

Census Techniques for
Snowshoe Hares

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Fay Herbert Hartman

1960

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
MAY 16 2012 08 27 14	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

MSU is An Affirmative Action/Equal Opportunity Institution
c:\pic\datedue.pm3-p.

CENSUS TECHNIQUES FOR
SNOWSHOE HARES

By

FAY HERBERT HARTMAN

A THESIS

Submitted to the College of Agriculture,
Michigan State University of Agriculture
and Applied Science, in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1960.

Accepted: George A. Petrie

ABSTRACT

A number of different census techniques were tested on snowshoe hares inhabiting a 267-acre area in Algonquin Provincial Park, Ontario. Work was mainly carried out over three different study periods during the winters of 1958 and 1959. The several census methods gave remarkably similar results.

Capture-recapture methods, using the Lincoln index and Schumacher-Eschmeyer formulae, resulted in fairly accurate estimates but required considerable work. Hares were found to exhibit homogeneous trap response possibly being influenced by frequent movement of the traps. The error in population estimates resulting from unknown emigration and immigration factors is believed to have been small. Other assumptions of the capture-recapture methods seem to have been met. The Lincoln index method gave estimates of 43 hares for the November-December 1958, 19 for March-April, and 16 for November-December 1959, trapping periods. The Schumacher-Eschmeyer formula gave estimates of 47, 19 and 18 respectively, for the same periods.

A single toe was clipped from the hind foot of 22 different hares and those which had lost a long centre toe made especially distinctive tracks. Ratios of clipped to unclipped tracks were found to be a simple and reliable method for making population estimates. Population levels of 21 hares for March and April, and 17 for November and December 1959, were obtained.

A fecal pellet census also proved to be an accurate technique. Defecation rates for snowshoe hares were calculated as 568 pellets per hare per day on summer diet and 583 on winter diet. A method for correcting for observer's inability to locate pellets was devised. The pellet survey results indicated that an average of 24 hares had used the area during the winter of 1958-1959.

Counts of tracks which crossed predetermined survey lines were found to be closely related to population levels and indicated the relative abundance of hares. The relation of about .008 tracks per chain for each hare per square mile is discussed for this study area. Factors affecting this census method were considered in view of testing this relationship on other areas.

At the close of the study a kill-removal by intensive snaring proved that estimates were close to true populations and that most animals had been handled during the earlier live-trapping. Seventeen animals were removed from the area.

Within two months following kill-removal, the area was reoccupied by snowshoe hares.

ACKNOWLEDGEMENTS

The information reported here was obtained while the author was working for the Wildlife Research Division of the Department of Lands and Forests, Ontario, Canada. Appreciation is extended to A.B. Stephenson for his suggestions and help during the field work. Thanks go to R. Stanfield and Dr. C. David Fowle and all those associated with the wildlife camp in Algonquin Provincial Park.

For help in organization and presentation of this thesis, sincere thanks go to Dr. George A. Petrides. Dr. Philip Clark's help with the statistical aspects of this paper was greatly appreciated.

TABLE OF CONTENTS

	Page
LIST OF TABLES	vi
LIST OF FIGURES	vi-vii
ACKNOWLEDGEMENTS	iv
INTRODUCTION	1
STUDY AREA DESCRIPTION	1-2
TRAPPING AND MARKING	3-8
CAPTURE-RECAPTURE METHODS.	8
Trapping results	8
Analysis of capture-recapture data.	8-17
TOE-CLIPPED TRACK RATIO METHOD	17-20
FECAL PELLET COUNT METHOD	20-27
TRACK COUNTS AS INDICES OF ABUNDANCE	28-33
REMOVAL-SNARING	33-34
DISCUSSION	34-36
SUMMARY	36-38
REFERENCES	39-40
APPENDICES	41-45

LIST OF TABLES

	Page
TABLE 1 Summary of snowshoe hare trapping results	9
TABLE 2 Comparison of the observed number of captures with the expected Poisson distribution	12
TABLE 3 Capture-recapture census data for snowshoe hares	16
TABLE 4 Population estimates for snowshoe hares based on records of toe-clipped and unclipped tracks taken in April and December, 1959.	19
TABLE 5 Analysis of fecal pellet survey results for the period of November 15, 1958 to May 31, 1959.	25
TABLE 6 Snowshoe hare tracks per chain (66 feet) for major regions of the study area.	29
TABLE 7 Summary of population estimates and indices.	35
TABLE 8 Results of strip census carried out on November 11, 1958.	46

LIST OF FIGURES

Figure 1 (a)	A box trap designed in this study which worked well in most weather conditions.	5
(b)	Trigger mechanism in set position, with protective can removed.	5
Figure 2	A toe-clipped hare made an easily recog- nized track. The third toe from the inside was removed from the right foot.	7
Figure 3	Comparison of projected population numbers as indicated by the Schumacher- Eschmeyer capture-recapture method with the population level as estimated by fecal pellet census (Winter 1958-1959)	27
Figure 4	Graph showing relationship between snow- shoe hares per square mile and tracks per chain.	31

LIST OF FIGURES (Cont.)

		Page
Figure 5	Graph showing number of traps visited by hares as related to minimum daily temperature, snowfall and rain	32

APPENDICES

Appendix 1	Calendar graph of snowshoe hare trapping results for November, 1958 to January, 1959	41-42
Appendix 2	Calendar graph of snowshoe hare trapping results for March and April, 1959	43
Appendix 3	Calendar graph of snowshoe hare trapping results for November and December, 1959	44
Appendix 4	Notes on the strip census method	45

INTRODUCTION

Inventory techniques for wild animals can seldom be properly evaluated because true populations are rarely known. The relative accuracies of two or more methods may be judged, however, by applying them simultaneously to the same population. This study was aimed at evaluating all feasible census methods applicable to the snowshoe hare (Lepus americanus). A number of methods were compared during three different study periods and a total kill-removal was undertaken at the end of the study.

The field work was carried out during 1958 and 1959 at the Wildlife Research Station of the Ontario Department of Lands and Forests in Algonquin Provincial Park.

STUDY AREA DESCRIPTION

The study area comprised a nearly-square, 267-acre block of land bounded on the west by Sasajewun Lake and the Madawaska River which drains the lake. Paint-blazed lines marked the other three sides. The grid pattern was based on 16 alphabetically-lettered transect lines running east and west at 264-foot intervals. Numbered wooden stakes were located every 132 feet along the transects. A total of 336 such reference points were designated. They were marked also by special paint blazes on nearby trees, since deep snow often

covered the stakes.

In general, the region was characterized by shade-tolerant hardwoods: sugar maple (Acer saccharum), yellow birch (Betula lutea), and a limited amount of beech (Fagus grandifolia). These hardwoods with patches of mature hemlock (Tsuga canadensis), comprising about 25 per cent of the study area, were seldom inhabited by hares.

Two lowland areas of muck and peat were covered mainly by a mixed-age stand of black spruce (Picea mariana), speckled alder (Alnus rugosa), and balsam fir (Abies balsamifera), and was commonly bordered by mature black spruce and white spruce (Picea glauca). These lowlands covered about 20 per cent of the total study area and served as major population centers for hares.

A water-laid sand flat was covered by an open stand of aspen (Populus tremuloides), balsam fir and white pine (Pinus strobus). An old logged-over area bordering the lake was covered by a forest of mixed age and species composition. This mixed growth and the aspen-pine flats, comprised about 25 per cent of the area and was almost equal to the lowlands in importance to hares. A white spruce - white birch (Betula papyrifera) association covered the remaining area.

TRAPPING AND MARKING

Hares were trapped during three periods: November 24, 1958 to January 3, March 30 to April 21, and November 23 to December 14, 1959. The transect stakes represented trapping stations.

Fifty box traps were used. Twenty-five were constructed on the pattern described by Libby (1957). In principle, the doors swing inward and are held open by a broad treadle or "false floor" that is raised just enough to hold the lower corner of each door. Under dry conditions the trap was satisfactory, but moisture between the door and treadle readily froze in cold weather and prevented depression of the treadle when a hare entered the trap. This trap was especially unsatisfactory under alternate thawing and freezing conditions.

Another type of box-trap designed in this study had advantages over the Libby type but required more care and upkeep. The box was 10 by 12 by 30 inches in size. The ends were attached solidly to a section of the trap roof, forming angled lids which lifted at hinges on the top of the box to open the trap. (Figure 1a).

A cross member, supported above the center of the trap by two vertical bars, held a trigger mechanism about ten inches above the box. Two short pieces of cord, with metal rings tied to their outer ends, were fixed at the apex of each angled lid. The trap was held open by inserting a nail through the two rings and through the eyes of two ring-screws on the cross-member (Figure 1b). The nail was tied on a short cord to the kill-wire of a mouse trap so that it

would be pulled free when the mouse trap was snapped. A wire led from the pan of the mouse trap to the inside of the box where the bait was fastened. Alfalfa hay served as a convenient and successful bait.

A 10 by 5 inch metal cylinder (a tin can with ends removed) was split along one side and slid along the cross member. It protected the mouse trap from rain and snow. Thus equipped, this box trap was effective even during heavy snowfalls. Like the Libby trap, it was ineffective in freezing rain.

The practice of taking hares with a wire snare is a well known and effective method of capture. Consequently an effort was made to "live-snare" hares. Though use was made of locks and padding on the wire, the effort was without success. The only hare taken alive died in captivity on the following day. There was extreme damage to the throat.

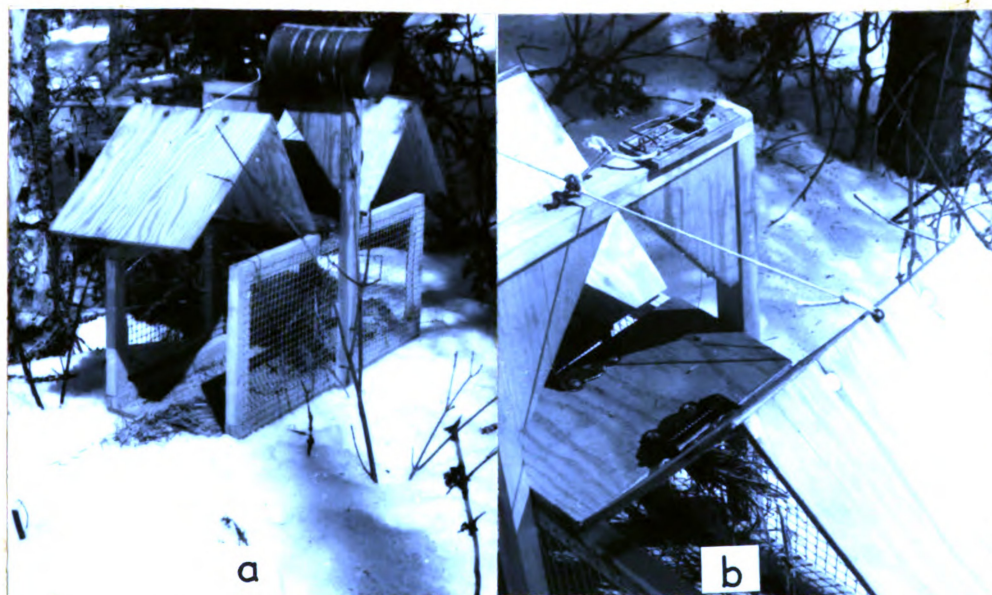
Only 50 traps were available for the 336 trapping stations; traps were normally moved every four to five days. Trapping was most intensive where hare tracks were abundant. Areas where tracks were seldom seen were sparsely trapped.

Trapped hares were put into a sack for handling. Laid on the ground in the sack, an animal remained quiet as long as its eyes were covered. As a result, marking and sex determination were made easy.

All hares were tagged in each ear using a button tag of the general type described by Tyndale-Biscoe (1953). Colored plastic discs were fixed under the tags in hope of facilitating field

Figure 1

- (a) A box trap designed in this study which worked well in most weather conditions.
- (b) Trigger mechanism in set position, with protective can removed.



identification. This was ineffectual, however, since untrapped animals were seldom sighted for enough time to be identified.

Of 13 hares tagged in November and December and retrapped in March and April only two had lost a single tag each and one of these losses occurred in a trap. During the second winter, 11 tagged animals were recaptured which had been tagged the previous winter. A 45 per cent tag loss had occurred. Scar tissue on the ears of some hares indicated where tags had been lost. No necrosis was evident around those tags that did hold. Although in the first case only four months had elapsed, compared to eight in the latter, these results are indicative that tag loss was greater in summer, than in winter months.

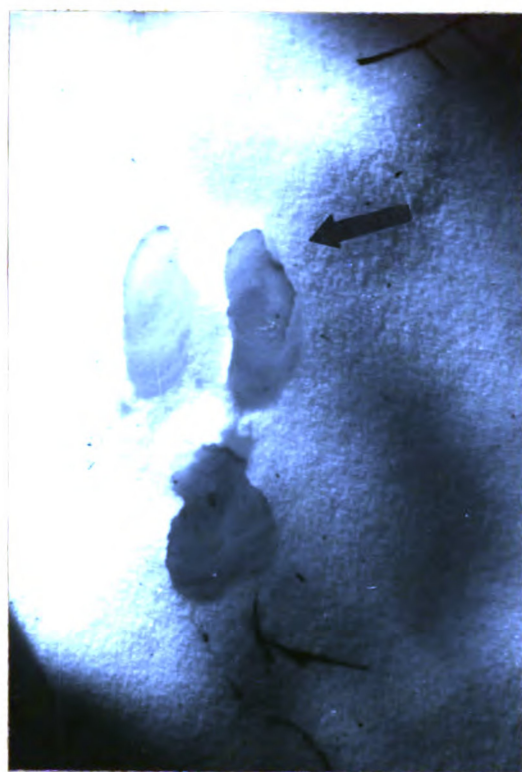
Dell (1957) described a toe-clipping technique for snowshoe hares which marked the hind foot of an animal so that individuals could be recognized by their tracks. He pointed out the possibilities of range and population studies using this technique.

In the present study, a toe was clipped from the hind foot of eight hares in April, and 14 in November and December, 1959. No harmful effects were noted and two hares toe-clipped in April were of normal vigor when recaptured the following winter.

Removal of either of the long center two toes gave distinctive tracks in all soft-snow conditions (Figure 2). Only four individuals in one locality can be recognized if just one of the center two toes is removed. When one of the outside toes was cut off, it was difficult to consistently identify tracks. The effect of

Figure 2.

A toe clipped hare made an easily recognized track. The third toe from the inside was removed from the right foot.



removing two or more toes from one individual was not tested, since the main aim in this study was to identify clipped or unclipped tracks, not individual hares.

CAPTURE-RECAPTURE CENSUS METHODS

Trapping results. During the three trapping periods, a total of 1,723 trap-nights resulted in 196 captures of 54 different hares. In November - December, 1958, 41 different hares were trapped, while 19 hares were caught in March and April and 17 in the following November - December (Table 1; Appendices 1, 2 and 3).

Twelve hares died in traps apparently as a result of hunger, exposure and possible shock. Four additional animals were killed by predators, three of these being taken by martens during the last trapping period. The other was taken by a marten, fisher or fox (Table 1).

Analysis of capture-recapture data

Green and Evans (1940) trapped more than 5,000 snowshoe hares from 1932 to 1939 and used the marked-unmarked ratio method (Lincoln, 1930). Adams (1959) found that the same method yielded hare population numbers only slightly greater than those for a fecal-pellet count method and for the total number captured.

Working with fish populations, Schumacher and Eschmeyer (1943)

TABLE 1 - Summary of Snowshoe Hare Trapping Results.

	Trapping Period		
	Nov.-Dec. 1958	March-April 1959	Nov. - Dec. 1959
Trap nights*	463	574	686
New captures	41	19	17
Recaptures	69	32	18
Trap Mortality:			
Predation	0	1	3
Exposure	8	4	0
Killed for removal count	0	2	14

* Trap-night; one trap set for one night, excluding traps made inoperative by weather or other factors.

pointed out that in a series of capture and release samples, there was a direct relation between the total number of fish previously marked and the proportion of marked fish in each sample. The authors described a straight-line relationship between these two variables and showed that the reciprocal of the slope of the line was equal to the population size.

Hayne (1949) applied this method to small mammals and discussed the assumptions made in its use. He pointed out that, since the method was in effect a way of averaging a series of marked-unmarked ratios, the assumptions were the same for this as for the marked-unmarked ratio (or Lincoln Index) method.

Briefly, these methods require the assumptions that: (1) no tags are lost, (2) no immigration or births occur, (3) tagged and untagged animals mix randomly and are all equally subject to capture and recapture, (4) tagged and untagged animals suffer proportional mortality and emigration.

Only two tag losses were noted during trapping periods, one of which occurred in a trap. Therefore, tag-loss did not cause inaccuracies in computing population estimates. No births occurred during the trapping seasons, and there was no reason to believe that there was an unequal natural mortality between marked and unmarked animals. The only assumptions obviously open to question concern; first, homogeneity of trap response and second, immigration and emigration.

Regarding the response of hares to trapping, it might be

expected that different hares, caught once, would respond differently to traps on later encounters, either entering more or less readily than the first time. Young, Neess and Emlen (1952) found that capture frequencies of house mice differed significantly from a normal binomial frequency distribution. Geis (1955) used the same test on cottontail rabbits and concluded that they also exhibited heterogeneous trap response.

In the present study, frequencies of capture were compared to a binomial distribution using the Poisson distribution as a close approximation (Table 2). The Poisson distribution was used to calculate the expected frequency where the average number of captures per hare equaled 2.2.

The number captured zero times was calculated to be the difference between the total number captured and the population estimated to be present on the area at that time. Estimates from the toe-clipped track ratio method were used because they were not affected by trap response (Table 4). However, hares were only toe-clipped in the March-April and November-December periods and therefore trap response data was only tested for these latter two periods. A total of 36 hares were captured during these two periods while estimates from toe-clipping totaled 38. This indicated that two hares were never captured.

Six animals, killed in traps during the early part of trapping periods, were not included in Table 2. Those that died just at the end of a period were included since they had no chance of further recapture.

TABLE 2 - Comparison of Observed Number of Captures with
the Expected Poisson Distribution for the
Periods of March-April and November-December, 1959.

NUMBER OF CAPTURES	OBSERVED NUMBER	EXPECTED NUMBER
0	2	3.5
1	12	7.8
2	6	8.6
3	6	6.3
4	4	3.5
5	1	1.5
6	0	0.6
7	0	0.2
8	1	0.0
TOTAL	32	32.0

Chi-square tests indicated that the difference between observed and expected frequencies were not significant at the five per cent level. On the basis of this test, this snowshoe hare population exhibited homogeneous trap response and the assumption of equal capture and recapture was met.

It is interesting that the above evidence is contrary to what was expected from field observations. It was noted early in the study that individuals, recognized by their tracks, were often seen to avoid traps where they had been previously captured. It would be instructive to test further the response of hares to traps not constantly moved as compared to those regularly relocated. A trap in a new location might elicit a different response than one in the same place in which the hare had been caught. It is felt that the practice of moving traps was important in obtaining homogeneous trap response.

The second possible error was introduced by the fact that an artificial boundary was used to delineate the area. The boundary regions at the southeast and northwest corners of the area were commonly inhabited by hares which moved on and off the area, especially at these points. Of 24 hares captured in one trapping period and recaptured in a subsequent period, 13 were retaken in the same local area, while eight had moved to different parts of the study area. The movements of three could not be determined since they had lost both ear tags. Four exceptionally long movements, ranging between 1,400 and 2,500 feet, were observed during trapping periods.

Adams (1959) found such dispersal movements quite common for snow-shoe hares in Montana.

It seems evident in this study that dispersal movements could have contributed to unknown emigration and immigration. Furthermore, movement of hares on to the area may have been increased as a result of lowered population density due to trapping mortality. Any such movements would have resulted in a reduction in the ratio of tagged animals actually present and would have caused an overestimation of the true population size.

Capture-recapture data (Table 3) were compiled so that the three study periods would yield independent population estimates. The north and south ends of the study area were treated separately in the first trapping period because up until December 23, only 26 traps were available and the area could not be trapped all at once. Trapping sub-periods were made on the basis of trap-nights.

In order to adjust for trapping mortality, animals that died during a trapping period were added to population estimates to give the total number of hares for the beginning of the period.

Each period listed in Table 3 was divided to obtain trapping and retrapping samples. In each case, the retrapping sample comprised the data below the median sub-period. A marked-unmarked ratio from a retrapping sample was used in the Lincoln Index manner to calculate the total number of animals. The following estimates were obtained where:

$$\text{The population} = \frac{\text{Total tagged} \times \text{Number captured in retrapping sample}}{\text{Number of tagged hare in retrapping sample}}$$

Confidence limits were calculated as the limits about the proportion of marked hares in the retrapping samples (Hald, 1958:66)

November-December 1958:

(a) North half - (including 1 dead) = 14 hares, $(P_{.95}^{\pm} 11 \text{ to } 30)$.

(b) South half - (including 7 dead) = 29 hares, $(P_{.95}^{\pm} 24 \text{ to } 41)$.

Total population 43 hares.

March-April 1959:

Total population (including 5 dead) = 19 hares, $(P_{.95}^{\pm} 17 \text{ to } 25)$.

November-December 1959:

Total population (including 5 dead) = 16 hares, $(P_{.95}^{\pm} 16 \text{ to } 33)$

The same data (Table 3) were used to estimate population numbers by the formula described by Schumacher and Eschmeyer (1943).

The total population = $\frac{\sum W X^2}{\sum W X Y}$, where W represents the total

number of hares captured in each sub-period, X is the number marked prior to the sub-period, and Y equals the proportion of previously captured hares in each sub-period. The product WX^2 and WXY were calculated for each sub-period and summed, as indicated by the symbol $\sum$. The confidence limits were calculated about the slope of the line, or relationship between WX and WY (Snedecor 1946:122).

Population estimates for each period were:

November-December 1958:

(a) North half (including 1 dead) - 14.4 hares, $(P_{.95}^{\pm} 10 \text{ to } 29)$.

(b) South half (including 7 dead) - 32.4 hares, $(P_{.95}^{\pm} 31 \text{ to } 34)$.

Total population 47 hares

TABLE 3. Capture-recapture census Data for Snowshoe Hares.

16

Sub-periods	Captures		Proportion of Catch Previously Marked (Y)	Total Number Previously Marked (X)	Total Captures (W)
	New	Recaptures			
<u>November 24 to December 31, 1958.</u>					
(a) North end of study area, one dead hare not included. Twenty trap-nights per sub-period.					
Dec.	2 - 4	3	0	0.0	3
"	6 -11	1	3	0.75	4
"	11 -14	5	3	0.37	8
"	15 -18	1	1	0.50	2
"	27 -29*	1	1	0.50	2
"	29 -30*	1	3	0.75	4
"	30 -31*	0	2	1.00	2
(b) South end of study area, seven dead hares not included. Twenty trap-nights per sub-period.					
Nov.	24 -27	1	0	0.0	1
"	28 -29	5	0	0.0	5
"	29 -30	5	3	0.37	8
"	30-Dec. 1	2	1	0.33	3
Dec.	1 - 2	1	1	0.50	2
"	2 - 3	1	1	0.50	2
"	3 - 4*	0	2	1.00	2
"	4 - 6*	1	2	0.66	3
"	6 - 7*	3	2	0.40	5
"	7 -10*	1	4	0.80	5
"	11	1	3	0.75	4
<u>March 31 to April 21, 1959. Five dead hares not included.</u>					
Eighty trap-nights per sub-period.					
March	31**	4	0	0.0	4
April	1 - 2	3	3	0.50	6
"	3 - 4	1	3	0.75	4
"	14 -15	4	4	0.50	8
"	16 -17*	0	4	1.00	4
"	18 -19*	2	5	0.71	7
"	20 -21*	0	4	1.00	4
<u>November 23 to December 10, 1959. Five dead hares not included.</u>					
Eighty trap-nights per sub-period.					
Nov.	23 -26	1	0	0.0	1
"	26 -29	5	0	0.0	5
Nov.	29-Dec. 1	4	3	0.43	7
Dec.	1 - 3	1	1	0.50	2
"	3 - 5*	0	3	1.00	3
"	5 - 6*	0	1	1.00	1
"	7 -10*	0	0	0.0	0

* data comprising retrapping samples for Lincoln Index calculation.

** only 40 trap-nights in this sub-period.

March - April, 1959:

Total population (including 5 dead) = 19 hares, ($P_{95}^{\pm}$ 16 to 25).

November - December 1959:

Total population (including 5 dead) = 18 hares, ($P_{95}^{\pm}$ 15 to 25).

Population estimates were made by the Lincoln Index and Schumacher-Eschmeyer methods on three different occasions. The average of the differences between the two methods did not differ significantly from zero at the 5 per cent level as indicated by the t-test. However with only three comparisons available, the power of the test is quite low.

On the basis of the assumptions previously discussed, the only bias likely to occur was probably due to a loss of marked hares from the area and their replacement by unmarked animals. It seems probable therefore that the estimates of both the Lincoln and Schumacher-Eschmeyer methods were, if anything, slightly high.

Capture locations indicated that the range of some hares was partly in and partly outside the study area. Since trapping was intensive, it is probable that most hares resident along the boundary were captured and that the population being studied occupied an area slightly larger than the described study area.

TOE-CLIPPED TRACK RATIO METHOD

If a known number of hares are toe-clipped so that their tracks

may be distinguished from unclipped tracks, a population estimate may be obtained from an unbiased ratio of clipped to unclipped tracks. The method is an application of the Lincoln Index principle.

Animals were toe-clipped and then, after a snowfall, straight-line routes were followed across the study area. These routes normally followed the transect lines, however, some counts were obtained while moving over the area to check traps. All hare tracks which crossed the lines of travel and could be identified as clipped or unclipped were recorded.

Calculation of the total number of hares was made (Table 4) using the following relationship:

$$\text{Population} = \frac{\text{Total number of hares clipped} \times \text{total number of tracks}}{\text{Number of toe-clipped tracks}}$$

Confidence limits were calculated as the limits about the proportion of clipped tracks in the track ratio samples.

An estimate of 21 hares was calculated on the basis of one track ratio count on April 10, 1959. Four counts taken in December, 1959, resulted in an average estimate of 17 hares. These results are very similar to the capture-recapture estimates. A kill-removal count carried out at the end of the last study period (see beyond) also yielded 17 hares. Considerable confidence is placed on the reliability of the kill-removal count, therefore it is concluded that the capture-recapture and the toe-clipping methods both yielded reliable results.

Of the basic assumptions in the application of capture-recapture methods mentioned earlier, the only apparent source of error, applicable

TABLE 4. Population Estimates for Snowshoe Hares based on records of toe-clipped and unclipped tracks during April and December, 1959.

DATE	NUMBER CLIPPED	<u>TRACKS RECORDED</u> TOTAL CLIPPED		POPULATION ESTIMATE	MORTALITY	TOTAL ESTIMATED POPULATION	CONFIDENCE LIMITS (95 per cent)
Apr. 10	8	51	20	20	1	21	16-31
Dec. 1	13	48	31	20	0	20	
Dec. 3	15	52	46	17	0	17	
Dec. 6	12	34	31	13	3	16	
Dec. 8	12	71	68	12	3	15	
Mean estimate for December, 1959						17	16-20

to track ratios, is that of possible trans-boundary movements. Inflation of population estimates could have occurred as a result of clipped hares leaving the area and being replaced by unclipped animals. However, in view of the agreement with the kill-removal count of the last period it seems probable that no appreciable trans-boundary movement occurred.

The track-ratio method is considered to be a simple and efficient method for determining snowshoe hare population levels in winter.

FECAL PELLETT COUNT METHOD

Censusing mammals by the fecal-pellet count method requires that three items be determined: (1) the average number of pellets defecated per day per individual for the species concerned, and the characteristics of the pellets with regard to loss and decomposition due to weathering; (2) the total number of droppings present on the study area, and (3) the number of days over which the droppings are deposited.

The solid composition and distinctive shape of lagomorph feces lend well to accumulating on the ground surface and to being counted. MacLulich (1937) used pellet counts in his work on snowshoe hares. He estimated the age of pellets and, sampling those assumed to have accumulated for one year, submitted that 9.5 pellets per square

meter equalled 1,000 hares per square mile. Hendrickson (1939) took an inventory of the cottontail (Sylvilagus floridanus) by counting pellets on cleared sample plots. Arnold and Reynolds (1943) discussed the use of the method in relation to Arizona jackrabbits (Lepus californicus) and antelope jackrabbits (Lepus alleni). Adams (1959), using a two month time interval, estimated snowshoe hare populations on a study area by counting pellets on cleared plots. He suggested that the defecation rate was between 250 and 480 pellets per hare per day.

The mean defecation rate for snowshoe hares was obtained in this study by recording the defecation rate of adult animals both in pens and in a field enclosure. The pens were 4 by 4.5 by 2 feet in size with one-half inch wire mesh floors above removable litter trays, as used by Severaid (1945). The pens were outdoors and the animals were fed as nearly a natural diet as could be obtained. During the summer months, fresh branches of woody plants as well as herbs and grasses were fed in variety. In winter months, branches of the commonly browsed shrubs and trees were cut and snow was substituted for water. The hares maintained apparent good health under these conditions.

Each day the pens were cleaned and the pellets in the trays counted. During July and August, five hares were kept on a summer diet for a total of 39 hare-days. The mean defecation rate then was 568 pellets per hare per day, with a standard error of the mean equal to ± 12.6 . During November, December and April, on winter diet,

six hares were kept for a total of 67 hare-days. The mean defecation rate was 583 pellets per hare per day, with a standard error of the mean of ± 14.9 .

The field enclosure was used in an attempt to check the validity of the pen counts against more natural conditions. A one-acre area was fenced with chicken wire. It included a vegetative continuum of black spruce to sugar maple. The lower edge of the fence was buried in a 6 to 10 inch trench but the hares never attempted to dig out, proving this precaution unnecessary.

Four equally-spaced strips were established and cleared of old pellets before releasing five hares into the area in late August. Four hares were removed after 11 days but the fifth was not captured until the following day. Thus, hares were kept in the enclosure for 56 hare-days. A total of 2,603 pellets were counted on the strips which comprised ten per cent of the area. These data indicated a pellet deposition rate of 465 pellets per hare per day.

The general magnitude of the pen counts was verified by the enclosure counts but certain variables had to be considered in comparing pen and enclosure counts and also in comparing either with field counts. In the field, for example, it became immediately apparent that some pellets were lost in the ground litter. An attempt was made to determine the magnitude of this loss. Pellets were marked by a small hole and distributed on a variety of litter types common to the area within 35 selected quarter-mile plots. In each case the number distributed was recorded and workers, who had

no knowledge of the records, searched the plots for the marked pellets, taking time equal to that used in the census tallies. Three people took part in this work to reduce the possible bias of good or poor searching qualities in a single worker. Of 188 pellets put out only 142 were recovered. This represented a failure to locate 24 per cent of the pellets under the field conditions encountered. Correcting the enclosure count by 100/76 resulted in an estimate of 612 pellets per hare per day. It is believed that the enclosure strips were searched more thoroughly than the field plots. This probably explains the difference between pen and enclosure counts.

The defecation rate used in this study was 583 pellets per hare per day which is believed to be the most accurate figure available for winter studies. A correction factor of 100/76 was applied to field counts.

It is suggested that for studies elsewhere, the correction for inability to locate pellets be calculated locally for the litter types common to the area.

Decomposition could also contribute to pellet loss. Taylor and Williams (1956), censusing the European rabbit (Oryctolagus cuniculus), did not clear their census plots but determined age and decomposition loss by comparing the condition of tallied pellets with known-age pellets.

In order to learn the magnitude of loss due to weathering in this study, groups of pellets were put out on various litter types in July and examined after one and two month periods. In general, there was no breakdown of droppings lying on dry leaf or needle

litter. Fecal pellets on needle litter appeared to have a life span of one year or more. In shrub cover, a decomposition loss of about five per cent occurred in two months. This loss approached 100 per cent for pellets lying either in water or on moist sphagnum for the same length of time. Moisture during the summer months seriously raises the decomposition rate. However, snow probably preserves pellets. Since counts were made roughly one and one half months after spring snow-melt and since water or wet moss covered a relatively small part of the study area no attempt was made to correct for pellet decomposition loss.

In this study, each quarter-mileacre, circular plot centered at transect stakes was cleared of old pellets on November 15, 1958. New pellets were counted on these plots on May 31, 1959. The time interval was 197 days.

Before pellet survey results (Table 5) were analysed, the area was stratified on the basis of track densities recorded during the study. Four strata of hare density were determined in an effort to reduce the variance of the estimate. Statistical analysis was made according to Cochran (1953: Ch. 5).

The total number of pellets on the study area, without correcting for loss, was calculated to be 2,120,862 with 95 per cent confidence limits of 1,177,406 and 3,064,318. The following formula was used to convert the mean totals to the average number of hares (P) present on the area during the period concerned:

$$P = \frac{100/76 \times \text{Total number of pellets calculated for the area}}{\text{Mean defecation rate (pellets per hare per day) } \times \text{time interval (days)}}$$

TABLE 5. Analysis of Fecal Pellet Survey Results for the
Period of November 15, 1958 to May 31, 1959.

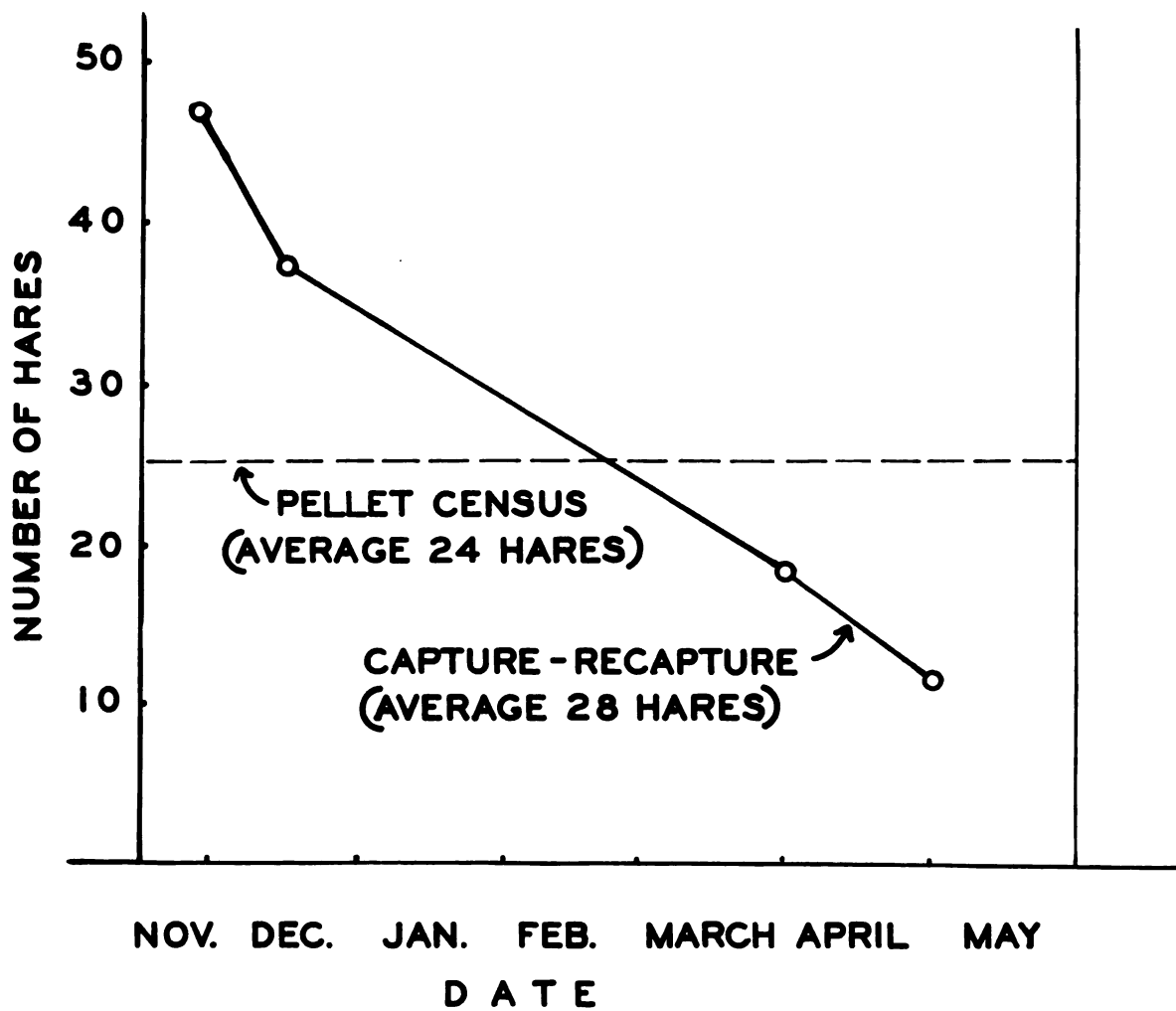
STRATUM	NO. OF $\frac{1}{4}$ MILACRE PLOTS (n_h)	TOTAL ACREAGE IN EACH STRATUM	MEAN NUMBER OF PELLETS PER PLOT ($\bar{y}_h$)	VARIANCE OF STRATUM SAMPLE (s^2_h)	NO. OF POSSIBLE PLOTS PER STRATUM (N_h)	TOTAL PELLETS PER STRATUM ($\bar{y}_h N_h$)
One	42	29	2.28571428	19.038	116,000	265,143
Two	112	93	4.42857140	180.661	372,000	1,647,429
Three	57	46	0.82456140	3.254	184,000	151,719
Four	119	99	0.14285714	0.395	396,000	56,571
Totals	330	267			1,068,000	2,120,862

This calculation indicated an average population of 24 hares [±] (P₉₅ 13 to 35) on the study area. The estimate from this technique had a major advantage over most other census method used. It represented the average number of hares on the area studied and was affected only proportionately by those animals using the area part of the time or as a portion of their home range. Also, if desired, pellet counts could be correlated with the various forest types to indicate relative hare use of the habitat available.

No information was secured by this method of the population size at any specific time. During the period of the pellet survey, the Schumacher-Eschmeyer capture-recapture method indicated that there were populations of 47 hares in November and 19 in April. These populations suffered known mortalities of 8 and 7, respectively. A graphic representation of animal numbers through the winter (Figure 3) permits comparison of results from the two methods. The effects of mortality during and between trapping periods were projected as straight lines. Capture-recapture results indicated an average population level of 28 hares, compared to that of 24 for the fecal pellet inventory. Probably the pellet count estimate was slightly low because no correction was made for pellet decomposition loss. It is believed that the true average population was between 24 and 28 hares.

Figure 3.

Comparison of projected population numbers
as indicated by the Schumacher-Eschmeyer
capture-recapture method with the population
level as estimated by fecal pellet census
(Winter 1958-1959).



TRACK COUNTS AS INDICES OF ABUNDANCE

Game management organizations can seldom afford the expense of the census methods discussed above. Where only the relative abundance of hares from year to year is required, track index counts, because of their simplicity, probably offer the most efficient means of obtaining the required information.

In the course of this study, tracks were recorded on 27.6 miles of track-counting line. Routes to be followed were predetermined without relation to known track densities. The lines most often followed the transects, but some counts were taken between transects. Counts were always made one day following a snowfall so that only the tracks made during a single night were tallied. These counts were made by recording each track that crossed the line of travel, regardless of whether successive tracks were made by the same or different animals. When trails were encountered, for which the number of tracks was indiscernable, the somewhat arbitrary rating of three was given.

The average number of tracks per chain per hare observed in this study ranged between 0.019 and 0.022 (Table 6), which indicates that the number of tracks per chain was closely related to estimated population levels. The total number of hares trapped in each period was used as the assumed population level for these calculations because that figure is believed to represent most closely the number of animals present when track counts were taken.

It was concluded that track counts, taken repeatedly on a single area, indicate the relative abundance of hares. For this study area,

TABLE 6. Snowshoe hare tracks per chain (66 feet) for
Major Regions of the Study Area.

FOREST COVER	PERIOD						AVERAGE NUMBER TRACKS PER CHAIN
	DEC. 1958-JAN.1959		MARCH-APRIL 1959		NOV.-DEC. 1959		
	CHAINS SAMPLED	TRACKS PER CHAIN	CHAINS SAMPLED	TRACKS PER CHAIN	CHAINS SAMPLED	TRACKS PER CHAIN	
Swamp & Spruce	199	1.0500	198	0.5151	299	0.7692	0.7773
Aspen,Pine and mixed old cut- over	114	0.8772	208	0.6106	351	0.3162	0.5022
White birch- Spruce	186	0.4731	205	0.2390	318	0.0912	0.2341
Hardwoods	20	0.0000	64	0.0937	49	0.0000	0.0451
Average tracks per chain		0.7642		0.4207		0.3638	
*Number of Hares square mile		98		45		41	
Tracks/chain/ hare on the area		.019		.022		.021	

* As determined by the total number of animals trapped during each period.

it would appear that track counts could be used to roughly calculate absolute numbers. Although data are limited and apply with certainty only to the area used for this study, the relationship of tracks per chain and hares per square mile is shown graphically in Figure 4. It is hoped that further studies of a similar nature will strengthen or disprove track index relationships as being of general application in areas of similar vegetative cover.

It might be postulated that hares move about in inverse relation to the abundance of food. If true, track numbers would be partly a factor of the amount of food present and this possible effect should be tested. Vegetation density, acting as cover, might similarly affect movements. The consistency of track index results in early and late winter (Table 6) however, appears to indicate no great seasonal variation in tracks per hare.

Indices based on forms of animal activity, i.e. roadside counts, track counts, etc., often fail due to non-recognition of the effect of weather on animal behavior. The usual way of correcting for this is by standardizing the census with regard to weather and time. Track counts in this study perhaps approached conformity because each census was taken one day following a snowfall.

The effect of weather on hare movements was examined by recording the number of traps visited by hares each day, as determined by signs around the traps. This function of activity is related to weather factors in Figure 5. Hare activity was reduced especially by rainfall. There was a general relationship between low temperatures and high rates of trap visitation.

Figure 4.

Graph showing relationship between
snowshoe hares per square mile and
tracks per chain.

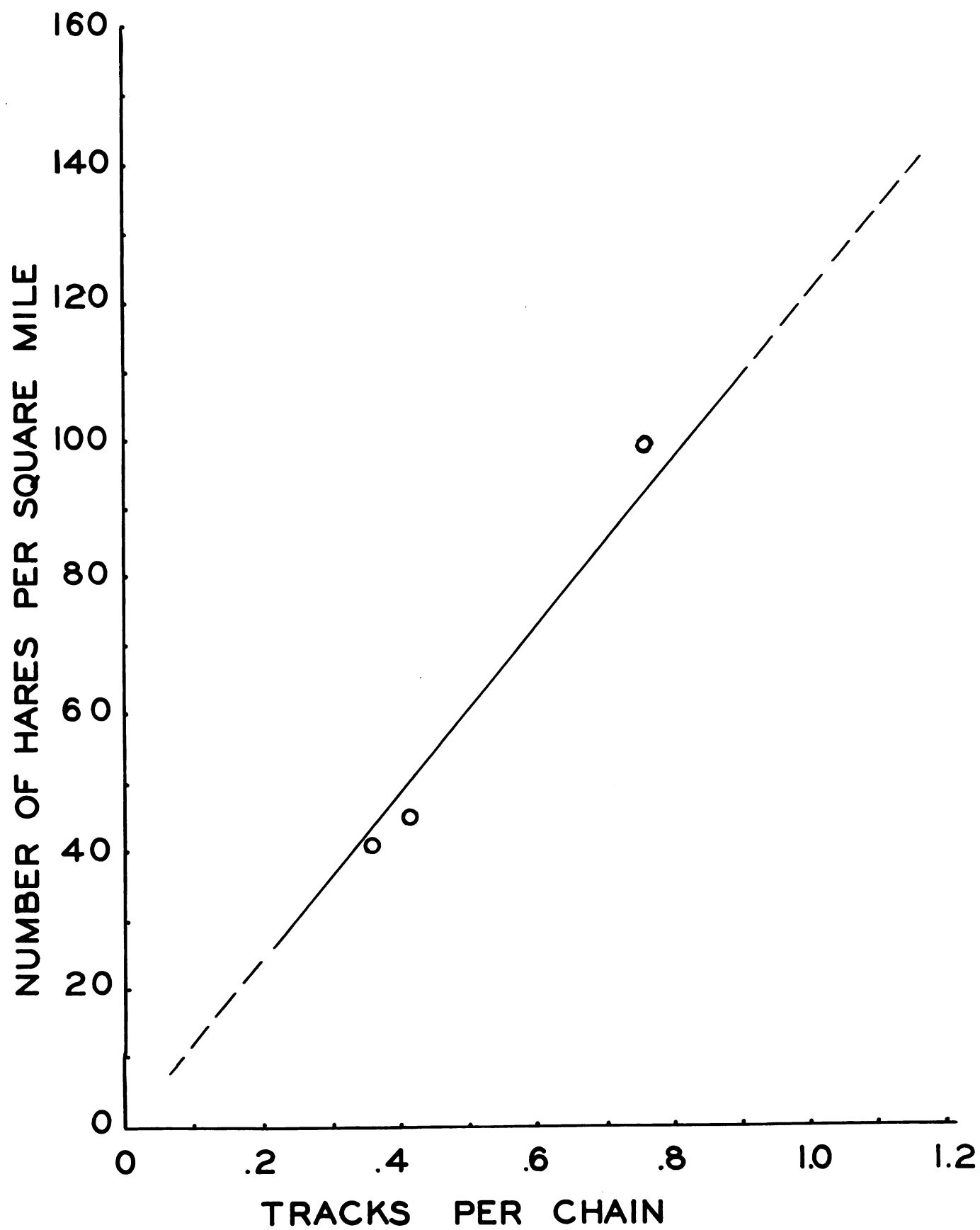
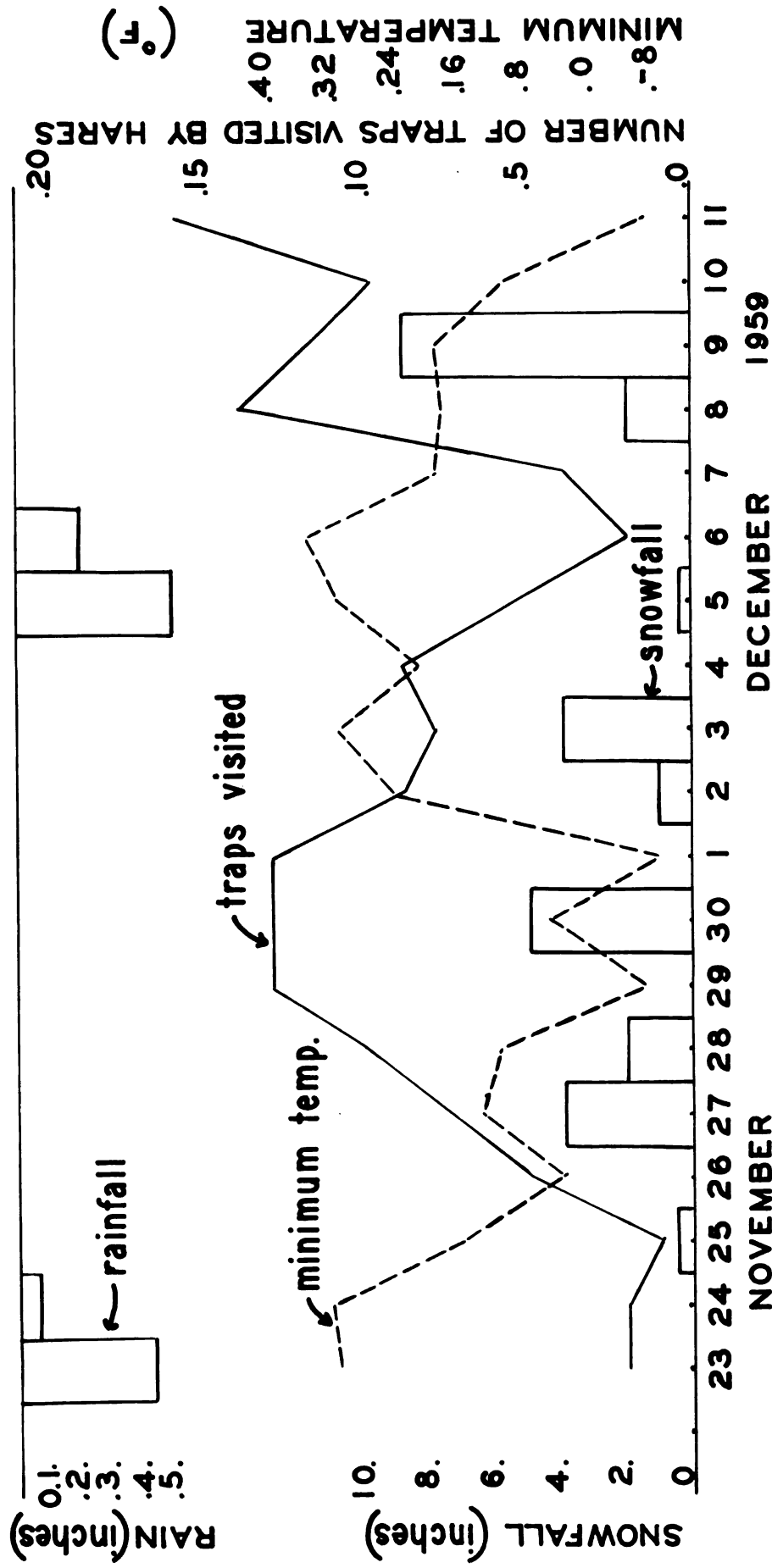


Figure 5.

Graph showing number of traps visited
by hares as related to minimum daily
temperature, snowfall and rain.



(weather records from Algonquin Park, Department of Transport, Canada.)

On the basis of the relationship between weather and activity found here, it is recommended that track counts be taken after nights when the temperature was below 20 to 24 degrees Fahrenheit. This temperature range was chosen as being safely below 32 degrees Fahrenheit which was normally the minimum temperature on days when rain occurred.

Track counts may also yield information on forest-type preference of hares. Counts taken in this study indicated that black spruce and alder lowland was most commonly used by hares (Table 6). This type of habitat became less important in March and April probably because deep snows of late winter covered most available food species there. In late winter, hares were relatively more active on the more elevated sites, especially those covered mainly by aspen and white pine and the mixed growth of secondary succession on areas logged off in the early part of this century.

REMOVAL-SNARING

At the end of the last trapping period, a total of 686 snare-nights during seven days resulted in the capture of 11 hares. Six others were killed near or at the end of the period yielding a total of 17. One tagged hare was not recovered and one of the snared animals had not been previously trapped in this period. For the last three days of snaring, tracks present could be attributed to

known individuals which eventually were snared. For three days following snaring no new tracks could be found. Evidently 17 to 18 hares used the study area during this period and most of the animals present had been live-trapped at least once. It is believed that the removal program was of short enough duration to prevent serious errors resulting from immigration induced by the hare removal. However, some of the animals snared may have been partial residents of the area.

It is interesting that on the fourth day after snaring, two hares ventured onto the area. From its tracks, one had traveled about one-quarter of a mile onto the area and then left during the same night that it had entered. Two months later, tracks indicated that all of the suitable cover had been reinhabited by hares.

DISCUSSION

The population estimates for the three census periods (Table 7) were similar for all techniques used. Perhaps because of the intensive trapping program and the relatively small hare populations involved, nearly all of the animals present were trapped. But only the methods involving capture and recapture were affected by trapping intensity.

The capture-recapture method required more effort than the

TABLE 7. Summary of population estimates and indices.

CENSUS METHOD	PERIOD ESTIMATES		
	Nov.-Dec. 1958	March-April 1959	Nov.-Dec. 1959
1) Lincoln Index	43	19	16
2) Schumacher-Eschmeyer Capture-recapture	47	19	18
3) Toe-clipped Track Ratio	-	21	17 *
4) Fecal Pellet Count	← 24 →		
5) Removal Snaring	-	-	17
INDICES			
1) Tracks per chain	0.7642	0.4207	0.3638
TOTAL NUMBER OF HARES HANDLED			
	41	19	17

* Average estimate from four independent track ratios taken in this period.

other techniques used. The toe-clipped track ratio method, though confined to the winter season, required less time and effort than the capture-recapture methods and is probably most practicable for application by untrained personnel. Distinctive patterns of toe-clipping also yields information on home range and movements of marked animals.

The fecal pellet count method, with its numerous variables, apparently may be used with good success if treated as described here. The method is subject, however, to inaccurate sample counts. Considerable care should be taken in searching for pellets and in obtaining an accurate correction factor. It has the advantage of requiring relatively less field work than other methods discussed above. If used for short time intervals during the summer, it is especially applicable to population trend studies, since pellets counted and removed leave the plots cleared for the next tally.

SUMMARY

A number of different census techniques were tested on snowshoe hares inhabiting a 267-acre area in Algonquin Provincial Park, Ontario. Work was mainly carried out over three different study periods during the winters of 1958 and 1959. The several census methods gave remarkably similar results.

Capture-recapture methods, using the Lincoln index and Schumacher-Eschmeyer formulae, resulted in fairly accurate estimates but required considerable work. Hares were found to exhibit homogeneous trap response possibly being influenced by frequent movement of the traps. The error in population estimates resulting from unknown emigration and immigration factors is believed to have been small. Other assumptions of the capture-recapture methods seem to have been met. The Lincoln index method gave estimates of 43 hares for the November-December 1958, 19 for March-April, and 16 for November-December 1959, trapping periods. The Schumacher-Eschmeyer formula gave estimates of 47, 19 and 18, respectively, for the same periods.

A single toe was clipped from the hind foot of 22 different hares and those which had lost a long centre toe made especially distinctive tracks. Ratios of clipped to unclipped tracks were found to be a simple and reliable method for making population estimates. Population levels of 21 hares for March and April, and 17 for November and December 1959, were obtained.

A fecal pellet census also proved to be an accurate technique. Defecation rates for snowshoe hares were calculated as 568 pellets per hare per day on summer diet and 583 on winter diet. A method for correcting for observer's inability to locate pellets was devised. The pellet survey results indicated that an average of 24 hares had used the area during the winter of 1958-1959.

Counts of tracks which crossed predetermined survey lines were found to be closely related to population levels and indicated the

relative abundance of hares. The relation of about .008 tracks per chain for each hare per square mile is discussed for this study area. Factors affecting this census method were considered in view of testing this relationship on other areas.

At the close of the study a kill-removal by intensive snaring proved that estimates were close to true populations and that most animals had been handled during the earlier live-trapping. Seventeen animals were removed from the area.

Within two months following kill-removal, the area was re-occupied by snowshoe hares.

REFERENCES

- Adams, Lowell. 1959. An analysis of a population of snowshoe hares in northwestern Montana. *Ecol. Monog.*, 29: 141-170.
- Arnold, J.P. and H.G. Reynolds, 1943. Droppings of Arizona and Antelope Jackrabbits and the "Pellet Census". *J. Wildl. Mgmt.*, 7: 322-327.
- Cochran, W.G. 1953. Sampling techniques. N.Y., Wiley and Sons, Inc., London, Chapman and Hall, 330 pp.
- Dell, Joseph, 1957. Toe clipping varying hare for track identification. *New York Fish and Game J.*, 4: 61-68.
- Geis, Aelred D. 1955. Trap response of the cottontail rabbit and its effect on censusing. *J. Wildl. Mgmt.*, 19: 466-472.
- Green, R.G. and C.A. Evans, 1940. Studies on a population cycle of snowshoe hare in Lake Alexander region. I Gross censuses 1932 - 1939. *J. Wildl. Mgmt.*, 4:220-238.
- Hald, A. 1958. Statistical Tables and Formulas. New York, John Wiley & Sons, London, Chapman & Hall, 97 pp.
- Hayne, D.W. 1949a. Two methods of estimating populations from trapping records. *J. Mammal.*, 30: 399-411.
- Hendrickson, G.O. 1939. Inventory methods for Mearns cottontails. *Trans. N. Amer. Wildl. Conf.*, 4: 209-215.
- Libby, W.L. 1957. A better snowshoe hare live-trap. *J. Wildl. Mgmt.*, 21: 452.
- Lincoln, F.C. 1930. Calculating waterfowl abundance on the basis of banding returns. *U.S.D.A. Circ. No. 118*: 1-4.
- MacLulich, D.A. 1937. Fluctuations in the numbers of Varying hare (Lepus americanus). *Univ. Toronto Studies. Biol. Series*, No. 43: 1-136.
- Schumacher, F.X. and R.W. Eschmeyer. 1943. The estimate of fish population in lakes and ponds. *J. Tenn. Acad. Sci.*, 18: 228-249.
- Severaïd, J.H. 1945. Breeding potential and artificial propagation of snowshoe hares. *J. Wildl. Mgmt.*, 9: 290-295.
- Snedecor, G.W. 1946. Statistical methods. The Iowa State College Press, Ames, Iowa. 485 pp.

REFERENCES, Cont.

- Taylor R.H. and R.H. Williams. 1956. The use of pellet counts for estimating the density of populations of the wild rabbit (Oryctolagus cuniculus). New Zealand J. of Sci. Tech., B 38: 236-256.
- Tyndale-Biscoe, C.H. 1953. A method of marking rabbits for field studies. J. Wildl. Mgmt., 17: 42-45.
- Young, H., John Neess and J.T. Emlen, Jr. 1952. Heterogeneity of trap response in a population of house mice. J. Wildl. Mgmt. 16: 169-180.

APPENDIX 1. Calendar Graph of Snowshoe Hare Trapping Results for November and December, 1958, and January 1959, Showing Date and Location of Capture and Recapture. Tag number given for right ear only. Animals found dead in the trap (d).

TAG NO.	SEX	NOVEMBER											DECEMBER											1958											1959																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
		25	26	27	28	29	30	1	2	3	4	5	6	7	...	10	11	12	13	14	15	16	17	18	...	27	28	29	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31

APPENDIX 1 - Cont.

TAG		SEX		NOVEMBER					DECEMBER					1958					1959																			
NO.				25	26	27	28	29	30	1	2	3	4	5	6	7	...	10	11	12	13	14	15	16	17	18	...	27	28	29	30	31	3	..	28	29	30	
63	F					G3	--	--	L6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
65	F					L1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
67	M							M23M27		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
69	F							N6		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
71	M							L5		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
73	F							O20		--	--	P3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75	M							P4		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P5	O19	--	--	P2	--	--	--	Q16	
77	M															O21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
79	F																	Q10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	L7	
81	F																															K24	--	L7	G1	--	--	
85	M																																	A5	--	--	--	--
TOTALS																																						
Traps set		9	9	9	18	19	20	20	21	26	26	26	26	25	26	26	6	6	6	6	6	3	6	6	6	6	6	6	16	16	16	16	24	44	29	23	9	528
Trap nights		8	7	1	13	17	19	20	21	25	22	1	24	22	25	26	6	6	6	6	6	3	5	6	6	6	6	6	14	15	16	22	39	28	22	9	460	
New captures		2	0	0	7	6	2	2	3	2	1	0	2	2	3	0	1	1	3	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	41		
Recaptures		0	0	0	1	2	4	2	3	5	0	0	5	5	5	6	1	2	0	0	1	0	0	0	0	0	0	1	4	0	2	8	4	4	4	69		
Traps visited		4	-	4	12	13	14	10	16	10	14	10	21	16	12	-	2	4	5	1	-	-	-	-	-	-	2	1	10	-	-	-	17	10	9	0	221	
Precipitation:																																						
Rain (inches)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Snow "		-	.5	1.5	.5	4	-	1	-	3	.5	-	.5	-	-	1	.5	1	.5	.5	.5	4	-	-	-	-	-	.5	6	-	-	-	-	-	.5	-	4	
Min. Temperature		9	20	13	10	7	-8	8	2	1	13	19	-1	-11	-22	-17	-4	-12	-11	2	-3	-5	-20	10	22	9	1	-20	29	4	9	15						
(Degrees Fahrenheit)																																						

APPENDIX 3. Calendar Graph of Snowshoe Hare Trapping Results for November and December, 1959, Showing Date and Location of Capture and Recapture. Tag number given for right ear only.

Animals snared (s), dead from other causes (d).																											
TAG SEX		TOE		TAGGED		DECEMBER												1959									
NO.		CLIPPED		1958-59		23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14
47	F	no	yes	L5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N5(s)		
101	F	yes	no		K26	--	--	--	--	--	N5	--	--	--	--	--	--	--	--	L6	--	--	N6(d)				
103	F	yes	no			P4	--	--	--	--	O18	--	O18	--	--	--	--	P5	--	--	--	--	--	--	O19(s)		
83	M	yes	yes					F3	--	C13	--	--	C13	--	--	--	--	--	--	--	--	--	--	--	C10(s)		
51	M	yes	yes			N5	--	--	--	--	F10	--	--	--	--	--	--	--	--	(no more record)							
105	M	yes	yes					C12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C13(s)	
107	M	yes	no					C13	--	--	--	--	--	D8	--	--	--	B4	--	--	--	--	--	--	E10(s)		
109	M	yes	no					E18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C12(s)	
111	F	yes	no					M24	--	--	--	--	--	--	--	--	--	N6(d)	--	--	--	--	--	--	--		
113	M	yes	yes					Q17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N6(s)	
115	M	yes	no					D1	--	--	--	--	--	F3	F5(d)	--	--	--	--	--	--	--	--	--	--	O16(s)	
79	F	yes	yes					M24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
89	M	yes	yes					M27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	L5(s)	
123	F	yes	no							P8	--	--	--	P8	--	O13	P8(d)	--	--	--	--	--	--	--	--	Q17(d)	
121	M	yes	yes							Q17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
39	M	yes	yes										C16	--	--	--	D5	--	--	--	--	--	--	--	--	C16(s)	
41	F	no	yes																						C14(d)		
69	F	no	yes																							N6(s)	
TOTALS																											
Traps set				19	24	33	34	35	35	35	37	36	37	37	41	44	46	43	43	44	42	46	42	33	28	25	802
Trap nights				19	23	32	16	32	34	34	35	35	34	36	36	27	41	40	40	4	40	43	40	33	27	21	686
New captures				1	1	0	1	1	5	4	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	17
Recaptures				0	0	0	0	0	0	3	1	1	1	3	1	1	1	5	0	1	1	1	0	0	0	0	18
Traps visited				2	2	1	5	-	10	13	-	13	9	8	9	9	-	2	4	14	-	10	16	-	1	1	1
Snare nights																											
Snare captures																											
Precipitation: Rain				.41	.04	-	-	-	-	-	-	-	-	-	-	-	.48	.18	-	-	-	-	-	-	-	-	-
(inches) Snow				-	-	.5	-	4	2	-	5	-	1	4	-	-	.2	-	-	2	9	-	-	3	-	1	1
Minimum temperature				32	33	17	4	14	12	-6	6	-8	25	32	32	22	32	36	21	19	20	11	-6	17	4	-13	-13
(degrees Fahrenheit)																											

APPENDIX 4. Notes on the strip census method.

The strip census method has been widely used for estimating the densities of wild animals. In the Ontario snowshoe hare investigation on November 11, 1958, five hares were flushed on 8.4 miles of survey line. The distances from the observer to each hare's form (the depression where the animal sits) and the angle to this location from the line of travel at the time of first sighting were recorded (Table 8). Although an animals had sometimes run a few yards from its form before it was sighted, the form was used as a reference point because it served as an easily-located fixed point.

Three different ways of treating strip census data have been published. The methods given by Leopold (1933:151 - adapted from the unpublished work of R.T. King), Webb (1942) and Hayne (1949), were applied to these data. Resulting population estimates were 58, 71, and 77 hares, respectively for the study area during November, 1958. All of these figures are considerably higher than population estimates by any of the other methods used in the study. Unfortunately only one strip census was carried out. The results, while not conclusive, indicate the probable accuracy of this method.

REFERENCES

- Hayne, D.W. 1949. An examination of the strip census method for estimating animal populations. *J. Wildl. Mgmt.*, 13:145-157.
- Leopold, Aldo. 1933. *Game Management*. Charles Scribner's Sons, New York, London. xxi plus 281 pp.
- Webb, W.L. 1942. Notes on a method for censusing snowshoe hares. *J. Wildl. Mgmt.*, 6:67-69.

TABLE 8. Results of Strip Census Carried Out
on November 11, 1958, Algonquin
Provincial Park, Ontario.

OBSERVATION NUMBER	FLUSHING DISTANCE (feet)	FLUSHING ANGLE (degrees)
1.	4	90
2.	21	10
3.	12	5
4.	8	90
5.	12	80

ROOM USE ONLY

~~MAY 19 1967~~ ~~ROOM USE ONLY~~
april 5/8/66

~~OCT 30 1963~~

~~NOV 13 1963~~

~~JAN 1 1968~~

~~OCT 11 1967~~

~~JAN 6 1969~~

~~AUG 15 1969~~

~~MAY 13 1970~~

~~MAY 11 1971~~

~~DEC 30 1971~~

~~JUN 13 1972~~

MICHIGAN STATE UNIV. LIBRARIES



31293102521642