high overcast, will have virtually eliminated the dark shadows which are the principal obstruction and large scale photos can easily be taken which will increase the apparent size of deer to a point where they can be easily recognized.

While further research is necessary, there is sufficient evidence to conclude that large scale, shadowless, aerial photographs have definite possibilities in future aerial counts of big game. Pictures taken with

THE EDWIN S GEORGE RESERVE

OBLIQUE AERIAL PHOTOGRAPH TAKEN FROM 1800 FEET
Variable scale and dense shadows
Very pretty but not allowing direct counts of deer
Fig. 12

hand cameras can readily be used as an aid to counting numbers of animals in large concentrations. This has been done with waterfowl in particular but it has been successfully used in counting deer concentrations in Illinois.

The Airplane in Combination with a Ground Census:*** The airplane was used to observe and plot deer movement occurring as a result of the activities of a census crew on the ground. This data was used to supplement that taken by the ground crew in obtaining the minimum population of deer on the Reserve.

The advantage of the airplane in this census was that: (a) It could take the place of several ground observers by gathering data from wide-spread locations. (b) It could often locate animals not otherwise seen and (c) it could trace individual groups between observer posts.

A minimum count of 47 deer was calculated for the Reserve, from the combination of data obtained by the ground crew and the aerial crew, this figure is 83% of the total number of deer present at that time. The census used was the only one of its type attempted and gives emphasis to the belief that large areas could be censused by this method, within 10% of the actual population, with an experienced crew. This count would always be low because of the fact that it is a minimum count so that with consistent results a factor could easily be worked out to provide an accurate total count. In regions where fire trails block out regular sections of deer range or where lines of visibility will bisect the census area, this method will be especially adaptable.

***A detailed explanation of this method will be found in the thesis written by Tody (1949 MS).

HAND CAMERA PHOTOGRAPHS

Deer being moved by drivers

Deer feeding on the Airstrip
Poor photo but the deer are easily seen

Fig 13.

Special Factors Affecting Aerial Census Methods:

Observer Experience: There are two principal requirements of an observer in aerial censusing, they are: (1) Previous aerial observation experience and, (2) Familiarization with the habits of the animals to be censused. In this problem one observer was used in all except two of the flights and it was noticed that definite increase in numbers of deer seen, was recorded on the flights taken with the experienced observer. The principal observer had spotted on four previous censuses, had had considerable previous flying experience and was familiar with the habits of deer. The other observer had had no previous flying experience and had only observed deer from a car as he drove through deer country. Because of this irregularity in the counts this data was not used in the compilation used in the previous tables.

Pilot Experience: Not only must the pilot be an experienced flyer but he must also know the area to be censused and know the habits of deer. On strip counts he must not only fly at low altitudes and keep himself orientated but he must act as an observer. In the circling methods his job is careful flying and orientation with less emphasis on the observation. If he gets out of his area or off his strip he not only misses possible observation but he may duplicate some others, this error may be of such a nature as to be compensatory but it is doubtful.

Pilot experience may not be quite as important in areas such as is found in the lake states as in some more mountainous areas but since low altitude flying is dangerous at best, it is a factor which cannot be overlooked.

Vegetative Cover Types and Distribution: One of the greatest factors contributing to the failure of the attempts to census deer from the air in the lake states has been the existence of heavy coniferous vegetation. In most cases these large coniferous forests have scattered small spots of open land through them, these spots seem to be the places where a factor can be worked out which will give a figure close to the actual population of the area.

In the spring the deer come out into the openings to feed on the new succulent grasses, this fact correlated with the ease of spotting deer on the open areas has made the spring censuses taken on this problem produce the highest and most consistent counts. The absence of snow in the spring is not a great disadvantage as may be believed since the best results, (those taken in March and April), were taken without snow cover.

Eighty-four per cent of all the deer seen during the flights made for this problem were seen on the grasslands. Only 32 of the 202 deer tallied were first seen in the woodlands and swamps, this indicates that a good census can only be made when there is good interspersion of open lands with wooded lands.

On the George Reserve there is little coniferous vegetation but the large groves of oaks which hold persistent leaves through the winter gave poor counts in these portions. The tangled masses of poison sumac and tamarack in the swamps allowed 11 deer to be seen during the winter months while only 6 deer were seen under the oaks, since the leaves have dropped in the spring 15 more deer have been seen in the woodlands. Even

with a large percentage of the Reserve covered with dense vegetation, there have been consistently high counts made in the open areas this spring.

There is no doubt that these scattered open grasslands not only permit a higher count of deer but tend to reduce the amount of variation in these counts.

Weather and Season: A very low percentage count of deer on the George Reserve was obtained during the winter months with the one exception of one count made when the deer were being moved by drivers on the ground. On this occasion approximately 50% of the deer present were seen. These winter counts ranged from 0% on three occasions to 11% on one occasion. The spring counts produced better results especially with the method of overlapping circles which produced counts of 54, 59 and 51 per cent, the strip counts made in the spring also produced higher counts though percentage of counts ranged from 5.3 to 31.6. There was absolutely no duplication of counts on deer because of the fact that they were observed in small herds in openings to far apart for them to cross between observation times.

This improvement in results seems to be caused by three primary factors: (1) The new succulent grasses in the openings are the principal source of food for whitetails in the springtime. (2) The deer are more easily seen because in coming out onto the openings they are forced to bunch up in greater numbers making themselves more obvious to the observers. (3) The length of the daylight feeding period is increased in the springtime so that more time is allowed for censusing.

The weather plays an important part in aerial censusing not only in that it determines whether or not flying can be done but because of its influence on the movements of the deer. Warm, calm weather is usually accompanied by greater deer movement while cold and stormy weather will find the deer taking cover in the heaviest vegetation available to them. Since it is true that white-tailed deer can be expected to do the unusual, this natural behavior must be taken into consideration when aerial censusing is being planned.

Spring is the only time of the year which brings all of these influences to bear on the deer simultaneously and it is a logical conclusion that this time of the year will produce the best results.

Time of Day: The activity of deer is the greatest from a few hours before sunset until a few hours after dawn this allows only a few short hours of daylight when aerial censusing is practical. Since the number of deer seen is partially dependent on their movements and their greatest movement comes at feeding time, the best census times are during those few hours just before dark and just after daybreak.

Airsickness: Among the disadvantages of the aerial census is the tendency of the observers to become airsick. The circling methods of censusing seem to increase the tendency toward airsickness, this cuts into the efficiency of the observer if not causing postponement. Chewing gum or intense outside interest seems to be the best methods of preventing airsickness but no sure method of prevention is known.

The Reaction of Deer to the Airplane: The reaction of the deer on this study area is probably dissimilar to that of the deer on other areas

due to the fact that the Reserve lies in the flight path of the commercial planes flying to and from the Willow Run Terminal. These planes pass over several times per day and at night at altitudes of less than 2000 feet. In addition to this the Reserve forms part of the practice area for students training in light planes at an airport one mile away. It is believed that the deer have become accustomed to low-flying planes to the extent where they now pay little if any attention to them. On several occasions, when the deer were observed feeding in open areas, special attempts were made to frighten them by diving down to within 100 feet of the feeding group. The usual response of the deer was to raise their heads and look for the source of annoyance or by running a few yards and then looking back but never did they run from the immediate vicinity or continue to be concerned to the extent that they didn't resume feeding almost immediately.

Two investigators have written about the reaction of game animals to airplanes. Davenport (1948) reports that elk are not disturbed by low flying planes. Saugstad (1942) says, "when flying over a herd of deer, deer will do one of three things. They will pay absolutely no attention at all to the plane, they will just show a very mild reaction, or they will get very frightened and pull out in high gear.

"When the plane is right opposite them, the deer usually head out laterally or directly away from the plane. When the plane passes over them, they begin to turn around to see where it is going. The result is they will run almost in a circle. They don't describe a perfect circle, but in general they tend to run out and come back at just about the place

they were at, which leads us to believe a lateral movement while we are censusing deer is not important, except in extreme cases."

It was hoped that some noise maker could be devised and attached to the plane which would startle the deer and make them run in order to observe their reaction as well as cause movement which would serve as an aid to spotting them, however, none was conceived which would be applicable to the situation and which could be easily attached to the plane without interfering with the flight characteristics of the airplane.

Cost of Aerial Censusing: The cost of aerial censusing is very low in proportion to the area which can be covered. This enclosure can be censused in 20 minutes, actual census time, by the method of overlapping circles. The cost of the airplane for that period of time was $3.66 which means a cost for the actual time over the reserve of less than $2.00 per section plus the wages or salary of two men. Saugstad (1942) figures that their census costs amounted to $5.50 per flying hour and he figured in the cost of the observers, a service unit, and insurance. This figure is probably lower than at the present time since his figures are based on expenses at prices prevalent in 1941 and they did not include the cost of the airplane and pilot which he found to be $6.50 to $7.50 per hour. At ten to fifteen minutes per section, doing a 100% census, this price is still considerably lower than most reliable methods of censusing; with 25% coverage it will be found to be much lower than any other methods.

The expenses on this problem were not carefully computed because the only actual expense was the rental of the airplane. The observers were other graduate students and the flying was done by the author. The

expense of censusing other areas will depend upon the accessibility of the area to be censused, whether the plane has to be rented or is owned by the organization doing the censusing, and who the pilot and observer are to be, if they are employees of the organization, if so their rank, or if they are hired to do the censusing, and last but not least the method of censusing to be used.

The factors listed on the previous pages are thosewhich will influence the dependability of all direct counting methods and must be taken into consideration by any one attempting a census of white-tailed deer and are especially applicable under conditions similar to those found on the Edwin S. George Reserve.

The accuracy of the census will depend on all these factors plus the ability of the pilot and observer to produce consistent counts to which a factor can be applied to compute the total population. In various areas it is probable that a ground drive will have to be made in order to establish the factor to be used in areas of similar vegetative conditions and on counts taken at a standard season of the year.

It is the belief of the author that the airplanes place in game censusing is not well understood and it is probable that the airplane census will become an extremely valuable tool in wildlife management.

SUMMARY

1. This problem is an attempt to evaluate aerial census methods of big game and to attempt to discover a method which can be used to make complete counts of white-tailed deer.
2. The study area was the Edwin S. George Reserve, a 1268 acre tract of land in Livingston County, Michigan.
3. The Reserve is enclosed in a deer proof fence which allows an accurate knowledge of existing populations. This known population is used as the basis for percentage figures obtained on the counts.
4. The low altitude methods used in censusing were: (1) The strip method. (2) The circling of a defined portion of the Reserve until all deer were counted and then moving to the next portion. (3) Overlapping circles over a defined strip. These methods were all flown at 375 feet above the average ground level.
5. Additional methods tried were (1) Full coverage aerial photographs. (2) High altitude with binoculars and (3) The airplane in combination with a ground census crew.
6. Eight censuses were made using the strip method and resulted in low and inconsistent counts. This was due principally to the speed with which the plane covered the ground, not allowing complete observation.
7. Four censuses were made by the method of circling a defined area. These produced fairly consistent counts but they were low in percentage of total population.
8. The series of overlapping circles method was a refinement of the

previous method and resulted in the highest and most consistent results. These counts were all within 8% of each other and all over 50% of the total population.

9. The full coverage aerial photographs were taken from three altitudes, 1800 foot obliques, 3600 foot verticals and 7200 foot verticals. The verticals had 50 per cent overlap for stereoscopic coverage and were found to be at to small a scale though the lower ones showed possibilities if the scale had been slightly larger and the day on which they were taken had been slightly overcast. The obliques varied to much in scale and the shadows were to dense to permit identification of deer on the photographs.

10. The vibration of the plane prevented the observer from holding the binoculars still enough to observe deer from 1000 feet. This method was only used on one occasion.

11. The plotting of movements of deer from the air was successfully used when combined with the data collected by a ground census crew to find the minimum count of deer on the area. The minimum count was found to be 83% of the total number present and this method is believed to be accurate to 90% when used with an experienced crew.

12. Spring counts on the open grasslands produced the best counts on the Reserve. This is due to more favorable weather, the existence of food on these areas in spring and the increase in length of daylight feeding time at this season.

13. The requirements of the airplane are primarily slow cruising speed and safety and good visibility, with most other things a matter of preference.

14. Experience of both the pilot and observer in this type of work will produce higher counts than when personnel without the experience is used.

15. The cost of censusing on the George Reserve was approximately $2.00 per section not counting the wages or salary of the pilot and observer.

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