THESIS

# DISPERSION AND DISPERSAL OF WHITE-TAILED AND BLACK-TAILED JACKRABBITS, PAWNEE NATIONAL GRASSLANDS


Submitted by

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## ABSTRACT OF THESIS


DISPERSION AND DISPERSAL OF WHITE-TAILED AND BLACK-TAILED JACKRABBITS, PAWNEE NATIONAL GRASSLANDS

Movements and densities of black-tailed (Lepus californicus) and white-tailed jackrabbits (L. townsendii) were measured on the Pawnee National Grasslands, Colorado, in 1970 and 1971. Areas occupied, rates of movement and distances moved were used as indices of jackrabbit activity. Vegetative types and sampling by drive plots provided area bases for density estimates. White-tails exhibited larger activity indices than black-tails. Significant changes in index sizes and preferences for cattle-grazed pastures occurred during April. Black-tailed jackrabbit densities were proportional to shrub density. White-tail densities were inversely proportional to shrub density. Seasonal fluctuations in density were greater for black-tails. Black-tailed jackrabbits occupied the entire study area while white-tails occupied specific areas. Avian and mammalian predators accounted for most known mortality of marked jackrabbits.



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# INTRODUCTION

This study, with information from simultaneous studies on reproduction, food habits and nutrition, was to help evaluate the functions of black-tailed (Lepus californicus) and white-tailed (L. townsendii) jackrabbits in the grassland ecosystem. Jackrabbits are medium-size primary consumers in ecosystems throughout the central and western United States (Hall and Kelson 1959). These primary consumers experience periodic and occasionally dramatic population fluctuations. They exhibit substantial changes in biomass and potential rate of energy flow between trophic levels.

The jackrabbits' role in the ecosystem is primarily dependent on their distribution and abundance. The objectives of this 2-year study were to: (1) measure daily, seasonal and annual areas of occupation for individuals; (2) estimate population densities in selected areas. Black-tailed and white-tailed jackrabbit ranges were sympatric on the study area, therefore a direct comparison was possible between the two species. To my knowledge, a study of this type has not been reported in the literature.

# STUDY AREA

## Location

The area chosen for this investigation covered 2784 ha (10.75 sq. miles) of the Central Plains Experimental Range (Fig. 1). The study area included the International Biological Program, Grassland Biome intensive study site (hereafter referred to as the Pawnee Site, 777 ha). The Central Plains Experimental Range lies at the western edge of the Pawnee National Grassland. The Agricultural Research Service, United States Department of Agriculture, administers the Range and is headquartered 19 km (12 miles) northeast of Nunn, Colorado, and 40 km (25 miles) southeast of Cheyenne, Wyoming. The Range covers 6682 ha (25.8 sq. miles) of native shortgrass prairie. Of this area, 5828 ha (22.5 sq. miles) is public land and 855 ha (3.3 sq. miles) is privately owned.

## Abiotic Features

The study area is characterized by gentle rolling topography with clay to sandy-loam soil types (Klipple and Costello 1960). Average elevation is approximately 1646.3 m (5400 ft) with a few hills as high as 1684.4 m (5525 ft) and runoff channels as low as 1621.9 m (5320 ft). Climate of the area is semi-arid with 25-38 cm (10 - 15 in) of annual precipitation. Most moisture (about 80 percent) occurs during the

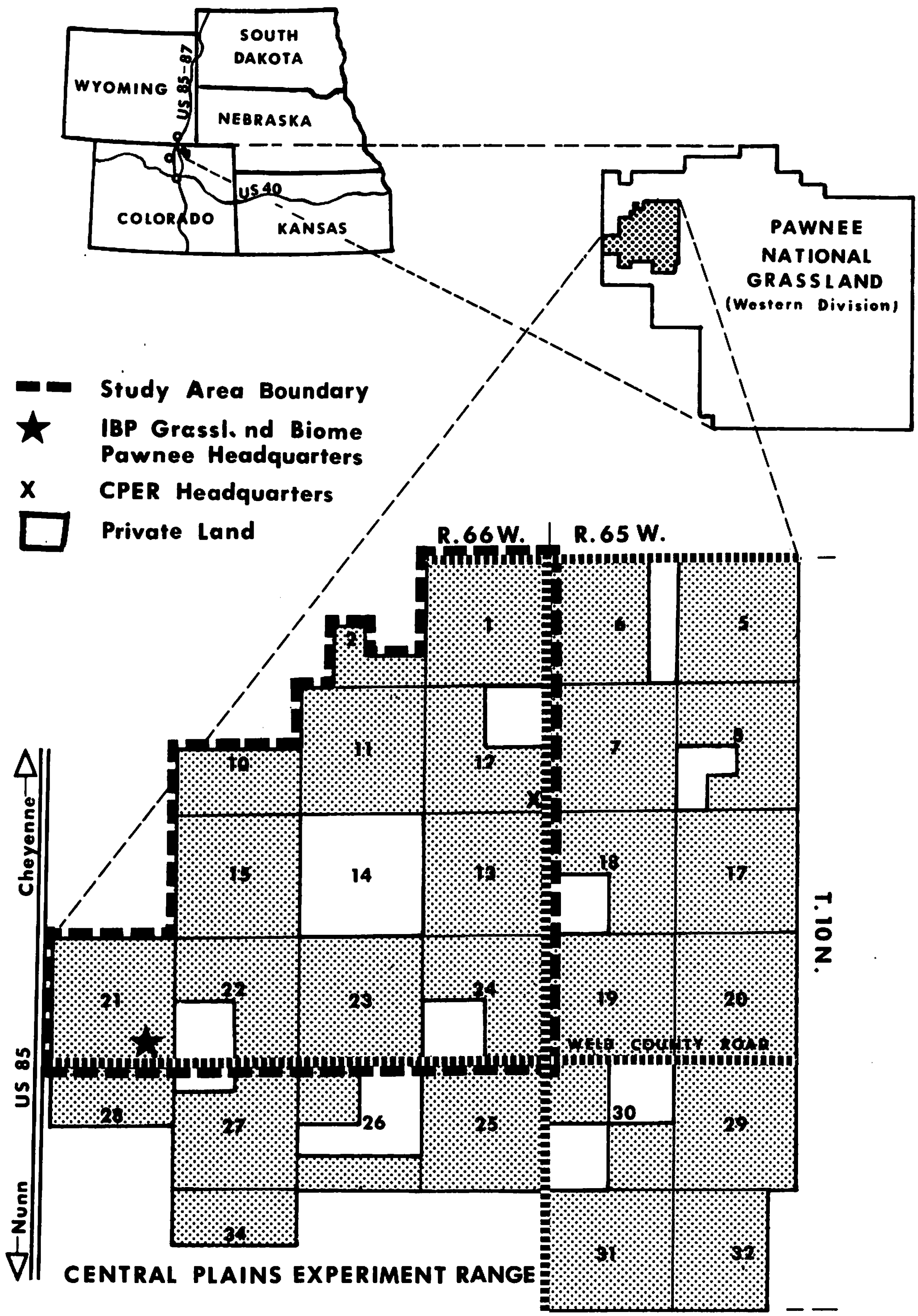



Figure 1. Geographic and administrative location of the jackrabbit study area.

vegetative growing season (166 days in 1970 and 204 days in 1971) in the form of summer showers and thunderstorms. Ambient air temperatures average a maximum of 4.4 C (40 F) and minimum of -12.2 C (10 F) for January, and a maximum of 29.4 C (85 F) and a minimum of 12.7 C (55 F) for July, the coldest and warmest months respectively. The average change in temperature between consecutive months is 4.6 $\pm$ 2.0 C (8.4 $\pm$ 3.6 F). (R. E. Bement, unpublished data)

## Biotic Features

### Floral associations

The native shortgrass prairie is primarily blue grama grass (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). Associated species are: red threeawn grass (*Aristida longiseta*); western wheatgrass (*Agropyron smithii*); summer cypress (*Kochia scoparia*); scarlet globemallow (*Sphaeralcea coccinea*); tumbling russian thistle (*Salsola kali*); rubber rabbitbrush (*Chrysothamnus nauseosus*); fringed sagewort (*Artemisia frigida*); broom snakeweed (*Gutirrezia sarothrae*); four-wing saltbush (*Atriplex canescens*); and plains prickly pear cactus (*Opuntia polycantha*) (Flinders and Hansen, in press).

Vegetative types were designated using the standard Interagency Big Game Range Analysis technique (United States Forest Service 1962). Four-wing saltbush is conspicuous in the vegetation and is of sufficient density that its spatial distribution may be described without meticulous measurements (Fig. 2). Topography appears to be an important ecological factor affecting its distribution. Ground cover by four-wing saltbush is sufficient in bottomlands to be classified a four-wing saltbush vegetative type (13-Atca). Scarcity of the shrub on uplands is reflected in their classification as a blue grama-buffalograss type (1-Bogr-Buda). Intermediate elevations were a transitional zone and were classified a saltbush-grass mixture type (16-Atca-Chna-Kosc).

Owl Creek (intermittent stream) traverses the study area. Its bottom is sand and gravel, barren of vegetation (vegetative type 8). A small portion (17 ha) of private land has been reseeded with western wheatgrass (18-Agsm).

The Agricultural Research Service has designated pastures within the study area for long-term experiments with cattle-grazing. These pastures have been grazed by cattle at different intensities and schedules (Fig. 3). Adjacent prairie has been moderately grazed by cattle in summer months.

The International Biological Program selected three of these pastures for intensive study and experimentation. Each pasture has had summer cattle grazing at different intensities, i. e. lightly grazed (section 23 W), moderately grazed (section 15 E), and heavily grazed (section 23 E). The percentages of standing crop of vegetation removed by grazing have been 20 percent (light), 40 percent (moderate), and 60 percent (heavy) on the three pastures, respectively (Mitchell 1971).

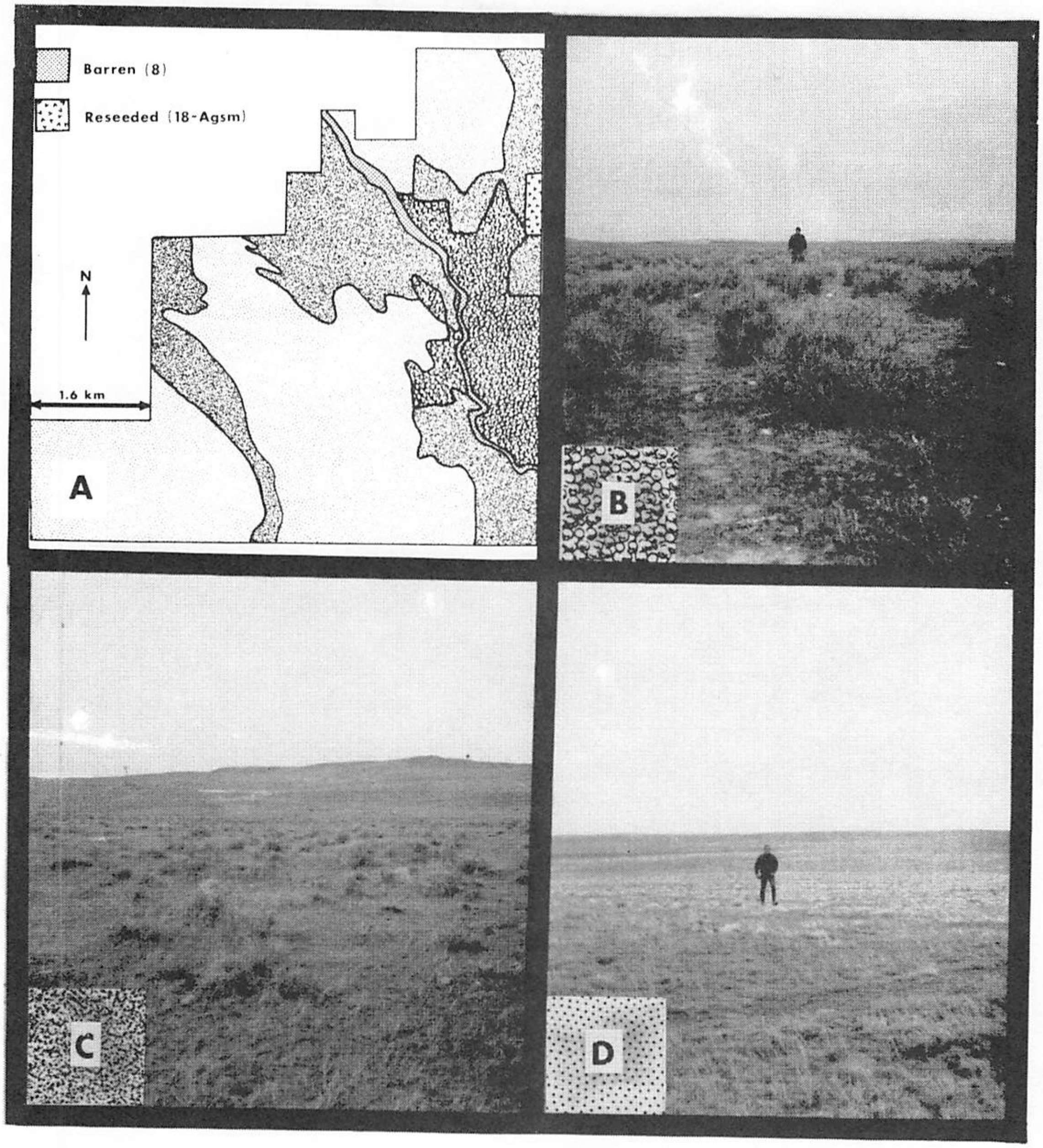
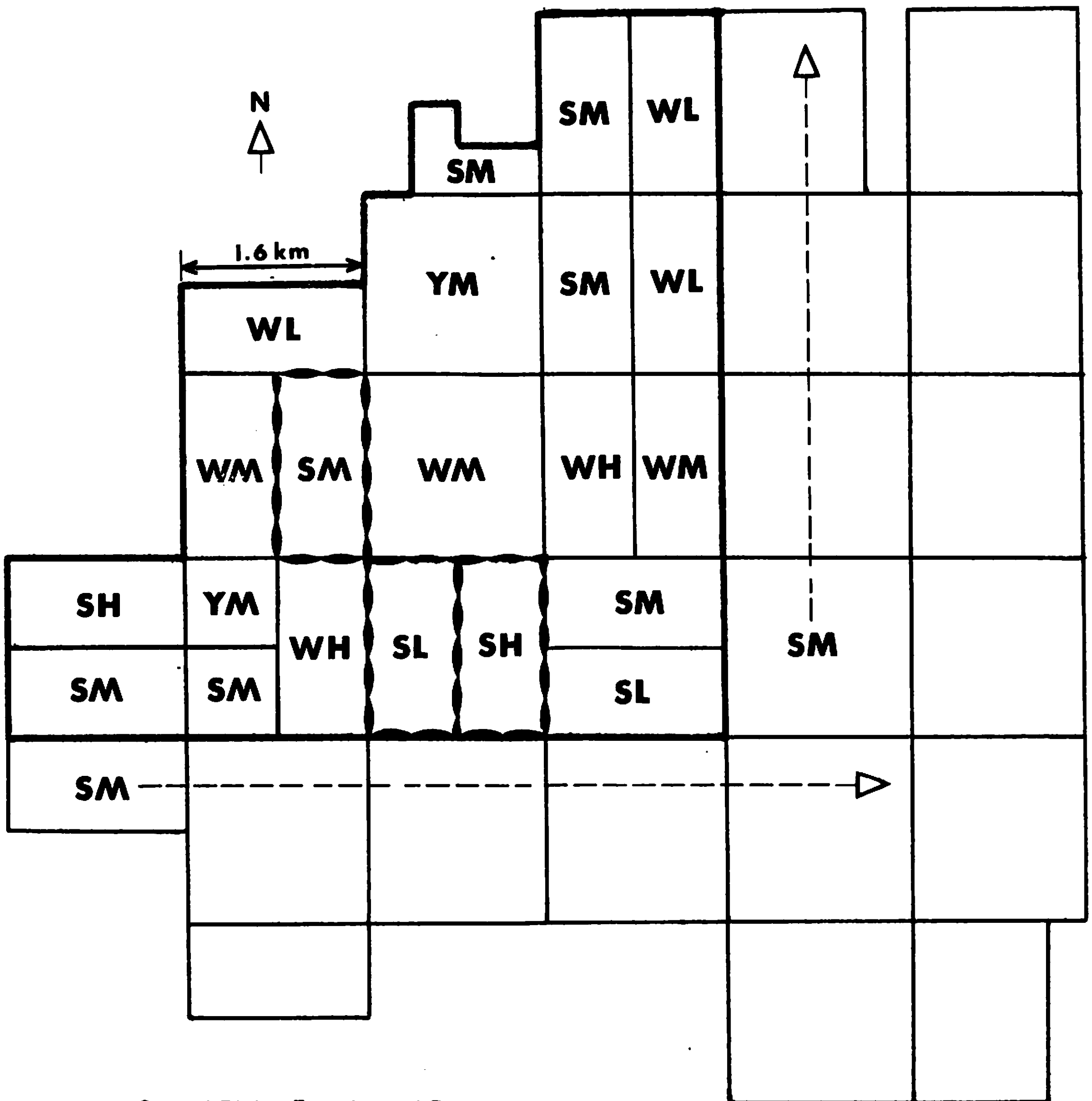



Figure 2. (A) Spatial distribution of vegetative types; (B) four-wing saltbush type (13-Atca); (C) saltbush-grass type (16-Atca-Chna-Kosc); (D) blue grama-buffalograss type (1-Bogr-Buda).




Central Plains Experimental Range

Jackrabbit Study Area Boundary

IBP Intensive Study Pastures

| Grazing Schedule | Grazing Intensity |
|---|---|
| **S** — Summer | **L** — Light |
| **W** — Winter | **M** — Moderate |
| **Y** — Yearlong | **H** — Heavy |

Figure 3. Pastures grazed by cattle at various schedules and intensities.

Vegetative cover in these pastures is characterized by 5, 1 and 0.01 percent shrubs (*Atriplex* spp., *Chrysothamnus* spp., *Guterrezia* spp., and *Artemisia* spp.) and 4.5, 2.7 and 0.2 percent bunchgrass (*Aristida* spp. and *Stipa* spp.) on the lightly-, moderately- and heavily-grazed pastures, respectively (D. H. Knight, unpublished data). Prickly pear cactus biomass is relatively homogeneous among pastures. But, it occurs in the greatest number of clumps in the lightly-grazed pasture, with irregular frequency and size in the moderately-grazed pasture, and in the largest clumps and least frequency in the heavily-grazed pasture (H. G. Fisser, unpublished data).

No cultivated crops were grown in the area studied although several cultivated fields lie within 1 km of the study-area boundary. Crops grown vary from season to season but usually include winter-wheat (*Triticum aestivum*), crested wheatgrass (*Agropyron cristatum*), alfalfa (*Medicago sativa*), and oats (*Avena sativa*).

## Faunal associations

The desert cottontail (*Sylvilagus audobonii*) and eastern cottontail (*S. floridanus*) are the only other lagomorphs known on the study area (from trap results). The more abundant associated rodent species are the deer mouse (*Peromyscus maniculatus*), northern grasshopper mouse (*Onychomys leucogaster*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), Ord's kangaroo rat (*Dipodomys ordii*), and the northern pocket gopher (*Thomomys talpoides*).

Diurnal avian predators, in decreasing order of abundance, include the golden eagle (Aguila chrysaetos), rough-legged hawk (Buteo lagopus), marsh hawk (Circus cyaneus), red-tailed hawk (Buteo jamaicensis), Swainson's hawk (B. swainsoni), and ferruginous hawk (B. regalis) (R. A. Ryder, unpublished data). Golden eagles, marsh hawks and ferruginous hawks are year-round residents but their abundance changes seasonally on the study area. Rough-legged hawks are primarily winter residents. Red-tailed hawks and Swainson's hawks are primarily summer residents. The only noctural avian predator of possible significance to jackrabbits through predation is the great horned owl (Bubo virginianus).

The chief mammalian predator was the coyote (Canus latrans). Bobcats (Lynx rufus) and red foxes (Vulpes vulpes) may occur on the study area although none were seen by the jackrabbit research team during this study. Badgers (Taxidea taxus) and striped skunks (Mephitis mephitis) were common and probably fed on jackrabbits, mostly as carrion.

Many species of small avian consumers occupied the study area. Among the more dominant species were: lark bunting (Calamospiza melanocorys), horned lark (Eremophila alpestris), western meadowlark (Sturnella neglecta), McCown's longspur (Rhynchophanes mccownii), mountain plover (Eupoda montana), mourning dove (Zenaidura macroura), loggerhead shrike (Lanius ludovicianus) and Brewer's sparrow (Spizella breweri).

# METHODS

## Study Design

The International Biological Program, Grassland Biome, and Agricultural Research Service made available extensive and simultaneously collected information on many abiotic and biotic factors in the grasslands environment. This information provided a unique opportunity to view the objectives of this study as a system. The experimental-component-analysis approach suggested by others (Holling 1966, Gross 1970) was adopted for analysis and decision making in this study.

System components were mapped (Figs. 4, 5 and 6) to indicate factors significant to jackrabbits during their life cycle (Odum 1959, Mason and Langenheim 1957). The system charts were structured using parameters that could be measured with reasonable accuracy in real-world populations. Components for which significant information was available are indicated. Other components were included in recognition of their possible importance but data were not available. The results section of this study follows the flow of components in Figs. 4, 5 and 6.

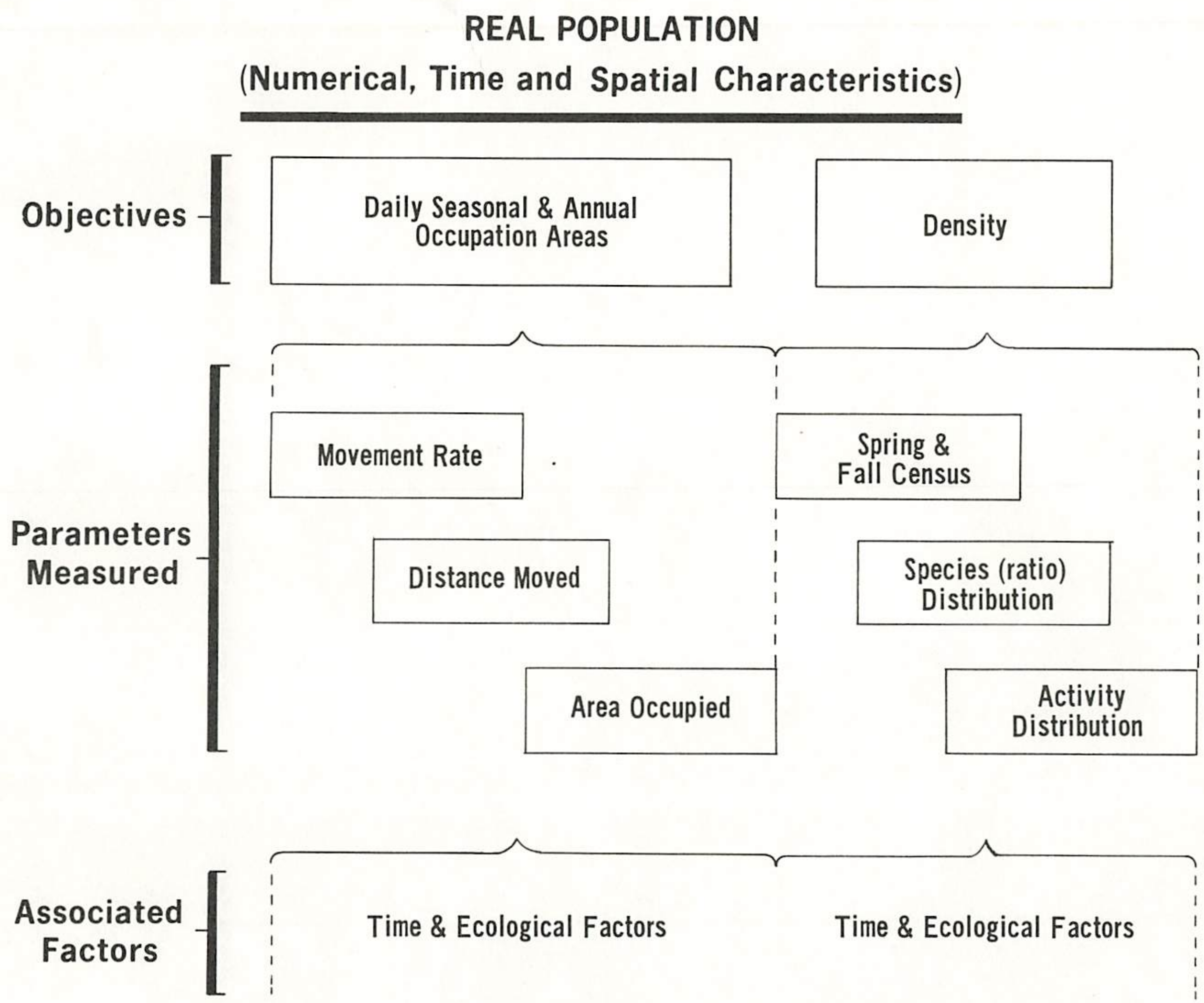



Figure 4. A suggested system component macro-chart for studying numerical, time and spatial characteristics of a real jackrabbit population.

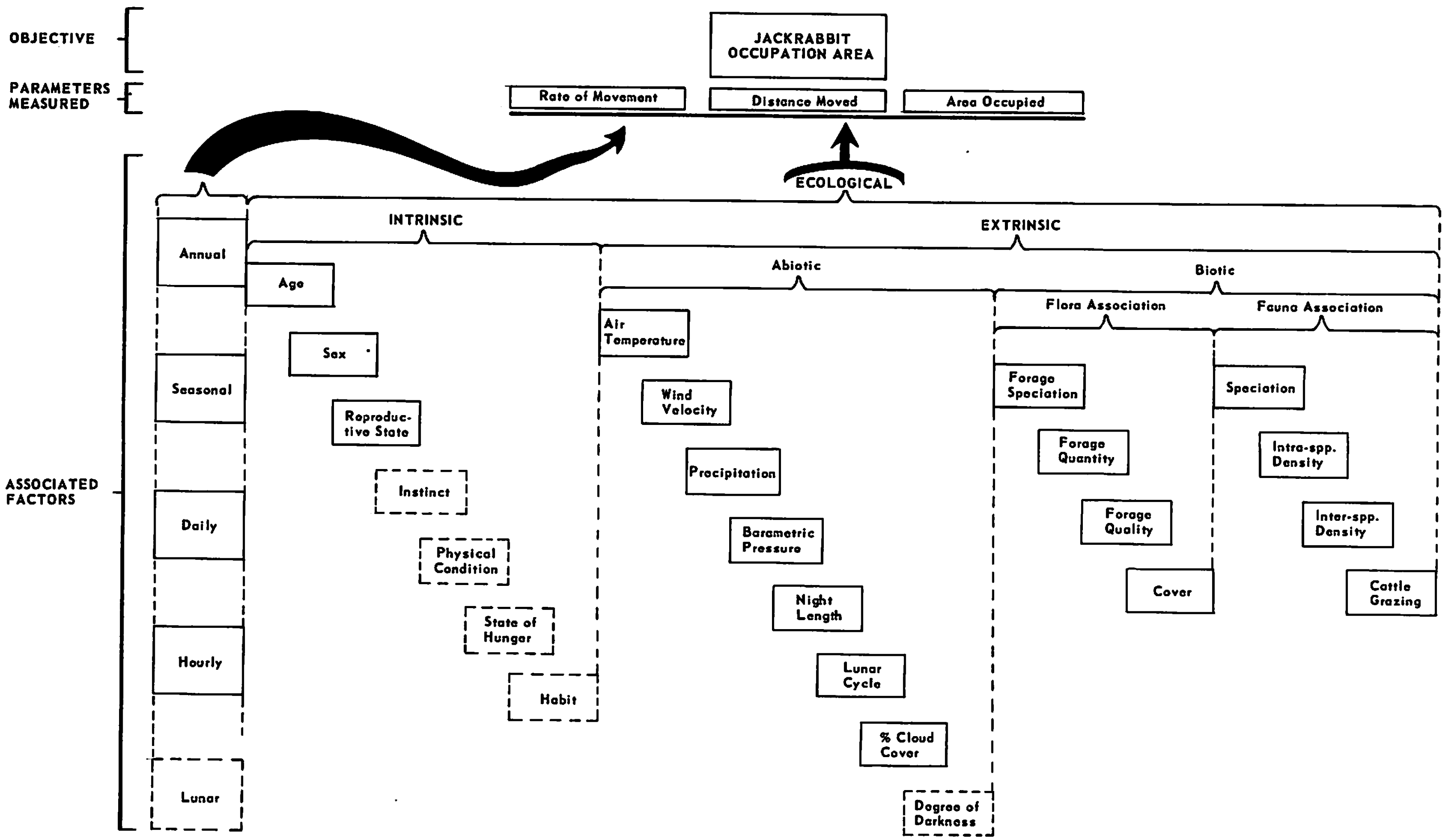



Figure 5. A system component micro-chart of jackrabbit occupation areas. Dashed boxes enclose components for which there was insufficient information for analysis.

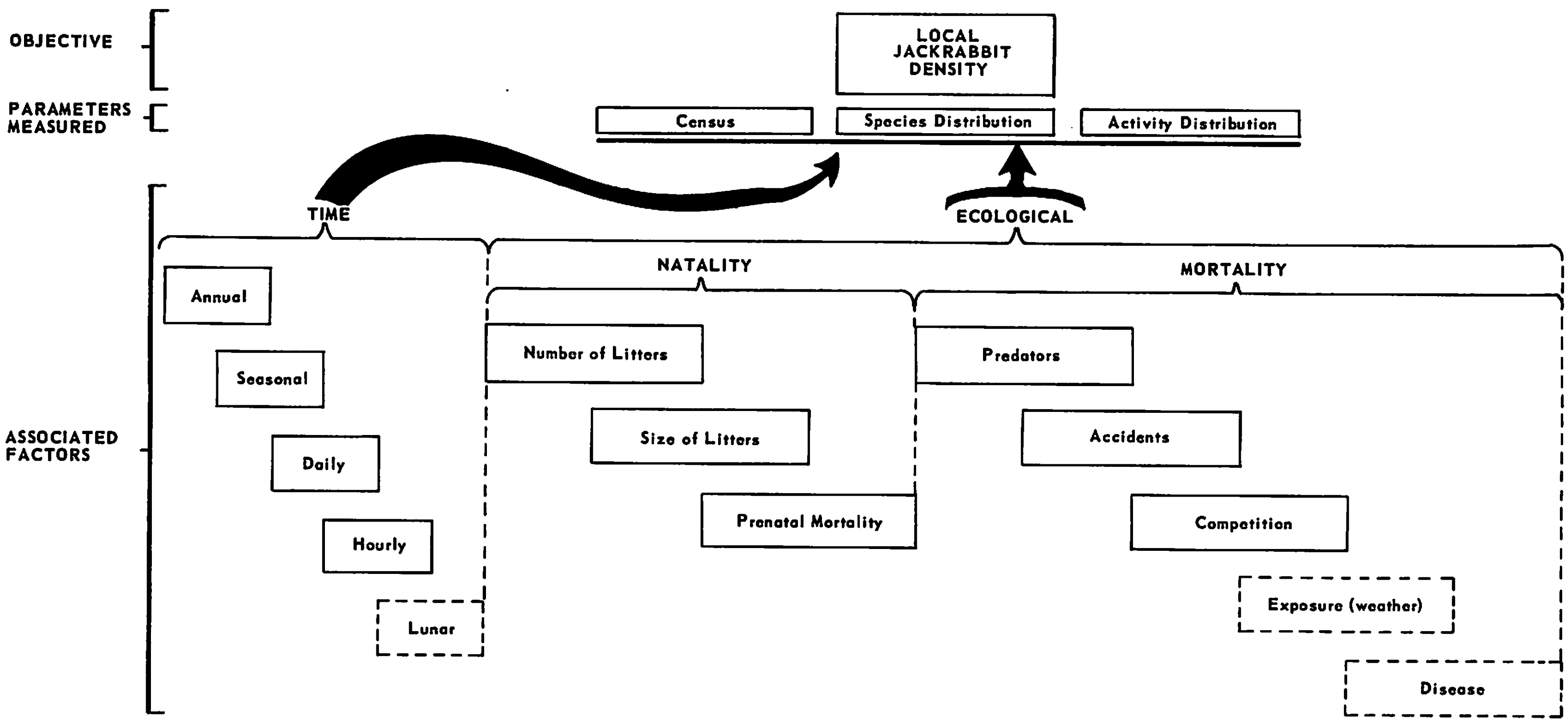



Figure 6. A system component micro-chart of local jackrabbit density. Dashed boxes enclose components for which there was insufficient information for analysis.

## Field Mechanics

### Trapping

Jackrabbits were live-trapped and released on the study area. Ninety wire cage-like traps were checked daily from February through September 1970, for 2-week trap periods each month from October 1970 through May 1971, and from June through September 1971. Seventy-three traps were spaced 0.4 km (0.25 mile) apart in a grid pattern on the Pawnee Site from June 1970 through June 1971 (Fig. 7). Seventeen traps were set over the remainder of the study area where they were expected to have the best chance to catch jackrabbits.

Dry ear corn was consistently the most successful bait for attracting jackrabbits. Other baits (alfalfa hay, fresh alfalfa, pelletized alfalfa, commercial rabbit pellets, fresh apples and other fruits and vegetables) gave unreliable trap success.

Multiple-recapture methods were not used to estimate population densities because assumptions necessary for these methods were not met. The study area did not constitute a closed system, therefore, movements of hares in and out could seriously bias results. All jackrabbits did not appear to have an equal probability of being trapped. Low trap success and variation of trap response as affected by weather, season, sex, age and habitat may not accurately reflect population structures (Bailey 1969). Also, interferences with traps by rodents

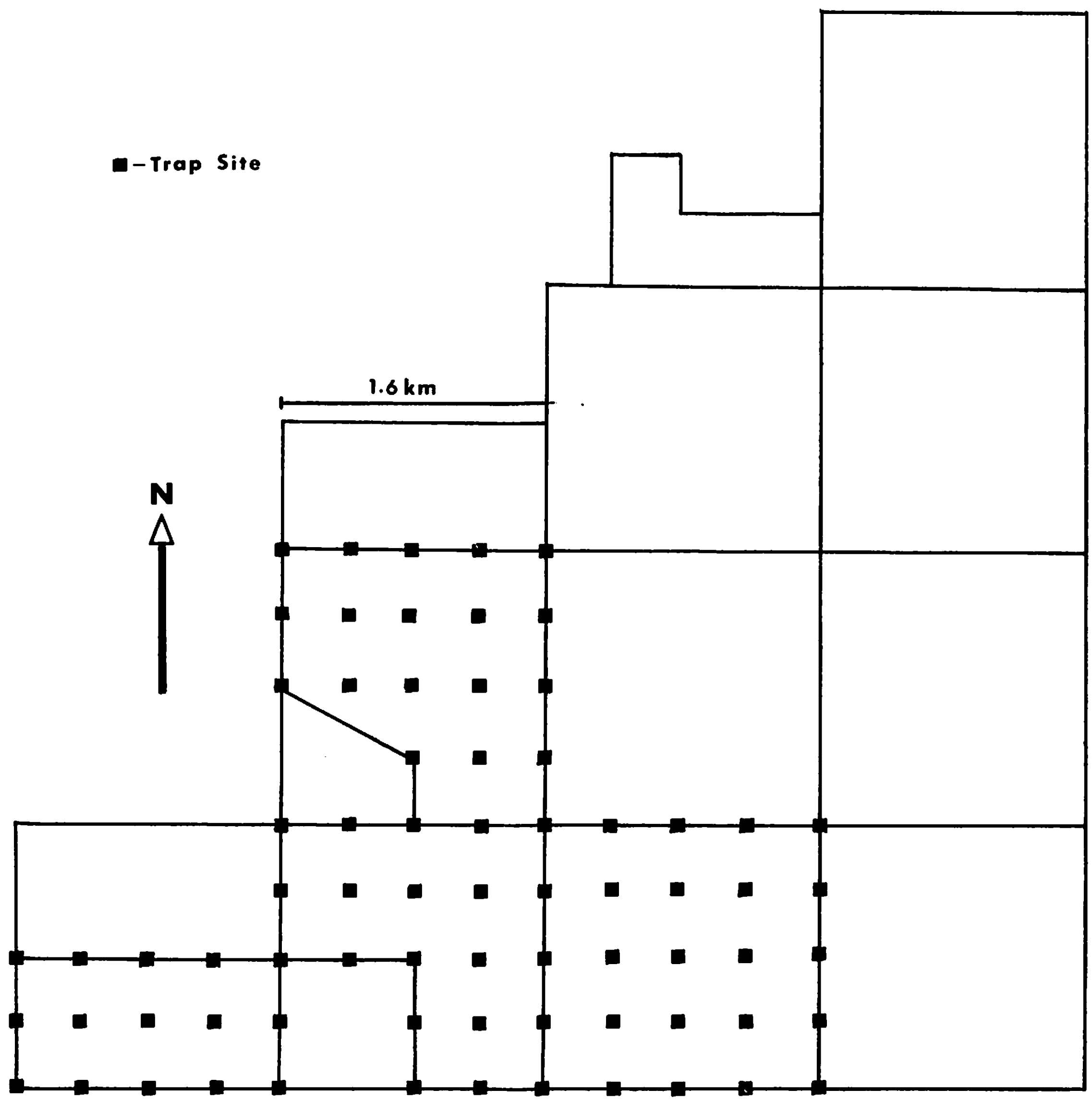



Figure 7. Jackrabbit trap-grid on the Pawnee Site.

and cattle resulted in irregular numbers and distribution of traps available to jackrabbits. The magnitude of interference varied among days and seasons.

### Ear marking

Trapped hares were ear-tagged and color-coded with a dual combination of five fluorescent color markers. A marker (5 X 9 cm of colored plastic fabric) was attached to each ear by folding it over the posterior border of the ear. Individually-numbered aluminum tags held each colored ear marker in place, thus allowing positive and redundant identification of each hare. Each combination of colored ear markers designated the area in which the hare was originally trapped (Fig. 8). Observations of marked hares were recorded on prepared forms available to all agricultural Research Service and Pawnee Site personnel working on the study area. These observations were used to help determine movements.

### Telemetry

Temperature-sensitive radio transmitters were used to examine movement patterns and to pinpoint mortality locations. Transmitter construction and telemetry technique were those described by Stoddard (1970). Two receivers (with rotating yagi antennas on stationary 21.3 m (70 ft) towers) were located 2 km (1.25 miles) apart and atop the two most prominent hills in the area. Transmitter locations were estimated

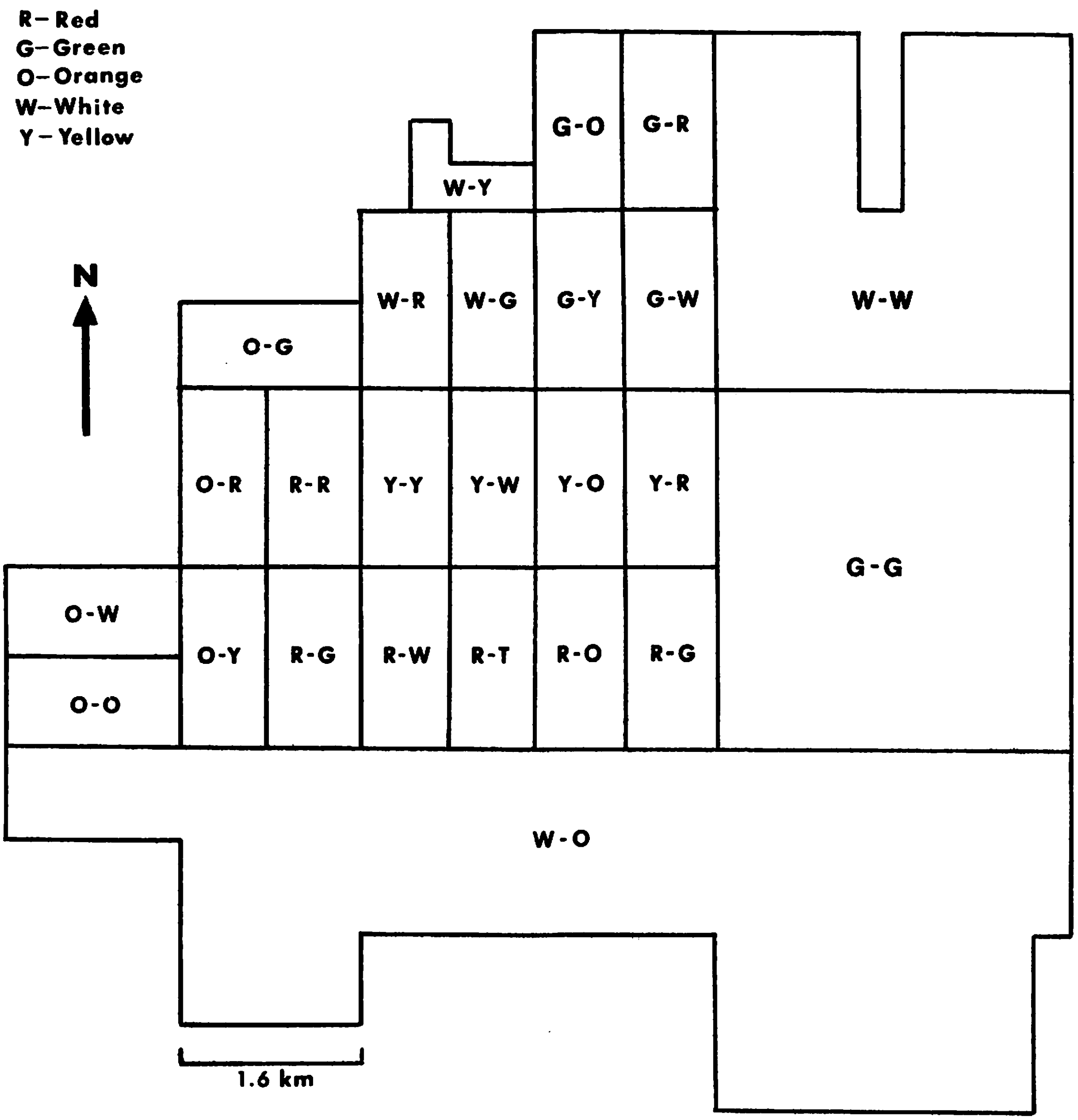



Figure 8. Jackrabbit ear marker color code map. Colors were recorded for left ear then the right.

by triangulation of asmiths from antennas. Transmitters had ranges up to 8 km (5 miles) under optimum conditions and a battery life of 6 $\pm$ 2 months. General locations were normally established by triangulation from the towers. A portable battery-powered receiver with directional loop antenna was used to recover transmitters or to find exact locations of instrumented jackrabbits.

In theory, radio transmissions travel in a relatively straight line and may be blocked by solid obstacles. Therefore, it was necessary to be aware of blind areas (areas out of line of sight) for each permanent antenna (Fig. 9). Field tests indicated that radio transmissions bent slightly around topographic obstacles. Only prominent elevations such as the antenna-based hills and Owl Creek ridge produced transmission blind spots. The combination of blind areas, range of signal, and location of experimental grazing pastures led to designation of telemetry work areas (Fig. 10).

Heezen and Tester (1967), evaluating radio-tracking by triangulation, considered many factors that may contribute to discrepancies between true and telemetered locations. Factors which may have been a source of error in my study were: twisting of towers and bending of antennas by wind; temperature changes; inaccurate referencing of the antennas; non-simultaneous recording by both receivers on a moving animal; human errors in reading and recording asmiths; and signal refraction by topography and subsurface geology.

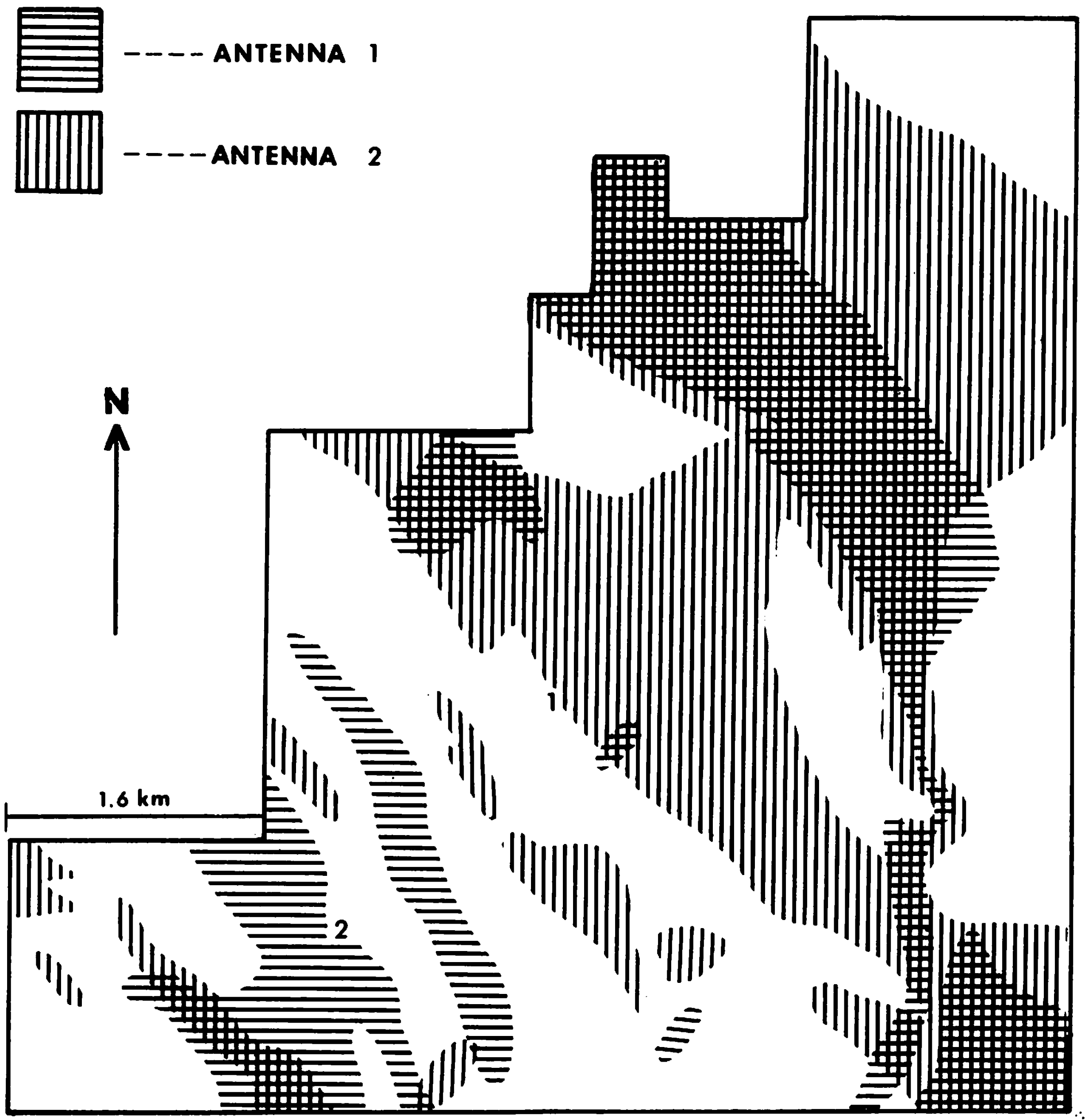
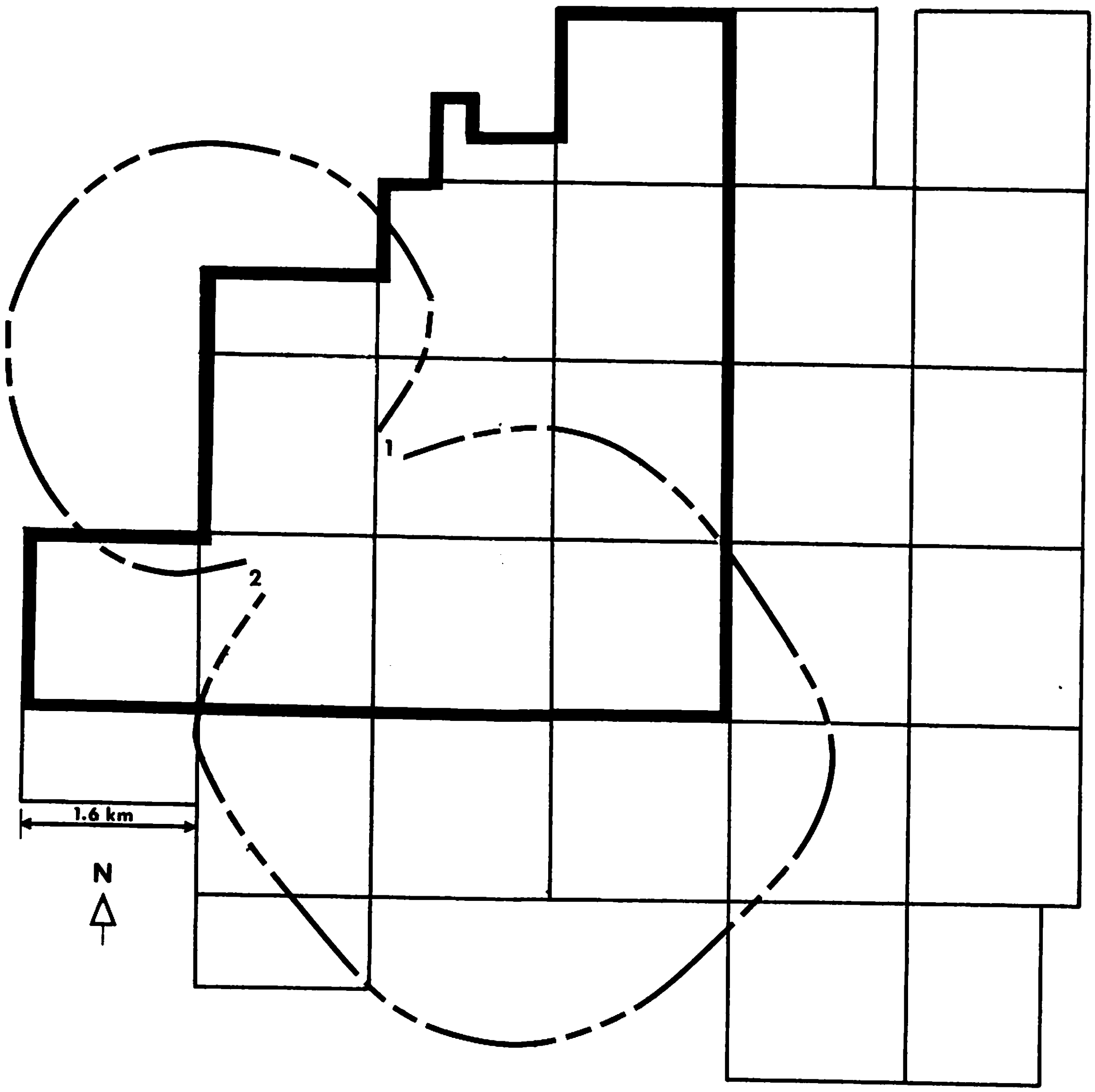



Figure 9. Areas within the study area that were out of line-of-sight from permanent receiving antennas.




— — — Optimum telemetry area

1 & 2 Permanent antenna sites

▬▬ Jackrabbit Study Area

Figure 10. Telemetry work areas in relation to stationary antennas and the jackrabbit study area.

Telemetered points are estimates of transmitter locations. Therefore, these points were used as indices. Jackrabbits were primarily instrumented in telemetry work areas that would produce the greatest triangulation accuracy possible. Telemetry accuracy in this area was checked using 15 known transmitter locations and their respective telemetered location. To simulate normal jackrabbit tracking conditions, receiver operators were unaware of the transmitter locations when asmiths were recorded. The area enclosed by lines drawn through the outermost points, forming a convex polygon, was measured for each (i. e., known and telemetered) set of data (Fig. 11). The same procedure for calculating minimum occupation areas (Mohr 1947, Jennrich 1969) was used for jackrabbit occupation area indices. The known area covered 205.18 ha and the telemetered-area covered 201.54 ha. The difference of 3.64 ha was negligible. The area of error between each actual transmitter location and its respective telemetered location indicate that actual locations were estimated by telemetry with an average error of 16.16 ha (range 0 to 62.75 ha). Area size instead of distance was used to measure error because of the nature of possible errors in estimating locations with triangulation.

Interpretation of "unused" areas within boundaries of occupation areas is dependent upon general movement behavior of the animals. Jackrabbits use pathways connecting high-use areas. Jackrabbit trails

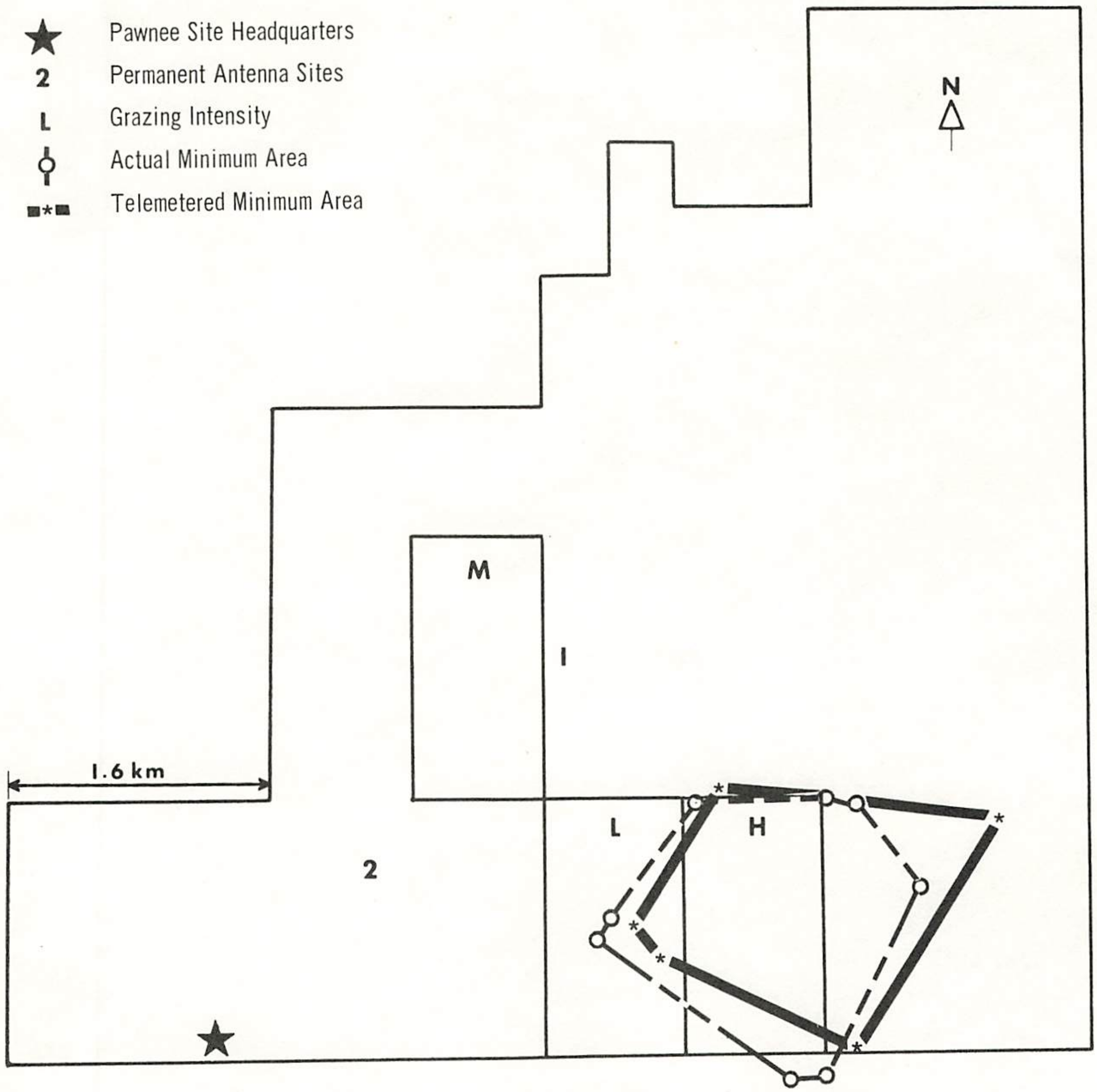



Figure 11. Minimum convex polygons derived by connecting the outermost points of actual test transmitter locations and their respective telemetered location.

on the Pawnee National Grasslands rarely exceed 50 m before diffusing to become indistinguishable. Ecological factors within occupation areas may influence jackrabbits and vice versa. Because "unused" areas within boundaries are important in the behavior of jackrabbits, no attempt was made to segregate them.

In telemetry, acceptable degree of accuracy and sampling interval depend on objectives of the study (Heezen and Tester 1967). In this study, sampling interval was restricted by manual operation of stationary receivers limiting recordings to one hare every 5 minutes. Monitoring several individuals for specified periods was desirable so that movement differences between species, sex and age classes could be evaluated.

Positions were obtained at 30-minute intervals for seven hares during the three nights of March 23-24, June 7-8, and July 1-2, 1971 (sample size = 9 hare-nights) to compare the effect of 30-minute and 1-hour intervals on observed minimum areas occupied. Differences between minimum areas occupied as calculated from the two sampling intervals were tested with paired t-tests and were not significant ($P > 0.20$). Thus, a sampling interval of 1 hour was selected so that more individuals could be monitored over continuous periods.

Three parameters of jackrabbit occupancy (occupation-area size, mean distance moved and rate of movement) were measured. The minimum-area method was selected for reasons of "simplicity, historical prominence and reasonably good statistical stability" (Jennrich and Turner 1969:236) over other methods (i. e. the boundary-strip method, the inclusive boundary-strip method, the exclusive-boundary-strip method, the observed-range length, the adjusted-range length, the composite home range, the center of activity, activity radius, recapture radius, recapture center, standard diameter, standard range, and others) of indexing areas occupied by animals (Stickel 1954; Sanderson 1966). Distances between successive pairs of recorded locations provided a rate-of-movement index based on minimum distances moved.

### Drive counts

A major objective was to measure jackrabbit population densities in selected areas. An absolute count of the entire study area was impractical due to insufficient manpower, money and time. Therefore, absolute counts were made on four randomly chosen 0.4 X 1.6 km (o. 25 X 1 mile) sample plots within the study area (Fig. 12). The four selected areas covered 9.75 percent of the total study area and 12.5 percent of the Pawnee Site. Drive plot 1 was in a four-wing saltbush vegetative type; plot 2 was in a blue grama-buffalograss type; and plots 3 and 4 were in a saltbush-grass mixture type. Plots were not distributed among the vegetative types in proportion to the total area of each type within the study area.

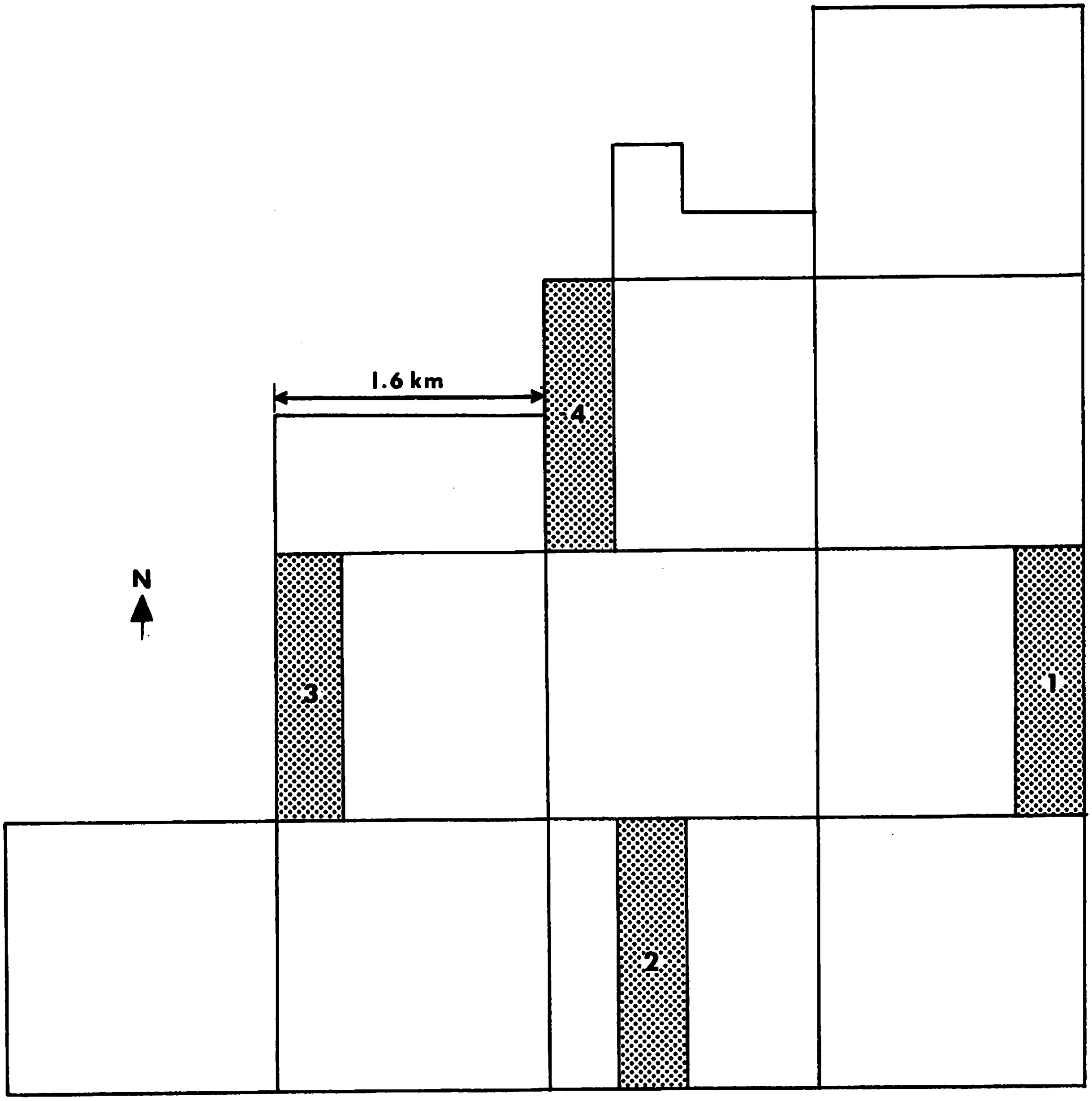



Figure 12. Drive plots (numbered rectangles) total 259 ha (1 sq. mile) and cover 12.50 percent of the Pawnee Site and 9.75 percent of the study area.

Hares were flushed by a line of drivers, 0.4 km long, spaced 18 to 27 m apart, who walked the length of each plot. From 20 to 30 drivers and 4 to 6 observers were utilized during each census. Hares were counted when they ran through the drive line and by observers watching the sides and ends of the plot as hares ran out.

Each of the four plots was censused in sequence once in April and November of 1970 and 1971. Censuses were conducted during these months because manpower was available and to reduce biases in counts due to the secretive nature of young jackrabbits. Tall four-wing saltbush may have allowed some hares to escape undetected along the western side of plot 1. Other sources of error may have been from hares failing to flush or using a burrow to escape. These errors were thought to be negligible. However, the counts represent minimum numbers. A schematic diagram shows temporal relationships of censuses to a hypothetical population fluctuation (Fig. 13).

Spotlight counts

Spotlight counts were conducted monthly to measure distributions and relative abundances of the two species of hares. Counts were conducted between sunset and midnight. The study area was divided into 43 quarter-sections which were spotlighted from roads. The tally for each quarter section was designated as one of the following five, arbitrary categories: (i) black-tailed only; (ii) black-tailed (75-99 percent), occasional white-tailed (1-25 percent); (iii) black-tailed

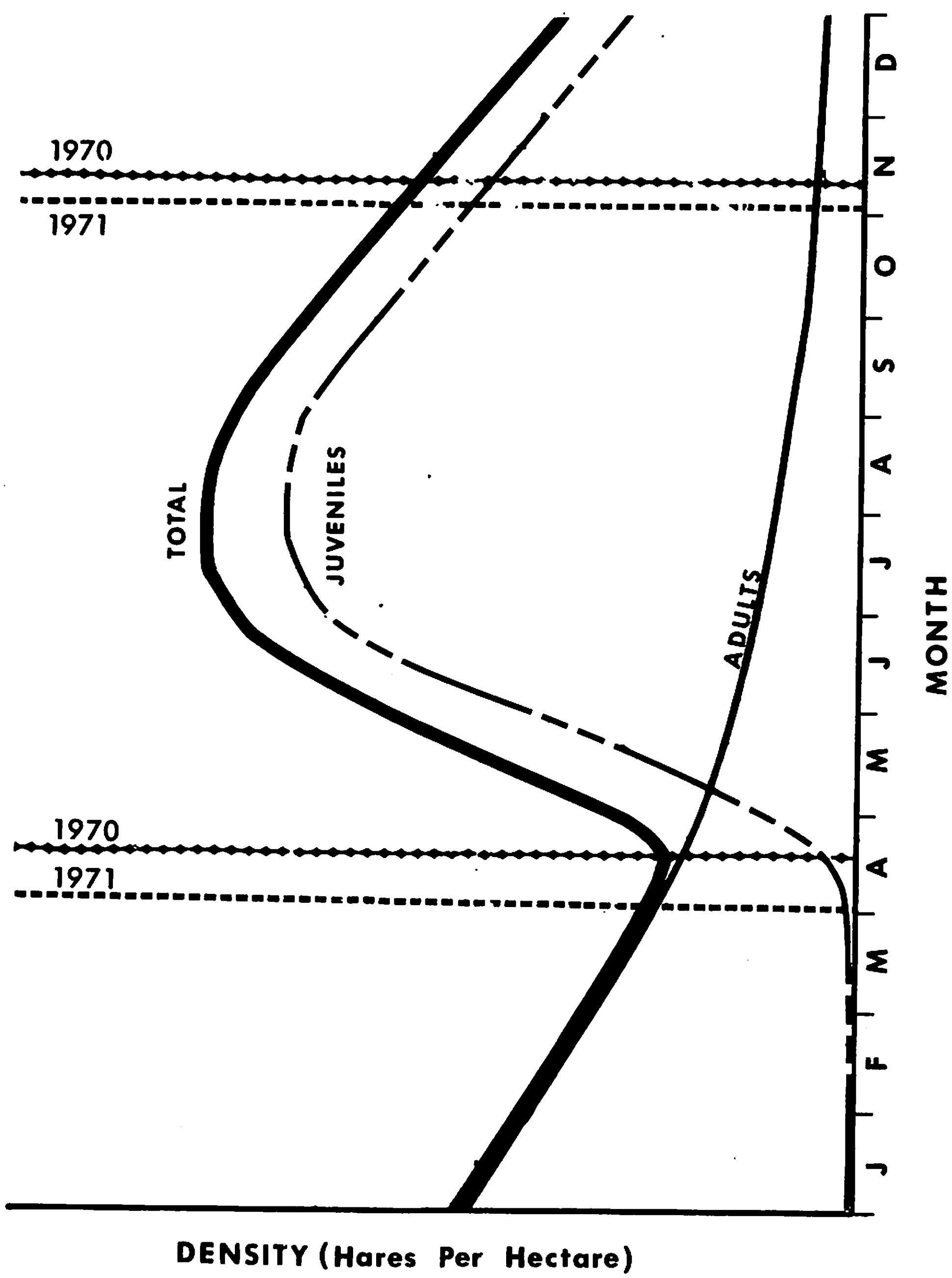



Figure 13. Schematic representation of a hypothetical, annual population density fluctuation and temporal relationship of censuses.

(26-74 percent) and white-tailed (26-74 percent); (iv) white-tailed (75-99 percent), occasional black-tailed (1-25 percent); and (v) white-tailed only.

Aerial track counts

Flights were made over the study area after ground-covering snows to map lagomorph relative track density. Mapping was accomplished by an observer tallying trails crossing each 0.4 km section of a 41 km transect. The aircraft was flown 48 to 96 km per hour (ground speed) at altitudes of 15 to 30 m (above the ground) over nine north-south transects (0.8 km apart). The track counts may have included cottontail trails, may be biased by differential wind effect on exposed ridges and shrubby bottoms, and may represent unknown degrees of differential behavior of species and sex and age classes immediately following a snow storm. The maps, however, appeared realistic when compared subjectively with spotlight counts, trap results and general observations.

Data Synthesis

Trap-retrap data and radio-telemetry data were keypunched onto computer data-processing cards. Descriptions of formats for the various types of data are given in Appendix A.

A computer program was written to manipulate trap data and telemetry data. The program, coded in FORTRAN, was designed for use on Colorado State University's CDC 6400 digital computer. Printed paper output consisted of a description of the individual hare; dates, times, and locations for each observation; and distance and rates of movement between consecutive recorded locations. Trap and telemetry data were analyzed separately.

A program was developed to plot recorded hare-locations for calculation of the area occupied by each hare. This program was designed for use on a Hewlett-Packard calculator, model 9100 B, equipped with an X-Y plotter. Recorded locations were plotted on graph paper. Areas occupied during predetermined periods were delineated, using the minimum area method, for each hare. Divisions on the graph paper allowed calculation of the sizes of occupied areas to the nearest 0.8 ha.

## Data Analysis

Statistical methods used in this report follow Snedecor and Cochran (1967) and are commonly used in related literature. A step-wise multiple regression was used to calculate partial correlation and regression coefficients and analysis of variance to test for hourly differences between two variates. Variates selected for analysis were rate of movement, distance between recorded locations, date, time, species, sex, age, air temperature, wind velocity, barometric pressure, night length and reproductive status (John R. Nunn, unpublished abiotic data). A high correlation coefficient ($r = 0.981$) between rate of movement and distance moved between locations justified deemphasizing of distance and selection of rate as the better indicator of movement. Rate was more desirable because of the time factor.

Factors such as species, sex and age may influence sizes of daily occupation areas. Age is a constantly changing individual factor. Field techniques were inadequate to estimate ages of live hares. Thus hares were grouped into two age classes, adult and juvenile. This division was based on conspicuous differences in body size. Adult age class may be biased because hares whose age class was uncertain were included in the adult class. Juveniles were considered to remain in the juvenile age class throughout their relatively short telemetry records (average 37 days, range 0 to 65 days).

Scientific names of mammals used in this report are on authority of Hall and Kelson (1959). Scientific names of birds are on authority of the 1957 A. O. U. Check-list of North American Birds. Scientific names of plants are on authority of Harrington (1954).

# RESULTS

A partial summary of data sample sizes is shown in Table 1. Sample sizes not included in the table are: telemetered hare location data points (786); hare-nights monitored with telemetry (39); sight observations of marked hares (53); track distribution maps (7); trap-retrap data points (293); census on drive plots (16); spotlight counts (14); and, number of hares observed on spotlight counts (327).

## Daily Occupation Areas

Daily occupation areas include night activity areas and day resting locations. Individual night activity areas and day resting locations were estimated in telemetry work areas from December 16, 1970 until September 10, 1971.

Several intrinsic factors (Fig. 5) were compared with inter- and intra-specific rates of movement, distances moved and areas occupied. White-tailed jackrabbits had larger average night activity areas, rates of movement and distances between recorded locations than did black-tailed jackrabbits (Table 2). Possible effects of sex and age on these occupation-area indices were evaluated. Adults had larger indices than juveniles for both species. Female black-tailed jackrabbits exhibited larger indices than males, whereas male white-tails had larger indices than their female counterparts.

Table 1. A partial summary of sample sizes of data collected from February 16, 1970 through September 30, 1971.

| Category | CLASSIFICATION | | | | | | Totals** |
|---|---|---|---|---|---|---|---|
| | BT | WT | Male | Female | Adult | Juv* | |
| Trapped | 127 | 48 | 82 | 88 | 127 | 47 | 176 |
| Ear Tagged | 90 | 26 | 59 | 57 | 88 | 29 | 117 |
| (Predator Mortality) | 4 | -- | 4 | -- | 3 | 1 | 4 |
| (Trap Mortality) | 5 | 1 | 3 | 3 | 5 | 1 | 6 |
| Radioed | 23 | 21 | 13 | 30 | 30 | 16 | 47 |
| (Mortality) | 10 | 7 | 6 | 11 | 8 | 9 | 17 |
| Tagged and Radioed | 12 | 2 | 6 | 5 | 12 | 0 | 14 |
| (Mortality) | 5 | -- | 2 | 1 | 3 | -- | 5 |
| Radios Recovered | 15 | 9 | 8 | 13 | 11 | 10 | 24 |
| Radios Not Recovered | 18 | 14 | 11 | 18 | 25 | 6 | 33 |

BT - Black-tailed Jackrabbit, WT - White-tailed Jackrabbit

*Minimum numbers of juveniles; some juveniles may have been recorded as adults.

**Incomplete data on seven hares account for discrepancies.

Table 2. Occupation-area indices for species and their respective sex and age classes.

| Species | Class | INDICES: Activity Area (ha)* | Movement rate (m/min)** | Distance between recorded locations (m)* | n |
|---|---|---|---|---|---|
| Black-tailed Jackrabbit | Male | 23.7 | 7.5 | 432.3 | 4 |
| | Female | 46.3 | 8.6 | 477.1 | 10 |
| | Adult | 39.4 | 9.1 | 522.0 | 8 |
| | Juvenile | 28.4 | 7.2 | 387.4 | 6 |
| | Overall | 29.7 | 8.3 | 464.2 | 14 |
| White-tailed Jackrabbit | Male | 187.4 | 13.6 | 676.5 | 8 |
| | Female | 74.1 | 11.6 | 554.7 | 20 |
| | Adult | 190.4 | 12.6 | 614.6 | 25 |
| | Juvenile | 90.0 | 10.8 | 260.6 | 3 |
| | Overall | 89.4 | 12.3 | 611.1 | 28 |

*Nightly means

**Hourly means

Hourly analyses of variates (listed on page 28) showed no significant correlations among each other. This result could have been due to one or more of the following possibilities: (1) Movement rates may be generalized and may not vary significantly unless severe conditions exist; (2) Techniques used were not precise enough; (3) Factors not considered may have been more important in determining movement.

Mean hourly and nightly rates of movement were calculated for all telemetered hares. No apparent differences (based on subjective comparisons) were observed in the pattern of movement between species, between sexes or between age classes. Data from all hares were combined into one plot of rate of movement versus time, in hours (Fig. 14). All hares showed slower movements during twilight hours than during night hours.

Day resting locations were within succeeding night activity areas about 50 percent of the time. The locations averaged 0.3 km from night-activity-area boundaries and ranged up to 1.2 km from them. Day resting locations appeared to be scattered in or near night activity areas in no discernible pattern.

## Seasonal Occupation Areas

A seasonal occupation area includes the total measured area that a jackrabbit occupied during some predetermined portion of a year. This definition presupposes changing intrinsic and environmental

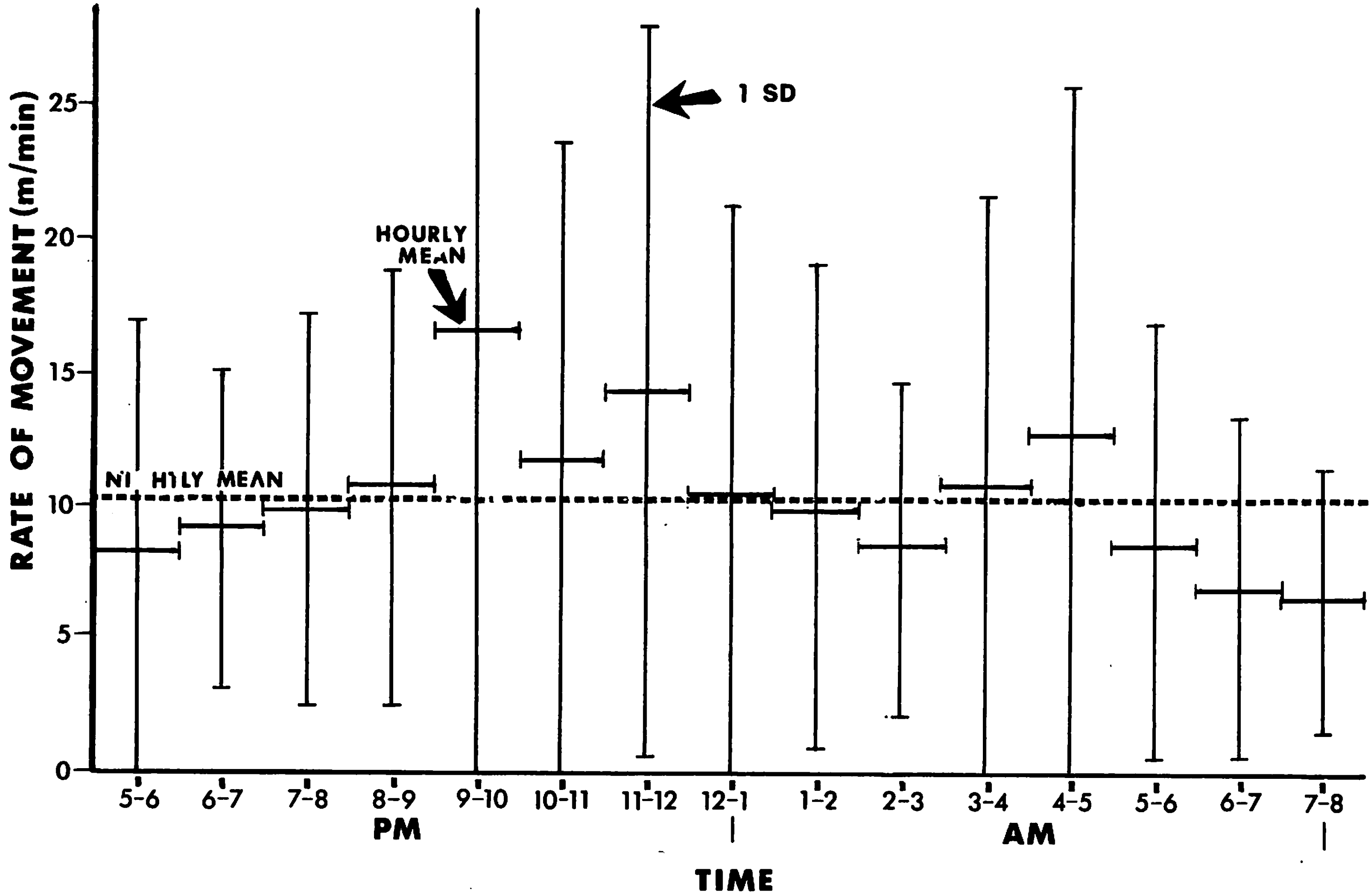



Figure 14. Activity of radio-telemetered jackrabbits during hourly periods from December 1970 to September 1971.

influences on occupation areas. Changes in night activity areas and mean rates of movement were used to estimate these influences.

Mean hourly and nightly rates of movement were grouped with respect to months. A comparison using months indicated that onset and cessation of activity varied with daylength (Keith 1965, Mech et al. 1966). Variations from this trend occurred when dense cloud cover decreased light intensity. Seasonal analyses of variates (listed on page 29) failed to show significant correlations.

The mean rate of movement for all hares from December 1970 to September 1971 was 10.8 m/min. Mean monthly rates were consistently lower than the overall mean during December to March and higher during April to September (Fig. 15). This significant ($P < 0.05$) shift in mean rates coincides with the approximate start of the vegetative growing season and jackrabbit parturition. First green shoots of vegetation were visible above ground surface on April 6.

Night-activity areas for all hares also changed abruptly in April (Fig. 15). However, these are probably not as sensitive an indicator of seasonal influences on activity as movement rates. Movement rates varied in response to seasonal changes while occupation area size may remain essentially the same size.

Evaluation of jackrabbit discrimination of cattle-grazed pastures showed seasonal variation by species (Appendix B). Discrimination was estimated by tallying the number of telemetered hare locations

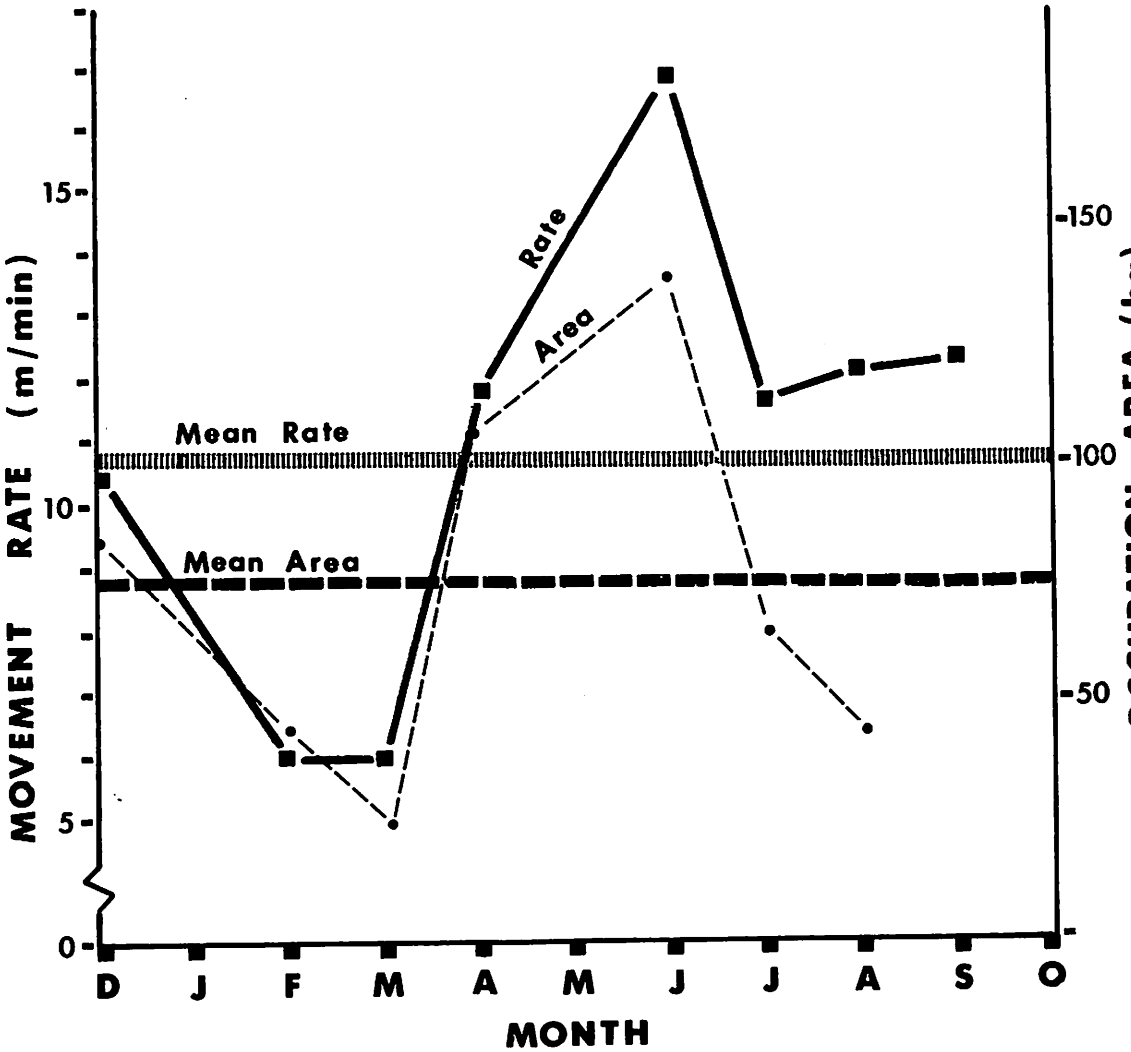



Figure 15. Mean nightly rates of jackrabbit movement were below the 9 month average before the vegetative growing started in April and above average after it. Mean nightly activity areas followed a similar pattern (correlation coefficient r = .654).

that occurred monthly in each pasture. White-tailed jackrabbits showed a marked shift in pasture use coinciding with the start of the vegetative growing season. White-tails exhibited a preference in winter months for pastures having taller vegetation (i. e., light grazed and the 16-Atca-Chna-Kosc type). Black-tails did not appear to markedly shift pasture use with onset of the vegetative growing season but did shift from pastures with taller vegetation to pastures with short vegetation (i. e., heavily grazed) about 3 months later. Both species returned to greater use of taller-vegetated pastures in December. An attempt to estimate pasture use from trap results failed to show significant shifts.

Of 53 sight observations of marked hares, only four indicated the hares had changed vegetative type between the tagging location and sight location. These changes in use of vegetative types did not appear to be related to seasonal climatic changes.

### Annual Occupation Areas

An annual occupation area includes the total measured area that a jackrabbit occupied during 1 year and is a composite of daily occupation areas. Generally, daily occupation areas overlapped each other and consecutive plotting usually added new territory to the cumulative area occupied. No telemetered jackrabbits were known to have lived over 9 months from the date they were instrumented. This high mortality rate prevented measurement of annual occupation area for any individual animal.

White-tailed jackrabbit daily occupation areas were significantly larger ($P < 0.05$) than those of black-tailed jackrabbits. And, white-tails covered their total area occupied at a faster rate than black-tails. Consequently, white-tails probably have larger annual occupation areas (Fig. 16).

Long-distance (over 3 km) movements outside of annual occupation areas were seldom detected. Of 53 sightings of marked hares and 59 radioed hares, only three long movements were recorded. One hare (black-tailed, ear code white-green) was sighted August 10, 1970 approximately 5 km southwest of the area in which it was tagged. Another hare (species unknown, ear code red-orange) was observed by a rancher July 24, 1971 approximately 11 km north of the area in which it was tagged. The remains of a radioed jackrabbit (white-tailed, No. 148) were found September 2, 1971 about 4 km east of its July-August occupation area. Evidence (portions of skeleton and intestines) at the scene of the remains indicated eagle predation.

Density

Results of aerial track counts (an index of hare density) (Fig. 17) and census results indicated that jackrabbit density and distribution varied by vegetative type. Therefore, jackrabbit densities, density trends and biomass were estimated in relation to vegetative type.

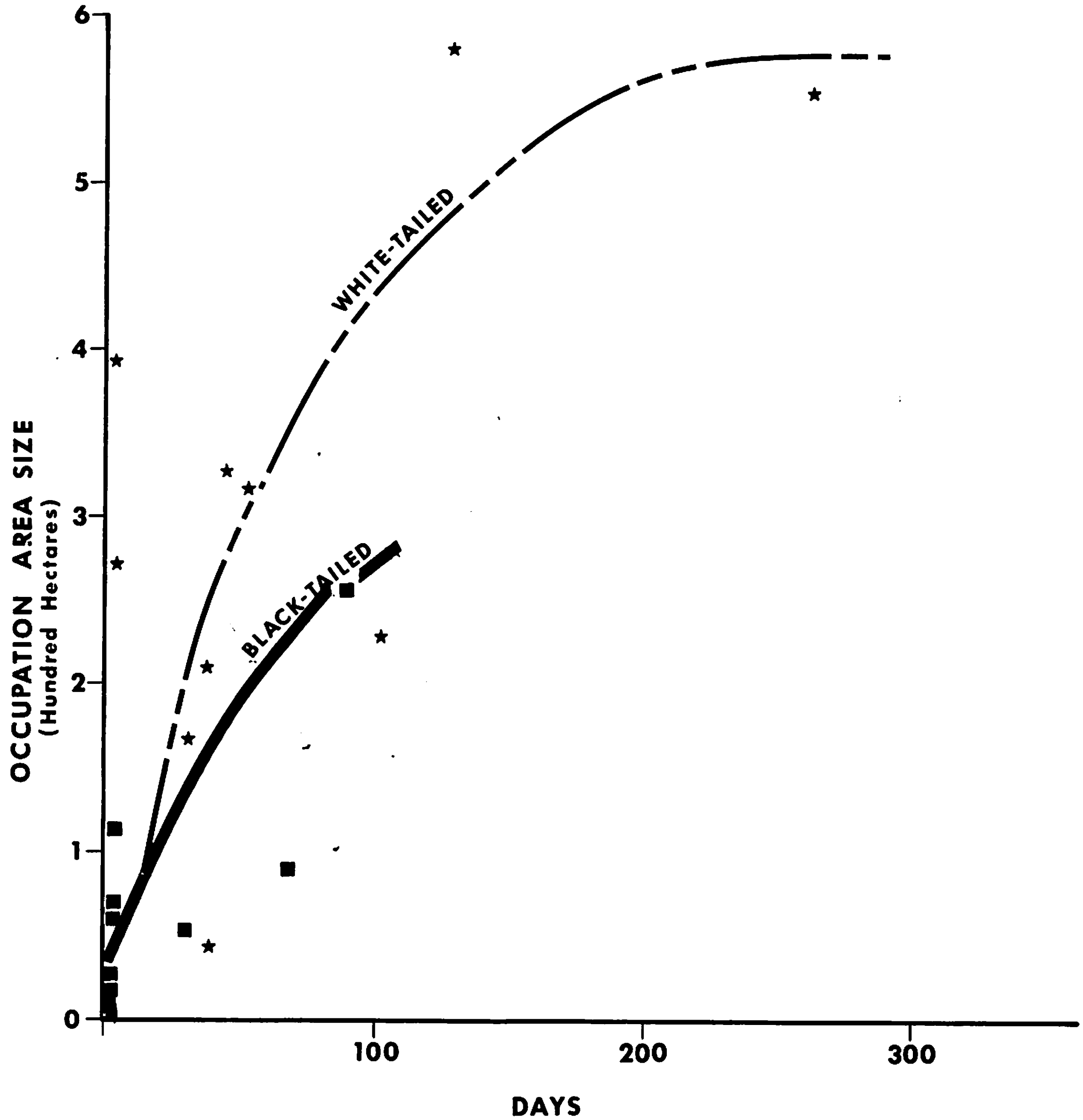



Figure 16. Hand-fitted curves illustrating relative increase in jackrabbit occupation area sizes as period of monitoring by telemetry increases.

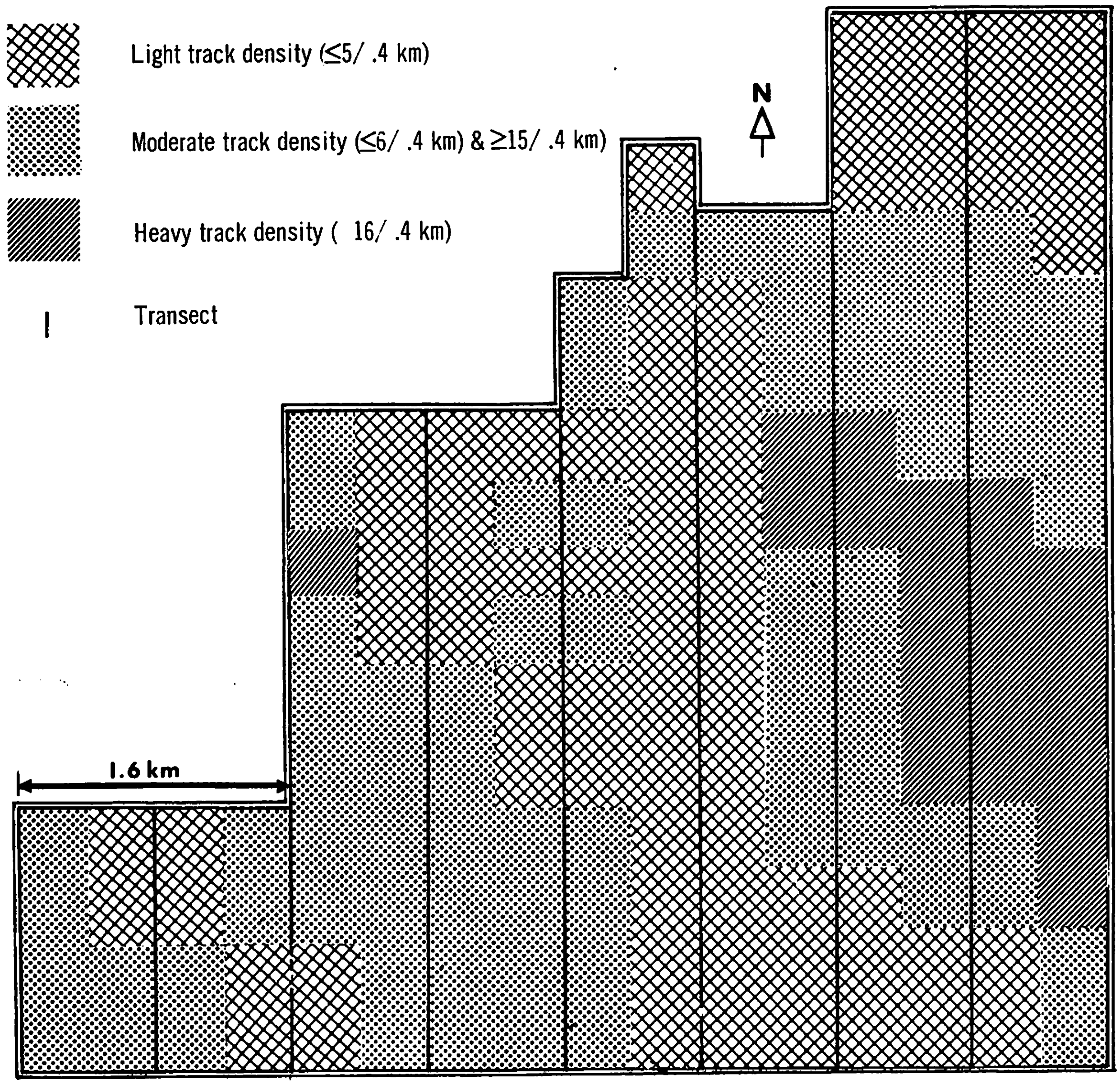



Figure 17. Relative lagomorph track density as determined by tallying numbers of tracks crossing each .4 km of transect.

Jackrabbit census results from drive plots fluctuated seasonally, with the magnitude depending on the species and the vegetative type (Appendix C). The magnitude of seasonal density fluctuations was greatest for black-tailed jackrabbits (Fig. 18). Seasonal density of each species also fluctuated between drive plots (vegetative type) (Fig. 19). Densities of black-tailed jackrabbits were greatest in plot 1 (13-Atca), least in plot 2 (Bogr-Buda), and intermediate in plots 3 (70 percent 16-Atca-Chna-Kosc and 30 percent 1-Bogr-Buda) and 4 (16-Atca-Chna-Kosc). White-tailed jackrabbit densities were greatest in plot 2, least in plot 1, and intermediate in plots 3 and 4.

Changes in black-tail densities were mostly responsible for most of the fluctuations of total hare biomass (Fig. 20 and Appendix D). Mean weights of black-tailed jackrabbits were 2792 g (SD 311) and 2519 g (SD 332) for April and November 1970 and 2654 g (SD 416) and 2480 g (SD 474) for April and November 1971. Mean weights of white-tailed jackrabbits were 3049 g (SD 539) and 2705 g (SD 246) in April and November 1970, and 3018 g (SD 435) and 2598 g (SD 439) for April and November 1971. (Gross, unpublished data)

Spotlight counts indicated a species distribution (based on species ratios) for the study area similar to the species distribution implied from drive-plot counts (Fig. 21). Species distribution appeared to be most influenced by relative elevation and vegetative types as diagrammatically illustrated in Fig. 22.

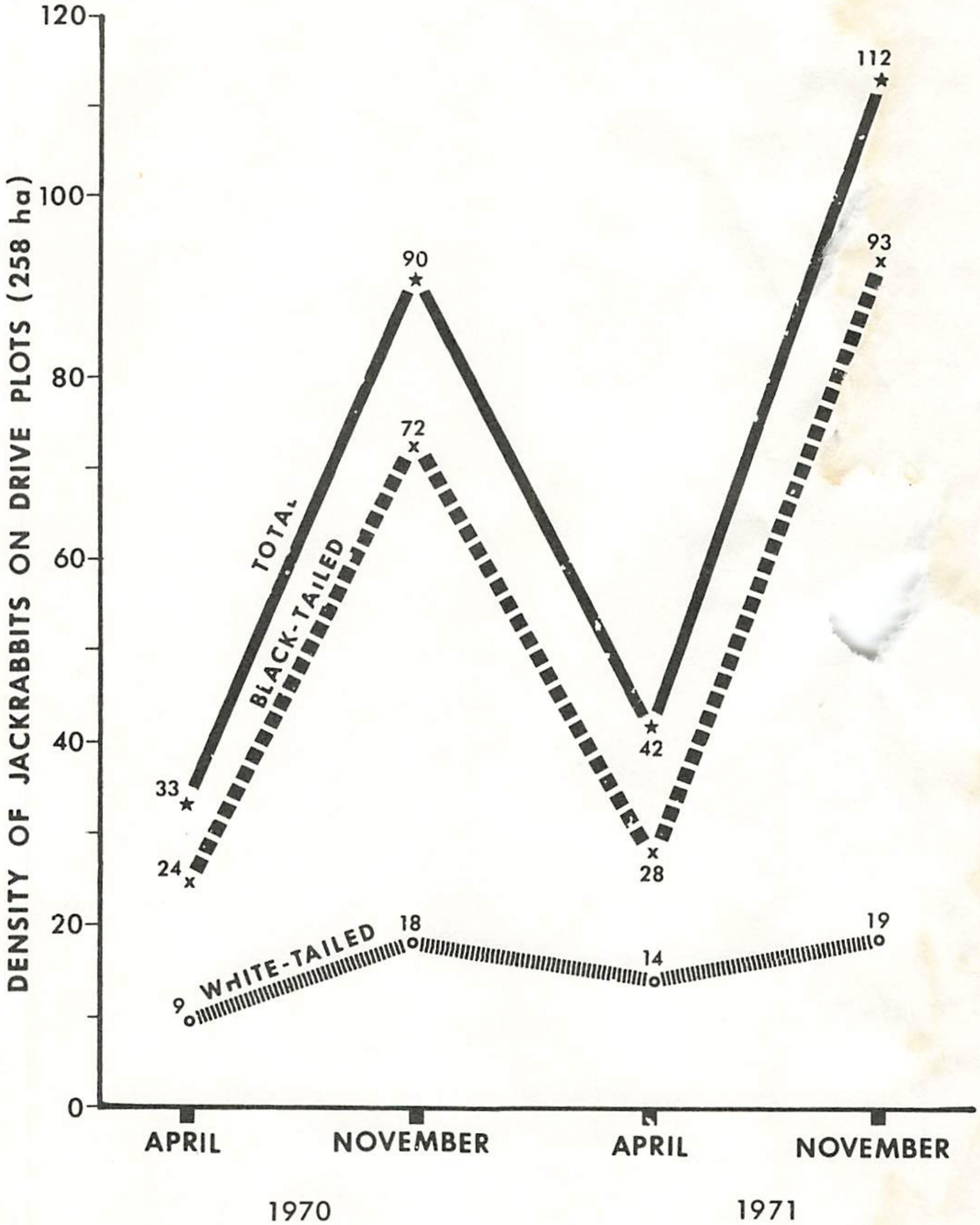



Figure 18. Census results and seasonal fluctuations of black-tailed and white-tailed jackrabbit populations on four census plots.

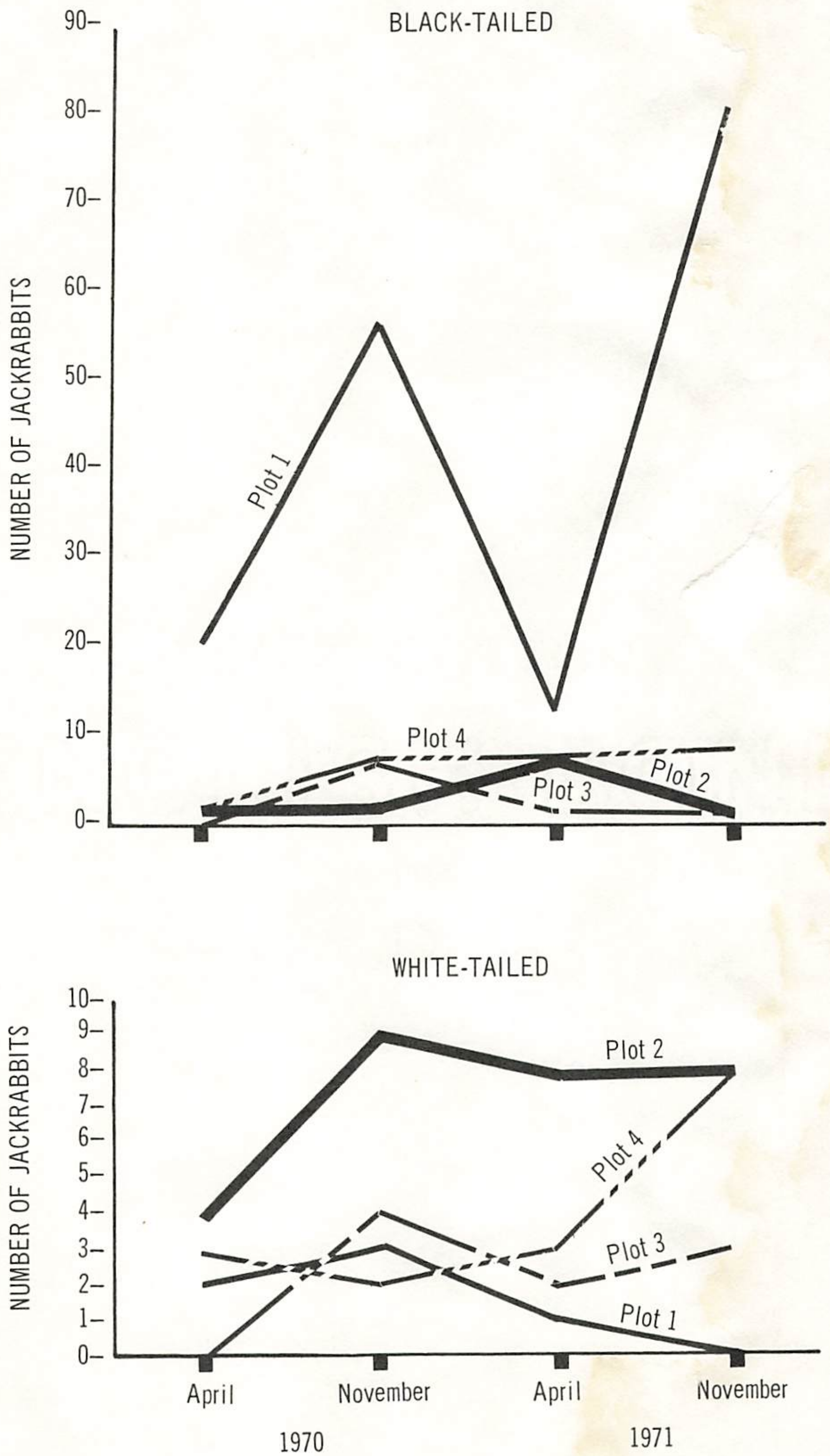



Figure 19. Seasonal comparison of jackrabbit densities between species and drive plots.

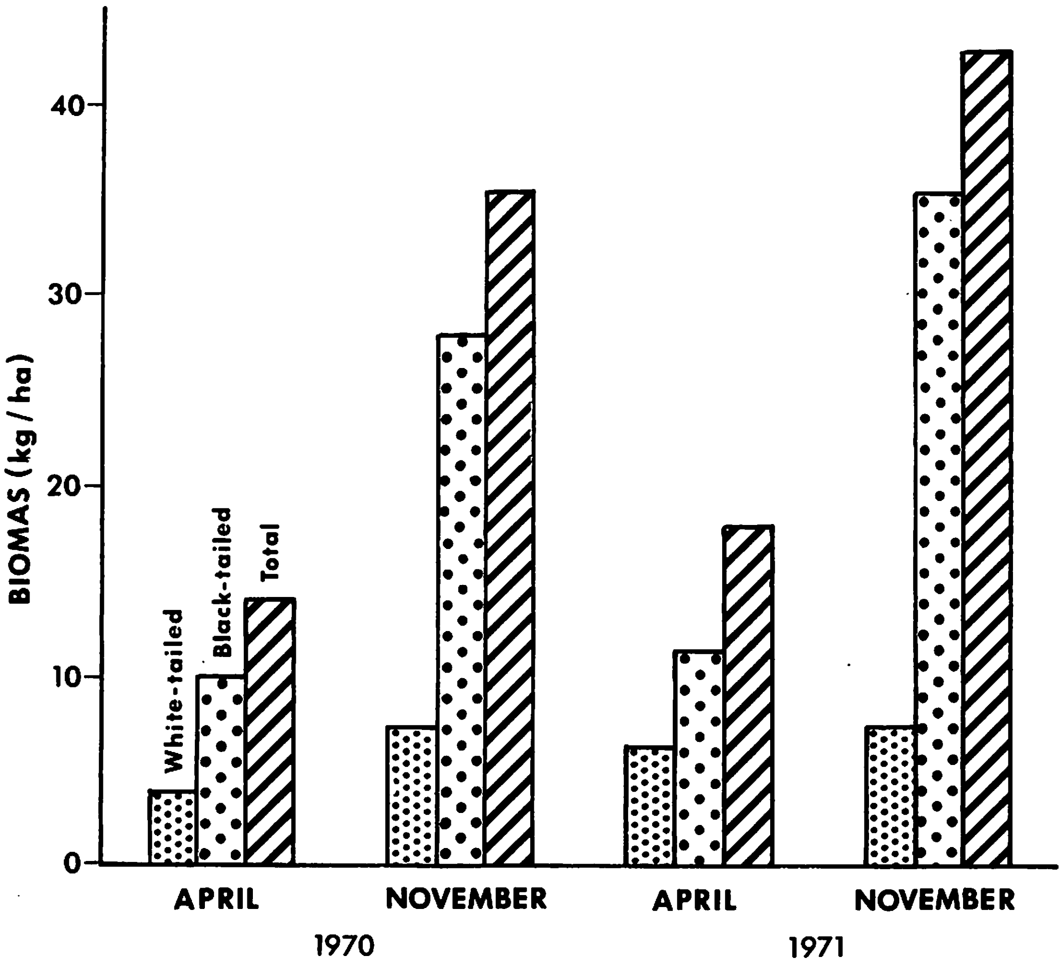



Figure 20. Jackrabbit species influence on total hare biomass.

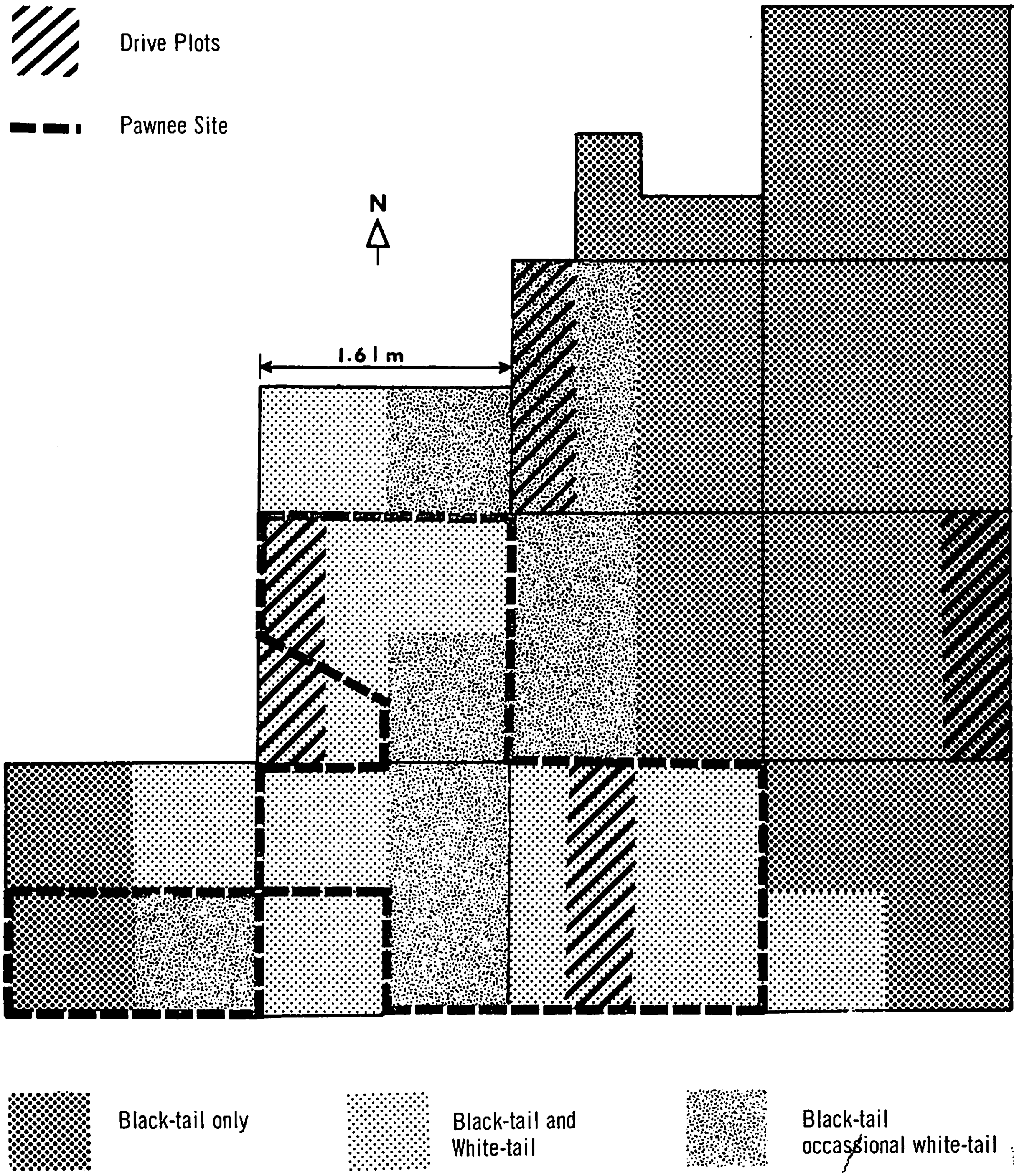



Figure 21. Jackrabbit species distribution on study area and Pawnee Site as determined by spotlight counts.

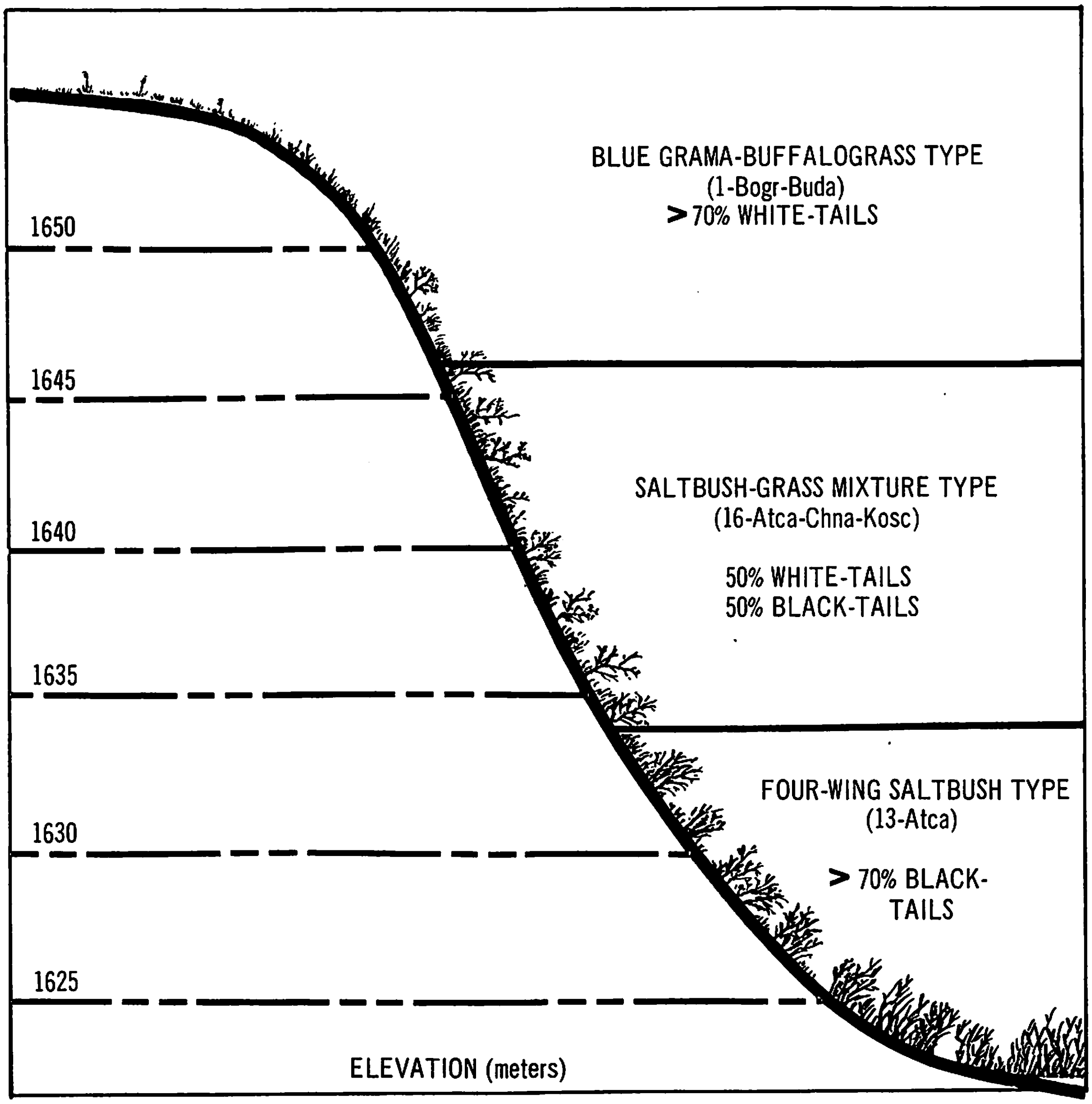



Figure 22. Schematic diagram illustrating the general relationships of vegetative cover type, jackrabbit species distribution, elevation and topography.

Mortality

Temperature-sensitive radio transmitters allowed location of 24 instrumented hares after their death. Distribution and frequency of suspected causes of mortality were: mammalian predation-7, avian predation-9, and unknown-5 (Fig. 23). There appears to have been a concentration of predation mortality, although statistically insignificant ($P > 0.20$), in the 16-Atca-Chna-Kosc vegetative type as compared to the 1-Bogr-Buda type. Recovery of ear tags indicated other mortality occurring with the following frequency: trap kills-6, shot by hunger-1, highway kill-4, and unknowns-3.

Mortality rates were not different ($X^2 = 0$) between radio-instrumented hares and hares having each a radio and colored ear markers. Mortality numbers of instrumented and radio-ear marked hares were pooled to test for differences in mortality rates between species, sex and age classes. There were no significant chi-square values for species ($P > 0.20$) and sex classes ($P > 0.50$). White-tailed jackrabbits and black-tailed females had slightly lower mortality rates than did their counterparts. Age classes showed a significant difference at the 0.10 level, juveniles having a higher mortality rate than adults.

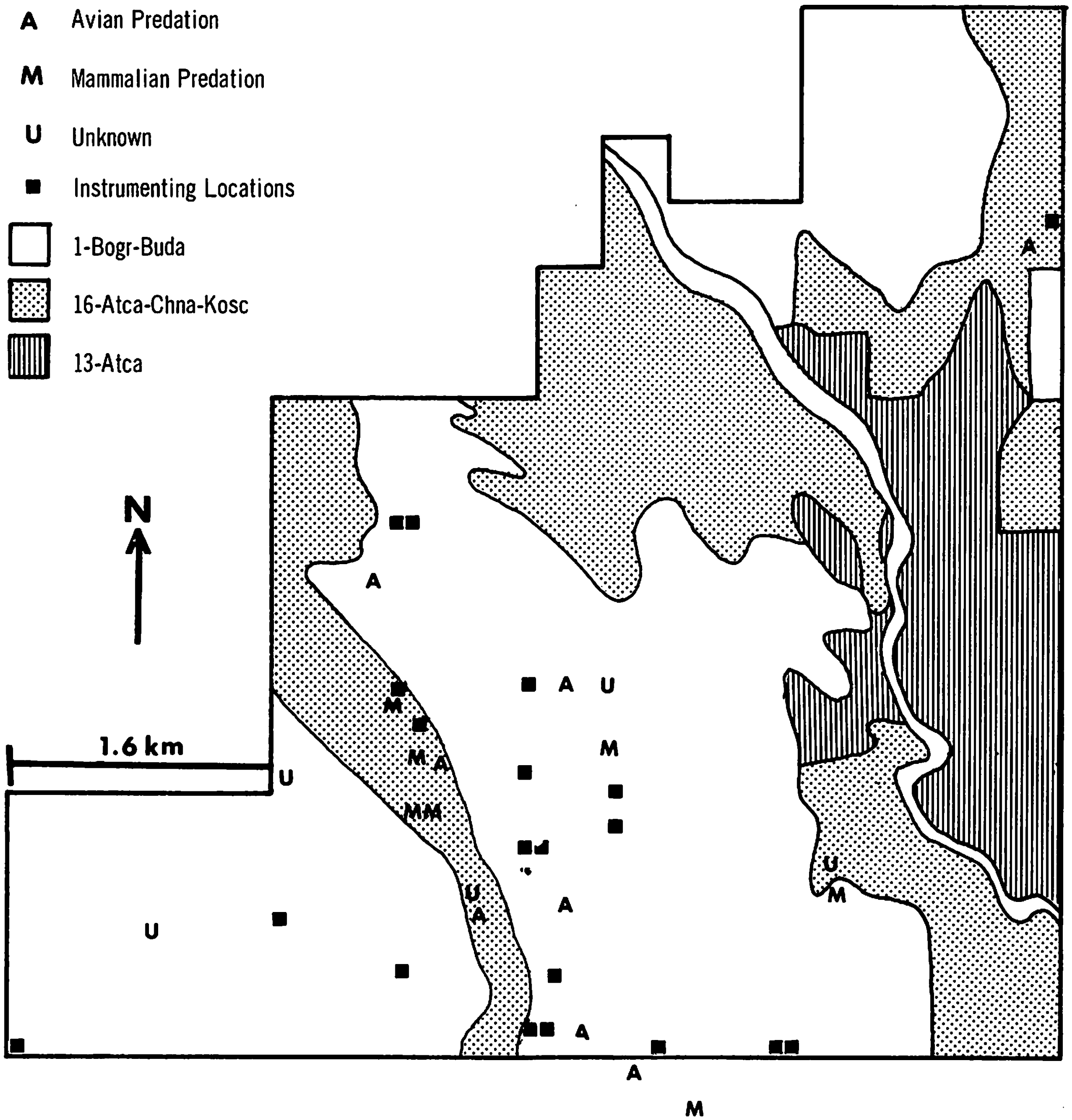



Figure 23. Natural mortality distribution of radio instrumented jackrabbits in relation to instrumentation locations and vegetative type.

# DISCUSSION

Flinders and Hansen (in press) concluded that "...black-tailed jackrabbits are biologically more efficient than white-tailed jackrabbits in the use of the portion of the over-all feeding habitat in which they occur." Results of my study and those of Flinders and Hansen (in press) suggest that black-tails did not occupy as large occupancy areas as did white-tails.

The influence of sex on activity indices (rate of movement, distance moved, occupation area) was less pronounced (as compared to inter-species) in the results of this study. Brown (1966) reported that male small mammals normally move over wider areas than do females. Table 2 (page 33 in this report) supports this hypothesis for white-tailed jackrabbits but not for black-tails. However, Lechleitner (1959) found that black-tail males moved over larger areas than did females. Contrarily, Nelson (1970) reported that female black-tails occupied the larger areas. Literature was lacking on sex-specific activity indices for white-tailed jackrabbits.

The concept of annual occupation areas for jackrabbits probably has little value for analysis of their role in an ecosystem. The primary reasons are relatively short life spans of jackrabbits, few hares lived to 1 year of age; and seasonal occupation areas tended to shift, thereby preventing stabilization of area size over time.

The spatial relationship of day resting areas to night activity areas may be a function of habitat. Where feeding areas and day resting areas were separate, jackrabbits have been known to travel daily distances up to 6.4 km (4 miles) between them (Vorhies and Taylor 1933; Bronson and Tiemeier 1958). My results indicated that the native shortgrass prairie provided adequate juxtaposition of food and resting cover resulting in little movement between day resting locations and night activity areas.

No long movements occurred at times when seasonal migrations have been reported by other authors (Rusch 1965; Currie and Goodwin 1966; Gross 1967). French et al. (1965) estimated that approximately 18 percent of a population of black-tailed jackrabbits in south-eastern Idaho moved distances greater than 0.4 km. They also hypothesized that dense local concentrations of black-tailed jackrabbits in Idaho resulted from short-distance movements. Jackrabbit movements on the Pawnee National Grasslands appear to support this hypothesis.

Certain relationships of movement rate to other activities were evident in this study. The crepuscular and nocturnal nature of jackrabbits is well known (Lechleitner 1958). Results in this study showed that movement rates were slower during twilight hours than during night hours (Fig. 13). Many authors (Thacker and Brandt 1955; Thompson and Worden 1956; and Tyndale-Biscoe 1959) have reported that rabbits follow a regular daily rhythm of feeding and reingesting.

Leichleitner (1957) described the rhythm for black-tailed jackrabbits. Generally, lagomorphs begin their activity period with voracious feeding that tapers off with satiation (Lockley 1966). In this study, the voracious feeding period corresponded to a period of relatively low rate of movement.

Seasonal influences on activity patterns of lagomorphs has been a subject of many investigations. Primary attention has been given to influences on onset and cessation of daily activity. Knowlton et al. (1968) investigated circadian activity patterns for black-tailed jackrabbits and found onset and cessation of activity to vary with ambient air temperatures. They telemetered one female jackrabbit and found earlier onset and later cessation with cooler temperatures.

Activity patterns of snowshoe hares (Lepus americanus) (Keith 1965. Mech et al. 1966) were similar to the results of my study. Keith (1965) suggested that a relationship may exist between periods of concentrated activity and changing periods of darkness. Mech et al. (1966) showed a high correlation (r = 0.95) between seasonal changes in periods of daily inactivity and seasonal changes in length of daylight. Lord (1963), Mech et al. (1966) and Hanson et al. (1969) reported on activity patterns of cottontail rabbits (Sylvilagus floridanus). Lord reported non-significant variation of onset and cessation of activity from a general 5 PM to 7 AM cycle. Mech et al. (1966) found the same high correlation for cottontails as they did for snowshoe hares. Hanson et al. (1969) found the rate of activity to vary with snow and wind conditions. My attempt to correlate weather variates to jackrabbit activity failed to show any significant relationships. However, analyses did indicate a significant shift from relatively slow rates of movement in winter months to higher rates in April. This shift correlates with Flinders and Hansen's (in press) finding that black-tails and white-tails abruptly change their food habits in April.

Jackrabbit distribution and density varied with vegetative type. Vorhies and Taylor (1933:563) also found varying abundance of black-tailed jackrabbits on different vegetative types. They remarked that black-tails were "...more abundant in the poorly grassed semi-desert type than...in either the better grassed mesa type or in the foothill type, where the best stand of grass in the region is to be found."

Wagner et al. (1965) suggested that mean densities of pheasant populations tended to be higher in good habitat and lower in poor habitat and that magnitudes of population fluctuation tended to be greater in good habitat than in poor habitat. If this hypothesis holds for jackrabbits, the observed mean density and fluctuation patterns indicated that the 13-Atca vegetative type was good habitat, 15-Atca-Chna-Kosc was intermediate and 1-Bogr-Buda was poor habitat for black-tailed jackrabbits.

For white-tailed jackrabbits, 1-Bogr-Buda vegetative type was good habitat, 16-Atca-Chna-Kosc was intermediate and 13-Atca was poor habitat. These conclusions are speculative since the time spanned by the study was not sufficient to insure that a total representative sample of jackrabbit demography was obtained.

Transmitters probably caused no abnormal mortality of instrumented jackrabbits. Stoddard (1970) used the same transmitter design in his study of jackrabbit mortality. He found no effects of transmitters on hares based on observations of the physical condition of instrumented hares and the similarity between mortality of instrumented hares and that measured demographically. I also found that instrumented hares showed no adverse physical affects from wearing the transmitter.

Stoddard (1970) found 64 percent of the mortality of radioed hares related to coyote predation. Coyotes accounted for 24 percent of all mortality recorded (except hares that died in traps) in my study. Avian predators, primarily golden eagle, took the largest amount (31 percent) of recorded mortality. Richard R. Olendorff (Personal communication) studied golden eagles on the Pawnee National Grasslands and found they consumed an average of 4 percent of their body weight in food each day. He estimated that as much as 80 percent of the food was comprised of jackrabbits with most hares taken during winter. Results from these two researchers substantiate my results and conclusion that eagles and coyotes account for the majority of jackrabbit natural mortality on the Grasslands.

Few research efforts fail to disclose areas needing further research and this study has been no exception. Guidelines may be suggested by the components on the systems charts (Figs. 5 and 6) which were not dealt with due to inadequate information. How the role of the ecosystem may vary in the functioning of jackrabbit populations with changes in latitude (Mullen 1968) is worthy of further investigation.

Individual behavioral constraints and the nature and extent of feedback mechanisms between plant and animal complexes are very difficult to measure. A model capable of simulating systems functions would be valuable in supplying information that is difficult to measure or generate optimum or maximum-likelihood combinations of variables that could produce known final-system conditions (Gross and Walters 1970).

The management implication from this study is essentially that jackrabbits on the Pawnee National Grassland are relatively sedentary animals. Therefore, ecological investigations or control programs should be conducted on a local basis. It would be economically inefficient to attempt to control jackrabbits whose range does not include a problem situation. French et al. (1965:23) came to the same conclusion and indicated "...the fallacy of conducting control programs... at distances greater than 1 mile from... alfalfa fields, since the problem is strictly a local one."

SUMMARY

This study measured black-tailed and white-tailed jackrabbit movements and densities on the Pawnee National Grasslands. Jackrabbit occupation-area and density systems components were mapped and discussed drawing from simultaneous studies.

Movements and densities were related to vegetative types and cattle grazing treatments. Vegetative types were designated using the standard Interagency Big Game Range Analysis technique. Pastures within the study area were designated for long term cattle grazing experimentation by the Agricultural Research Service.

Trap-retrapping, ear tagging and radio-telemetry techniques were used to index rates of movement, distances moved and areas occupied. Drive plot censuses, spotlight counts and aerial track counts were used to estimate densities.

White-tailed jackrabbits occupied larger areas in 24-hour periods and moved at faster rates than did black-tailed jackrabbits. Adults had larger movement indices than juveniles for both species. Black-tail females exhibited larger indices than males, whereas white-tail males had larger indices than their female counterparts.

Both species had slower movement rates during twilight hours than night hours. Feeding periods appeared to correspond with periods

of relatively low rates of movement. Day resting locations were scattered in or near night activity areas in no discernible pattern.

Generally, onset and cessation of activity covaried with seasonal changes in sunset and sunrise. Rates of movement were significantly greater during April and following months than in previous months. This increase corresponded with the onset of the vegetative growing season.

No large scale seasonal migrations were documented. Prior to April, white-tailed jackrabbits occupied cattle-grazed pastures having taller vegetation and pastures having shorter vegetation during and after April. Black-tails had the same preferences but changed from pastures with taller to those with shorter vegetation about 3 months later than white-tails.

White-tails increased their total area occupied at a faster rate than black-tails and they probably have a larger annual occupation area.

Long distance (over 3 km) excursions outside of occupation areas were a rare occurrence. None of three recorded long distance movements occurred at a time when seasonal movements might have been expected.

Black-tailed jackrabbit seasonal densities fluctuated in greater magnitude than white-tail densities and exhibited greater fluctuations in the four-wing saltbush vegetative type (13-Atca) than in other types.

White-tailed jackrabbit seasonal densities fluctuated in greatest magnitude in the bluegrama-buffalograss type (1-Bogr-Buda).

Although black-tailed jackrabbits averaged smaller individual weights than white-tails, they accounted for more biomass due to their larger numbers on the study area.

Species distribution appeared to be influenced by relative elevation and vegetative types. Generally, white-tails occupied higher elevations and open grassy vegetative types and were not concentrated. Black-tails were found over the entire study area with concentrations in dense-shrub covered bottomlands.

Most natural mortality of both species was attributed to avian (eagles) and mammalian (coyotes) predation. Predation was concentrated more in shrub dominated washes than in surrounding open grassy areas. White-tailed jackrabbits and adults of both species had lower mortality rates than black-tails and juveniles, respectively. Mortality rates were essentially the same for both sexes.

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# APPENDICES

# APPENDIX A

## I-Trap-Retrap Data Format

The Jackrabbit trap-retrap data collected at the Pawnee Site in 1970-71 is Grassland Biome data set A2U103B. The data consists of three types of cards: (i) initial trap card for each rabbit, (ii) mortality card if rabbit has died, and (iii) retrap card(s). A description and listing of the data types follow.

| Column | Contents |
|---|---|
| i. Initial trap card | |
| 1 | Card type code |
| 2-4 | Rabbit number |
| 6-7 | Year |
| 8-10 | Day of year |
| 12-15 | Time |
| 17-19 | Right ear tag number |
| 21-23 | Left ear tag number |
| 25 | Right tag color code |
| 27 | Left tag color code |
| 29-30 | Color number |
| 32-34 | Radio number |
| 36-37 | Channel number |
| 39 | Species code |
| 41 | Age code |
| 43 | Sex code |
| 45-47 | X coordinate |

| | |
|---|---|
| 49-50 | Y coordinate |
| 52 | Reproductive status code |
| 54 | Mortality code |

ii. Mortality card

| | |
|---|---|
| 1 | Card type code |
| 2-4 | Rabbit number |
| 6-7 | Year |
| 8-10 | Day of year |
| 12-15 | Time |
| 17 | Reproductive status code |
| 19 | Cause of death code |
| 21 | Condition of victim code |
| 23-25 | X coordinate |
| 27-28 | Y coordinate |

iii. Retrap card

| | |
|---|---|
| 1 | Card type code |
| 2-4 | Rabbit number |
| 6-7 | Year |
| 8-10 | Day of year |
| 12-15 | Time |
| 17 | Capture type code |
| 19-21 | New tag number |
| 23-25 | X coordinate |
| 27-28 | Y coordinate |
| 30 | Instrument replace code |
| 32 | Reproductive status code |

## Codes Used in Trap-retrap Data

### Card Type Code

I - Initial trap card

M - Mortality card

R - Retrap card

### Species Code

1 - BT - Jack

2 - WT - Jack

3 - Cottontail

### Age Code

1 - Juvenile

2 - Adult

### Reproductive Status Code

0 - None

1 - Pea

2 - Grape

3 - Walnut

4 - Egg

5 - Term

6 - Unknown

7 - Scrotal testicles

### Mortality Code

1 - Living

2 - Dead

### Capture Type Code

1 - Sighting

2 - Retrap

### Color Code

1 - Red

2 - Green

3 - Orange

4 - White

5 - Yellow

### Sex Code

1 - Male

2 - Female

3 - Unknown

### Cause of Death Code

1 - Mammal predator

2 - Avian predator

3 - Disease

4 - Accident

5 - Weather

6 - Unknown

7 - Other

8 - Shot

9 - Shock

0 - Trap

### Condition of Victim Code

1 - Fresh kill

2 - Remains

### Instrument Replace Code

0 - Not replaced

1 - Replaced battery

2 - Replaced transmitter

## II-Telemetry Data Format

The Jackrabbit telemetry data collected at the Pawnee Site in 1970-71 is Grassland Biome data set A2U104B. The data consists of three types of cards: (i) initial trap card, (ii) mortality card if rabbit has died, and (iii) telemetry card(s). A description and listing of the data types follow.

| Column | Contents |
|---|---|
| i. Initial trap card | |
| 1 | Card type code |
| 2-4 | Rabbit number |
| 6-7 | Year |
| 8-10 | Day of year |
| 12-15 | Time |
| 17-19 | Right ear tag number |
| 21-23 | Left ear tag number |
| 25 | Right tag color code |
| 27 | Left tag color code |
| 29-30 | Color number |
| 32-34 | Radio number |
| 36-37 | Channel number |
| 39 | Species code |
| 41 | Age code |
| 43 | Sex code |
| 45-47 | X coordinate |
| 49-50 | Y coordinate |

| | |
|---|---|
| 52 | Reproductive status code |
| 54 | Mortality code |

ii. Mortality card

| | |
|---|---|
| 1 | Card type code |
| 2-4 | Rabbit number |
| 6-7 | Year |
| 8-10 | Day of year |
| 12-15 | Time |
| 17 | Reproductive status code |
| 19 | Cause of death code |
| 21 | Condition of victim code |
| 23-25 | X coordinate |
| 27-28 | Y coordinate |

iii. Telemetry card

| | |
|---|---|
| 1 | Card type code |
| 2-4 | Rabbit number |
| 6-7 | Year |
| 8-10 | Day of year |
| 12-15 | Time |
| 17-18 | Channel number |
| 19 | Channel changed rabbits code |
| 21-23 | Bearing #1 |
| 25-27 | Bearing #2 |
| 29-31 | Ambient temperature |
| 33-35 | Beeps per minute (BPM) |

## Codes Used in Telemetry Data

**Card Type Code**

I - Initial trap card

M - Mortality card

T - Telemetry card

**Species**

1 - BT - Jack

2 - WT - Jack

3 - Cottontail

**Age Code**

1 - Juvenile

2 - Adult

**Reproductive Status Code**

0 - None

1 - Pea

2 - Grape

3 - Walnut

4 - Egg

5 - Term

6 - Unknown

7 - Scrotal testicles

**Mortality Code**

1 - Living

2 - Dead

**Channel Changed Rabbits Code**

0 - Not changed

1 - Changed rabbits once

2 - Changed rabbits twice

3 - Etc.

**Color Code**

1 - Red

2 - Green

3 - Orange

4 - White

5 - Yellow

**Sex Code**

1 - Male

2 - Female

3 - Unknown

**Cause of Death Code**

1 - Mammal predator

2 - Avian predator

3 - Disease

4 - Accident

5 - Weather

6 - Unknown

7 - Other

8 - Shot

9 - Shock

0 - Trap

**Condition of Victim Code**

1 - Fresh kill

2 - Remains

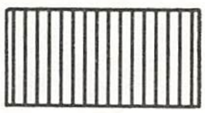
# APPENDIX B

# APPENDIX B

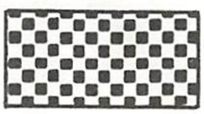
## Seasonal Jackrabbit Discrimination of Cattle-Grazed Pastures

Description of Pastures

Pastures are comprised of relatively homogeneous vegetative types (1-Bogr-Buda and 16-Atca-Chna-Kosc).

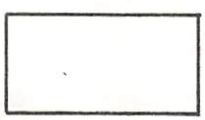


Moderately grazed in winter, section 15W½ is 62 percent type 16 and 38 percent type 1, section 145 is type 1.



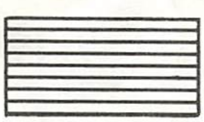
Heavily grazed in winter, section 22E½ is 62 percent type 1 and 38 percent type 16.

Lightly grazed in summer, section 23W½ is type 1.



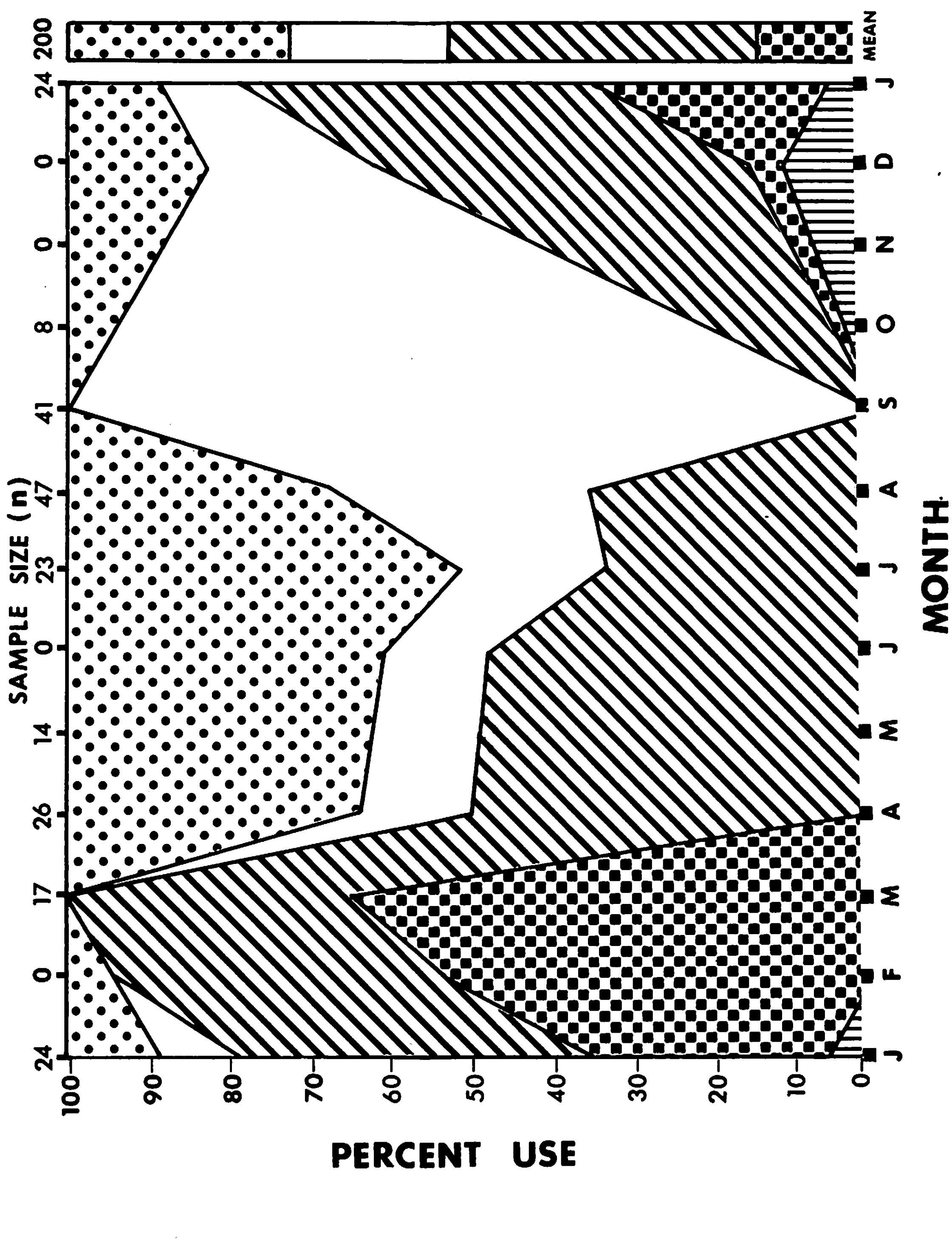
Moderately grazed in summer, section 15E½ is 90 percent type 1 and 10 percent type 16, sections 27, 28 and 29 are type 1.

Heavily grazed in summer, section 23E½ is type 1.

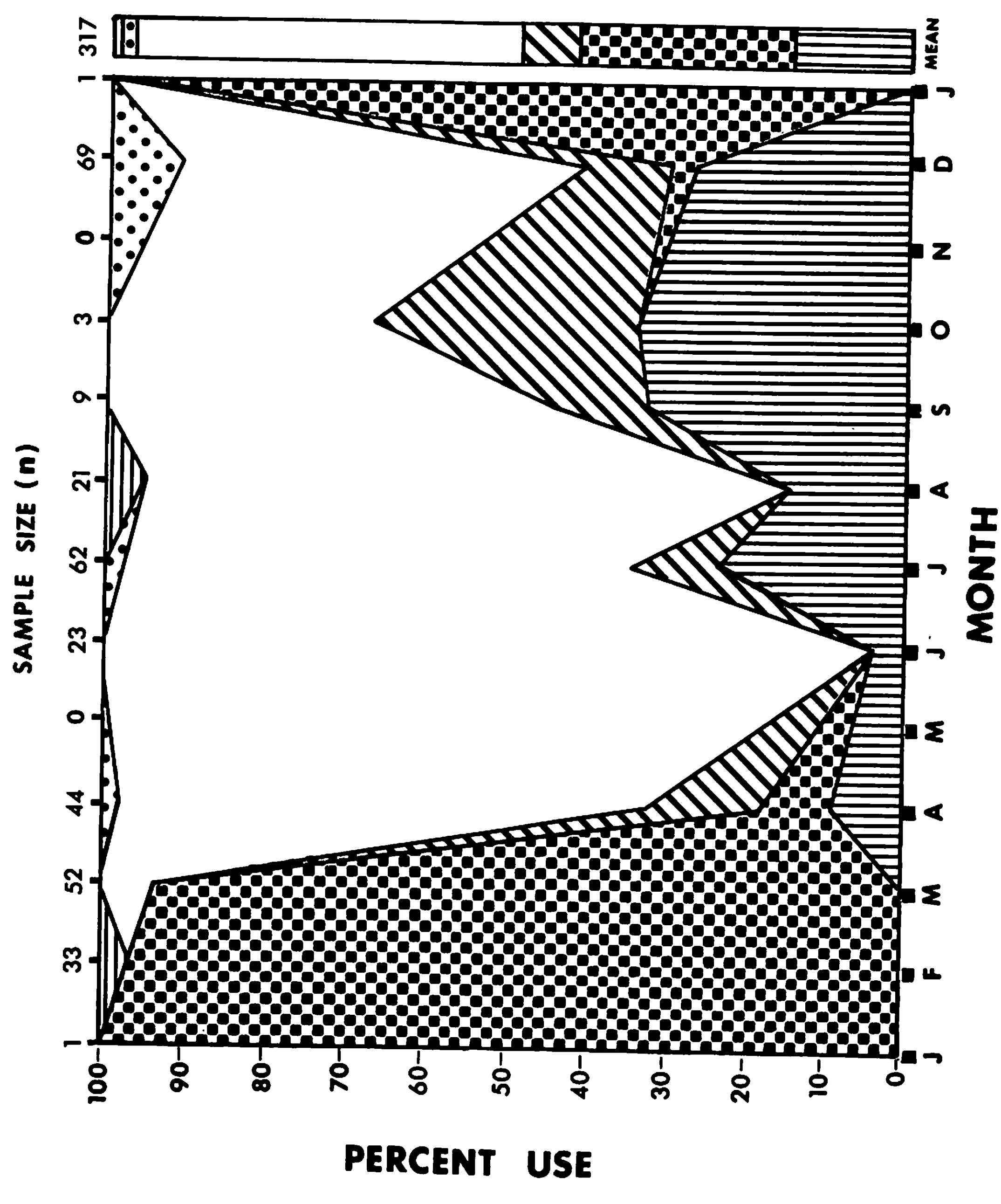


Moderately grazed yearlong, section 22NW¼ is type 1.

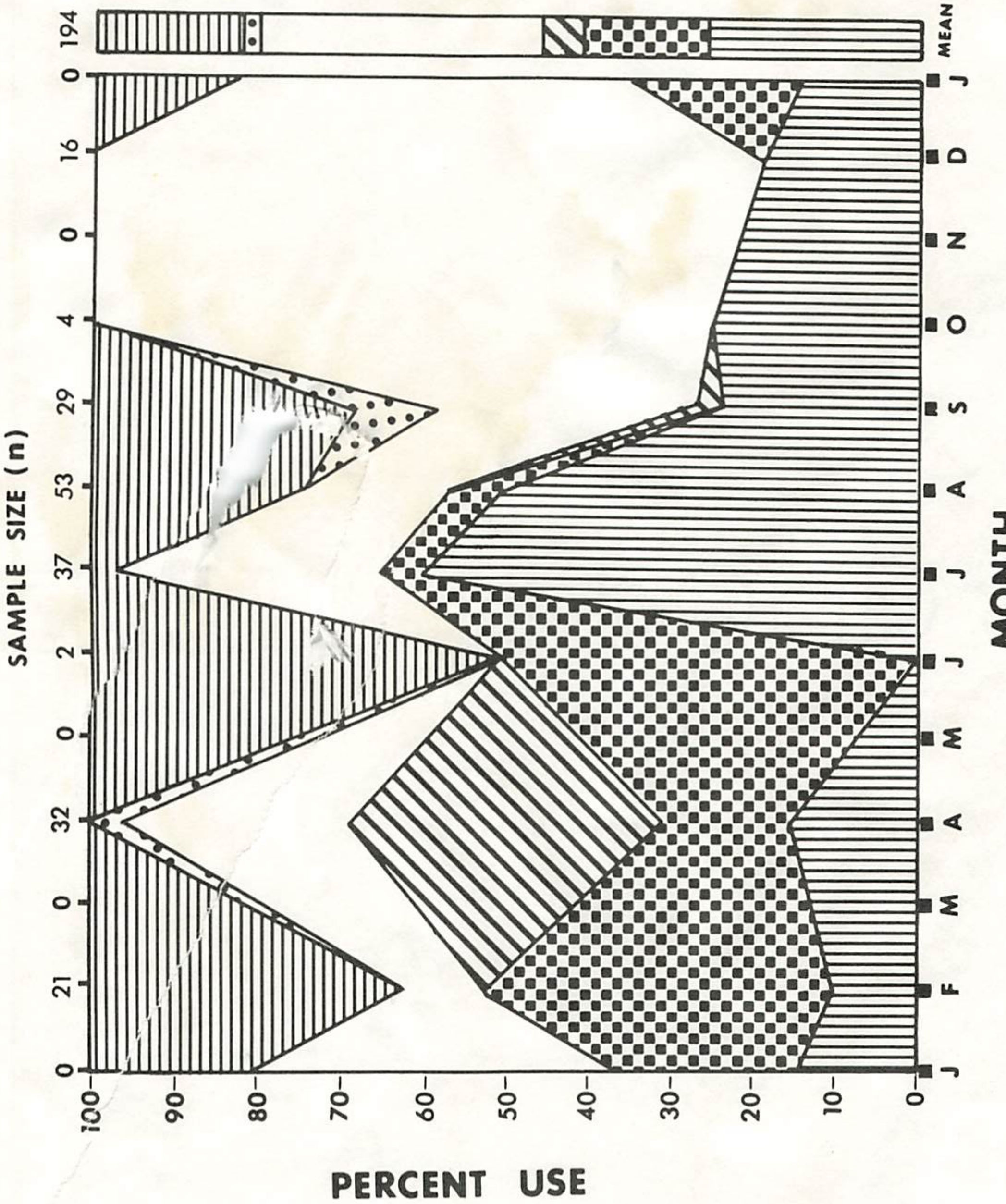
I- White-tailed jackrabbit No. 121 (adult, female) discrimination of cattle-grazed pastures.



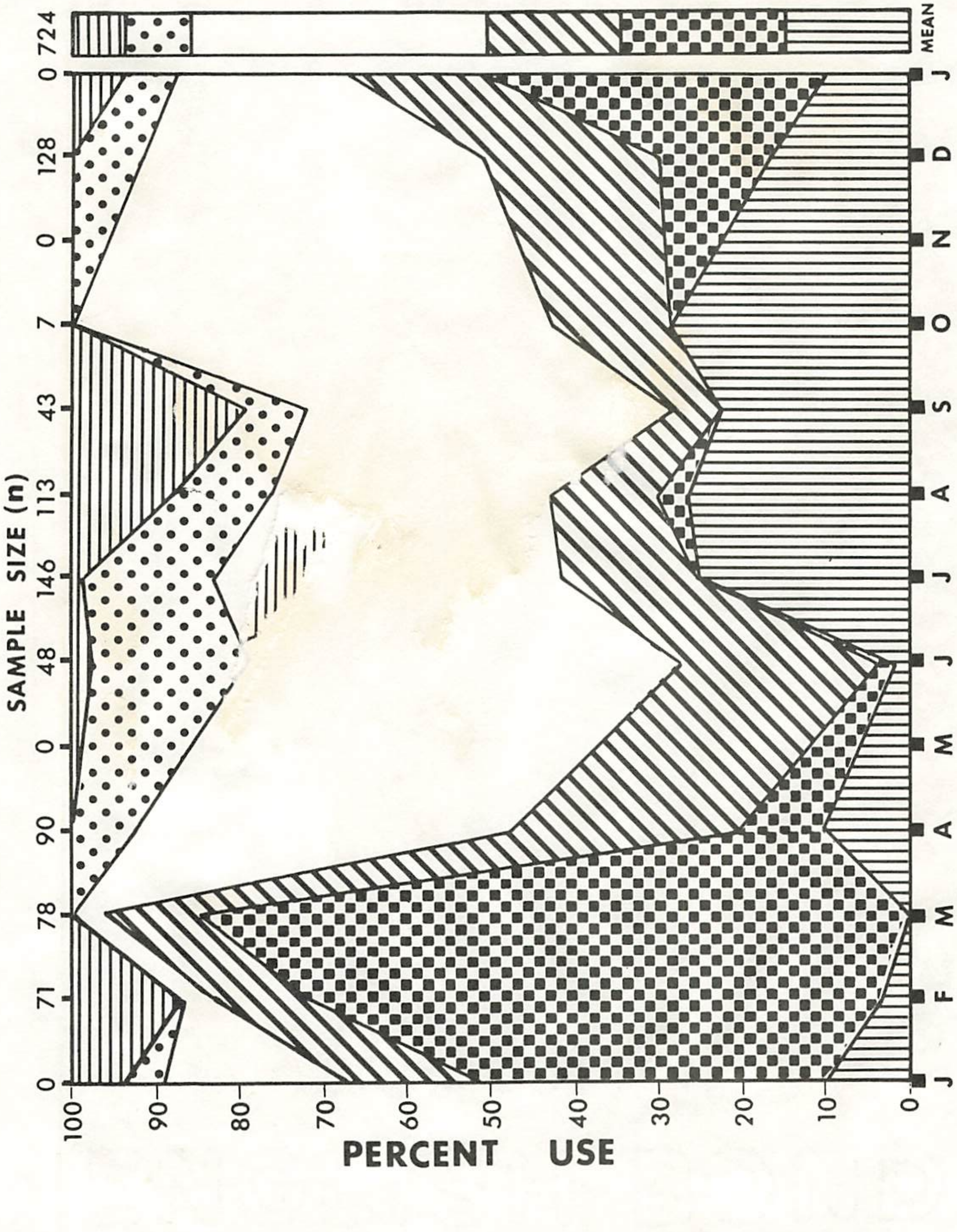
II - White-tailed jackrabbit (except white-tailed No. 121) discrimination of cattle-grazed pastures.



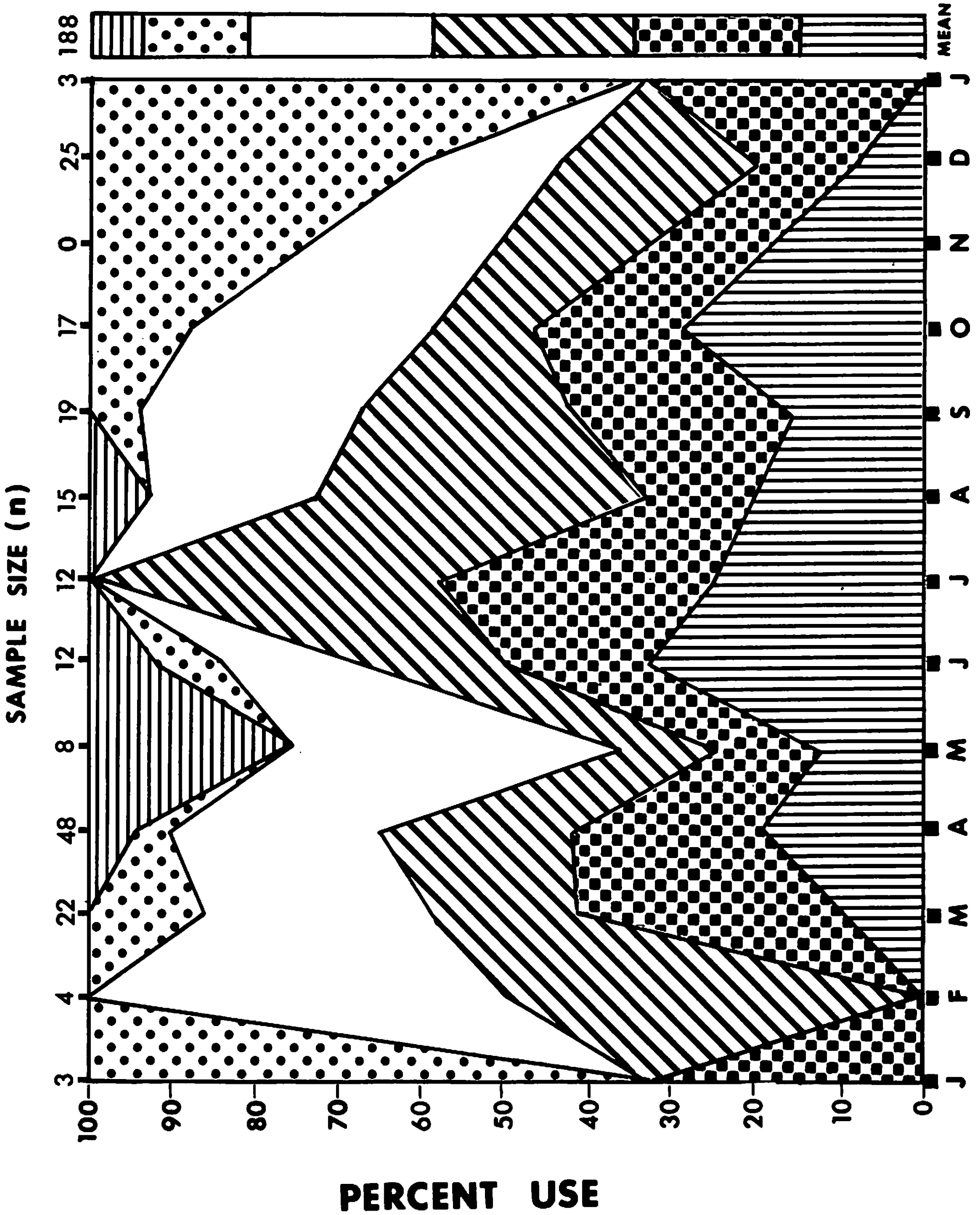
III - Black-tailed jackrabbit discrimination of cattle-grazed pastures.



IV - Total jackrabbit discrimination of cattle-grazed pastures (telemetry data).



V - Total jackrabbit discrimination of cattle-grazed pastures (trap-retrap data).



# APPENDIX C

I-Calculations of white-tailed jackrabbit density and biomass by vegetative type on the study area.

| Date | Vegetative type* | Hares/ha | Grams/ha | Veg. type size (ha) | Hares/veg. type | Kg/veg. type | Total Hares | Total Kg. |
|---|---|---|---|---|---|---|---|---|
| 1970 | A | .308 | 94 | 320 | 99 | 30.08 | 175 | 405.56 |
| Apr. | B | .062 | 188 | 1531 | 37 | 215.87 | | |
| | C | .046 | 141 | 849 | 39 | 159.61 | | |
| | A | .046 | 125 | 320 | 15 | 40.00 | 489 | 486.29 |
| Nov. | B | .139 | 376 | 1531 | 213 | 127.07 | | |
| | C | .308 | 83 | 849 | 261 | 319.22 | | |
| 1971 | A | .015 | 47 | 320 | 5 | 15.04 | 232 | 546.06 |
| Apr. | B | .123 | 373 | 1531 | 188 | 214.34 | | |
| | C | .046 | 140 | 849 | 39 | 316.68 | | |
| | A | 0 | 0 | 320 | 0 | 0 | 292 | 610.88 |
| Nov. | B | .123 | 321 | 1531 | 188 | 338.35 | | |
| | C | .123 | 221 | 849 | 104 | 272.53 | | |

*A, 13-Atca; B, 1-Bogr-Buda; C, 16-Atca-Chna-Kosc.

II-Calculations of black-tailed jackrabbit density and biomass by vegetative type on the study area.

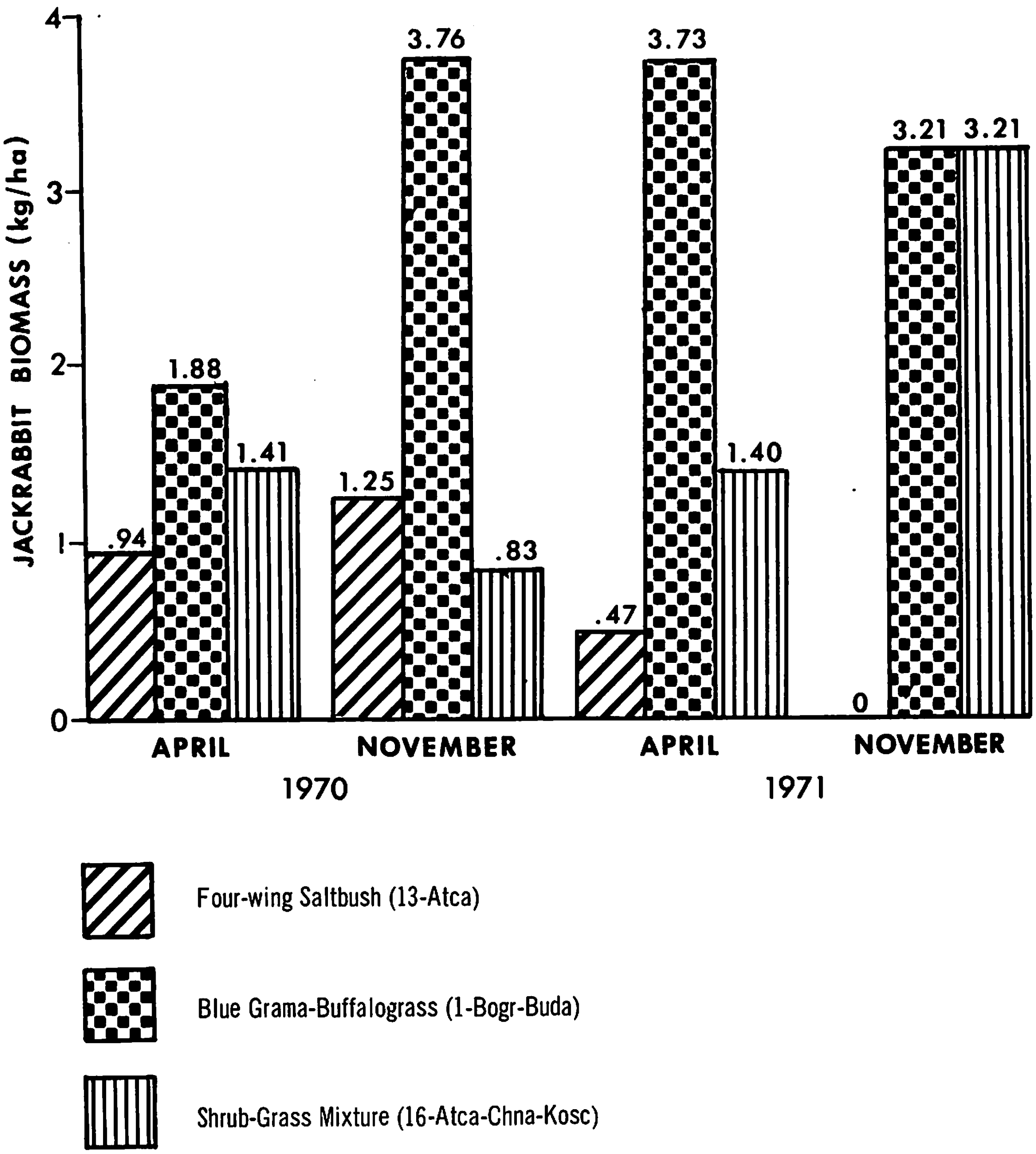
| Date | Vegetative type* | Hares/ha | Grams/ha | Veg. Type size (ha) | Hares/veg. type | Kg/veg. type | Total Hares | Total kg. |
|---|---|---|---|---|---|---|---|---|
| 1970 | A | .324 | 905 | 320 | 104 | 289.60 | 388 | 457.77 |
| Apr. | B | .015 | 43 | 1531 | 23 | 131.67 | | |
| | C | .308 | 86 | 849 | 261 | 36.51 | | |
| | A | .880 | 2217 | 320 | 282 | 709.44 | 845 | 1192.09 |
| Nov. | B | .308 | 78 | 1531 | 471 | 416.43 | | |
| | C | .108 | 272 | 849 | 92 | 66.22 | | |
| 1971 | A | .201 | 533 | 320 | 64 | 170.56 | 298 | 818.81 |
| Apr. | B | .093 | 246 | 1531 | 142 | 439.40 | | |
| | C | .108 | 287 | 849 | 92 | 208.85 | | |
| | A | 1.251 | 3102 | 320 | 400 | 992.64 | 975 | 1526.50 |
| Nov. | B | .308 | 77 | 1531 | 471 | 468.49 | | |
| | C | .123 | 306 | 849 | 104 | 65.37 | | |

*A, 13-Atca; B, 1-Bogr-Buda; C, 16-Atca-Chna-Kosc.

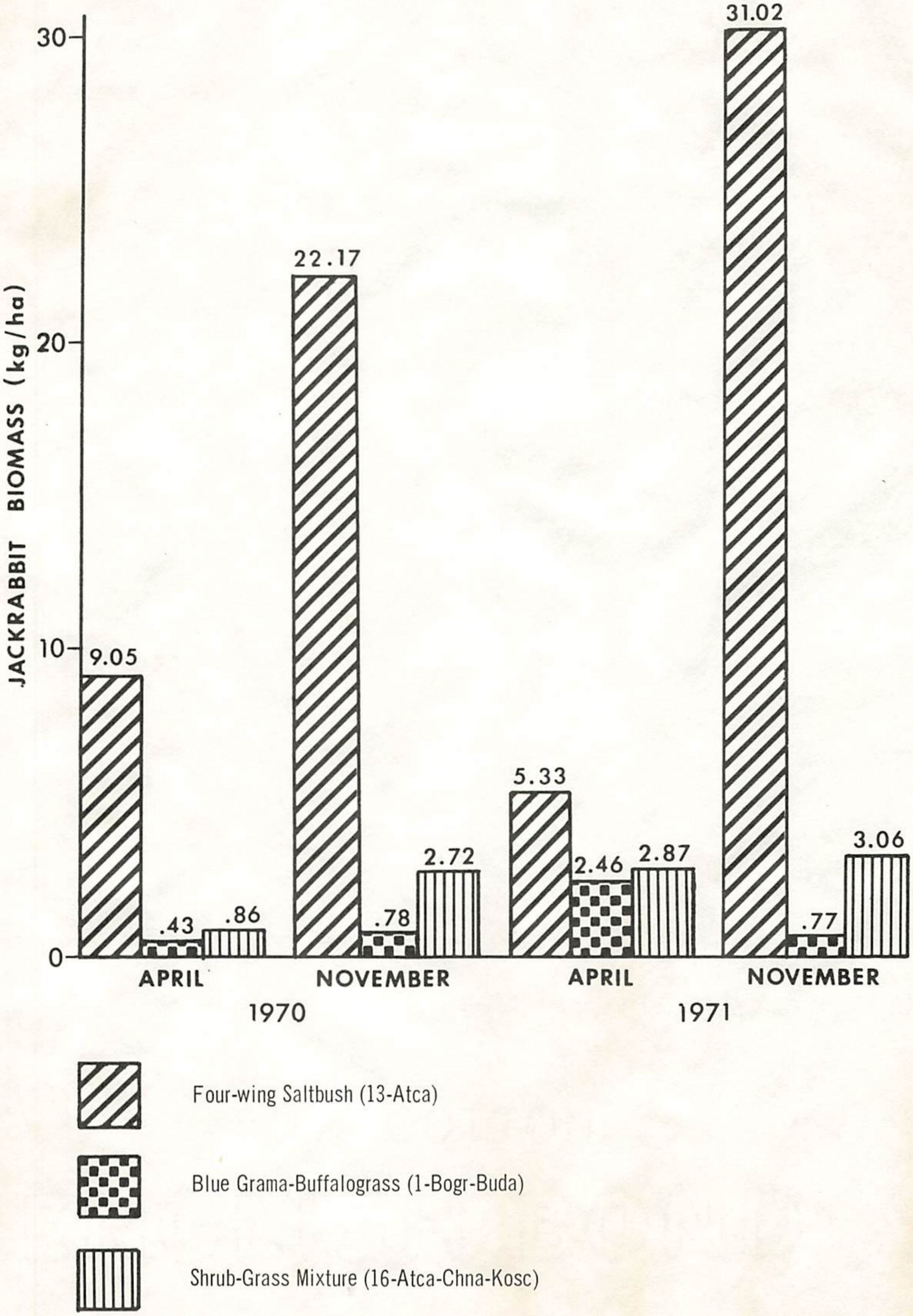
# APPENDIX D

APPENDIX D

I-Seasonal Biomass of White-tailed Jackrabbits by Vegetative Type



II- Seasonal Biomass of Black-tailed Jackrabbits by Vegetative Type



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