

AN ABSTRACT OF THE THESIS OF

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Title: DYNAMICS OF A POPULATION OF MOUNTAIN

COTTONTAIL RABBITS IN CENTRAL OREGON

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B. J. Verts

Data from 186 mountain cottontail rabbits (Sylvilagus nuttallii) captured 455 times by livetrapping and from 46 rabbits collected by shooting were evaluated to determine monthly densities, survival rates, extent of movements, dispersion in relation to habitat types, and criteria for determining ages of mountain cottontails. Estimates of density computed for each month ranged from a high of 102.9 per 100 acres (40.4 ha) in August 1972 to a low of 2.7 per 100 acres (40.4 ha) in November 1973. A 74 percent decline in numbers of cottontails occurred between August 1972 to August 1973. Calculated dates of conception indicated that four litter groups of juvenile cottontails were conceived during the breeding season in 1972 while three litter groups were conceived in 1973. Onset of drought periods that began in July 1972 and June 1973 were thought to be responsible for cessation of breeding of mountain cottontails. Survival of cottontails

from August 1972 to April 1973 was 18 percent. Numbers of cottontails born in litter groups one through three that survived from birth through August 1972 were significantly different ($\underline{P} < 0.01$) from numbers that survived from birth through August 1973. Poor survival of the third litter group, and absence of production of a fourth litter group in 1973 were thought to be responsible for lower densities of cottontails in 1973. Average distances between points of capture for mountain cottontails caught two or more times within a 30-day period ranged from 7.7 to 213.3 yards (7.0 to 195.0 m) in 1972, and from 19.7 to 171.9 yards (18 to 157.2 m) in 1973. Analysis of the locations at which cottontails were observed during drive censuses and at which cottontails were captured by livetrapping indicated differences between diurnal and nocturnal dispersion of cottontails. These differences occurred because cottontails occurred more frequently than expected in low flats at night, and more frequently in transition areas between flats and rocky outcrops during the day. Forearms, lenses of eyes, and dentaries of 46 cottontails collected by shooting, and of 15 cottontails that died in traps or during handling between 12 July 1972 and 30 August 1973 were evaluated to determine criteria for determining ages of mountain cottontails. None of 25 cottontails less than 1 year old had ossified epiphyseal cartilages in their humeri and only 2 had ossified epiphyseal cartilages in their radii and ulnae. Seven cottontails older than 1 year had ossified

cartilages in all bones of the foreleg. The relationship between ages (in days) and lens weights of mountain cottontails is expressed by:

$$Y = -158.49 + 136.42 \log_{10} X$$

Examination of sectioned dentaries of 31 cottontails for which the approximate age was known indicated that animals that were less than 1 year old had no adhesion lines in the periosteum, while all cottontails older than 1 year had at least one adhesion line.

Dynamics of a Population of Mountain Cottontail
Rabbits in Central Oregon

by

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DYNAMICS OF A POPULATION OF MOUNTAIN COTTONTAIL RABBITS IN CENTRAL OREGON

INTRODUCTION

The mountain cottontail rabbit (*Sylvilagus nuttallii*) occurs in 14 of the western United States and in 4 western provinces of Canada (Hall and Kelson 1959). In Oregon, mountain cottontails occur east of the Cascade Mountains in the Upper Sonoran life zone (Dice 1926, Bailey 1936).

Powers and Verts (1971), in reviewing the literature on mountain cottontails, emphasized the paucity of ecological information on the species. No quantitative information regarding mortality rates or movements is available for the mountain cottontail. Janson (1946) estimated density on four small areas (0.16 to 8.90 ha) in Utah; these appear to be the only quantitative estimates of density for the species. However, his methods of estimation were not presented, sample sizes were small, and estimates of density were inversely related to the sizes of the study areas. For these reasons, the reliability of Janson's estimates appears questionable.

Powers and Verts (1971) found that the female reproductive cycle extended from 22 February to 29 July 1969. They reported that breeding in the mountain cottontail appeared to be synchronous and to occur immediately postpartum. They calculated maximum

productivity for females that survived through the reproductive season to be 22 young in five synchronous litters.

Powers and Verts (1971) found the sex ratios of mountain cottontails were not significantly different from 1:1. Information concerning sex ratios from other areas of the range apparently is not available.

No techniques designed specifically to determine age of the mountain cottontail have been developed. Powers and Verts (1971) used the degree of ossification of the epiphyseal cartilages in the radius, ulna, and humerus to estimate ages of mountain cottontails based on criteria developed for the eastern cottontail rabbit (S. floridanus) in Wisconsin (Hale 1949). No information was provided concerning age ratios because they attempted to collect only adult-sized cottontails in their study.

In Oregon, the mountain cottontail is not legally classified a game animal, and no information is available concerning the numbers of cottontails harvested annually by hunters. As the hunting pressure on game species increases throughout the state, hunters may begin to exploit species of animals not classified as game animals including the mountain cottontail rabbit. Because the productivity of the mountain cottontail appears to be lower than that of related species (Powers and Verts 1971), the proportion of the population available for exploitation may be smaller. If this game resource is to be

properly managed, information on which to base management decisions must be made available.

OBJECTIVES

The purpose of this research was to determine some of the demographic parameters of a population of mountain cottontails through at least one annual cycle. Specific objectives of the study were as follows:

1. To determine the changes in density of a mountain cottontail population throughout the year.
2. To determine if there were differences in survival among segments of the population of different age.
3. To determine the extent of movements, and distribution in relation to habitats of mountain cottontails.
4. To develop reliable criteria for determining ages of mountain cottontails.

STUDY AREA

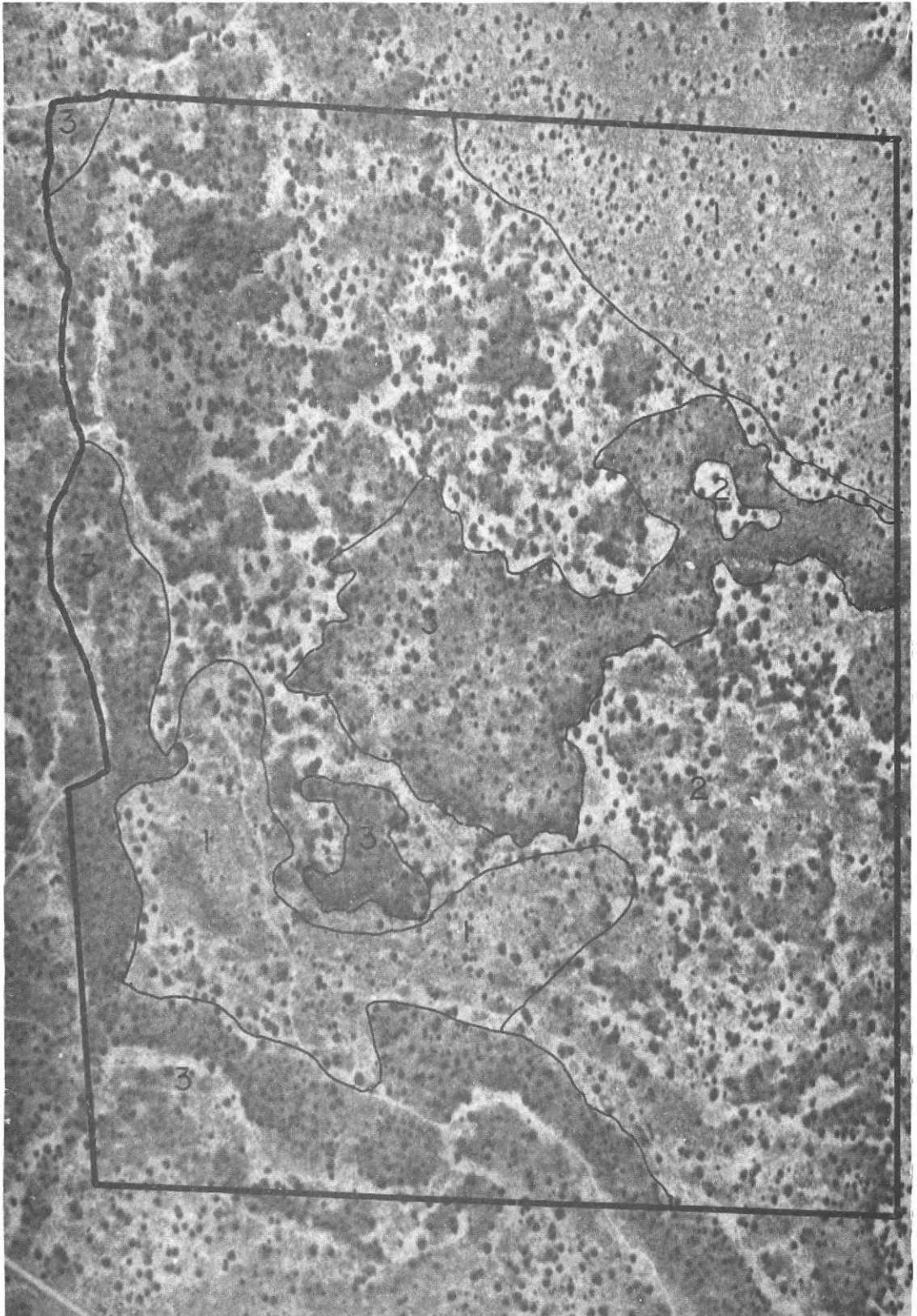
A 210-acre (84.9-ha) study area, hereafter referred to as the Terrebonne Study Area, was established on land administered by the Bureau of Land Management in Deschutes County, approximately 3 miles (4.9 km) west of Terrebonne, Oregon (R. 12 E., T. 14 S., Sect. 13 and 24), in August 1972. In an effort to reduce vandalism to traps, the study area was shifted to the north in April 1973, by approximately 100 yards (91.4 m). This resulted in an increase in the size of the area to 215 acres (87.0 ha) (Figure 1).

The Terrebonne Study Area was situated in a sagebrush-juniper community (Figure 1). Vegetative species commonly found in this community were: western juniper (Juniperus occidentalis), big sagebrush (Artemisia tridentata), bitterbrush (Purshia tridentata), rabbitbrush (Chrysothamnus sp.), cheatgrass (Bromus tectorum) bluebunch wheatgrass (Agropyron spicatum), and Idaho fescue (Festuca idahoensis). Additional plants found on the study area are listed in the appendix (Table A, Column 1). Soils on the area ranged from stony to loam. Numerous lava hummocks occurred on the area, which combined with vegetative and physiographic aspects of the site, produced many ecotones.

In 1972, 35 transect lines were established at 100-foot (30.5-m) intervals throughout the Terrebonne Study Area. Different colors of

flagging tape were used to delineate the lines. In 1973, the number of transect lines was reduced to 32. In addition, lines were numbered, and numbered markers were established at 100-foot (30.5-m) intervals along each transect line. These transect lines provided routes to be followed by observers during drive censuses.

Figure 1. Aerial photograph of the Terrebonne Study Area showing relative sizes and spatial arrangements of habitat types 1, 2, and 3. Habitat type 1 is considered to be an Artemisia tridentata, subsp. vaseyana, form xericensis/Stipa thurberiana association. Habitat type 2 is a mosaic of vegetative species found in habitat types 1 and 3, but is not considered a distinct plant association. Habitat type 3 is an Juniperus occidentalis/Artemisia tridentata, subsp. vaseyana, form xericensis/Festuca idahoensis/Agropyron spicatum association. Scale: 1 inch = 0.10 mile (2.54 cm = 0.16 km).



METHODS AND MATERIALS

General

The population of mountain cottontails on the study area was sampled by livetrapping using 6-x 7.5-x 23-inch (15-x 18.7-x 58-cm) unbaited wooden box-traps. During August 1972, 113 traps were distributed throughout the study area in an 80-x 160-pace grid. During 1973, 117 traps were distributed on the study area in a 100-x 100-pace grid.

Livetrapping was conducted continuously from 1 August to 30 August 1972. In 1973, livetrapping was conducted for two 3-day periods each month from 13 April to 23 June 1973. Livetrapping was conducted for one 3-day period each week in July, and for 30 consecutive days from 1 August to 30 August 1973.

Cottontails were removed from traps and taken to a pickup truck where they were weighed and measured. Sex was determined for each cottontail rabbit by examination of the genitals. Cottontails were assigned to an age cohort on the basis of body weight and total length. Cottontails were examined for the presence of external parasites, tagged with a vinyl and a metal eartag in each ear, returned to the point of capture and released. Mountain cottontails recaptured more frequently than once per week were released without being reweighed and remeasured.

Initially, cottontails were marked with eartags fashioned from vinyl-nylon fabric cut into 2-inch (5.1-cm) squares (Labisky and Lord 1959). The squares were coded with numerals and letters, folded longitudinally, and attached to the ears of the cottontail rabbit with an aluminum rabbit eartag and washer obtained from the National Band and Tag Company, Newport, Kentucky.

In 1973, captured cottontails were handled following the same procedure reported for 1972, except that the marking procedure was modified. Animals were marked with an aluminum rabbit eartag (National Band and Tag Co., Newport, Kentucky) in each ear and their tails were colored with a specific color of dye. Tails of adult cottontails were dyed green (malachite green), first litter juveniles yellow (picric acid), second litter juveniles red (rhodamine 6 G), and third litter juveniles purple (basic fuchsin). These color codes were used through July 1973. In August 1973, the tails of all cottontails captured, including animals that had been marked previously, were dyed yellow-orange (mixture of picric acid and rhodamine 6 G).

Dates of Conception

To determine dates on which litters were conceived, cottontails were collected by shooting from nearby areas with habitat similar to that on the study area. Fifteen mountain cottontails were collected between 18 March and 11 June 1972, and six were collected during

March and April 1973. These animals were necropsied at Oregon State University, and reproductive tracts were excised and examined for degree of sexual maturity, presence of spermatozoa, implantation sites, and developing embryos. Embryos considered to have gestated more than 14 days were measured with a string from the tip of the nose to the base of the tail along the curvature of the spine (Rongstad 1969) and preserved in 10 percent buffered formalin. Duration of gestation was estimated from length measurements using the criterion established for embryos of eastern cottontails (Rongstad 1969). Durations of gestation (in days) of embryos were subtracted from dates on which females were collected to determine dates that embryos were conceived.

Determination of Age of Juvenile Rabbits Captured in Field

Mean dates of birth of each of the synchronous litter groups of juvenile cottontails were calculated. Assuming a 27-day gestation period (Powers and Verts 1971), mean dates of birth were expected to occur 27-days following estimated dates of conception. Juvenile cottontails were assigned to specific litter groups or age cohorts on the basis of total length and body weight at the time of first capture. Age was considered to be the time (days) from the mean date of expected birth for a specific litter group, to the date of capture of each member of the cohort.

Density

All transect lines were traversed by at least 4 individuals between daylight and 1000 hours at least once each month from September through March 1972-73, and 1973-74. All cottontails sighted during the drive censuses that were in the study area were recorded. Attempts were made to record the color and the code of eartags of marked cottontails in 1972, to record the color of tails of cottontails marked in 1973, and the location to the nearest numbered marker of each cottontail sighted in 1973.

Estimates of density were calculated for each month of the study from August 1972 through March 1974. Estimates of population size in August 1972 and from April to September 1973 were made using the maximum likelihood estimation (MLE) (Edwards and Eberhardt 1967), the Lincoln Index (Petersen 1896), and the Bailey modification of the Lincoln Index (Bailey 1952). An additional method (Relative Abundance) of estimation was employed to obtain population estimates for months when mark and recapture data were not available. This method provided a basis for converting the number of cottontails seen on drive censuses into monthly estimates of density using the following formula:

$$N = \frac{P_1 n_2}{n_1}$$

where:

N = Monthly estimate of density.

P_1 = Estimate of density in August using MLE.

n_1 = Number of cottontails observed on drive census
at end of August.

n_2 = Number of cottontails observed on the monthly drive
census.

Movements

An index to the extent of movements of mountain cottontails was calculated by determining the average distance between points of capture. Age-specific and sex-specific movements were calculated for all cottontails captured at least twice during any 30-day period.

Survival

Because sample sizes of cottontails obtained during 1973 were too small to allow the use of methods of estimating survival proposed by Ricker (1958) and Eberhardt et al. (1963), estimates of survival were obtained by a method similar to that used by Meslow and Keith (1968). An estimate of density of the breeding population was required to calculate survival by their method. The number of adults alive in August 1972 was assumed to represent the breeding population in April 1972. An estimate of density for April 1972 was

obtained by multiplying the percentage of adult cottontails observed in the August 1972 population by the estimate of density of all age classes in August 1972.

Calculation of survival rates of juvenile cottontail rabbits from birth through August during 1972 and 1973 was based on the assumption that the average number of viable embryos found in females pregnant with each synchronous litter group by Powers and Verts (1971) in 1969 were equal to the number of cottontails born in each synchronous litter group in 1972 and 1973. In addition, all female cottontails in the population were considered to be pregnant throughout the breeding season. This assumption is supported by findings of Powers and Verts (1971) who reported that all of 35 females collected during the breeding season in 1969 were pregnant. The number of young born in each litter group was calculated by multiplying the average number of embryos for a specific litter group for each pregnant female (Powers and Verts 1971) by half of the April estimate of density (females). The percentage of juveniles in each age class (obtained from trapped samples in the August population) was multiplied by the August estimate of density to obtain the number of young estimated to be alive in each litter group in August. Survival was computed for each litter group using the following model:

$$\text{Survival rate} = \frac{\text{Number of young in litter group } i \text{ alive in August}}{\text{Estimated number of young born in litter group } i} \times 100$$

Survival rates of mountain cottontails from August 1972 to April 1973 were calculated using the following model:

$$\text{Survival rate} = \frac{\text{April estimate of density year } i + 1}{\text{August estimate of density year } i} \times 100$$

Vegetative Survey and Habitat Types

During 1972, cottontails appeared to use certain portions of the study area more intensely than others. Therefore, an analysis of the vegetation was conducted to determine if different plant associations existed on different portions of the study area. Apparent habitat types were delineated on an aerial photograph and the vegetation of each was sampled. The vegetative survey was conducted by establishing 1-foot by 2-foot (0.30-x 0.61-m) rectangular sample plots at 10-pace intervals along 10 transects in each habitat type. All species of plants that were in 10 sample plots along each transect were recorded.

Dispersion in Relation to Habitat Type

Dispersion of mountain cottontail rabbits was analysed by the distribution of the locations of captures and of the locations of sites at which cottontails were flushed. Captures were considered to indicate nocturnal dispersion; whereas, sites at which cottontails were flushed were considered to represent diurnal dispersion.

Contingency tables (Chapman and Schaufele 1970) were used to determine if cottontails were captured or observed more frequently in one habitat type than another, if dispersion of cottontails differed between 1972 and 1973, and to determine if mountain cottontails used specific habitats more frequently during day or during night.

Criteria for Determining Age

To establish criteria for determining age, the right humeri, radii, and ulnae; dentaries; and eye-lenses of 21 cottontails necropsied for reproductive evaluation during the study were preserved. In addition, 25 cottontails were collected from the study area by shooting between 11 September and 11 October 1973, and 15 cottontails that died in traps or during handling between 12 July 1972 and 30 August 1973 provided a sample of animals for evaluation of physiological age in relation to chronological age.

The humeri, radii and ulnae of 57 cottontail rabbits were examined. Thirty-two humeri, and 33 radii and ulnae were removed from animals for which the approximate age in days was known. Twenty-four humeri, radii and ulnae were removed from cottontails for which the age was not known. These forelegs were cleaned in a 25 percent solution of laundry bleach, and were examined to determine the degree of ossification of the epiphyseal cartilages.

Eyeballs of 59 cottontails were removed and placed in 10

percent buffered formalin for at least 30 days (Friend 1968). Lenses were removed from the eyeball after fixation and dried at 80 C for 7 days (Edwards 1967). Lenses were weighed to the nearest milligram. Lens weights of 29 cottontails for which the approximate age in days was known were evaluated by regression analysis.

Dentaries of mountain cottontail rabbits were decalcified in a 5 percent solution of 67 percent nitric acid for approximately 12 hours, rinsed in running water for 12 hours, and stored in 70 percent ethanol until they were embedded. Diastemas were removed from the dentary with a scalpel, dehydrated in a graded series of ethyl alcohol, infiltrated with paraffin and embedded in paraffin (Humason 1967). Dentaries of each cottontail were cross-sectioned at 11 micra on a microtome. Several sections of each dentary were mounted on slides with Mayer's albumen, stained with Papanicoloau (Harris) haematoxylin, and examined under a microscope.

Climatological data were obtained from the U. S. Weather Bureau Station located at Redmond, Oregon (U. S. Department of Commerce 1971, 1972, 1973, 1974), 7 miles (11.27 km) from the Terrebonne Study Area.

Numbers of degree-days were calculated for periods of declining temperatures that occurred between 30 August and 29 December 1972, and between 30 August 1973 and 12 January 1974. Degree-days were calculated by subtracting the mean daily temperature from 65° F and

summing the results over a designated time period to provide an index to the severity and duration of periods of cold weather.

RESULTS AND DISCUSSION

During this research 186 mountain cottontail rabbits were captured in livetraps 455 times, and 46 rabbits were collected by shooting. One-hundred and twenty-four individual rabbits were captured in August 1972 (Table B, Appendix) while 32 individuals were captured in August 1973 (Table C, Appendix).

Dates of Conception and Numbers of Litters Produced

Dates of conception in 1972 were calculated for four pregnant females and two females that had recently given birth and had spermatozoa in their vaginae. Calculated dates of conception indicated that at least four litters were conceived during the breeding season in 1972 (Figure 2). The first litter was estimated to have been conceived about 5 March 1972. The last litter was calculated to have been conceived about 20 May 1972. During August 1972, four cohorts of juvenile cottontails were captured; 6 belonged to one group, 16 to another, 41 to a third, and 32 to a fourth. These groups were believed to represent litters produced as a result of the four synchronous periods of breeding.

Examination of the reproductive tracts of three females collected in March and April 1973 indicated that the first litter group of the 1973 breeding season was conceived about 25 February, and the last litter group was conceived about 18 April (Figure 3).

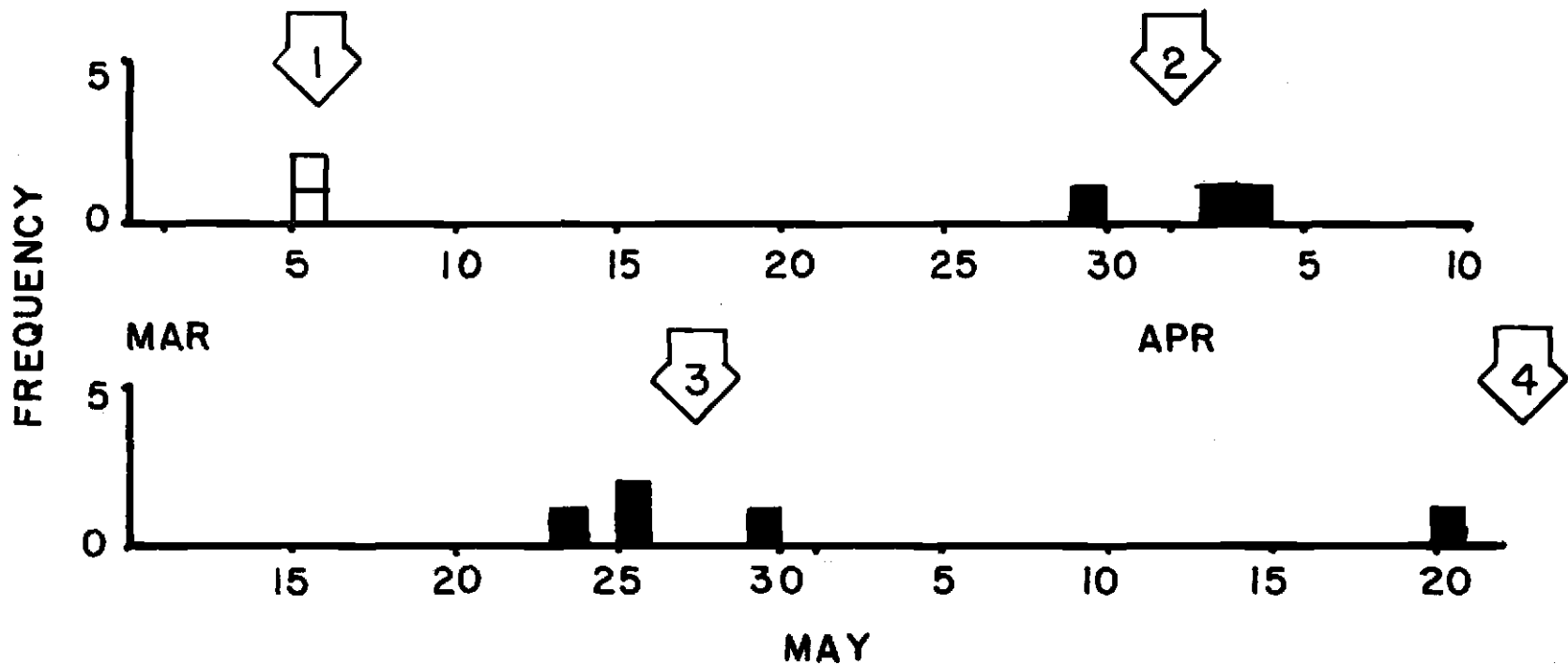


Figure 2. Dates of conception for litters of mountain cottontail rabbits in 1972. Open squares designate first litters of the year. Closed squares designate subsequent litters. Numbers and arrows placed at 27-day intervals indicate number of each synchronous litter group and an average date on which litter group was conceived.

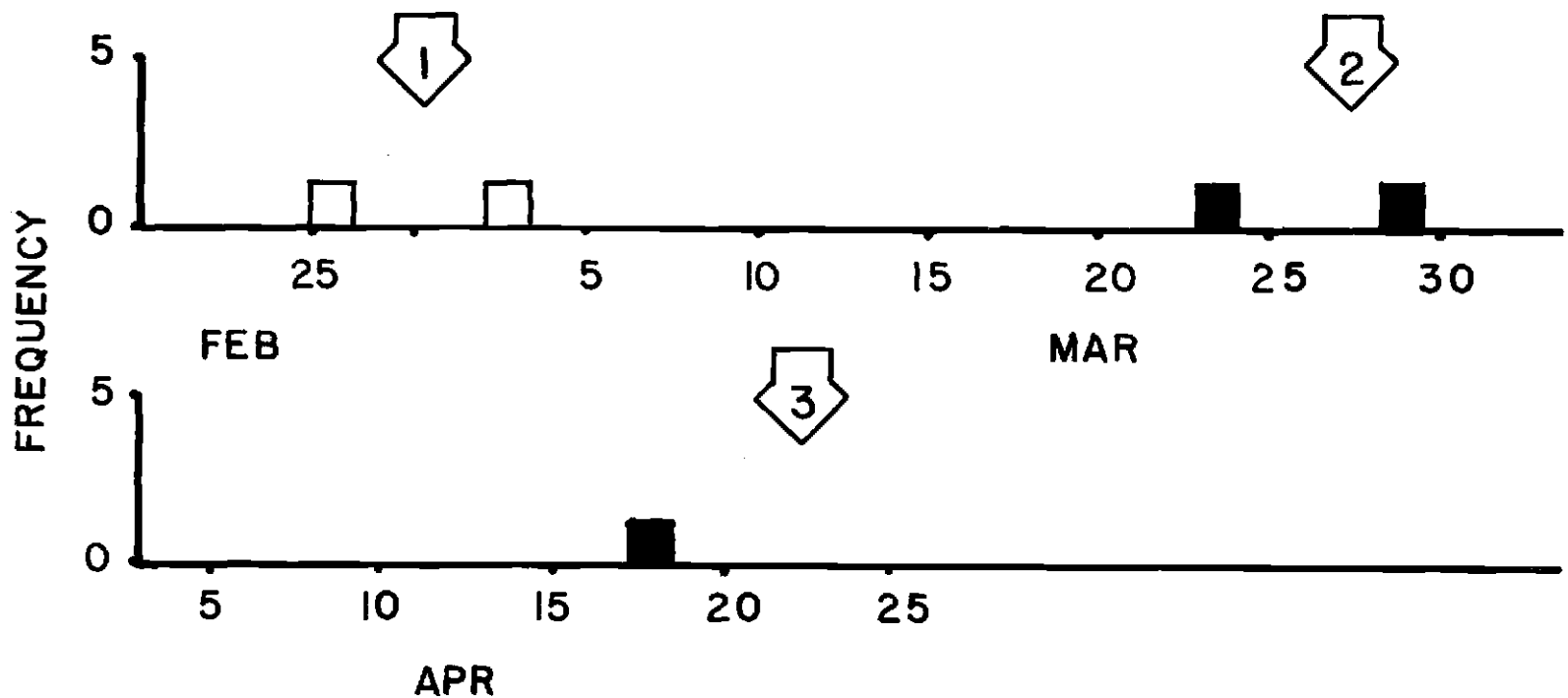


Figure 3. Dates of conception for litters of mountain cottontail rabbits in 1973. Open squares designate first litters of the year. Closed squares designate subsequent litters. Numbers and arrows placed at 27-day intervals indicate number of each synchronous litter group and an average date on which litter group was conceived.

Because attempts to collect additional cottontails for necropsy after 18 April were unsuccessful, nine adult females caught in live-traps on the Terrebonne Study Area during April, May, and June were examined by palpation and inspection of mammae to determine if additional litters were produced. All of these rabbits appeared to have stopped breeding and nursing young by 25 May 1973 (Table 1). Assuming a 27-day gestation period (Powers and Verts 1971), only three litters could have been produced between 25 February and 25 May 1973. From these data, and because only three cohorts of juveniles appeared in the trapped sample between April and August 1973 (Table D, Appendix), it is probable that only three litters were produced during the breeding season in 1973.

Table 1. Reproductive condition of nine female mountain cottontails captured on the Terrebonne Study Area between 13 April and 12 June 1973, determined by inspection of mammae, vaginae, and by palpation.

Rabbit Number	Date Examined	Reproductive Status
612	13 APR	Pregnant and Lactating
734	14 APR	Lactating
718	15 APR	Teats Elongated
1002	28 APR	Pregnant and Lactating
608	28 APR	Pregnant and Lactating
1075	29 APR	Pregnant and Lactating
605	18 MAY	Lactating
1025	25 MAY	Neither Pregnant nor Lactating
1043	26 MAY	Recent Parturition
1043	10 JUNE	Not Pregnant, Mammary Tissue Regressing
612	23 JUNE	Not Pregnant, Mammary Tissue Regressing

Reduced amounts of precipitation between 1972 and 1973 may have been related to the reduction in the number of litter groups produced in 1973. Powers and Verts (1971) found that the breeding season for mountain cottontails began in February and extended into July. During this period in 1972, the study area received 4.54 inches (11.53 cm) of precipitation (Table E, Appendix). During the same period in 1973, the study area received only 2.05 inches (5.20 cm) of precipitation (Table E, Appendix). In 1972, the last month with significant amounts of precipitation was June (Table E, Appendix), the month during which the fourth litter group of cottontails was born. In 1973, the last month with significant precipitation was May (Table E, Appendix), the month during which the third litter was born. In both years, less than 0.1 inch (0.25 cm) of precipitation was recorded during the month immediately following the birth of the last litter groups of the breeding season (Table E, Appendix). The above data suggest that either breeding ceased by 25 May 1973, or that embryos were resorbed as the drought began. Amount of moisture accumulated over the breeding season may be important to cottontail productivity; therefore, onset of drought periods may be responsible for cessation of breeding. Other workers suggested that low amounts of precipitation was related to the cessation of breeding in other species of rabbits. Tretheway and Verts (1971) suggested that unusually low amounts of precipitation may have caused an early cessation of

breeding in eastern cottontails in western Oregon. Hill (1972) found that drought reduced pregnancy rates in eastern cottontails. He, too, was unable to determine if breeding had stopped, or if embryos were resorbed. Sheffer (1958) working with penned eastern cottontails found that drought caused a termination of reproduction. Mossman (1955) found that the period of infertility in brush rabbits (S. bachmani) in California coincided with the dry season.

The mechanism thought to cause cessation of breeding of mountain cottontails in relation to reduced amounts of precipitation is reduced amounts of forage. From the relationship between amounts of precipitation and forage yields for native ranges in the western United States established by Sneva and Hyder (1962), forage yields were estimated to be 44.8 percent lower in 1973 than in 1972 on the Terrebonne Study Area. Differences in forage yields measured at Squaw Butte Experiment Station in southeastern Oregon were of the same magnitude. Production of non-forage species at Squaw Butte was 41.5 percent lower in 1973 than 1972 (Forest A. Sneva, Personal communication). Other workers suggested that green forage was necessary for continued breeding in lagomorphs. Hill (1972) concluded that green vegetation was necessary for continuous reproduction in the eastern cottontail. Hughes and Rowley (1966), working with the European rabbit (Oryctolagus cuniculus), found that the breeding response (pregnancy and lactation) reached a maximum

when rabbits grazed green pastures, while reduced breeding activity occurred as pasture plants formed seed and dried. They concluded that a primary requirement for optimal reproduction was fresh-growing food plants. In addition, Fitch (1947) found that the breeding season of the desert cottontail (S. auduboni) was limited to late fall, winter and spring months when green forage was abundant. The conclusion that green vegetation is important to the continuance of reproduction is further supported by the report of pregnant females, lactating females, or nestling desert cottontails occurring in California during all months except January, July and October (Ingles 1941). This evidence of extended breeding activity occurred in an irrigated valley where green vegetation was available throughout the year.

Density

Estimates of the number of mountain cottontails on the Terrebonne Study Area were computed for each month from August 1972 through March 1974 (Table 2, Column 5). These numbers were converted to densities (Table 2, Column 6; Figure 4) to facilitate comparison of estimates between the different years of the study.

Although monthly estimates of density were computed by one of three different models, they appear to be similar. Estimates of density computed by the MLE and the Lincoln Index (Petersen 1896)

yielded similar results (Table 2) for months that estimates could be computed by both models using the same data (August 1972, August 1973). Results computed by the MLE and the Lincoln Index differed by 9.2 percent in August 1972, and 13.1 percent in August 1973. The MLE consistently yielded the highest numbers. The Relative Abundance estimate and the Lincoln Index also yielded similar results (Table 2) when computed using the same data (13 September 1972). Results computed by the Lincoln Index and Relative Abundance estimate for September 1972 differed by 2.7 percent. In addition, the Relative Abundance estimate appeared to be sensitive to changes in numbers of cottontail rabbits on the study area. For example, between 11 September and 11 October 1973, 25 cottontails were removed from the study area by shooting, and an additional three animals were crippled and lost. The Relative Abundance estimate for the end of October indicated that the population declined by 35.6 cottontails. If no natural mortality occurred between 11 September and 11 October, then the model accounted for 74 percent of the estimated change in numbers of cottontails on the study area.

A comparison of all estimates of density from August 1972 through March 1974 indicated that a decline in numbers of cottontails had occurred on the study area (Figure 4). In 1972, density declined 22.7 percent from 30 August to 13 September, 26.8 percent from 14 September to 25 November, and 80.1 percent from 26 November to

Table 2. Population estimates, estimates of densities, methods of computing population estimates, and methods of resampling population on the Terrebonne Study Area between August 1972 and March 1974.

Date	Method of Estimating Population	Method of Sampling		Population Estimate	Density per 100 Acre (40.4 ha)
		1st Sample	Resample		
15 AUG 1972	L. I. ^b	Trap	Trap	196.05	93.36
30 AUG 1972	MLE ^a	Trap	----	216.00	102.86
5 SEPT 1972	L. I.	Trap	D. C.	157.25	74.88
13 SEPT 1972	L. I.	Trap	D. C.	162.50	77.38
13 SEPT 1972	R. A. ^c	D. C. ^e	D. C.	167.09	79.57
30 SEPT 1972	R. A.	D. C.	D. C.	110.03	52.40
28 OCT 1972	R. A.	D. C.	D. C.	105.96	50.46
25 NOV 1972	R. A.	D. C.	D. C.	122.26	58.22
29 DEC 1972	R. A.	D. C.	D. C.	24.45	11.64
6 JAN 1973	R. A.	D. C.	D. C.	20.37	9.70
27 JAN 1973	R. A.	D. C.	D. C.	32.60	15.52
24 FEB 1973	R. A.	D. C.	D. C.	24.45	11.64
31 MAR 1973	R. A. ₁	D. C.	D. C.	16.30	7.76
15 APR 1973	MLI ^d	Trap	Trap	40.00	18.60
20 MAY 1973	MLI	Trap	Trap	30.00	13.95
10 JUNE 1973	MLI	Trap	Trap	30.00	13.95
14 JULY 1973	L. I.	Trap	Trap	72.00	33.49
15 AUG 1973	L. I.	Trap	Trap	50.00	23.26
30 AUG 1973	MLE	Trap	----	57.55	26.77
7 SEPT 1973	L. I.	Trap	D. C.	55.71	25.91
11 SEPT 1973	L. I.	Trap	Shot	63.14	29.37
27 OCT 1973	R. A.	D. C.	D. C.	20.14	9.37
17 NOV 1973	R. A.	D. C.	D. C.	5.75	2.67
15 DEC 1973	R. A.	D. C.	D. C.	8.63	4.01
19 JAN 1974	R. A.	D. C.	D. C.	8.63	4.01
23 FEB 1974	R. A.	D. C.	D. C.	14.37	6.68
30 MAR 1974	R. A.	D. C.	D. C.	17.26	8.04

^aMLE = Most Likelihood Estimate (Edwards and Eberhardt 1967)

^bL. I. = Lincoln Index (Petersen 1896)

^cR. A. = Relative Abundance

^dMLI = Modified Lincoln Index (Bailey 1952)

^eD. C. = Drive Census

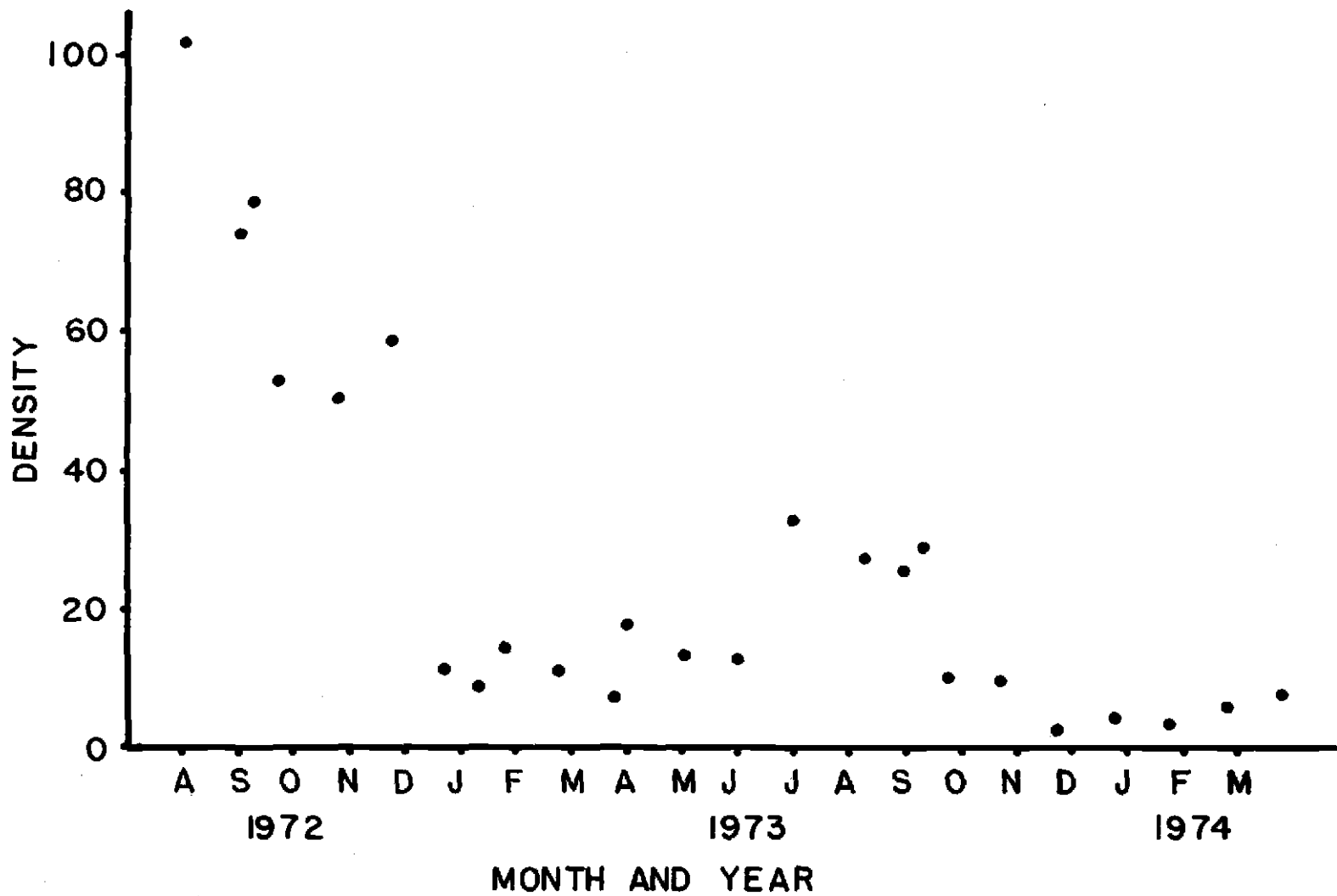


Figure 4. Monthly estimates of density per 100 acres (40.4 ha) for mountain cottontail rabbits on the Terrebonne Study Area from August 1972 through March 1974.

29 December; a total of 88.7 percent from 30 August to 29 December. Because of the magnitude of the change in density between November and December, an additional estimate was made 6 January 1973. This estimate, and the relative constancy of those from 27 January through 31 March 1973, indicated that the decline in density was of the approximate magnitude observed between 25 November and 29 December (Table 2, Figure 4).

In 1973, density was highest in July, declined 20.0 percent from 14 July to 30 August, and remained relatively stable from 30 August to 11 September (Table 2, Figure 4). Harvest of 25 cottontails between 11 September and 11 October 1973 was responsible for most of the 63.8 percent difference in densities between 7 September and 27 October.

During both years of the study minor increases in estimated density occurred during months that no recruitment could have occurred. I believe that these increases resulted from changing weather conditions that affected census results.

The magnitude of changes in density of mountain cottontails during autumn 1972 tended to correspond with severity of periods of minimum daily temperature (Figure 5). There was a corresponding decline in density and temperature between 30 August and 13 September, between 14 September and 25 November, and between 26 November and 29 December 1972 (Figure 5). Numbers of degree-days were

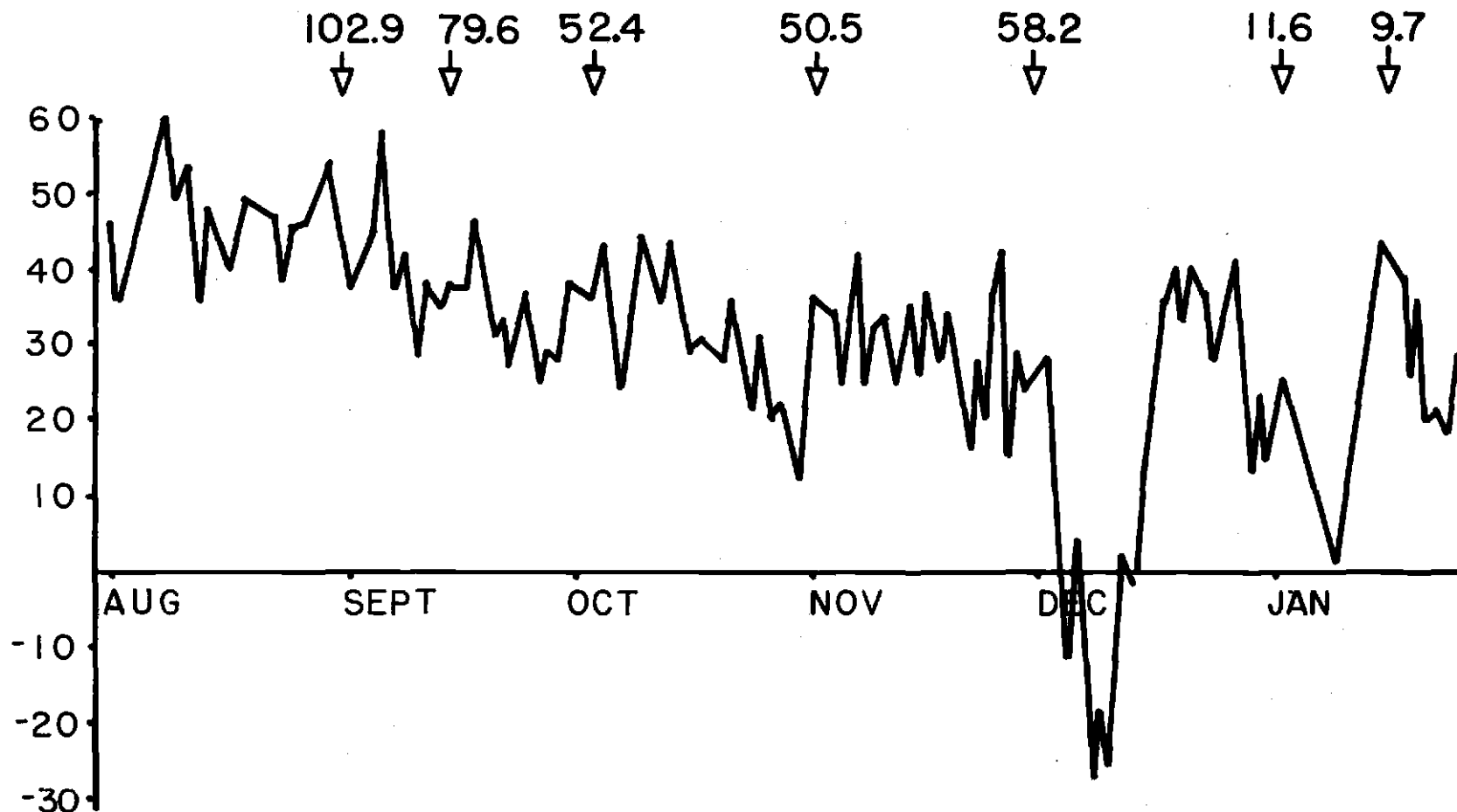


Figure 5. Minimum daily temperatures (F) recorded at Redmond, Oregon (U. S. Department of Commerce, 1972, 1973) from August 1972 to January 1973. Numbers above figure indicate estimates of density of mountain cottontails per 100 acres (40.4 ha) on the Terrebonne Study Area. Dates on which estimates of density apply are indicated by arrows.

calculated for each of the three periods of decline: 98.5 degree-days for period 1 (30 August to 13 September 1972); 1,482.0 for period 2 (14 September to 25 November 1972); and 1,267.5 for period 3 (26 November to 29 December 1972). The importance of durations of periods of low minimum daily temperatures to survival of mountain cottontails is unclear. Because numbers of degree-days did not increase in proportion to percentage decreases in densities for each of the three periods (22.7, 26.8, 80.1 respectively), severity of minimum daily temperatures may have been more important in contributing to cottontail mortality than duration of periods of minimum temperatures. It appeared that as temperatures declined further below the freezing level, density of cottontails continued to decline. As periods of colder temperatures occurred, a portion of the cottontail rabbit population apparently was not able to adapt to additional stresses, and was lost from the population. These conclusions are supported by findings of Meslow and Keith (1971), who reported that survival of adult snowshoe hares declined as temperatures declined and snow depth increased. However, they believed that these factors reduced nutrition which increased mortality.

Between 30 August 1973 and 14 January 1974 minimum daily low temperatures indicated four major periods of decline (Figure 6). These occurred from 30 August to 30 September (period 1), from 1 October to 1 November (period 2), from 2 November to 31 December

(period 3), and from 1 to 12 January (period 4) (Figure 6). Numbers of degree-days were calculated for each of the four periods of decline: 214.0 degree-days for period 1; 542.5 for period 2; 1600.0 for period 3; and 681.0 for period 4. Percentage decreases in densities did not correspond with periods of declines in minimum daily temperatures or with numbers of degree-days calculated for the same periods. Densities declined 62.4 percent between 7 September and 27 October 1973. However, a large proportion of this decline was a direct result of harvest of 25 animals between 11 September and 11 October 1973. Density declined 58.8 percent between 27 October and 15 December. Because all estimated densities between 27 October 1973 and 30 March 1974 were higher than the 15 December 1973 estimate, this decrease was thought to be a function of behavior of cottontails to cold and high winds that affected censuses during winter months. Density remained stationary during December 1973 and January 1974. Removal of 25 cottontails (approximately 50 percent of the 30 August estimate) in September and October 1973 may have been responsible for the absence of marked declines in density associated with rapid changes in minimum daily temperatures as noted during autumn 1972.

Survival and Productivity

Comparison of estimated numbers of juveniles born in the first three litter groups (Table 3, Column 3) indicated that productivity

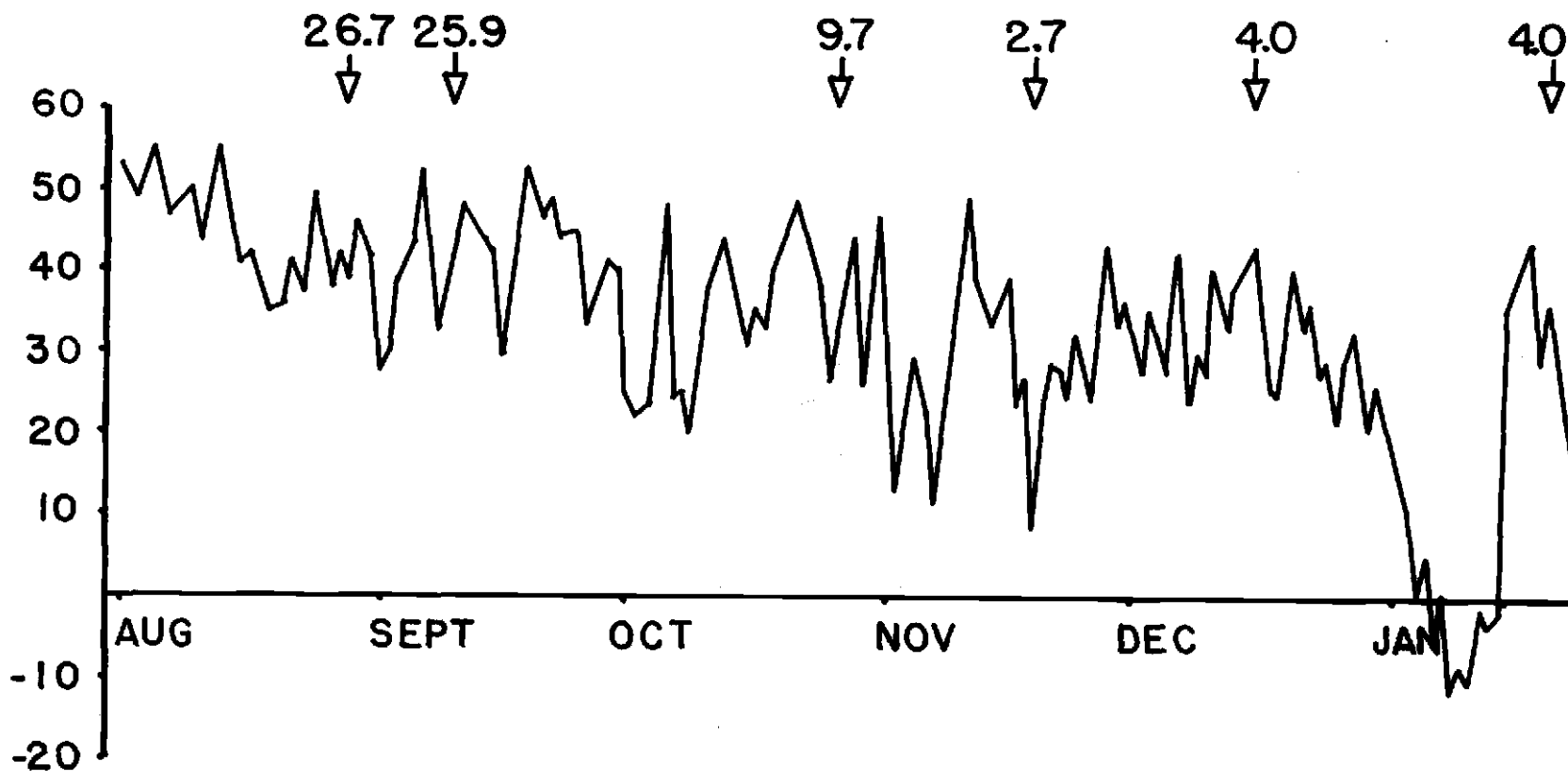


Figure 6. Minimum daily temperatures (F) recorded at Redmond, Oregon (U. S. Department of Commerce, 1973, 1974) from August 1973 to January 1974. Numbers above figure indicate estimates of density of mountain cottontails per 100 acres (40.4 ha) on the Terrebonne Study Area. Dates on which estimates of density apply are indicated by arrows.

was approximately 34 percent higher in 1972 than in 1973. However, four litter groups were produced in 1972, whereas three litter groups were produced in 1973. Estimated numbers of young born in the first three litter groups in 1972 were 18 percent higher than in 1973. However, differences between numbers of young produced during the breeding season of the two years in the first three litters were not significant ($P > 0.01$). Numbers of juveniles born in litter groups 1 through 3 that survived from birth through August 1972 were significantly different ($P < 0.01$) from numbers that survived from birth through August 1973 (Table 3, Column 6). These data, combined with age specific survival rates (Table 3, Column 7), suggested that poor survival of the third litter group, and the absence of production of the fourth litter group in 1973 were at least partially responsible for the 74 percent decline in density from August 1972 to August 1973.

Survival of cottontails from August 1972 to April 1973 was 18 percent; less than the calculated 23 percent survival required to produce a stationary population. The 40 cottontail rabbits that were estimated to be on the study area in April 1973 had the reproductive potential to produce 82 percent of the juveniles that were produced during the previous breeding season. Because no fourth litter group was produced in 1973, only 66 percent of the juveniles that were produced in 1972 were produced in 1973.

These data indicate that winter mortality reduced the spring

1973 breeding population by 18 percent. Survival rates determined for eastern cottontails suggest that mountain cottontails may require slightly higher over-winter survival rates to maintain stable populations. Lord (1963) found 21 percent fall to spring survival rates for eastern cottontails in Illinois. Eberhardt et al. (1963) found that annual survival rates of eastern cottontails in Michigan from 1935 to 1955 ranged between 14 and 19 percent.

Table 3. Comparison of survival of juvenile cottontail rabbits in each litter group from birth through August in 1972 and 1973 on the Terrebonne Study Area.

Year	Litter Number	(A)	(B)	(C)	(D)	Survival Rate D/A
		Estimated Number Young Born	Population Estimate August	Percentage Juveniles in Each Age Class	Estimated Number Young Alive in August	
1972	1	97.6	216.0	4.8	10.4	10.5
1972	2	124.4	216.0	12.9	27.9	22.4
1972	3	112.2	216.0	33.1	71.5	63.7
1972	4	82.9	216.0	26.6	57.5	69.4
1973	1	80.0	57.5	37.5	21.6	27.0
1973	2	102.0	57.5	37.5	21.6	21.2
1973	3	92.0	57.5	15.6	9.0	9.8
1973	4	0.0	-----	-----	-----	-----

Differences in age-specific survival of juveniles from birth through August also may have been influenced by drought. In 1972, 1.90 inches (4.82 cm) of precipitation fell on the study area from June through August. Only 0.08 inches (0.20 cm) (Table E, Appendix) fell during the same period in 1973. Survival of juveniles of the third litter group was estimated to be 63.7 percent in 1972 and only 9.8 percent in 1973. There was 40.3 percent less precipitation recorded during the crop-year (Sneva and Hyder 1962) of 1973 than during 1972. In addition, drought began in June in 1973 and in July in 1972 (Table E, Appendix). Because juvenile cottontails were between 2 and 3 weeks old in June of both years, rabbits in the third litter group were subjected to different environmental conditions. The drought was more severe in 1973, and began 1 month earlier than in 1972; it may have reduced the survival rate of juveniles in the third litter group. Myers and Gilbert (1968) stated that as pastures dry, juvenile European rabbits did not survive. They further stated that rabbits born 10 weeks and 14 weeks after rains stopped suffered high mortality from the following dry conditions. However, they supplied no data or documentation to support these statements.

Movements

The average distance between points of capture for mountain cottontails caught two or more times in 1972 ranged from 7.7 to 213.3

yards (7.0 to 195.0 m) (Table 4). In 1973, average distance between points of capture ranged between 19.7 and 171.9 yards (18 to 157.2 m) (Table 5). Movements of mountain cottontails were extremely limited, and of a magnitude similar to that reported for other species of rabbits (Haugen 1942, Janes 1959, Toll *et al.* 1960, Huber 1962, Lord 1963, Chapman and Trethewey 1972).

Table 4. Mean distances between points of capture for all cottontail rabbits caught at least twice on the Terrebonne Study Area during August 1972.

Age Class	Males			Females		
	Yards	Meters	Captures	Yards	Meters	Captures
Adults	50.8	46.4	10	20.0	18.3	6
1st litter	65.4	59.8	8	213.3	195.0	3
2nd litter	61.5	56.2	12	94.3	86.2	9
3rd litter	16.9	15.4	68	92.6	84.6	42
4th litter	7.7	7.0	16	51.1	46.7	45

Table 5. Mean distances between points of capture for all cottontail rabbits caught at least twice on the Terrebonne Study Area within a 30-day period between April and August 1973.

Month	Age Class	Distance-Males			Distance - Females		
		Yards	Meters	Captures	Yards	Meters	Captures
APR	Adults	87.1	79.6	6	54.4	49.7	2
MAY-JUNE	Adults	----	----	--	171.9	157.2	2
JULY-AUG	Adults	----	----	--	51.9	54.0	2
MAY-JUNE	1st litter	78.6	71.8	6	-----	-----	--
JULY-AUG	1st litter	----	----	--	59.2	54.1	22
MAY-JUNE	2nd litter	----	----	--	60.5	55.3	4
JULY-AUG	2nd litter	19.7	18.0	21	69.9	63.9	17
JULY-AUG	3rd litter	38.1	34.8	11	-----	-----	--

Influence of Marking on Cottontail Survival

Chi-square analysis of samples of marked and unmarked cottontails obtained between September 1972 and March 1973 indicated that a significant ($P < 0.01$) change in ratios of marked to unmarked cottontails occurred (Table 6). The ratio of cottontails marked with colored vinyl-plastic to unmarked cottontails declined from 3.90:1 in September 1972, to 0.20:1 in January 1973 (Table 6). This change could have been caused by increased mortality of marked animals, egress of marked animals, ingress of unmarked animals, a loss of marks by cottontail rabbits, or a combination of all of these factors. Restricted movements of mountain cottontails (Tables 4 and 5) suggested that significant ingress and egress on the study area was unlikely. Because the habitat of the study area was homogeneous with that of surrounding areas, there probably were no pressures to cause ingress or egress of cottontails. The loss of marks was probably not a significant factor causing the change in ratios. Only 1 cottontail rabbit of 12 marked in 1972 and recaptured in 1973 had lost both eartags, and only 3 of 12 had lost one eartag. These data suggested that differential mortality of marked individuals may have been the most significant factor that contributed to the observed change in ratios. The significance of these additional losses to the population was not determined. As result of differential mortality,

Table 6. Ratios^a of marked to unmarked cottontails observed during drive censuses from September 1972 through March 1973.

	Marked	Unmarked	Ratio	Total
5 SEPT 1972	31	8	3.90:1	39
13 SEPT 1972	20	6	3.30:1	26
28 OCT 1972	14	9	1.60:1	23
25 NOV 1972	12	10	1.20:1	22
29 DEC 1972	4	1	4.00:1	5
6 JAN 1973	1	3	0.33:1	4
27 JAN 1973	1	5	0.20:1	6
24 FEB 1973	0	5	-----	5
31 MAR 1973	2	1	2.00:1	3

^aSignificantly different ($\underline{P} < 0.005$, $X^2 = 24.81$, d.f. = 8).

cottontails were marked with metal eartags and dyes in 1973. Labisky and Lord (1959), who designed the type of eartag used in 1972, reported no indication of increased mortality among eastern cottontails marked with similar eartags in Illinois.

Vegetative Survey and Habitat Types

Three different habitat types were discernible on an aerial photograph of the study area. Habitat type 1 comprised about 45 acres (18.2 ha) of the study area, was about 2,740 feet (835.36 m) in elevation, and had a flat topography with loam soils. Habitat type 2 consisted of 114 acres (46.1 ha), ranged in elevation from 2,740 to 2,760 feet (835.36 to 841.46 m), and consisted of a mosaic of small lava hummocks and narrow valleys of sandy or loamy soils. Habitat type 3 was about 56 acres (22.6 ha), was at 2,760 feet (841.46 m) elevation, and was situated on tops of lava hummocks and ridges. This area was also flat, the soil was shallow with a large number of stones.

Data obtained through the vegetative survey indicated that two plant associations occurred on the study area (Table A, Appendix).

Of the three habitat types previously described, type 1 and type 3 were determined to be separate plant associations, and type 2 was considered to represent a transition of plant species from type 1 to type 3. This transitional habitat type is thought to be a result of ecotones. Habitat type 1 was named Artemisia tridentata subsp. vaseyana form xericensis (Winward 1970)/Stipa thurberiana. The dominant shrub was big sagebrush (Artemisia tridentata) and the dominant plant was needlegrass (Stipa thurberiana). Habitat type 3

was named Juniperus occidentalis/Artemisia tridentata subsp.

vaseyana form xericensis/Festuca idahoensis/Agropyron spicatum.

Western juniper (Juniperus occidentalis) was the dominant tree, while big sagebrush was the dominant shrub. Idaho fescue (Festuca idahoensis) and bluebunch wheatgrass (Agropyron spicatum) were considered to be the most important grasses on this site. Low frequencies of occurrence of western juniper on all sites resulted from the small size of sample quadrats. Quadrats used were best suited for sampling shrubs and herbaceous plants.

Dispersion in Relation to Habitat Type

Numbers of cottontails observed in the three habitat types did not differ significantly from expected numbers on the basis of the total area of each habitat type ($P > 0.05$, $X^2 = 4.759$, d. f. = 2). However, numbers of cottontails captured in livetraps in the three habitat types in both 1972 and 1973 were significantly different from expected numbers on the basis of total area of each habitat type (Table 7). Mountain cottontails were captured more frequently than expected in habitat types 1 and 2 (low flats and transition areas), and less frequently than expected in type 3 (high flats).

Table 7. Nocturnal and diurnal dispersion of mountain cottontails on the Terrebonne Study Area in 1972 and 1973 on the basis of numbers observed and captured in each habitat type. (Expected numbers in parenthesis).

Year	Time Period	Sampling Method	Habitat		
			Type 1	Type 2	Type 3
1972	Night	Livetrapping	84(65) ^a	168(153) ^a	38(72) ^a
1973	Day	Observation	11(18)	46(46)	29(22)
1973	Night	Livetrapping	46(35) ^b	92(89) ^b	29(43) ^b

^aStatistically different from values expected had rabbits been captured in proportion to the size of the area in each habitat type ($P < 0.05$, $X^2 = 23.37$, d. f. = 2).

^bStatistically different from values expected had rabbits been captured in proportion to the size of the area in each habitat type ($P < 0.05$, $X^2 = 8.32$, d. f. = 2).

Dispersion of cottontails on the study area in relation to habitat type did not change significantly ($P > 0.05$, $X^2 = 1.529$, d. f. = 2) from 1972 to 1973, even though density declined between the years. Because there were no differences between years, numbers of captures for 1972 and 1973 were pooled. There were significant differences in dispersion of cottontails between day and night (Table 8). These differences occurred because cottontails occurred more frequently than expected in habitat type 1 at night and more frequently

than expected in type 3 in the day (Table 8). Habitat type 1 appeared to have less shrubby cover and fewer rocky outcrops which may have caused cottontails to avoid these areas during the day time. Habitat type 3, with more shrubby cover and more extensive rocky outcrops, was probably a preferred day time retreat for mountain cottontails.

Table 8. Nocturnal and diurnal dispersion^a of mountain cottontails on the Terrebonne Study Area in 1972 and 1973 on the basis of numbers observed and captured in each habitat type. (Expected numbers in parenthesis).

Time Period	Sampling Method	Habitat		
		Type 1	Type 2	Type 3
Night	Livetrapping	130(119)	260(258)	67(81)
Day	Observation	11(22)	46(48)	29(15)

^aNocturnal dispersion statistically different from diurnal dispersion ($P < 0.05$, $\chi^2 = 22.102$, d. f. = 2).

Criteria for Determining Age

Cottontails for which the approximate age was known were evaluated by three different techniques to determine criteria for estimating age. The oldest juvenile of known age was 177 days and the youngest adult (rabbit born before 1 January of any year) was 383 days. Because of the vast difference in age between juveniles

and adults in the sample, physiological differences between adults and juveniles were distinct. None of 25 cottontails less than 1 year old had ossified epiphyseal cartilages in their humeri, and only 2 had ossified epiphyseal cartilages in their radii and ulnae. All of the seven animals older than 1 year had ossified epiphyseal cartilages in all the bones of the foreleg (Table 9). These results are in complete agreement with criteria presented by Thomsen and Mortensen (1946), Hale (1949), and Petrides (1951). The degree of ossification of the epiphyseal cartilage can be used to separate adult from juvenile mountain cottontails at least through October. Although no mountain cottontails were collected during November and December, separation of juveniles from adults on the basis of ossification of epiphyseal cartilages may be difficult during these months. Wight and Conaway (1962) found that separation of juvenile from adult eastern cottontails in November, December, and January by the degree of ossification of the epiphyseal cartilages was difficult because the epiphyseal cartilages of some juveniles had ossified. Degree of ossification of the epiphyseal cartilage of the foreleg was used to separate adults from juveniles for all rabbits for which age in days was not known. Of these, 5 cottontails were determined to be juveniles, and 21 were determined to be adults (Table 10).

Regression analysis indicated that 91 percent of the observed variation in lens weight is explained by age in days ($R^2 = 0.91$). The

Table 9. Lens weights, degree of ossification of epiphyseal cartilages of forearms, and numbers of adhesion lines in dentaries of mountain cottontails collected from the Terrebonne Study Area, for which the approximate age was known.

Lens Weight ^a (mg)	Ossification of Epiphysis ^b		Number Adhesion Lines	Age in Days
	Humerus	Radius and Ulna		
53	0	0	0	28
88	0	0	0	56
72	0	0	0	60
78	0	0	0	61
91	0	0	-	70
89	0	0	0	74
110	0	0	0	79
100	0	0	0	79
94	-	-	-	87
111	0	0	0	88
102	0	0	0	92
129	0	0	0	94
131	0	C	0	104
92	0	0	0	112
121	0	0	0	121
138	0	0	0	121
148	0	0	0	142
138	0	0	0	148
131	0	0	0	149
129	0	0	0	154
148	0	0	0	154
150	0	C	0	169
150	0	C	0	170
148	0	0	0	171
137	0	0	0	172
131	0	0	0	177
---	C	C	1	383
235	C	C	3	407 ^c
250	C	C	1	407 ^c
220	C	C	1	408 ^c
232	C	C	2	408 ^c
211	-	-	-	411
201	-	C	1	507
225	C	C	1	537
220	C	C	3	780 ^c

^aRegression of lens weight on age in days yielded the relationship $Y = -158.49 + 136.42 \log_{10} X$ with an R^2 value of 0.918.

^b0 = epiphyseal cartilage present C = epiphyseal cartilage ossified

^cMinimum age of mountain cottontails that were originally captured and marked as adults during the study.

Table 10. Lens weights, degree of ossification of epiphyseal cartilages of forearms, and numbers of adhesion lines in dentaries of juvenile and adult mountain cottontails for which age in days was not known.

Lens Weight (mg)	Ossification of Epiphysis ^a		Number Adhesion Lines	Age Class ^b
	Humerus	Radius and Ulna		
131	0	0	0	Juv
136	0	-	0	Juv
100	0	0	0	Juv
118	0	0	0	Juv
142	0	0	1	Juv
200	-	C	0	Adult
240	-	C	2	Adult
188	C	-	1	Adult
225	C	C	2	Adult
191	C	C	1	Adult
204	C	C	1	Adult
262	C	C	1	Adult
245	C	C	1	Adult
202	C	C	1	Adult
238	C	C	1	Adult
208	C	C	1	Adult
252	C	C	3	Adult
222	C	C	1	Adult
242	C	C	1	Adult
178	C	C	1	Adult
220	C	C	2	Adult
204	C	C	1	Adult
---	C	C	2	Adult
189	C	C	0	Adult
204	C	C	0	Adult
181	C	C	1	Adult

^a0 = epiphyseal cartilage present; C = epiphyseal cartilage ossified.

^bOn the basis of ossification of the epiphyseal cartilages of the forearms (Hale 1949).

relationship between age (in days) and lens weights of mountain cottontails is expressed by the equation:

$$Y = -158.49 + 136.42 \log_{10} X \text{ (Figure 7).}$$

All cottontails known to be less than 1 year old had lens weights less than or equal to 150 mg (Tables 9 and 10). Lens weights of cottontails that were at least 1 year old were at least 178 mg (Tables 9 and 10).

The usefulness of the lens technique for determining age of mountain cottontails has not been adequately tested. However, it is probably most useful in determining the approximate ages of juvenile cottontails up to 1 year of age, and separating juvenile from adult mountain cottontails. Wight and Conaway (1962) found the method most useful in determining ages of eastern cottontails during November through January. During those months they found that estimation of age using the ossification of the epiphyseal cartilage disagreed with the lens technique by as much as 48 percent. Only Myers and Gilbert (1968) and Lord (1959) found the lens technique to be useful in determining year classes. Other workers (Rongstad 1966, Hill 1972, Edwards 1962, Friend 1968) considered the technique unreliable for separating year classes of cottontails older than 1 year.

Examination of sectioned dentaries from 31 cottontails for which the approximate age was known indicated that animals that

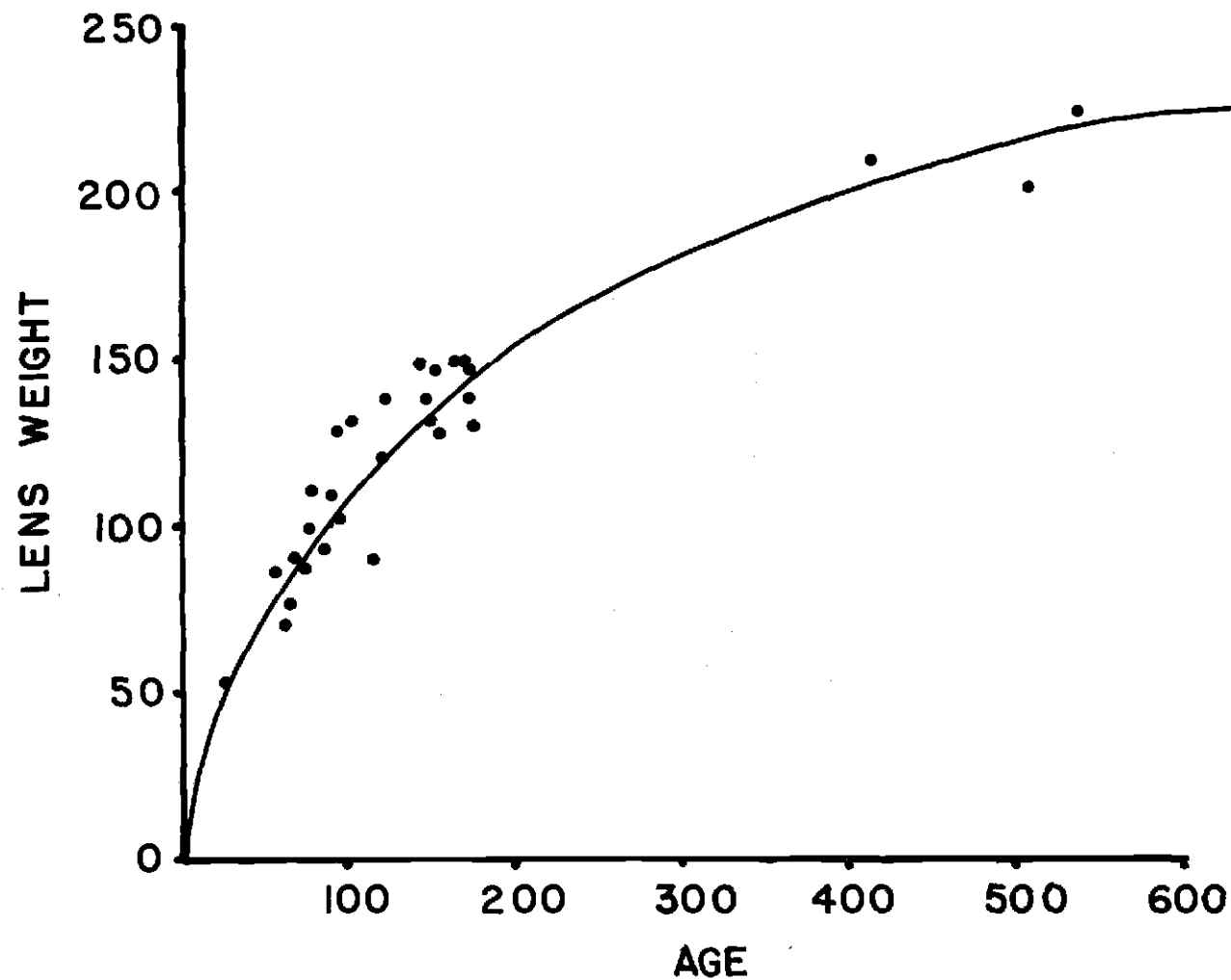


Figure 7. Relationship between weights (mg) of the lens of the eye and age (days) for mountain cottontails for which the approximate age was known. Regression equation relating lens weight to age is $Y = -158.49 + 136.42 \log_{10} X$; where X is age and Y is lens weight.

were less than 1 year old had no "adhesion lines" (dark-staining lines) in the periosteum (Klevezal' and Kleinenberg 1967), while all cottontails older than 1 year had at least one adhesion line (Table 9). There was total agreement in separating adults from juveniles by all methods of determining age. Juvenile mountain cottontails for which the approximate age was known had lens weights of 150 mg or less, unossified epiphyseal cartilages, and had no adhesion lines. Adult cottontails for which approximate age was known had lens weights of at least 178 mg ossified epiphyseal cartilages, and one to three adhesion lines in the periosteum of their dentaries. Three cottontails, marked as juveniles, and collected between the ages of 383 and 537 days had one adhesion line. Four cottontails that were originally captured and marked as adults in 1973 and were collected in September and October 1973 had from one to three adhesion lines. One cottontail marked as an adult in 1972 had three adhesion lines, indicating that the animal was probably 2 years old when first captured. Millar and Zwickel (1972) found that yearling pikas (Ochotona princeps) had one adhesion line in the periosteum of the lower jaw, and that animals known to be 2 or more years old had two or more adhesion lines. Data from both pikas and mountain cottontails suggest that adhesion lines may be formed annually.

Four of five mountain cottontails for which the age in days were unknown, had lens weights less than 150 mg, and unossified

epiphyseal cartilages, also had no adhesion lines in the periosteal bone (Table 10). One animal that had a lens weight less than 150 mg and unossified epiphyseal cartilages indicating that it was a juvenile, had one adhesion line. Three of 21 mountain cottontails for which age in days was not known, but were determined to be adults by other methods, had no adhesion lines. These animals were taken in March and April of 1972 and 1973, a period during which juveniles were separable from adults by size alone. The remaining cottontails for which age in days was unknown, but were determined to be adults on the basis of lens weight and ossification of epiphyseal cartilages, had one to three adhesion lines (Table 10).

The exact time of formation and mechanism of formation of adhesion lines is unknown. The fact that one juvenile collected in September had one adhesion line, and three adults collected in early spring had no adhesion lines suggest that the time of formation may be variable.

I feel that this technique is best applied to estimating the year class of cottontail rabbits. The method is useful for separating juveniles from adults, but it is more difficult to use and is no more reliable for this purpose than the lens technique.

Management Implications

Data collected on the Terrebonne Study Area and presented in this thesis not only provide information about the population ecology of mountain cottontail rabbits that was previously unknown, but provide information basic to managing this game resource. Monthly estimates of density indicate that the number of cottontails on the study area, and the number available for harvest may vary annually. However, there is an exploitable resource during years of both high and low cottontail densities.

First litter groups are born during the latter week in March or first week in April. To determine the number of litters produced per breeding season, three or four adult cottontails should be collected by either trapping or shooting at 27-day intervals from 1 March to 1 July. Examination of female cottontails by necropsy (if shot) or palpation and inspection of mammae and vaginae over the period would provide results that would indicate the number of litters produced during the breeding season.

Amounts of precipitation between 1 September and 30 June could be used to predict annual fluctuations in forage production. This information could be used to predict the survival of juvenile cottontails in the third and fourth litter groups, which combined with information concerning numbers of litter groups produced during the

breeding season could be used to predict the relative number of cottontails available for harvest in the fall.

Monthly estimates of density indicated an 82 percent mortality between 30 August and 15 April. Comparison of monthly estimates of density and minimum daily temperatures indicated that mortality was related to weather conditions. Harvest of this game resource should begin as early as possible, before cottontail rabbit populations are reduced by severe minimum temperatures. Delay in harvest may result in fewer animals available for harvest.

Yeatter and Thompson (1952) suggested that the incidence of tularemia in humans could be minimized if hunting seasons for mountain cottontail rabbits were delayed until after the first 10 freezing nights in autumn. In central Oregon, the period of first frost usually occurs during the third week of September (U. S. Department of Commerce 1972, 1973). If tularemia in mountain cottontails becomes a management consideration, harvest of cottontails in central Oregon probably could be delayed until early October without reducing significantly numbers available for harvest.

LITERATURE CITED

- Bailey, N. T. J. 1952. Improvements in the interpretation of recapture data. *J. Anim. Ecol.* 21:120-127.
- Bailey, V. 1936. The mammals and life zones of Oregon. U. S. Dept. Agr., N. Am. Fauna 55. 416 pp.
- Chapman, D. G., and R. A. Schaufele. 1970. Elementary probability models and statistical inference. Ginn and Co. Waltham, Massachusetts. 358 pp.
- Chapman, J. A., and D. E. C. Trethewey. 1972. Movements within a population of introduced eastern cottontails. *J. Wildl. Manage.* 36(1):155-158.
- Dice, L. E. 1926. Notes on Pacific coast rabbits and pikas. Univ. of Michigan Museum of Zool. Occasional Papers 166. 28 pp.
- Eberhardt, L., T. J. Peterle, and R. Schofield. 1963. Problems in a rabbit population study. *Wildl. Monog.* 10. 51 pp.
- Edwards, W. R. 1962. Age structures of Ohio cottontail populations from weights of lenses. *J. Wildl. Manage.* 13(2):216-225.
- _____. 1967. Tables for estimating ages and birth dates of cottontail rabbits with suggestions for handling lenses. *Illinois Nat. Hist. Surv. Biol. Notes* 59. 4 pp.
- _____, and L. Eberhardt. 1967. Estimating cottontail abundance from livetrapping data. *J. Wildl. Manage.* 31(1):87-96.
- Fitch, H. S. 1947. Ecology of the cottontail rabbit (*Sylvilagus auduboni*) in central California. *California Fish and Game.* 33(3):159-184.
- Friend, M. W. 1968. The lens technique. *Trans. N. Am. Wildl. and Nat. Resource Conf.* 33:279-298.
- Hale, J. B. 1949. Aging cottontail rabbits by bone growth. *J. Wildl. Manage.* 13(2):216-225.
- Hall, E. R., and K. Kelson. 1959. The mammals of North America. Vol. 1. The Ronald Press Company, New York. 546 + 79 index pages.

- Haugen, A. O. 1942. Home range of the cottontail rabbit. *Ecology* 23(3):354-367.
- Hill, E. P. 1972. The cottontail rabbit in Alabama. *Alabama Agr. Exp. Sta. Bull.* 440. 103 pp.
- Huber, J. J. 1962. Trap response of confined cottontail populations. *J. Wildl. Manage.* 26(2):177-185.
- Hughes, R., and I. Rowley. 1966. Breeding season of female wild rabbits in natural populations in the Riverina and southern tablelands districts of New South Wales. *C.S.I.R.O. Wildl. Research.* 11(1):1-10.
- Humason, G. L. 1967. Animal tissue techniques. 2nd ed. W. H. Freeman and Company, San Francisco. 569 pp.
- Ingles, L. G. 1941. Natural history observations on the Audubon cottontail. *J. Mammal.* 22(3):227-250.
- Janes, D. W. 1959. Home range and movements of the eastern cottontail in Kansas. *University of Kansas Museum Nat. Hist. Publ.* 10(7):553-572.
- Janson, R. G. 1946. A survey of the native rabbits of Utah with reference to their classification, distribution, life histories and ecology. M.S. thesis. *Utah State Agr. Coll.* 103 pp.
- Klevezal', G. A., and S. E. Kleinenberg. 1967. Age determination of mammals from annual layers in teeth and bones. *Israel Program for Sci. Transl., U. S. Dept. of the Interior and National Sci. Foundation.* 128 pp. (Translated from Russian 1969).
- Labisky, R. F., and R. D. Lord, Jr. 1959. A flexible plastic eartag for rabbits. *J. Wildl. Manage.* 23(3):363-365.
- Lord, R. D., Jr. 1959. The lens as an indicator of age in cottontail rabbits. *J. Wildl. Manage.* 23(3):358-360.
- _____. 1963. The cottontail rabbit in Illinois. *Illinois Dept. Conserv. Tech. Bull.* 3. 94 pp.
- Meslow, E. C., and L. B. Keith. 1968. Demographic parameters of a snowshoe hare population. *J. Wildl. Manage.* 32(4):812-834.

- Meslow, E. C., and L. B. Keith. 1971. A correlation analysis of weather versus snowshoe hare population parameters. *J. Wildl. Manage.* 35(1):1-15.
- Millar, J. S., and F. C. Zwickel. 1972. Determination of age, age structure, and mortality of the pika, Ochotona princeps (Richardson). *Can. J. Zool.* 50(2):229-232.
- Mossman, A. S. 1955. Reproduction of the brush rabbit in California. *J. Wildl. Manage.* 19(2):77-184.
- Myers, K., and N. Gilbert. 1968. Determination of age of wild rabbits in Australia. *J. Wildl. Manage.* 32(4):841-849.
- Petersen, C. G. J. 1896. The yearly immigration of young plaice into the Limfjord from the German Sea. *Rept. Danish Biol. Sta. for 1895.* 6:1-77.
- Petrides, G. A. 1951. The determination of sex and age ratios in the cottontail rabbit. *Am. Midl. Nat.* 46(2):312-336.
- Powers, R. A., and B. J. Verts. 1971. Reproduction in the mountain cottontail rabbit in Oregon. *J. Wildl. Manage.* 35(4):605-613.
- Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fisheries Research Board of Canada Bull. 119. 300 pp.
- Rongstad, O. J. 1966. A cottontail rabbit lens-growth curve from southern Wisconsin. *J. Wildl. Manage.* 30(1):114-121.
- _____. 1969. Gross prenatal development of cottontail rabbits. *J. Wildl. Manage.* 33(1):164-168.
- Sheffer, D. E. 1958. Rabbit propagation experiment. *Maryland Conservationist.* 35(3):6-8.
- Sneva, F. A., and D. N. Hyder. 1962. Forecasting range herbage production in eastern Oregon. *Oregon Agr. Exp. Sta. Bull.* 588. 11 pp.
- Thomsen, H. P., and O. A. Mortensen. 1946. Bone growth as an age criterion in the cottontail rabbit. *J. Wildl. Manage.* 10(2):171-174.

- Toll, J. E., T. S. Baskett, and C. H. Conaway. 1960. Home range, reproduction, and food of the swamp rabbit in Missouri. *Am. Midl. Nat.* 63(2):398-412.
- Trethewey, D. E. C., and B. J. Verts. 1971. Reproduction in eastern cottontail rabbits in western Oregon. *Am. Midl. Nat.* 86(2):463-476.
- U. S. Department of Commerce. 1971. Climatological data, Oregon. *Annual Summary.* 77(13):251-265.
- _____. 1972. Climatological data, Oregon. August. 78(8):155-174.
- _____. 1972. Climatological data, Oregon. September. 78(9):175-194.
- _____. 1972. Climatological data, Oregon. October. 78(10):195-214.
- _____. 1972. Climatological data, Oregon. November. 78(11):215-234.
- _____. 1972. Climatological data, Oregon. December. 78(12):235-258.
- _____. 1972. Climatological data, Oregon. Annual Summary. 78(13):260-274.
- _____. 1973. Climatological data, Oregon. January. 79(1):1-28.
- _____. 1973. Climatological data, Oregon. August. 79(8):1-26.
- _____. 1973. Climatological data, Oregon. September. 79(9):1-28.
- _____. 1973. Climatological data, Oregon. October. 79(10):1-28.
- _____. 1973. Climatological data, Oregon. November. 79(11):1-28.
- _____. 1973. Climatological data, Oregon. December. 79(12):1-34.

- U. S. Department of Commerce. 1974. Climatological data, Oregon. January. 80(1):1-28.
- Wight, H. M., and C. H. Conaway. 1962. A comparison of methods for determining age of cottontails. J. Wildl. Manage. 26(2): 160-163.
- Winward, A. H. 1970. Taxonomic and ecological relationship of the big sagebrush complex in Idaho. Univ. of Idaho. Ph. D. thesis. 80 pp.
- Yeatter, R. E., and D. Thompson. 1952. Tularemia weather, and rabbit populations. Illinois Nat. Hist. Surv. Bull. 25(6):351-382.

APPENDIX

Table A. Vegetative association table showing species that occurred in each habitat type. Habitat type 1 is considered to be an Artemisia tridentata, subsp. vaseyana, form xericensis/Stipa thurberiana association. Habitat type 2 is a mosaic of vegetative species found in habitat types 1 and 3, but is not considered a distinct plant association. Habitat 3 is an Juniperus occidentalis/Artemisia tridentata, subsp. vaseyana, form xericensis/Festuca idahoensis/Agropyron spicatum association. Numbers indicate the frequency in which species occurred in sample plots.

Species	Type 1 Transect Number										Type 2 Transect Number										Type 3 Transect Number									
	9	7	3	5	4	6	8	10	1	2	1	3	6	7	8	10	2	4	5	9	7	8	2	1	3	5	6	9	10	4
<u>Bromus tectorum</u>	40	20	40	70	70	50	10	40	30	60	90	70	70	70	100	70	90	60	60	70	100	80	70	70	80	60	100	100	100	80
<u>Stipa thurberiana</u>	10	20		10	20	20	30	20	20	30	10	20	20	40	20	40	50	40	20	60	30	20			20					
<u>Sitanion hystrix</u>	10	60	10	10	10	20	40	10	30	30	10	10	10	20	20	40	10				10	20				10				
<u>Poa secunda</u>							10															20	10	30		10	10			
<u>Agropyron spicatum</u>																						10	20	10			20	20	10	
<u>Festuca idahoensis</u>											10					20		10			10	10	20							
<u>Agropyron dasystachum</u>											30	20	10									10								
<u>Poa cusichii</u>																								20	20					
<u>Chrysothamnus viscidiflorus</u>	20	20	50	30	40	10	20	30	30	40	50	70	20	40	30	30	20	10	10	40	10	10			10	20				
<u>Artemisia tridentata</u>	20	30	20	30	10	10	10	30				10	10	10	20								30	40	10		10	20	10	10
<u>Chrysothamnus nauseosus</u>	10					10										10							10	20						
<u>Juniperus occidentalis</u>		10											10								10		10							
<u>Purshia tridentata</u>												10											10				10			
<u>Leptodactylon pungens</u>																							10							
<u>Eriogonum vimineum</u>	20	10			20	10	10		10	20	10											20			10					
<u>Mentzelia albicaulis</u>												20	30	20	30	10	10	30	10	10	10									
<u>Sisymbrium altissimum</u>				10																										

Table B. Total numbers of cottontails, numbers of new cottontails, numbers of recaptures, and numbers of trap-mortalities recorded daily during 1-30 August 1972 on the Terrebonne Study Area.

Date	Total Captures	Marked (New)	Recaptures	Trap Mortalities ^c
1	15	15	0	0
2	16	14	2	0
3	15	10	5	0
4	14	7	7	2 ^{a, b}
5	13	6	7	0
6	9	4	5	1 ^a
7	9	6	3	1 ^a
8	9	4	5	0
9	5	3	2	0
10	10	5	5	0
11	11	2	9	0
12	15	4	11	1 ^b
13	21	12	9	2 ^{a, b}
14	13	3	10	0
15	10	2	8	0
16	9	5	4	1 ^b
17	9	1	8	1 ^b
18	10	2	8	0
19	10	3	7	1 ^b
20	11	4	7	0
21	7	1	6	0
22	7	4	3	0
23	11	2	9	0
24	3	0	3	0
25	5	1	4	0
26	6	1	5	1 ^b
27	6	0	6	0
28	3	1	2	0
29	5	1	4	0
30	4	1	3	0

^a Mortality occurred as a new animal.

^b Mortality was a recaptured animal.

^c Trap mortalities are considered in data as any other capture.

Table C. Total numbers of cottontails, numbers of new cottontails, numbers of recaptures, and numbers of trap-mortalities recorded daily during 1-30 August 1973 on the Terrebonne Study Area.

Date	Total Captures	Marked (New)	Recaptures	Trap Mortalities ^b
1	5	5	0	0
2	3	2	1	0
3	3	1	2	0
4	2	1	1	0
5	3	2	1	0
6	3	2	1	0
7	4	2	2 ^a	1
8	4	2	2	0
9	2	1	1	0
10	3	1	2	0
11	1	0	1	0
12	0	0	0	0
13	1	0	1	0
14	2	0	2	0
15	2	1	1 ^a	1
16	2	2	0	0
17	2	0	2	0
18	6	2	4	0
19	2	0	2	0
20	6	3	3	0
21	1	0	1	0
22	2	0	2	0
23	2	0	2	0
24	0	0	0	0
25	2	0	2	0
26	1	0	1	0
27	1	1	0	0
28	2	1	1	0
29	4	3	1	0
30	1	0	1	0

^a—Mortality was a recaptured animal.

^b—Trap mortalities are considered in data as any other capture.

Table D. Number of individual cottontails captured in each age class from April through August 1973 on the Terrebonne Study Area.

Month	Age Class			
	Adult	1st litter	2nd litter	3rd litter
APR	16	0	0	0
MAY	4	7	3	0
JUNE	5	5	4	1
JULY	4	7	14	5
AUG	3	12	12	5

Table E. Amounts of precipitation from September to August recorded at Redmond, Oregon (U. S. Department of Commerce 1971, 1972, 1973) 7 miles (11.27 km) from the Terrebonne Study Area.

Month	1971-1972		1972-1973	
	Inches	Centimeters	Inches	Centimeters
SEPT	0.37	0.94	0.24	0.61
OCT	0.30	0.76	0.60	1.52
NOV	0.66	1.68	0.21	0.53
DEC	0.96	2.44	1.02	2.59
JAN	1.15	2.92	0.59	1.50
FEB	0.35	0.89	0.54	1.37
MAR	1.38	3.51	0.20	0.51
APR	0.19	0.48	0.11	0.28
MAY	0.94	2.39	1.18	3.00
JUNE	1.60	4.07	0.02	0.05
JULY	0.08	0.20	0.00	0.00
AUG	0.22	0.56	0.06	0.15
Total	8.20	20.84	4.77	12.11