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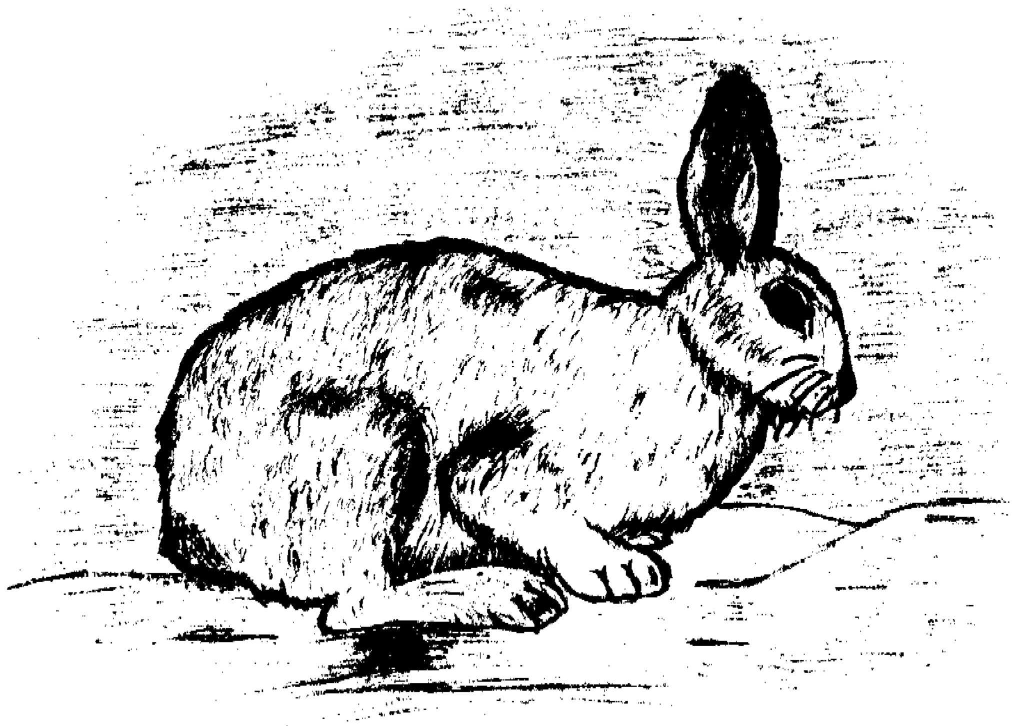
ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

SNOWSHOE HARE STUDIES

By Jeannette Ernest



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Final Report
Federal Aid in Wildlife Restoration
Projects W-17-4, W-17-5 and W-17-6
Jobs 10.7R and 10.8R

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FINAL REPORT (RESEARCH)

State: Alaska

Cooperator: Jeannette Ernest

Project Nos.: W-17-4, W-17-5 & W-17-6   Project Title: Small Game Investigations

Job Nos.: 10.7R   Job Titles: Snowshoe Hare Population Enumeration

10.8R   Productivity of Snowshoe Hares

Period Covered: June 1, 1970 to December 15, 1973

SUMMARY

Snowshoe hare populations were studied in the Central and Fairbanks areas from June 1970 to December 1973. Population estimates were derived from livetrapping two study areas, one of 0.57 square miles at Central and one of 0.5 square miles at Fairbanks. Female snowshoe hares were collected during the three months of the breeding season each year in Central, Fairbanks, and Delta and their reproductive tracts examined for embryos, fetuses, placental scars and resorbed embryos.

Livetrapping studies indicated the hare population on the Central study area was around 400 animals in August 1970, 150 in May 1971 and 960 in August 1971. Hare populations on the Fairbanks study area were estimated at 782 hares in August 1971, 244 hares in April 1972, 297 in August 1972, 112 in March 1973 and 221 in November 1973.

Sex ratios and adult-juvenile ratios of livetrapped hares were determined and changes in sex ratio in relation to population size are discussed. Adult-juvenile ratios, when compared with the average birth rates, provided an indication of juvenile survival.

Reproductive data collected from female hares for three years in Delta and Fairbanks and four years in Central indicate that almost all female hares from these three areas produced at least two litters each summer, and some hares produced a third litter in some years.

Dates of conception for first and second litters were closely synchronized in each area during any one year and early onset of breeding seemed to influence the production of a third litter.

Second litters averaged larger than first litters. Significant yearly differences in the mean size of second litters occurred in both Central and Fairbanks hares. The mean size of the second litter was significantly lower in 1972 than in 1971 in both areas.

Prenatal sex ratios showed a trend toward more than 50 percent males as the population declined. Implications of this trend are discussed.

Movements of tagged hares showed that hares are relatively sedentary and recapture data indicate that some hares live at least two and one-half to three years in the wild.

Small game abundance survey returns and trapper questionnaires indicated that hare population levels were considered high around Fairbanks and the Tanana Valley in 1971-72 but moderate and declining in 1973.

Other snowshoe hare population studies are discussed and estimates of population size obtained from various studies are compared. Factors involved in population fluctuations are discussed.

CONTENTS

BACKGROUND

Snowshoe hare (*Lepus americanus*) population fluctuations have been recorded in Alaska as far back as the late 1800's. Buckley (1954) reviewed the known history of animal population fluctuations in Alaska. Information was obtained from records kept by the Alaska Game Commission and the U. S. Fish and Wildlife Service, and from various published accounts. Snowshoe hares were abundant in the Interior in 1885, one of the first notations of hare populations. There was no further information until 1898, when populations were reported to be low, but increasing. By 1905 hares had again reached a peak in the Interior. The next peak was evidently from 1913-1915 around Fairbanks. In 1924 hares were so numerous around Fairbanks they were destroying crops, and the population remained high through 1925, dropping to a low in 1928 and 1929. The next peak was in 1935, then again in 1943, and 1946-1947 (several minor peaks.) Hares were again abundant in 1953 and 1954, but suffered a "crash" in the winter of 1954 and were at a very low level in the Fairbanks area in 1955.

The Cooperative Wildlife Research Unit, University of Alaska, initiated ecological investigations of snowshoe hare populations in the Interior in 1955. Paul Tovey, a student with the Wildlife Unit, conducted a study of the physiological effects of population trends on hares in the Interior. Tovey's study compared the effects of population densities on the endocrine glands and reproductive organs, using roadside counts and collections. Results of his study were compiled in 1962 by Bishop (Tovey and Bishop 1962) after Tovey's death in a plane crash. O'Farrel (1960) studied the home range and ecology of the snowshoe hare during the ascending phase of the cycle. He estimated the population of a 160-acre plot near the University of Alaska, from June 1958 through April 1960, using the Lincoln Index and Schnabel method and the calendar graph. Trapp (1962) continued the study of this population, concentrating on the relationship of population density to home range and studying reproduction, behavior and ecology. This population reached a peak in 1963 and declined shortly after that to build up again around 1970. The present study was initiated in June, 1970 under S & I Job 10.

Interest in snowshoe hares grows as populations increase and the animals become more noticeable, and the number of studies seems to increase on the same order as the hares. When hare populations around Fairbanks reached their peak in 1972, three major hare studies were active, involving the Alaska Department of Fish and Game, the Institute of Arctic Biology (University of Alaska), and the Institute of Northern Forestry, (U.S.D.A.).

In other parts of its range the snowshoe hare has received a good deal of attention. Studies of hare populations outlining the breeding biology of natural populations and involving population estimation were done by Green and Evans (1940a,b,c) in the Lake Alexander area of Minnesota. Severaid (1942) outlined the breeding biology for captive populations in Maine in the late 1930's. Adams (1959) studied population dynamics and reproduction of snowshoe hares in Montana concurrently with Dodds (1965) in Newfoundland and Hartman (1960) in Michigan. Bookhout (1964,1965) emphasized breeding biology and prenatal development in an extensive study of the snowshoe hare in Michigan in the early 1960's. Newson and deVos (1964), conducted a broad study of two adjacent hare populations on Manitoulin Island, Ontario, involving population dynamics and reproduction, while at the same time, Meslow and Keith (1968) were involved in a very extensive study of the snowshoe hare covering all parameters from 1961 through 1968 in Alberta. The Alberta study followed snowshoe hare populations during a peak, decline to a low and the initial stages of population recovery. Meslow and Keith concluded that the decline in the hare population resulted from a decrease in adult survival, an extremely low juvenile survival and a halving of the reproductive rate.

The Institute of Arctic Biology, University of Alaska, began physiological studies of snowshoe hares in spring, 1972, became involved in the spring of 1972 in a study of the physiology of snowshoe hare during various stages of the cycle, and has since conducted livetrapping and initiated population studies in the Fairbanks area. The Institute of Northern Forestry set up a hare study area on the Wickersham Dome burn on the Elliot Highway outside of Fairbanks and livetrapped two adjacent areas for population studies of hares in the burned and unburned areas.

From June 1970 until May 1971, the present study concentrated on the hare populations around Central, with livetrapping studies restricted to the Central study area. In the spring of 1971 the study was expanded to include the Fairbanks area, and a study area was set up near Fairbanks in the summer of 1971.

This report covers the entire study period from May 1970 through December 1973, and includes efforts at Central, Fairbanks and Delta.

OBJECTIVES

To determine the density of snowshoe hares on selected study areas during the spring and fall and to correlate the estimated density with other indices of abundance.

To determine the annual productivity of snowshoe hares during different phases of the cycle and to relate the annual productivity to population trends.

STUDY AREAS

The general areas of this snowshoe hare study and collections of specimens were around Central, Delta, and Fairbanks, in habitat representative of what is found in Interior Alaska. Two intensive study areas were set up near Central and Fairbanks. These were each about one-half square mile in area.

Central Study Area

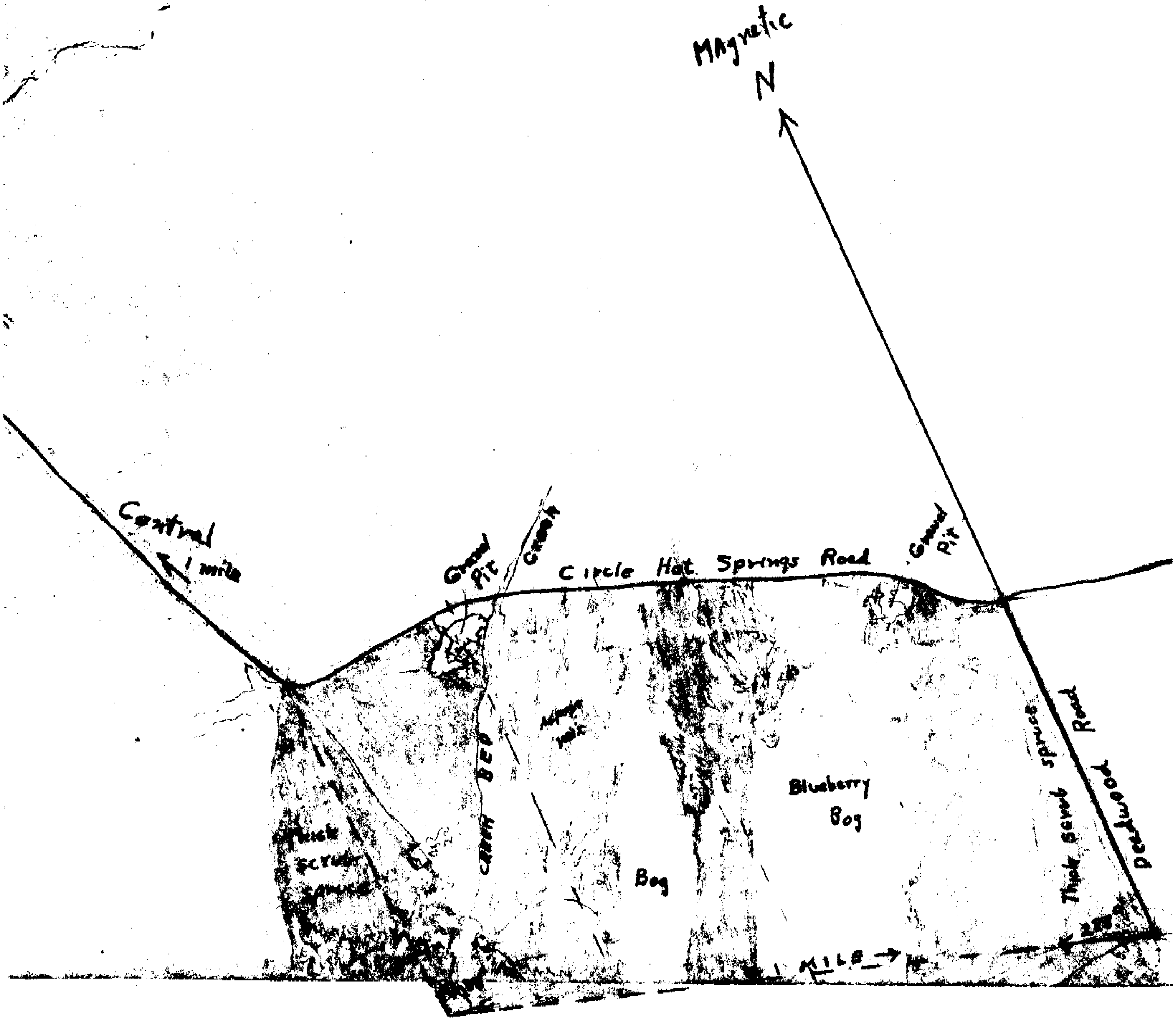
The study area at Central is located one mile from the town of Central (65°54' N Lat., 144°50'W Long.) on the Circle Hot Springs Road. It is 0.57 square miles in area, of a somewhat irregular parallelogram shape and bordered on two sides by roads, the Circle Hot Springs Road and Deadwood Road (Fig. 1). The terrain is essentially flat, with a small rise in the southwestern corner. Vegetation consists largely of scrub black spruce (*Picea mariana*), willow (*Salix* sp.), aspen (*Populus tremuloides*) and large boggy areas covered with blueberry (*Vaccinium uliginosum*) and dwarf birch (*Betula nana*).

The Central study area was deactivated, as far as the livetrapping program was concerned, after the August 1971 trapping because of logistical problems of working in the area, and the plans of the Bureau of Land Management to open up part of the area to home site selection. Hare collections and observations of habitat conditions were continued through 1973.

Fairbanks Study Area

The Fairbanks study area is located just outside of the Fairbanks city limits (64°50' N Lat., 147°50' W Long.) on land belonging to the

Figure 1. Central Study Area



Department of Fish and Game. It occupies the south 1/2 of Section 28, T1N, R1W of the Fairbanks Meridian (Fig. 2). Section lines were already marked on the area, which is 1/2 mile by 1 mile in extent. North-south and east-west lines were established every one-eighth mile through the area, and trap sites were located at the intersections of these lines and numbered 1 through 9 from east to west, and A through E from north to south. This gave each trap site a binomial designation, e.g. A-1, B-4, etc. There were 45 trap sites.

The terrain is flat, with several small lakes totaling 27 acres in area (0.0425 square mile). Vegetation (Fig. 3) consists of black spruce (*Picea mariana*), blueberry (*Vaccinium uliginosum*) and dwarf birch (*Betula nana*) in the more open, boggy areas, and patches of alder (*Alnus fruticosa*) and willow (*Salix* sp.), with patches of birch (*Betula papyrifera*) and aspen (*Populus tremuloides*). The southeastern corner tends to be marshy and the whole area was very wet after continuous heavy rains in the latter part of August each year. The area is heavily used by moose (*Alces alces*), especially in the eastern half. Several old dogsled trails winding through the area provide additional access.

PROCEDURES

Job 10.7 Population Estimation

Two study areas were live trapped in this study. The study area near Central (Fig. 1), approximately 0.57 square miles in extent, was set up in July 1970 and trapped in August 1970, May 1971 and August 1971. The Fairbanks study area (Figs. 2 and 3), of 0.5 square miles, was set up in July 1971 and trapped in August 1971, April 1972, August 1972, March 1973, August 1973 and November 1973.

Hares were livetrapped on these areas using Tomahawk collapsible wire livetraps (size 9" x 9" x 26"). Traps were set in well used runways at the intersections of transects running north-south and east-west every one-eighth mile through the areas. In the spring compressed alfalfa cubes were used as bait. No bait was used in the August trapping.

Traps were checked daily during the trapping period and hares were removed from the traps by picking up the trap and inverting it into a burlap sack. All hares were handled in the sack which facilitated the procedures and prevented injury to the animals. All hares were weighed with a Chatillon spring balance. Measurements were taken of the right hind foot, and right ear, notch to tip. The sex and approximate age of the animals were then determined, and they were examined for signs of pregnancy if the trapping period was in the breeding season (April-May). Hares were marked with a #3 fingerling tag placed in the lower anterior portion of the ear. At Central, colored Saflag was fastened to the ear with the tag in the first two trapping periods, to facilitate sighting of marked animals at a distance. Saflag was not used for the August 1971 trapping period due to attraction of predators to the ear-flagged animals. Capture date, location and other information was kept daily.

Fig. 2. Fairbanks Study Area.

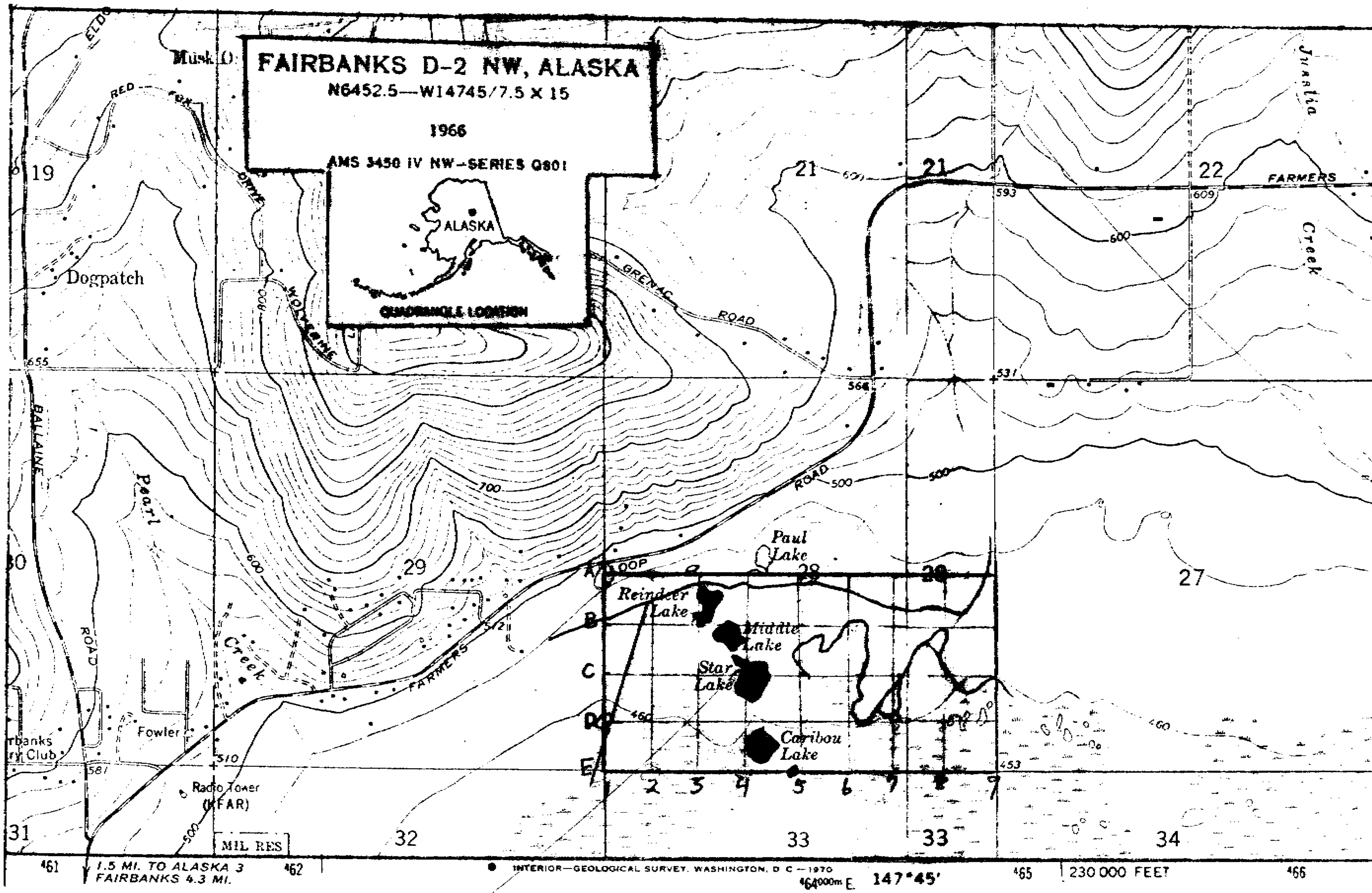
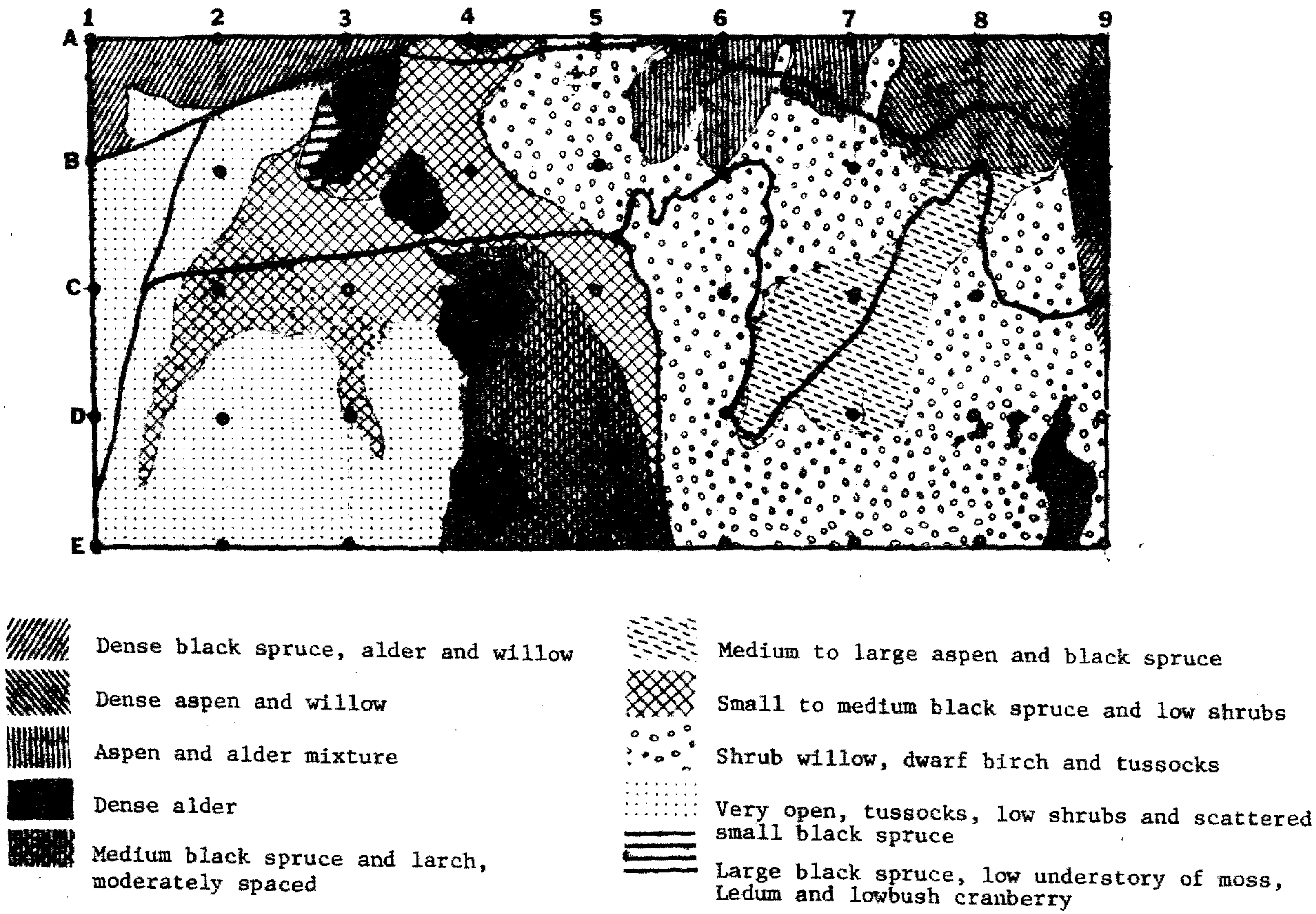


Figure 3. Simplified cover map of Fairbanks study area.



Population estimates were based on the Schnabel method (Schnabel 1938) or the Peterson or Lincoln Index. Adult-juvenile ratios were used to give a rough estimate of population size based on the population of the previous spring.

The types of vegetation on the study areas were determined by describing the stands at each trap site and referring to aerial maps to determine extent of various stands.

Road counts were conducted throughout the summer of 1970 and during several periods in the summer of 1971 in the lynx study area (Berrie 1971) near Central. Hares per mile were recorded on the Circle Hot Springs Road, Deadwood Road, and Ketchem Creek Road. Counts were conducted at all hours, but only those between the hours of 6:00 p.m. and 6:00 a.m. have been considered in this report. Counts were considered invalid on days with rain or wind during the count periods.

Job 10.8 Productivity

Samples of at least 20 adult female hares were collected from the Central, Fairbanks and Delta areas in May, June, and July. According to Bookhout (1964), there are two to three periods of peak breeding activity spaced about 36 days apart (the length of the gestation period), as hares generally breed immediately post-partum. When possible, collections were timed to correspond with the period when most pregnancies would be easily detectable by enlargements of the uterus at the implantation site, but before they were so far advanced as to make detection of placental scars difficult. Evidence of embryos in the uterus becomes discernible on the seventh day of gestation (Bookhout 1964).

All female hares were weighed with a Chatillon spring balance, measurements were taken of hind foot and ear lengths, and the reproductive tract was removed. Hares were examined briefly for signs of disease, parasites or abnormalities, and a note was made of the general physical condition. Embryos and fetuses were counted and measured, and placental scars were counted. Ovaries and uteri were preserved in 10 percent formalin.

When possible, a blood sample was collected for disease studies being conducted by the Disease and Parasite Section. The chest cavity was opened immediately after death of the animal and blood removed by syringe directly from the heart or aorta and stored in vials or vacutainers. Over 100 blood samples were collected from Central, Fairbanks and Delta hares.

Ages of embryos and fetuses were calculated from measurements and morphological characteristics using a scale developed by Bookhout (1964). Probable conception and paturition dates were calculated using these ages and counting back from the date of collection. Incidence of pregnancy and average litter size were calculated from the embryo and placental scar counts.

Fetal Sex Determination

Sex of fetuses 25 days old or older was determined by examination of external genitalia and internal organs. Slight differences in placement of the gonads were a guide to sex of the very early fetuses.

Males shot during these collections were also weighed, measured and examined. Testes were removed and preserved in 10 percent formalin prior to weighing. It is interesting to note that most adult hares shot along roadsides were females. In the Central area this ratio was as high as 95 percent females to 5 percent males.

FINDINGS (Population Estimation)

Central Study Area

August 1970 Trapping Period

August 1970 livetrapping results were reported in detail earlier (Ernest 1971). However, they will be briefly summarized here as the data are useful in evaluating later trapping data.

Livetrapping was conducted for three weeks beginning August 15, 1970 for a total of 1002 trap nights. There were 105 captures, for a trapping success of 10.4 percent. There were ten recaptures, and the population was estimated at 407 animals in 0.57 square miles (190-759 at the 95% confidence level, Table 1).

Ninety individual hares were captured and examined. Of these, 30 percent (27) were adults and 70 percent (63) were juveniles born in the 1971 breeding season (Table 2). The sex ratio was 59 percent females and 41 percent males in both adult and juvenile groups (Table 3), indicating that there were approximately 18 adult females per 100 hares. The ratio of juveniles to adult female hares was estimated to be 3.9 per female. The yearly birth rate calculated from data gathered from females during the breeding season was an average of 11.7 young per female. Calculated survival of young was about 33.3 percent from birth until the latter part of August (Table 4).

May 1971 Trapping Period

Trapping was initiated on May 18, 1971 and continued for two weeks. During this period, 133 individual hares were captured a total of 262 times. Two were animals marked the previous August. Trapping success was excellent during the period, with 25-50 percent success on most nights, and an overall average of 37.4 percent as compared to 10.5 percent the previous August. Population estimates were calculated each day from day 8 to the end of the trapping period, and the population was estimated at 157 hares (130-188 at the 95% confidence level) on the last day of trapping (Table 5). All animals were considered adults, with a sex ratio of 50 males (39%) to 77 females (61%), (Table 3). Sex ratios the previous August had been 41 percent males and 59 percent females. The May population estimate suggested a survival rate of 39 percent from the previous August.

Table 1. Central Study Area, August 1970. Estimates of a snowshoe hare population calculated from livetrapping results, using a Schnabel Index. (Estimates were calculated daily from the 14th day to the end of the trapping period.)

Day	Total Captures	Total Marked	Recaptures To Date	Schnabel Estimate
14	84	63	7	373
15	86	63	7	380
16	86	65	7	390
17	88	65	7	409
18	91	67	8	384
19	97	68	10	348
20	101	72	10	376
21	101	76	10	376
22	105	76	10	407

The final population estimate was 407 (190-759 at the 95% confidence level).

Table 2. Adult-juvenile ratios found in live-trapped samples in August trapping periods.

Location	Date	Adults	Percent	Juveniles	Percent	Total
Central	August 1970	27	30	63	70	90
Central	August 1971	19	15	105	85	124
Fairbanks	August 1971*	20	20	80	80	100
Fairbanks	August 1972	19	24	59	76	78
Fairbanks	August 1973	2	20	8	80	10

*Ages difficult to determine in several hares of sample. Ratio only approximate.

Table 3. Sex ratios of hares in live-trapped samples.

Location	Date	Age Group	Females	Per-Cent	Males	Per-Cent	Total Number
Central	August 1970	Adult	14	59	11	41	25
		Juv.	36	59	24	41	60
Central	May 1971	Adult	77	61	50	39	127
		Juv.	-	-	-	-	-
Central	August 1971	Adult	16	89	2	11	18
		Juv.	44	43	60	57	104
Fairbanks	August 1971	Adult	11	54	10	46	21
		Juv.	46	45	52	55	98
Fairbanks	April 1972	Adult	82	45	100	55	182
		Juv.	-	-	-	-	-
Fairbanks	August 1972	Adult	13	68	6	32	19
		Juv.	27	46	32	54	59
Fairbanks	March 1973	Adult	29	34	57	66	86
		Juv.	-	-	-	-	-
Fairbanks	Nov. 1973	Adult	17	33	35	67	52
		Juv.	-	-	-	-	-

Table 4. Juvenile survival rate - birth to August 15.

Location	Year	Average No. Young Produced/female	Ratio of Juveniles to Adult Female in August	Juvenile Survival Rate
Central	1970	11.7	3.9:1	33%
Central	1971	10.8	6.6:1	61%
Fairbanks	1971	9.9	7.3:1	74%
Fairbanks	1972	8.2	4.5:1	49%
Fairbanks	1973*	9.1	-	-

*August trapping results were so poor that no figures are available for juvenile-adult female ratios or juvenile survival rate.

Table 5. Central Study Area, May 1971. Estimates of a snowshoe hare population calculated from livetrapping results using a Schnabel Index. (Calculated daily from day 8 - 14).

Day	Daily Captures	Daily Recaptures	Total Captures	Total Recaptures	Marked Hares in Population	Schnabel Estimate
8	17	11	171	63	91	171
9	16	12	187	75	97	164
10	20	14	207	89	100	161
11	11	10	218	99	105	156
12	15	8	233	107	103	159
13	8	6	241	113	110	159
14	21	16	262	129	112	157

The final population estimate was 157 (130-188 at 95% confidence level).
Total area: 0.57 square miles.

August 1971 Trapping Period

Trapping was initiated August 15, 1971, and continued for two weeks. During this time 126 individual hares were captured a total of 133 times, with 7 recaptures. This provided a population estimate of 967 hares (380-2092 at the 95% confidence level, Table 6), and indicated an increase of 809 hares, or a little over 500 percent since the spring census. Trapping success averaged 17.7 percent.

The adult-juvenile ratio was 19 adults to 105 juveniles (Table 2) and of the 19 hares classified as adults, 8 were first tagged in May, 1971. If the population estimate for May were assumed to reflect the number of adults in the August population, this ratio would give an approximation of the population estimate derived by applying the Schnabel formula to the retrap data. For example, if zero mortality and no migration in or out of the area were assumed, we would obtain a figure of 1040 hares in August from the adult-juvenile ratio. If 10 percent mortality and no migration were assumed, the figure would be around 940 animals. These figures are well within the range of the population estimate derived from the recapture data (Table 6).

Sex ratios of animals captured in this trapping period were 60 males (57%) to 44 females (43%) in the juvenile group, but only two males (11%) to 16 females (89%) in the adult group (Table 3). The ratio of juveniles of both sexes to adult females averaged 6.6 juveniles per adult female, indicating a survival rate of 61.1 percent of the calculated average number of young (10.8) produced by Central hares in the 1971 breeding season (Table 4).

Road Counts in Central Area, Summer 1970

Road counts on the area, accomplished in a one-month period (June 16 - July 14) and standardized as to time of day (6:00 p.m. - 6:00 am.), indicated an overall average of 1.8 hares per mile on the roads covered. Count figures are broken down into days, etc. in Table 7.

Observations on Hare Populations at Central

<u>1972</u> Adult female hares were collected along the roads in the Central area during the spring and summer months, May, June, and July. Hares were abundant about 10 miles south of Central. Populations seemed somewhat reduced in the study area and on the Circle Hot Springs Road and Deadwood Road. However, it was not difficult to collect the required sample of 20 adult females each month.

<u>1973</u> Hares had become reduced in numbers in the Central area, although some were seen ten miles north of the town. It was difficult to collect hares for reproductive studies and a total of only 11 adult female hares were collected during May and June. Few hares were seen on the Circle Hot Springs Road where before, in 1970 and 1971, there were often four to five seen per mile.

Table 6. Central Study Area, August 1971. Estimates of a snowshoe hare population calculated from livetrapping results using a Schnabel Index. Calculated daily from day 12-15.

Day	Daily Captures	Total Captures	Total Recaptures	Marked Hares in Population	Schnabel Estimate
12	6	102	3	80	1275
13	10	112	4	86	1172
14	10	122	6	95	939
15	11	133	7	103	967

The final population estimate was 967 (380-2092 at 95% confidence level). Total area: 0.57 square miles.

Table 7. Snowshoe hares sighted in road counts, Central, Alaska, June 16 - July 14, 1970.

Date	Hares Seen	Miles Driven	Hares/Mile
June 16	17	14	1.2
17	24	15	1.6
18	33	38	.9
19	45	33	1.4
20	54	24	2.3
21	72	31	2.3
25	37	45	.8
26	25	23	1.1
27	44	23	1.9
28	19	9	2.1
29	77	48	1.6
July 1	63	41	1.5
2	30	21	1.4
3	59	35	1.7
4	13	15	.9
6	147	29	5.1
8	40	24	1.7
9	76	27	2.8
10	63	30	2.1
12	67	26	2.6
13	41	31	1.3
14	46	24	1.9

Average number of hares per mile: 1.8

Fairbanks Study Area

August 1971 Trapping Period

Forty-five traps were set on August 22, and were checked each day for a total of 15 days, from August 22 to September 11. Traps were closed during periods of extremely heavy rainfall. During the trapping period 106 individual hares were captured, with a total of 112 captures. There were six recaptures, from which a population estimate of 782 (282-1821 at 95% confidence level) animals was derived (Table 8). Trapping success in the Fairbanks study area was 16.6 percent which was almost the same as that in the Central area in the August, 1971 trapping.

Poor weather conditions contributed to very low trapping success on about half the days. Rain was very heavy, with water standing in all low areas, and often in the runways where traps were set.

The adult:juvenile ratio was approximately 20:80 (Table 2). There was some question as to age of eight of the hares. The sex ratio was 11 (54%) females to 10 (46%) males for the adults and 46 (45%) females to 52 (55%) males for the juveniles (Table 3). Perhaps males are more vulnerable to mortality, or sex ratios vary between years. Fetal sex ratios for the 1971 season were 52 percent females to 48 percent males, not differing significantly from a 50:50 ratio.

The ratio of juveniles of both sexes to adult females was 7:1 which would indicate a survival rate of 74 percent of the total number of young produced by Fairbanks hares in the 1971 breeding season (Table 4).

April 1972 Trapping Period

Plans to livetrap the Fairbanks area in May were altered when it appeared that trapping would be more easily carried out with better results if the area were trapped in April, just before the snow melted. Trails were broken with a snow machine and skis were used to work the trap line. Traps were baited with compressed alfalfa cubes, which strongly attracted hares at this time of year.

Traps were set on the 5th of April, and closed on the 13th, for a total of eight days of trapping. In this period, 192 individual hares were captured a total of 293 times for an average trapping success of 81 percent. There were 101 recaptures from which a population estimate of 249 hares was derived (204-304 at the 95% confidence level, Table 9).

All hares captured were considered adults, as they would have been born the preceding summer. There were several very small (2 lbs.) hares, one of which would have been classified as juvenile by a "stubby penis." The sex ratio was 55.5 percent males to 44.5 percent females (Table 3). Survival from the previous August was estimated at 31.9 percent.

Table 8. Fairbanks Study Area, August 1971. Estimates of a snowshoe hare population calculated from livetrapping results using a Schnabel Index. (Estimates calculated daily from the 12th day to the end of period.)

Day	Daily Captures	Total Captures	Total Marked	Recaptures To Date	Schnabel Estimate
12	6	92	70	3	1046
13	8	100	73	5	744
14	6	106	78	5	838
15	6	112	84	6	782

Final Population Estimate: 782 (282-1821 at 95% confidence level).
Total area: 0.5 square miles.

Table 9. Fairbanks Study Area, April 1972. Estimates of a snowshoe hare population calculated from livetrapping results using a Schnabel Index. (Calculated daily from day 2 - 8.)

Day	Daily Captures	Daily Recaptures	Total Captures	Total Recaptures	Marked Hares in Population	Schnabel Estimate
1	21	0	21	0	0	-
2	38	1	59	1	20	760
3	39	4	98	5	49	534
4	37	9	135	14	76	392
5	40	17	175	31	98	302
6	39	18	214	49	119	287
7	42	29	256	78	135	253
8	37	23	293	101	147	249

Final Population Estimate: 249 (204-304 at 95% confidence level).
Total area: 0.5 square miles.

August 1972 Trapping Period

Forty-five traps were set on August 14 and checked daily from the 15th to the 29th. During this period 81 individual hares were caught with a total of 90 captures. There were nine recaptures, from which a population estimate of 257 animals (115-501 at the 95% confidence level) was derived (Table 10). Trapping success averaged 13.3 percent.

The adult-juvenile ratio (Table 2) was 19:59, or about one adult to three juveniles. Sex ratio (Table 3) was 6 males (31.6%), 13 females (68.4%) in the adults, and 32 males (54.2%), 27 females (45.8%) in the juveniles.

The ratio of juveniles of both sexes to adult females was 4.5 to 1 which indicated a juvenile survival rate of 49 percent (Table 4).

March 1973 Trapping Period

The Fairbanks study area was trapped in late March, just before the snow became too soft to work in. Trails were broken with snow machines and skiis, and traps checked on skiis. Traps were baited with alfalfa cubes.

Traps were run for five days, beginning on March 23rd. Depredation by dogs forced the closure of traps at this time, as loss of trapped hares rose to over 50 percent. Trapping success averaged 60 percent during this period.

High trapping success permitted an estimation of population from the third day on. The final estimate was 112 animals in the area, not counting animals lost to dogs (Table 11). If the number of hares killed in traps were considered in the estimates, the total number of animals in the area would be about the same from day three through day 5. Six hares were lost the third day and thirteen on the fourth making a total of 19 hares removed from the area by the 5th day of trapping. When 19 is added to the fifth day estimate, a total of 131 animals is obtained, very close to the estimate of 130 derived on day three.

Sex ratios of hares trapped in the March trapping period averaged 66 percent males (57 males to 29 females, Table 3). All hares were considered to be adults, as they would have been born the preceding breeding season or before.

August 1973 Trapping Period

Twenty-two traps were set on the Fairbanks study area and were run for 11 days beginning August 20. Results were so poor, with an average daily catch of one hare, that traps were closed on August 31. Heavy rain and standing water in the study area contributed to the poor results. Of the 11 hares caught, there were two adults and eight juveniles and one escaped before age and sex were determined. The juvenile sex ratio was six males to two females.

Table 10. Fairbanks Study Area, August 1972. Estimates of a snowshow hare population calculated from livetrapping results using a Schnabel Index. (Estimates calculated from 12th day to end of period.)

Day	Daily Captures	Total Captures	Total Marked	Recaptures To Date	Schnabel Estimate
11	7	79	45	7	249
12	2	81	51	8	230
13	3	84	51	8	249
14	3	87	52	9	238
15	3	90	54	9	257

Final Population Estimate: 257.0 (115-501 at 95% confidence level).

Table 11. Fairbanks Study Area, March 1973. Estimates of a snowshow hare population calculated from livetrapping results using a Schnabel Index.

Day	Daily Captures	Daily Recaptures	Total Captures	Total Recaptures	Marked Hares in Population	Schnabel Estimate
1	24	0	24	0	0	-
2	25	2	49	2	23	288
3	30	13	79	15	46	130
4	30	17	109	32	57	115
5	26	14	135	46	57	112

Final Population Estimate: 112 (81-149 at 95% confidence level).

November 1973 Trapping Period

A portion of the Fairbanks study area supporting an estimated 60 percent of the total hare population was livetrapped in November in an attempt to estimate the fall population of the study area.

Twenty traps were baited with compressed alfalfa and run for six days starting on the 6th of November, then closed when a heavy snowfall made them partially inoperative. They were reopened on the 28th of November for a four-day period with good, usable results. Trapping success averaged 41 percent during both periods. A total of 74 hares were captured with 12 recaptures, for a population estimate of 134 hares (73-291 at 95% confidence level, Table 12) in that portion of the study area. Since this portion, a little less than a quarter square mile, had had 60 percent of previous hare captures, the population of the entire half square mile study area was assumed to be 1.67 times that of the smaller portion. The total population was then estimated to be 221 (119-480 at 95% confidence level).

Sex ratio during the November trapping period was 67 percent males and 33 percent females (Table 3). It was not possible to differentiate juveniles from adults at this time, except for some of the males, so no juvenile-adult ratio was established.

FINDINGS (Productivity)

The reproductive performance of snowshoe hares in the three areas studied was evaluated by examining a number of factors: 1) the number of litter groups produced each season, and the dates of conception and birth of each litter; 2) pregnancy rates for each litter group; 3) average litter size; and 4) intrauterine loss of young (resorbed embryos and fetuses).

The four years of reproductive data for Central and three years for Fairbanks and Delta are summarized in Tables 13 to 16.

Annual Number of Litter Groups

At least two litters have been produced each year and in some years a third litter was conceived by some of the hares on some areas. No evidence of fourth litters was found. Dates of conception for first and second litters were closely synchronized in each area during any one year, but varied from year to year and from area to area. Years in which spring was early tended to show earlier onset of breeding. Central hares were generally later in breeding than were Fairbanks and Delta hares, and Delta was somewhat earlier than Fairbanks in at least one breeding season. The earliest conception date for Central was April 24, with young born about May 30 (Fig. 9). Hares in Fairbanks bred as early as April 10, with young born about May 16, and Delta hares bred as early as April 1 and had young by May 7. Conception dates are compared by year for each area (Figs. 7-9). and by area for each year (Figs. 4-6).

Table 12. Fairbanks Study Area, November 1973. Estimates of a snowshoe hare population using a Schnabel Index.

Day	Daily Captures	Daily Recaptures	Total Captures	Total Recaptures	Marked Hares in Population	Schnabel Estimate
Nov 6-) Nov 11)* Summary	-	-	42*	2*	34*	[150]*
1) Nov 28	7	1	7	1	34*	-
2) Nov 29	12	4	19	5	40	144
3) Nov 30	6	2	25	7	47	143
4) Dec 1	7	3	32	10	50	134

Final Estimate: 134 (73-291 at 95% confidence level).
*The first trapping period was ended by a heavy snowstorm. Animals marked in this period were considered present when traps were reopened November 28.

Table 13. Reproductive data from female snowshoe hares collected in the Central area, 1970.

Sample Size	Month	Average No. Embryos	Average No. Placental Scars	Percent Pregnant
46	May	4.2	-	97*
26	June	6.3	4.1	100
27	July	4.0	6.1	30

*The 97% figure for the May group includes those females found to be post-partum. This figure, therefore, indicates the percent which were pregnant during the first breeding period.

Table 14. Reproductive data from adult female hares collected in 1971 breeding season.

Area	Month	Sample Size	Average No. of Embryos	Average No. Placental Scars	Percent Pregnant
Central	May	28	4.7	0	100
	June	19	6.2	4.4	100
	July	20	4.0*	5.7	10
Fairbanks	April-May	30	4.1	0	100
	June	15	5.8	4.7	100
	July	17	3.0**	5.9	6
Delta	June	23	4.9	3.2	100
	July	24	4.0**	5.0	4

* Only two females with embryos.
** Only one female with embryos.

Table 15. Reproductive data from adult female hares collected in 1972 breeding season.

Area	Month	Sample Size	Average No. of Embryos	Average No. Placental Scars	Percent Pregnant
Central	May	20	4.1	-	100
	June	20	5.1	4.2	100
	July	21	-	4.5	0
Fairbanks	May	31	4.1	-	100
	June	19	4.1	3.5	100
	July	26	-	5.0	0
Delta	May	18	3.9	-	100
	June	21	4.4	3.1	100
	July	19	-	4.8	0

Table 16. Reproductive data from adult female hares collected in 1973 breeding season.

Area	Month	Sample Size	Average No. of Embryos	Average No. Placental Scars	Percent Pregnant
Central	May	6	3.7	-	100
	June	5	6.0	4	-
	July	-	-	-	-
Fairbanks	May	30	4.3	-	100
	June	20	4.8	3.9	100
	July	11	-	4.0	0
Delta*	April (I)	2	3.5	-	100
	May (II)	33	4.6	3.2	100
	June (III)	26	3.1	4.1	38.4

* Onset of breeding was very early in Delta and animals collected in May were carrying their second litter.

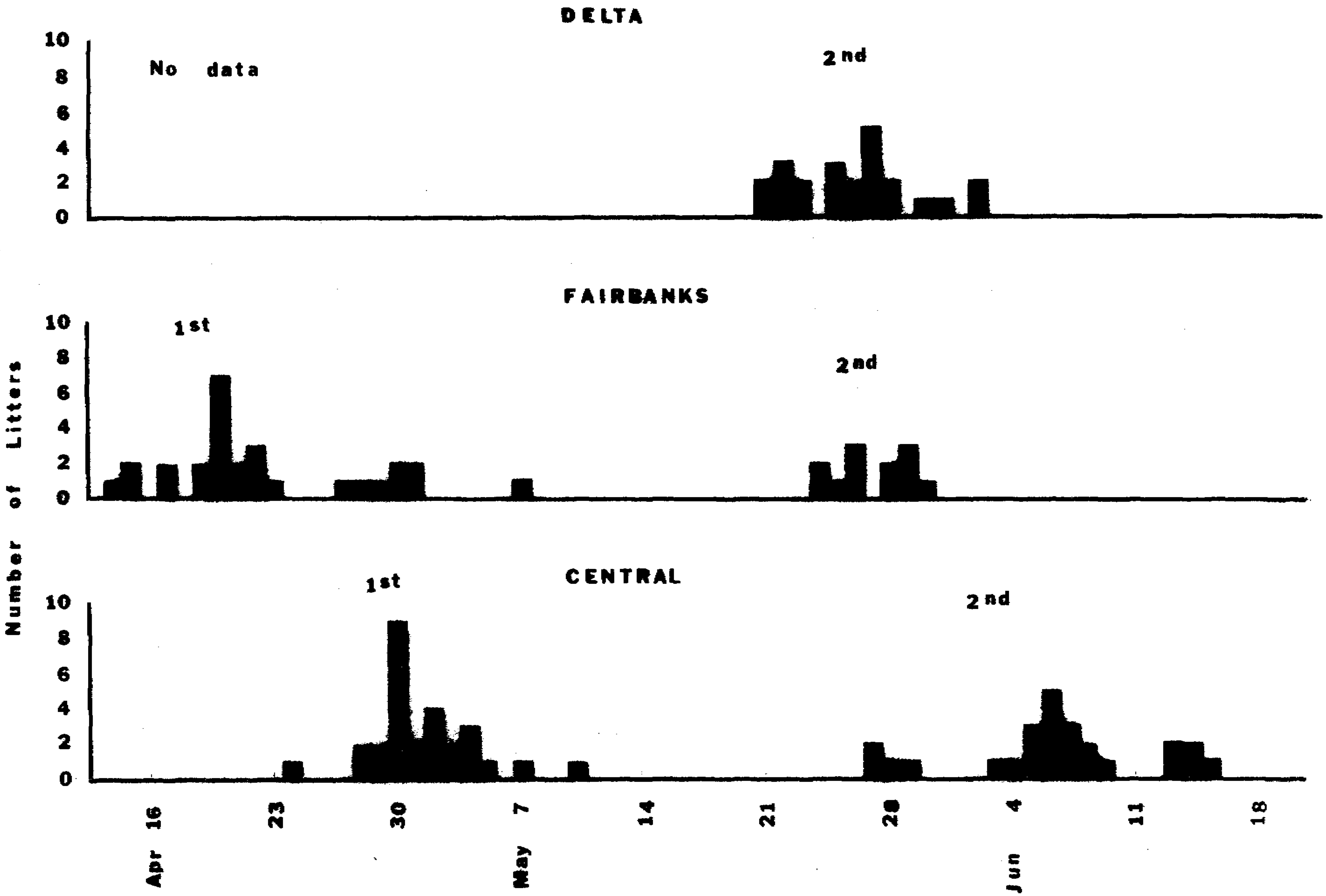


Figure 4. Litter conception dates for snowshoe hares from interior Alaska in 1971.

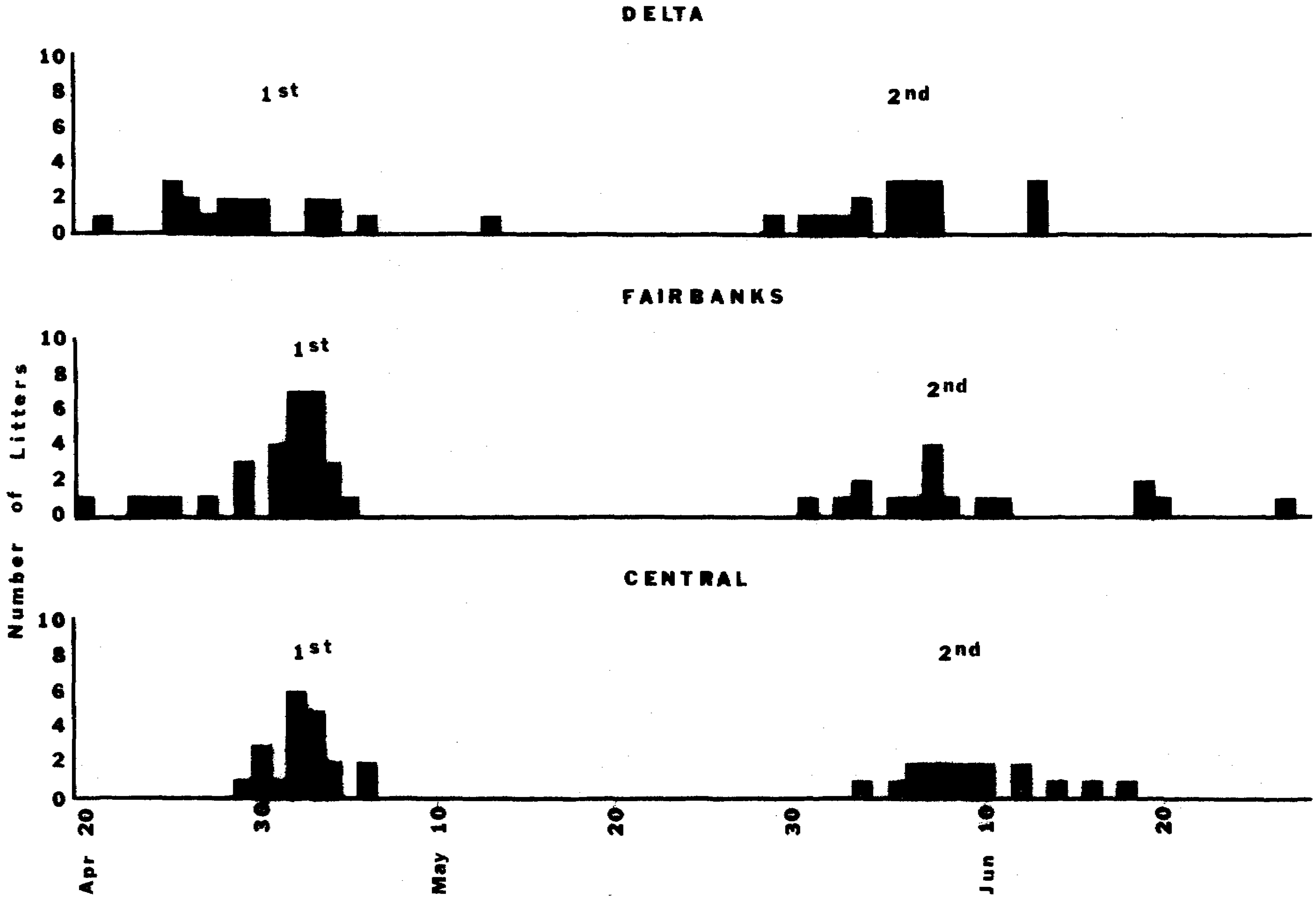


Figure 5. Litter conception dates for snowshoe hares from interior Alaska in 1972.

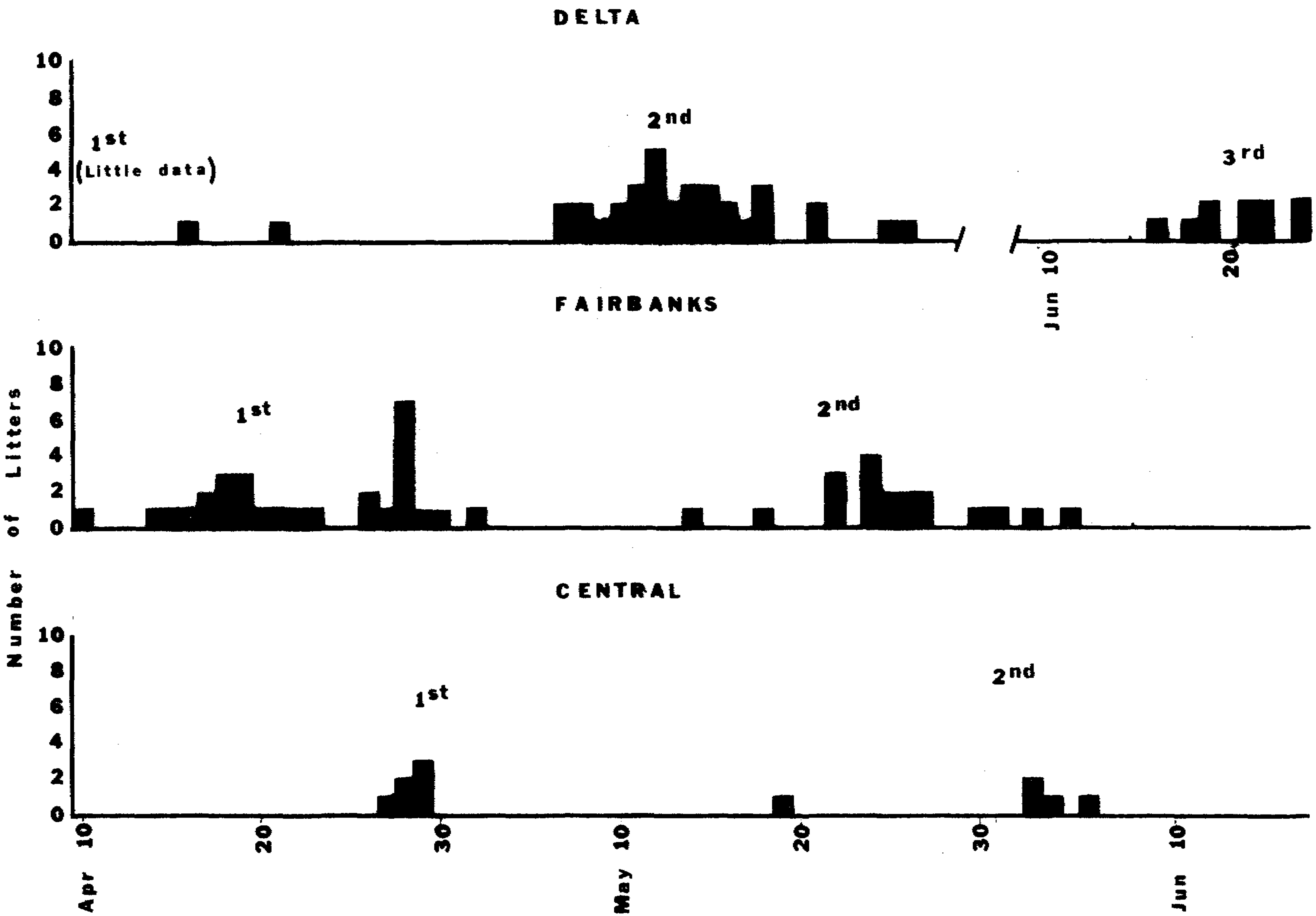


Figure 6. Litter conception dates for snowshoe hares from interior Alaska in 1973

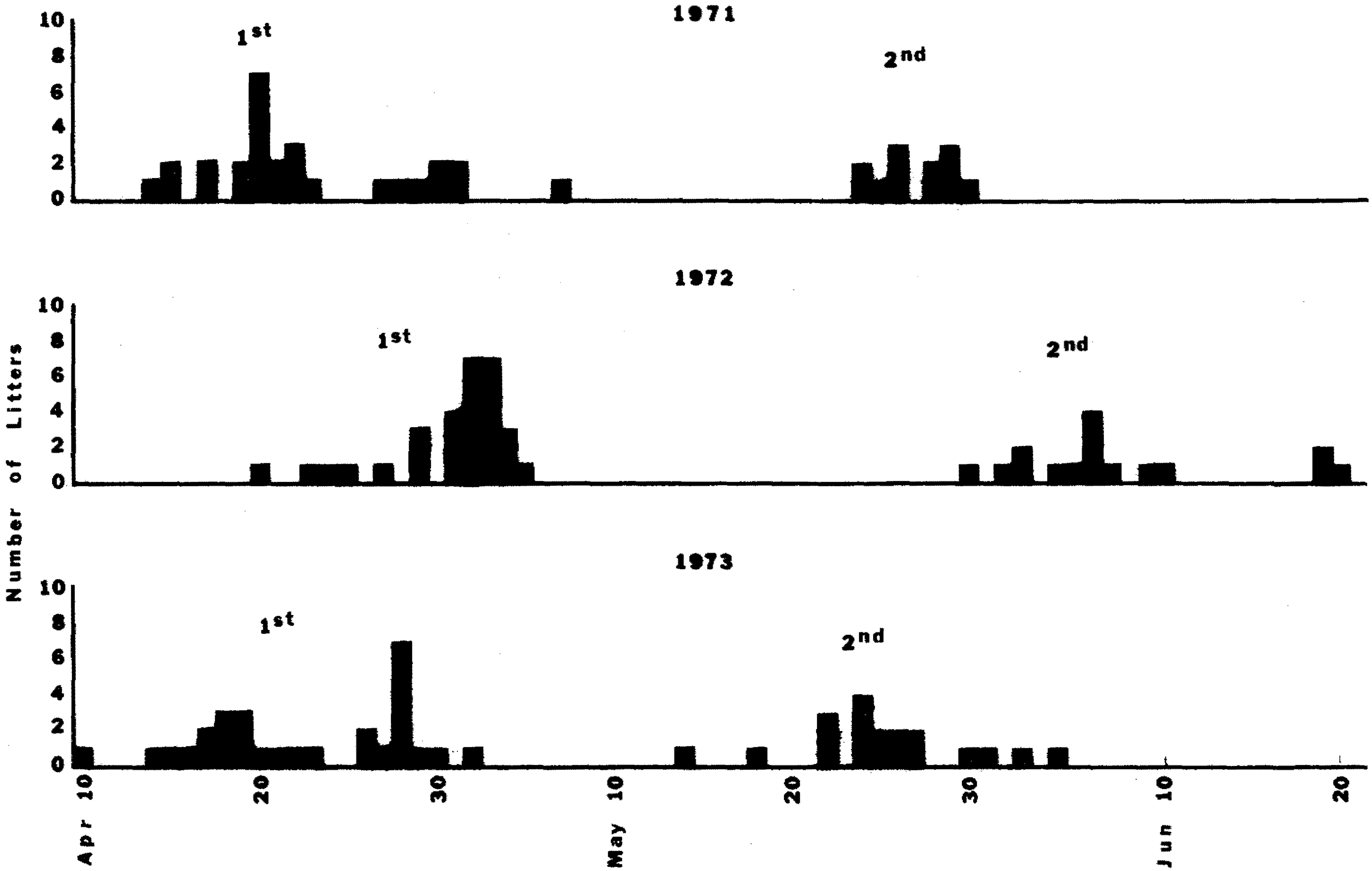


Figure 7. Litter conception dates for snowshoe hares collected around Fairbanks in 1971, 1972, 1973.

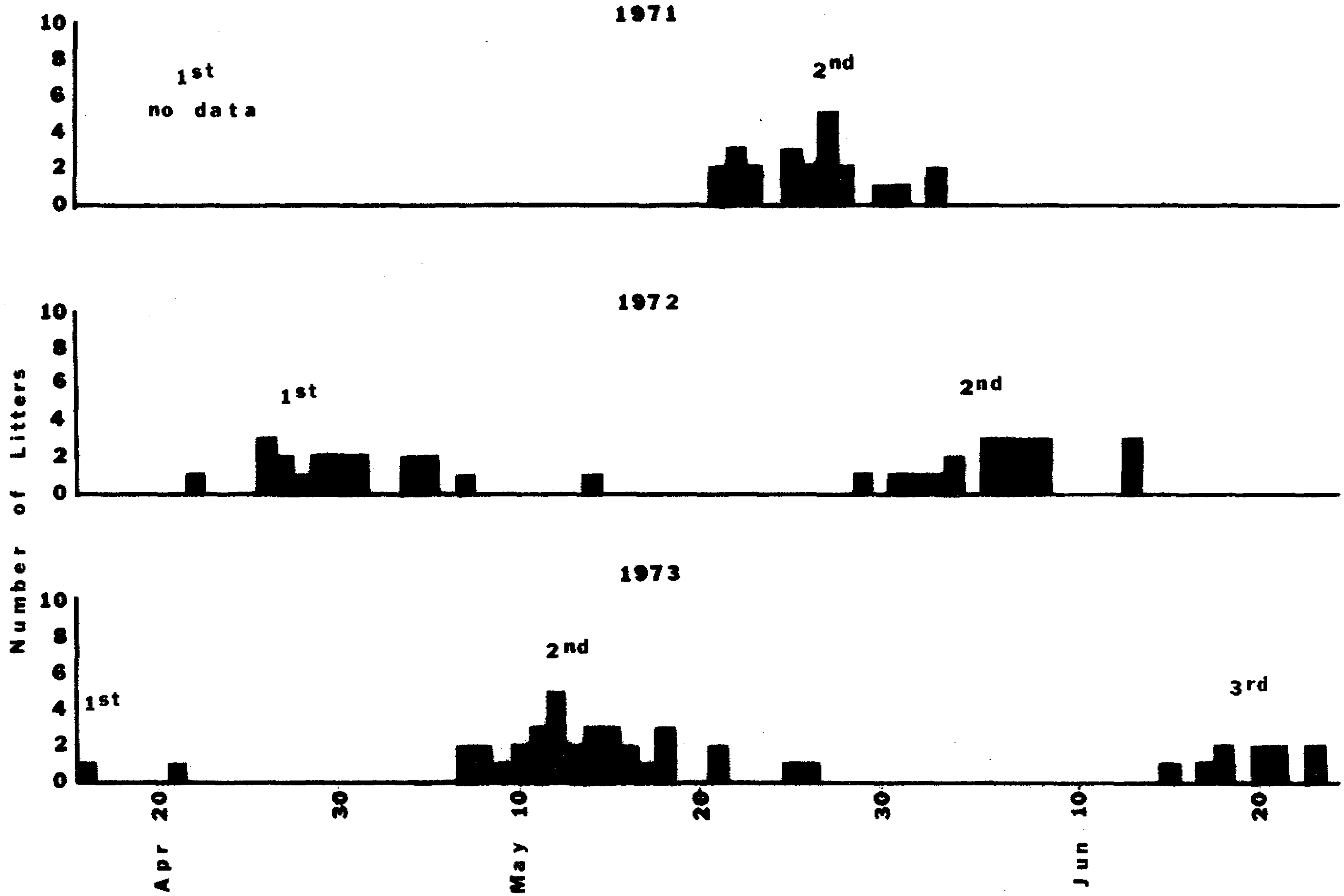


Figure 8. Litter conception dates for snowshoe hares collected in Delta in 1971, 1972, and 1973.

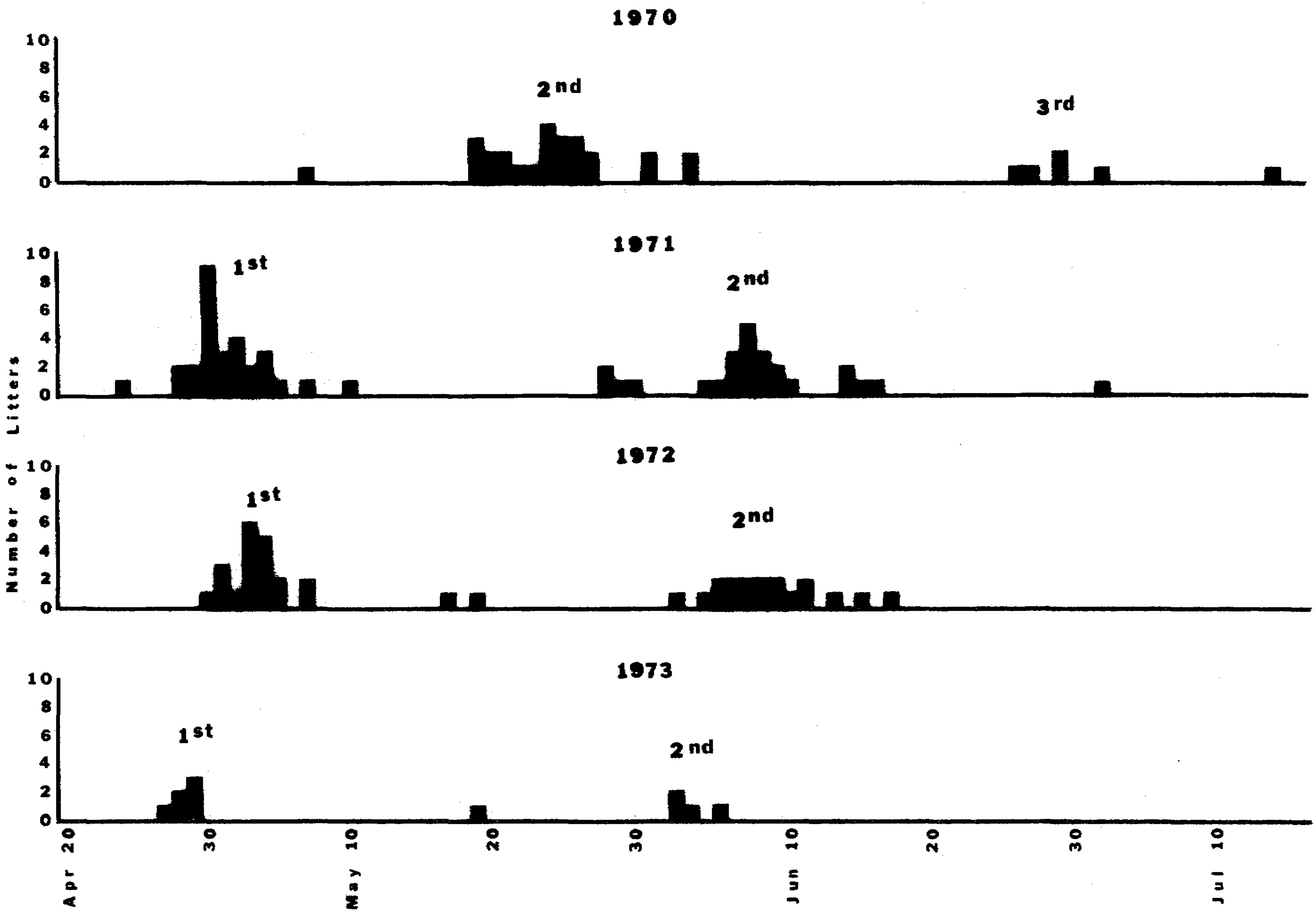


Figure 9. Litter conception dates for hares collected in Central during four breeding seasons.

Pregnancy Rates

Attempts were made to time collections of adult females for reproductive studies during periods when they would be carrying their first, second or third litters. For all three areas it was found that the pregnancy rate for the first and second litter groups was generally 100 percent. The pregnancy rate for the third litter group was the noticeable variable (Tables 13-16). Hares in Central had a third litter pregnancy rate of 30 percent in 1970, but only 10 percent in 1971 and zero percent in 1972 (Table 17). Six percent of Fairbanks hares (females) conceived a third litter in 1971, none in 1972 and none in 1973 (Table 18). Delta hares had a third litter in 1971 (4% pregnancy rate), none in 1972, but 38 percent of female hares in Delta had a third litter in 1973 (Table 19), a figure which might be explained in part by the early first litter dates (Fig. 7).

Litter Size

Average litter size for first, second and third litters was compared for each year in each area (Tables 13-19). Annual variations in litter size represent changing ovulation rates, as pre-implantation losses determined from counts of corpora lutea were negligible. Second litters were generally larger than first, and third litters, when present, were about the same as first litter in number of young. Only Central, in 1970, and Delta, in 1973, had a significant rate of third litter pregnancies.

Significant yearly differences in the mean size of second litters occurred in both Central and Fairbanks hares. The mean size of the second litter was significantly lower in 1972 than in 1970 and 1971 in Central (Table 17), dropping from 6.3 and 6.2 to 5.1. In Fairbanks, the mean litter size was 5.8 in 1971 and 4.1 in 1972. There was not a significant change in first litter size. Reduction in size of second litters would reduce the total number of young produced in a season.

The average reproductive potential represents the mean number of young produced per adult female hare during the breeding season. This figure is calculated from the average number of young in first litters plus that of second litters plus the third litter pregnancy rate times average third litter size. These figures are given in Tables 20-22. If adult female mortality were zero during the breeding season, this would give an estimate of recruitment to the population.

Prenatal Loss

Pre-implantation loss appeared to be negligible, but in some areas during some years resorbtion of embryos was a significant factor. The second litter group from Central had a resorption rate of 5.5 percent for July 1970, and 7.3 percent in 1971. However, the rate of resorption of fetuses in the second litter group from Delta in 1972 was unusually high at 16 percent, and 38 percent of the female hares examined in this group had one or more resorbed fetuses.

Table 17. Comparison of four years' hare reproductive data from Central, Alaska. Sample size in parentheses.

Year	1st Litter	2nd Litter	3rd Litter	Percent Pregnant with 3rd Litter	Average total of young per female 1st and 2nd Litter
1970	4.2 (46)	6.3 (26)	4.0	30 (27)	10.4
1971	4.7 (28)	6.2 (19)	4.0	10 (20)	10.9
1972	4.1 (20)	5.1** (20)	-	0 (21)	9.1**
1973*	3.7 (6)	6.0 (5)	-	-	9.7

* Sample sizes were small as only seven female hares were collected in each period.
** Significantly lower than 1970 and 1971 figures ($P < 0.05$).

Table 18. Comparison of three years' hare reproductive data from Fairbanks area, Alaska. Sample sizes in parentheses.

Year	1st Litter	2nd Litter	3rd Litter	Percent Pregnant with 3rd Litter	Average total of young per female 1st and 2nd Litter
1971	4.1 (30)	5.8 (15)	3.0	6 (17)	9.9
1972	4.1 (31)	4.1* (19)	-	0 (26)	8.2*
1973	4.3 (30)	4.8 (20)	-	0 (11)	9.1

* Significantly lower than 1971 figures ($P < 0.05$).

Table 19. Comparison of three years' hare reproductive data from Delta area, Alaska. Sample sizes in parentheses.

Year	1st Litter	2nd Litter	3rd Litter	Percent Pregnant with 3rd Litter	Average total of young per female 1st and 2nd Litter
1971	3.2* (23)	4.9 (23)	4.0 (24)	4	8.1
1972	3.9 (18)	4.4 (21)	- (19)	0	8.3
1973	3.5 (2)	4.6 (33)	3.1 (26)	38	8.1

* No collection made in May, thus this figure was derived from placental scar counts.

Table 20. Calculated average reproductive potential and mean litter size of female snowshoe hares collected in the 1971 breeding season.

Area	Sample Size	Mean Litter Size	Calculated Average Reproductive Potential*
Central	68	4.9	10.8
Fairbanks	62	4.5	10.1
Delta	47	4.0	8.3

* The average number of young that would have been produced per female during the breeding season calculated from placental scars, embryos and fetuses, including third litters.

Table 21. Calculated average reproductive potential and mean litter size of female snowshoe hares collected in the 1972 breeding season.

Area	Sample Size	Mean Litter Size	Calculated Average Reproductive Potential*
Central	61	4.6	9.1
Fairbanks	76	4.1	8.2
Delta	58	4.2	8.3

* The average number of young that would have been produced per female during the breeding season calculated from placental scars, embryos and fetuses, including third litters.

Table 22. Calculated average reproductive potential and mean litter size of female snowshoe hares collected in the 1973 breeding season.

Area	Sample Size	Mean Litter Size	Calculated Average Reproductive Potential*
Central	11	4.7	9.7
Fairbanks	51	4.5	9.1
Delta	63	4.2	9.4

* The average number of young that would have been produced per female during the breeding season calculated from placental scars, embryos and fetuses, including the third litter.

Prenatal Sex Ratios

Fetal sex ratios (Table 23) would give an accurate indication of the primary sex ratio of a hare population unless there was differential intra-uterine mortality. Changes in this sex ratio might be significant in population changes.

MISCELLANEOUS FINDINGS

Movements

Recapture data for hares on the Fairbanks study area indicate limited movements. Regardless, most recaptures were at the original capture site, even more than a year later. One hare was captured 5/8 of a mile from the original capture site, although most movements were to the next trap down the line. Often a hare would be captured first at one site, move to the next trap site, then be captured a third time back at the original trap site. The pattern of some movements suggests that hares may utilize established trails, especially when snow is present.

Longevity

Hares are relatively shortlived in the wild. Aldous (1937) felt that snowshoe hares survive an average of two years. Livetrapping records from the Fairbanks study area indicate that several hares were at least two and one-half years old when recaptured in November 1973, as they were adults, at least 10 months old when first captured in April 1972.

Questionnaires on Hare Abundance

Small game abundance questionnaire replies, returned in late winter each year, and trapper questionnaire replies, returned in the spring of each year at the end of the trapping season, give some indications of the population trends of hares in Interior Alaska. Detailed results of the questionnaires are available in Survey and Inventory Reports.

Questionnaire replies indicated that hare populations were at a high in the Fort Yukon area about one season before they reached a peak around Central in 1971. Fairbanks seems to be a season behind Central and further south toward the Alaska Range the hare population highs were about a year behind Fairbanks.

Hare populations around Fairbanks appear to have reached a high in late 1971 and early 1972. By the 1972-73 trapping season they were apparently starting to decline slightly. Trappers in Delta felt that the hares were still increasing at the end of 1972.

Questionnaire replies covering the later part of 1973 indicate that hare populations in the Fairbanks area were at a moderate level and declining. Populations in Central were at a moderately low level and Delta hare populations were still high.

Table 23. Fetal sex ratios.

Area	Year	Litter Group	No. of Litters	Female	Male	Percent Male
Fairbanks	1971	Total season	?	14	13	48
Fairbanks/ Goldstream	1972	I	8	14	16	53
Fairbanks/ Murphy Dome Road	1972	II	9	22	16	42
Murphy Dome Road	1973	I	5	9	13	59
Murphy Dome Road	1973	II	3	8	4	33
Delta	1972	I	9	22	14	39
Fairbanks total	1973	I	8	11	20	65
Central	1973	I	6	8	15	65
Central	1973	II	3	9	6	40
Delta	1973	II	13	26	33	56
				143	150	Ave. 51

DISCUSSION

Population estimates on the two study areas were based on the Schnabel formula (Schnabel 1938) which is a multiple census based on tagging, releasing and recapturing animals. It is similar to the Peterson or Lincoln Index, often called the tagging ratio, wherein the population (N) is related to the number marked and released (M) in the same way that the total caught at a subsequent time (n) is related to the number of recaptures (m). $\frac{N}{M} = \frac{n}{m} \therefore N = \frac{Mn}{m}$

Several conditions must be met when methods based on recaptures are used to measure populations (Trapp 1962). Marked individuals must remain identifiable and natural mortality among marked and unmarked must be the same. There must be no recruitment by births, ingress or egress, and there should be the same susceptibility to capture in marked and unmarked individuals. Most of these conditions were met in this study. Ear tags were seldom lost and handling and tagging did not seem to increase the animals' susceptibility to predation once the use of Saflag flagging was discontinued. Trapping was conducted before and after the breeding season and trapping periods were short, reducing movements in and out of the area. However, some hares may have developed a "trap habit," returning to baited traps time after time, and traps were spaced too far apart to sample the entire area evenly. Still, the population estimates for this area were probably as reliable as those obtained by Meslow and Keith (1968) on their square-mile study area.

From August 1971 to the spring of 1973 the populations of hares on the Fairbanks study area steadily decreased from 782 to 130 hares. There was a slight increase over the summer of 1973 from 130 to 220 hares, but the peak apparently occurred the latter part of 1971 in this local area at least. In other local areas higher on the ridges, populations were still quite high in 1972. In October 1972 the Institute of Northern Forestry estimated a hare population on a study area on Wickersham Dome to be about 600 per square mile. The Institute of Arctic Biology started population estimates in the Goldstream Road area the spring of 1973 and estimated 600-900 hares per square mile that summer in that area.

The population estimates derived by other researchers for two live-trapped study areas near Fairbanks may be biased because of smaller size of the areas (1/12 and 1/9 sq. mile) and probably actually represent the population of a larger area incorporating a border around the actual grid area.

Meslow and Keith (1968) obtained estimates of around 600 hares on a square-mile study area near Rochester, Alberta in April 1962. Two years later the population had declined to around 33 animals and by June 1965, they estimated only 3 animals in the area. They also found that the geographic area occupied by hares on the square-mile study area shrank approximately 72 percent (640 to 180 acres) while the population of the study area shrank 94 percent. The remaining hares seemed to move into brushy habitat leaving the more open habitat vacant.

In the Fairbanks area many observations of changes in local populations were reported. Where hares were abundant one year, they appeared to be scarce the next, while on some adjacent areas high populations remained. There also appeared to be a general decline in the lower altitudes while hares were still abundant on higher ridges.

One weakness of a study such as this lies in the fact that reproduction data was acquired from hares collected in the general Fairbanks area, and hares were collected mainly where they were fairly abundant. No hares were collected on the study areas themselves and therefore population estimates, while pertaining to the immediate area around the study area, do not necessarily pertain to the sites where adult female hares were collected. Because of the apparent local variation in numbers, these two groups of data should be compared only with caution.

What are the factors most consistently involved in a decline? One significant factor seems to be the rate of juvenile survival. Monthly survival rates given by Meslow and Keith (1968) in their Alberta study and figures from Minnesota (Green and Evans 1940a, b, c) and Montana (Adams 1959) indicate that in years of population increase the juvenile survival rate tends to be higher than in years of population decrease. The monthly survival rate for juveniles in Alberta increased from 0.69 to 0.87 from 1962-1967. The mean juvenile survival rates in the Minnesota study were 0.85, 0.87, 0.79 and 0.75 monthly in years of population decline. The declining Montana population had an average monthly survival rate of 0.76. Green and Evans' data indicate juvenile survival was 0.92 and 0.99 in years of population increase.

Juvenile survival rates from birth to the middle of August for the Fairbanks and Central study areas are given in Table 4. Juvenile survival rates can be determined from the adult/juvenile ratio compared with the reproductive potential. These data are expressed in terms of survival from birth until the middle of August rather than a monthly rate.

At Central, the juvenile survival rate was almost twice as high in 1971 as in 1970. The population was higher in 1971 than in 1970 and increasing both years. The juvenile survival rate was 74 percent in Fairbanks in 1971, but dropped to 49 percent in 1972, although the juvenile/adult ratio dropped only slightly (Table 2). This can be explained by the high proportion of adult females (68% in 1972 as compared to 45 % in 1971, Table 3). Significance of changes in sex ratios will be discussed later. No data were available for August 1973 in Fairbanks.

Data are too limited to draw definite conclusions, but a greatly decreased juvenile survival rate could foretell a population decline.

Meslow and Keith (1968) found that by early fall young snowshoes have the same mortality rate as older hares. The ratio of juveniles to adults becomes stabilized as early as October in Alberta, and it is likely that this is the case in Alaska as well. Over-winter mortality in the two populations studied was estimated from the differences in the population estimates of an area.

The population of the Central study area in May 1971 was apparently only 39 percent of the population of the previous August. The population of the Fairbanks study area in April 1972 decreased to 32 percent of the population of August 1971 and the March 1973 population was about 50 percent of the August 1972 population.

Significant changes in sex ratios during various phases of the cycle have been noted by some authors, while others found relatively little deviation from a 50:50 ratio. Sex ratios of livetrapped hares in this study (Table 3) indicate that there were significantly more females than males in August 1970 and May 1971 in the Central study area, but the juvenile group of hares trapped in August 1971 showed a trend toward a higher proportion of males.

In Fairbanks, the August 1971 sex ratio was 55 percent females in adult hares but only 45 percent females in juvenile hares. In April 1972 the sex ratio remained at 45 percent females, but adult hares trapped in August had a sex ratio of 68 percent females to 32 percent males. In 1973 there was a significant switch in sex ratio to predominately males (66%) in both the March and November trappings.

Fetal sex ratios showed a predominately male trend in first litter groups in both Fairbanks and Central in 1973 (Table 23) with 65 percent males in both areas. Second litter group samples were small, three litters from each area with fetuses old enough to determine sex, but the proportion of males was only 33 percent in the Fairbanks sample and 40 percent from the Central group. Some caution must be used with these data, as the sample size was small, and the Fairbanks sample of the second litter group was collected on the Murphy Dome Road, in an area of high hare population, even in 1973.

Some mention of sex ratios in snowshoe hare literature indicates that there may be a significant switch in sex ratio from 50 percent or more females to predominately male (55 - 66%) in a declining population (Rowan and Keith 1956). Rowan and Keith (1956) recorded 36 percent males during a high at Anzc, Alberta, and 55 percent males the following year as the population began to decline. However, a sample of 83 hares from an increasing population in Newfoundland (Dodds 1965) had a sex ratio of 63 percent males. These conflicting reports may reflect increasing adult male activity, making them more vulnerable to capture at certain times, while at other times, such as during the breeding season, adult females may be more available along the road systems. Fetal sex ratios, at least, show the initial sex ratio in a population, but this may change if there is differential mortality among males and females.

If there actually was an increase in the proportion of males in the hare population around Fairbanks as the population declined, we can only speculate as to what effect this would have on the population. A lower proportion of females would mean fewer young produced even if total numbers of hares remained the same, however.

Changes in reproductive rates have often been thought to be one of the causes of population fluctuations in small mammals. In microtine populations, an inverse relationship between reproductive rates and increasing population density has led some researchers to postulate that reproductive change is a major causative factor in these fluctuations. Among snowshoe hare studies, the data from Rochester, Alberta (Meslow and Keith 1968) support the idea of reproductive involvement in population changes. However, earlier work by Green and Evans (1940a, b, c) at Lake Alexander, Minnesota showed no significant variation in reproductive rate, but found that juvenile mortality increased greatly during the decline. Severaid (1942) also reported there was no correlation between litter size and cyclic fluctuations in populations, but Macfarlane (1905), Preble (1908), Elton (1924) and Maclulich (1937) suggested that litter size varied from year to year, with large litters during years of population increase and smaller litters during years of decline.

Changes in litter size would be a prime factor in changing birth rates, which would undoubtedly affect the population level (Meslow and Keith 1968). Litter sizes from the three areas of collections for three breeding seasons are compared in Tables 13-16.

While there was little change from year to year in mean size of first litters in an area, the mean size of second litters did change significantly in both Central and Fairbanks. Mean litter size dropped from 6.3 and 6.2 in 1970 and 1971 to 5.1 in 1972 in Central (Table 17). In Fairbanks (Table 18) mean size of second litters dropped from 5.8 in 1971 to 4.1 in 1972. The hare population of Central was definitely declining in 1972, after reaching a peak in 1971, and in Fairbanks, the hare population was peaking and starting to decline in some areas in 1972.

Central hares seem to have had slightly higher reproductive rates than those of either Fairbanks or Delta, with Delta being the lowest of the three areas. Whether this is related to the relative latitudes of the three areas is not known. Variations in reproductive rates between populations at different regions and latitudes may give some clues as to the factors affecting population levels. Rowan and Keith (1956) suggested that the fecundity of hares of northern latitudes may be greater than that of more southern latitudes. This may account for the greater magnitude of population fluctuations in the more northern latitudes of the range of the snowshoe hare.

Both first and second litter sizes of hares in interior Alaska seem considerably larger than the mean litter size recorded for hares in Alberta, Michigan or Newfoundland. Alaskan hares had fewer litters per season on the average, but first litters averaged around four, while the mean of first litter sizes over six years in Alberta was only three (Meslow and Keith 1968). Second litters were also larger in Alaska than those seen in the Alberta studies. Second litters averaged 4.8 in Alberta and 5.3 in interior Alaska.

First litters were smaller on the average than second litters (Tables 13-16). The same situation has been found in Michigan (Bookhout 1965), Alberta (Rowan and Keith 1956) and Newfoundland (Dodds 1965). The significance of this phenomenon is not clear. That it may be a factor of nutrition is suggested by Meslow and Keith (1971). These workers found, when weather factors were compared with snowshoe hare population parameters, the colder the temperatures in the 250 days preceding mid-February and the deeper the winter's accumulation of snow the larger the litters the next spring. This was possibly due to the fact that as snow depth increases, the height above ground level at which a hare feeds also increases. They postulated that the hares were able to reach more nutritious browse with the help of the increased snow depth and that this influenced the size of their first litter. Perhaps the nutritive value of this food is such that it promotes a greater ovulation rate. A higher ovulation rate for second litters may be due to the availability of green plants which provide more nutrition than winter browse.

The date of onset of breeding in an area can be determined from the first litter conception and parturition dates. Figs. 3 to 8 compare conception dates for the three areas by area and by year. The onset of breeding in Central was about two weeks earlier in 1970 than in 1971. In 1971 the breeding season was two weeks later in Central than in either Delta or Fairbanks. Fairbanks data indicate a later breeding season in 1972 than in 1971 or 1973, while Delta hares seemed to have an extremely early breeding season in 1973, at least three weeks earlier than in 1972, and almost two weeks earlier than Fairbanks hares in 1973 (Figs. 6 and 8).

Meslow and Keith (1971) in studies in Alberta, found that the intensity of illumination in mid-winter, as measured by cloud cover, was significantly correlated with the date of onset of breeding the following spring. Measurements of cloud cover in Interior Alaska were not available, but climatological data recording temperatures and precipitation are available.

Mean temperatures recorded in Fairbanks, Delta and Central are given in Table 24 for the first four months of each year from 1970 through 1973. Temperatures averaged 5 to 10 degrees colder in 1971 than in 1970 in Central, and more than 10 degrees colder in February, March and April of 1972 than those months in 1973 in Fairbanks, which may have had some influence on conception dates (Figs. 3 to 8). Delta temperatures (Table 24), however, were very close to Fairbanks temperatures during those three months in both 1972 and 1973, yet the onset of breeding was much earlier in Delta in 1973 than in Fairbanks.

If breeding begins relatively early, as in Delta in 1973, there seemingly would be more chance to have three litters and the breeding season might be extended if dates of testicular regression remained relatively the same. This is not always the case, of course, as Meslow and Keith (1971) found the mean date of testes regression varied 39 days between years. It is interesting to note, however, that the percentage of female hares from the Central area having third litters was higher

Table 24. Average mean temperatures for Central, Fairbanks and Delta for the first four months of 1970, 1971, 1972 and 1973.

Month	Area	1970	1971	1972	1973
January	Central	-27.8	-37.4	-24.2	-22.4
	Delta	-12.9	-24.4	-16.2	-16.5
	Fairbanks	-16.2	-31.7	-16.3	-18.2
February	Central	-9.6	-18.0	-19.9	-7.1
	Delta	-14.3	2.5	-9.0	2.9
	Fairbanks	8.0	-4.6	-10.1	-1.5
March	Central	5.1	-9.5	-6.0	-1.4
	Delta	25.8	.7	-1.7	12.2
	Fairbanks	20.9	-.4	-2.8	11.9
April	Central	24.8	18.3	12.9	26.6
	Delta	30.1	26.4	18.9	34.5
	Fairbanks	32.8	26.7	20.8	35.3

(33% compared to 10% and 0%) in the year that onset of breeding was early (1970) and in Delta 38 percent of the female hares had a third litter in 1973 when onset of breeding was extremely early, preceding Fairbanks hares by ten days to two weeks.

It is very difficult to arrive at any hard and fast conclusions from these data collected over the three years of the hare study, as hares have not totally declined, and there are many questions left unanswered. The Institute of Arctic Biology has only a limited amount of physiological data on hares during this cycle, but is continuing to collect such data. They have considerable information on parasite loads of hares collected the past two years, but there are virtually no data on hare nutrition during various phases of the cycle. This lack of data on nutrition in hares represents a very large gap in our knowledge of hare cycles and would logically be the next step in hare research. A study of food habits and nutrient content of forage is planned for this coming year (1974-75) by the Institute of Northern Forestry, but more detailed studies on hare nutritional needs would be helpful. Also, very little data of any kind are available for hares during the extremely low phase of the cycle due to the difficulty of obtaining hare specimens.

More information is needed concerning the role of predators in hare population fluctuations and the influence of a fluctuating hare population on its predators. We don't known how much predation may have to do with the decline of a hare population. Perhaps the only way to measure this would be to eliminate all predators from a large area, or to completely predator-proof a study area of at least several acres. Needless to say, this would be an expensive if not impossible proposition. Further research on predator-prey relationships is almost as important as nutritional research, but would be more difficult to accomplish.

More should be known about the competition between hares and other herbivorous species such as moose and the influence of each on available food. Moose and hare exclosures and browse analysis would be one method of measuring this, and perhaps this could be related to nutritional studies. John Coady of the Alaska Department of Fish and Game is conducting some moose browse work, including observations of hare use, and the Institute of Northern Forestry is setting up some hare and moose exclosures on the Wickersham Dome burn area.

The Department of Fish and Game should also continue monitoring hare populations in the Interior through this present hare cycle until the next population peak. Limited livetrapping should be continued in the Fairbanks study area, although livetrapping is time consuming and results are often poor due to interference by people, dogs and weather. It also samples a small local area, but would provide an indication of population trends, especially when combined with road surveys.

Hare road counts, while not providing a real estimate of actual numbers of hares in an area, would provide a valuable index of relative abundance of hares, if conducted during certain special periods on sections of roads selected for their hare activity. I strongly recommend that the Department of Fish and Game conduct hare road counts as outlined here:

Fairbanks Area: Chena Hot Springs Road, Mile 1 to Mile 11 (Little Chena River); Old Murphy Dome Road, Mile 0 to Mile 7; Goldstream Road, from Steese, Mile 1 to 5; Old Nenana Road, Mile 0 to 3 (all of road).

Dates: About April 1, depending on when hare breeding activity begins. Unless weather and snow conditions indicate a late spring, surveys should begin April 1 and be continued for five days. If no signs of hare activity (hares seen along roads, dead on highways, etc.) are noted, further counts should be delayed until April 10, when surveys again should be run for 5 days. If no signs of hare activity are noted by the end of April, it may be concluded that hare populations are at an extreme low. Times: Dawn (2-3 a.m.) and/or evening (10-11 p.m.) (dawn is preferred). June 1 - 15, again depending on hare activity. Ten good counts (fair weather, no wind, etc.) should be conducted each period.

These surveys can be done in the Fairbanks area at little cost in time or manpower. If budgetary considerations allow, surveys should also be conducted in Delta and Central.

Delta: Richardson Highway, Donnelly Dome area. Alaska Highway, from Delta Junction south 20 miles. Dates and times same as Fairbanks. The Delta Area Biologist could conduct these counts.

Central: Steese Highway, Mile 128 - 138; Circle Hot Springs Road, Mile 0 - 8; Deadwood Road, Mile 0 - 6. Dates determined by highway conditions in April, again in June.

The Small Game Abundance Questionnaire and the Trapper Questionnaire will be continued and expanded to reach more observers.

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