AN ABSTRACT OF THE THESIS OF

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in Fisheries and Wildlife presented on December 12, 1979

Title: Seasonal Movements and Home Ranges of Mule Deer at Lava Beds National Monument

Abstract approved: Redacted for Privacy

Edward Starkey

From April 1977 through May 1978, research was conducted to determine the seasonal movements and home ranges of mule deer (*Odocoileus hemionus hemionus*) does at Lava Beds National Monument, California. Radiotelemetry was used to locate migration routes and summer ranges of migratory deer. Information was obtained also on the seasonal use of burns by deer.

Deer migrated from the monument in a south-easterly direction to low elevation summer range (below 1500 m). Distances travelled to summer ranges varied from 19 to 65 km. Movements of migratory does during summer appeared to be associated with drought conditions that prevailed in 1977 on the summer range.

Migratory and non-migratory does occupied site-specific home ranges on the winter range. Migratory does returned to essentially the same home ranges on the winter range. Size of home ranges did not vary significantly ($P > 0.05$) among seasons. Mean minimum daily distance moved by radio-collared does was significantly ($P < 0.05$) greater during the fall and was probably associated with dry forage conditions in early September and the extensive movements of some does during the rut.

Radio-collared does used burned areas within their home ranges frequently throughout all seasons. Most does selected burned areas in the fall and spring and used them at least in proportion to their availability during winter. Adult does did not abandon or extend their home ranges as a result of burns within or adjacent to their home ranges. The frequent use of burned areas by radio-collared does appeared to be associated with the availability of herbaceous forage in the burns.

Based on reports of range burning in the literature (Champlin and Winward 1979, Christensen 1973, Sampson 1944), prescribed burns on the winter range in the monument and recent wildfires on seasonal ranges to the south, are likely to increase the quantity and improve the nutritional quality of forage. As a result of typical warming trends in March, herbaceous vegetation is likely to be available in burns by early or mid spring. The increased availability of forage during the third trimester of gestation may result in increased fawn survival and an eventual increase in the deer population.

Seasonal Movements and Home Ranges of Mule Deer at Lava Beds National Monument

by

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A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed December 1979

Commencement June 1980

APPROVED:

Redacted for Privacy

Associate Professor of Fisheries and Wildlife in charge of major

Redacted for Privacy

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Redacted for Privacy

Dean of Graduate School

Date thesis is presented December 12, 1979

Typed by Sharon Mosley for Alice Purcell

ACKNOWLEDGEMENTS

I extend my thanks to the many people who assisted me during the course of my study and research. In particular, I thank my major professor, Dr. Ed Starkey, for providing me the opportunity for study and research, and for his advice and encouragement throughout the entire process. I also appreciate the advice and editorial comments of my graduate committee members, Drs. Dave deCalesta, William Krueger and Virgil Freed.

Jim Blaisdell provided advice and assistance in the field and Paul Hartel and Jim Sleznick permitted me access to data on file at Lava Beds for which I am grateful. I thank other staff members of Lava Beds for their assistance in the field, especially the maintenance crew who kept the mobile tracking system functional. Dave Zezulak and Rick Frenzel also deserve thanks for their assistance in capturing and handling deer.

I thank Doug Thayer of the California Department of Fish and Game for his helpful comments and for making accessable data on the Glass Mountain deer herd. A special thanks goes to Marcel and Edna Kresge, of the National Forest Service, who offered me their friendship and provided much helpful information on activity of collared does at Round Mountain, and the layout of roads in the Modoc National Forest.

I appreciate the encouragement of my friends in the Cooperative Park Studies Unit, Kurt Jenkins and Chip Leslie; Chip Leslie also deserves credit for editing the early drafts of this thesis.

My greatest appreciation and thanks go to Roger Schnoes for his outstanding assistance in all phases of this study, from beginning to end. I particularly wish to acknowledge his part in tracking the movements of migratory does in spring 1978.

Finally, I appreciate the time and effort of Sharon Mosley for typing the thesis manuscript.

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INTRODUCTION

Lava Beds National Monument lies within the winter range of the Glass Mountain mule deer (*Odocoileus hemionus hemionus*) herd (Figure 1). The winter ranges of the Mount Shasta and Interstate deer herds lie to the west and east, respectively (Figure 1). It is probable that some deer from the Mount Shasta and Interstate herds are present in the monument. The majority of deer of the Interstate herd migrate north to summer range in Oregon. Most deer of the Glass Mountain and Mount Shasta herds migrate to summer range in the Modoc and Shasta-Trinity National Forests south of the monument. It is the deer of the Glass Mountain herd that winter in the monument with which this study is concerned.

The majority of deer in the vicinity of Lava Beds are Rocky Mountain mule deer (*O. h. hemionus*). However, Columbian black-tailed deer (*O. h. columbianus*) are abundant on the western fringe of the range of the Glass Mountain herd and an intergradation of the two subspecies is evident in the area (Cowan 1956).

Prior to the arrival of white settlers, the floristic communities of Lava Beds were shaped and maintained by frequent wildfires (Johnson and Smathers 1976). Fire suppression since the early 1900's is partially responsible for alterations that occurred in the pristine plant communities. In 1973, a wildfire occurred in the southern part of Lava Beds. It burned approximately 200 ha of vegetation and nearly consumed Park Service headquarters and residential buildings. This conflagration prompted a prescribed burning program in the monument to investigate the return of fire to the Lava Beds ecosystem.

With the initiation of prescribed burning, several studies were started to determine its effects on plant and animal communities in Lava Beds. In 1976, Schnoes (1978) began research on the impact of

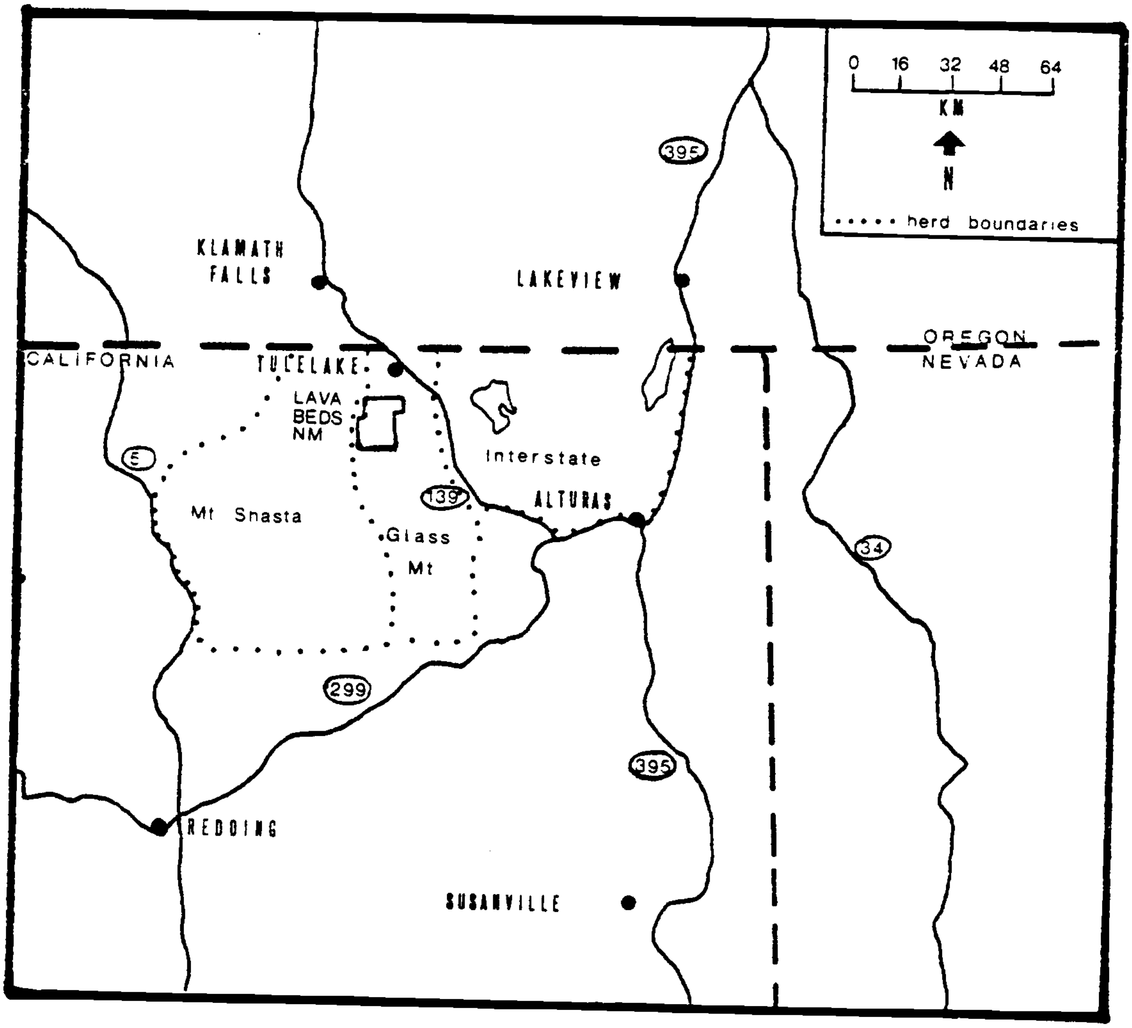

Figure 1. Location of Lava Beds National Monument in relation to the ranges of three mule deer herds in northeastern California.

prescribed burning on mule deer that wintered in the monument. His study focused on deer movements, behavior, and feeding habits in relation to burned areas.

In the present study, seasonal movements of ear-tagged and radio-collared deer that wintered in the monument were monitored from April 1977 through May 1978. The general objectives of the study were to provide information on seasonal movements of deer in the monument and to obtain additional information that would aid interpretation of deer response to the prescribed burning program. The specific objectives of the study were as follows:

1) to locate summer range and migration routes of migratory deer that winter in the monument;
2) to determine home ranges of deer on the winter range and ultimately, to determine if migratory deer return to site-specific home ranges in Lava Beds; and
3) to monitor daily activity patterns and seasonal and daily use of burns by deer in the monument.

In the past, habitat management for deer frequently focused on winter ranges. However, cover and nutritional characteristics of summer and migratory transitional ranges were also found to influence productivity and fawn survival (Robinette and Gashwiler 1951, Julander et al. 1961, Salwasser et al. 1978, and Holl et al. 1979). The majority of deer in the monument are migratory yet there is minimal documentation on the location of migration routes and summer range of these deer. Herd composition counts from the California Department of Fish and Game indicate that fawn losses are greatest during the summer (Appendix 1). Since habitat conditions on transitional and summer ranges influence the population level of deer in the monument, and baseline information is lacking on seasonal movements of migratory deer, the first objective was undertaken to locate migration routes and summer range of these deer.

Many investigations have shown that mule deer return to traditional seasonal ranges (Leopold et al. 1951, Gruell and Papez 1963, and Zalunardo 1965). Leckenby (1977) showed that individual deer return to the same specific areas on their seasonal ranges. He noted that habit confines subpopulations to their traditional areas even though better habitat may exist in other areas of a seasonal range (Leckenby 1977). In the winters of 1976 and 1977, Schnoes (1978) obtained data which suggested that deer in Lava Beds also returned to site-specific home ranges in the monument. He hypothesized that prescribed burns may affect directly only those subpopulations with home ranges adjacent to or overlapping burned areas. Thus the second objective was undertaken to augment data obtained by Schnoes on the home range patterns of deer.

Schnoes (1978) documented daily activity and movement patterns of deer in relation to burns in the winters of 1976 and 1977. However, deer are on the winter range in Lava Beds from fall through mid spring. The third objective was undertaken to determine the response of deer to burned areas during those seasons and for a third winter period.

STUDY AREA

Lava Beds National Monument is located in northeastern California, approximately 72 km south of Klamath Falls, Oregon (Figure 1). The monument was established in 1925 and is presently administered by the National Park Service for its geological and historical significance. Geologically, the area is a result of relatively recent (within the last 1600 yrs) volcanic activity. Historically, it is the site of the 1873 Modoc Indian war.

The area is characterized by a semi-arid climate. The mean annual precipitation is 36.8 cm. Summers are moderately warm and dry with a mean maximum temperature of 27°C and precipitation averaging 1.6 cm. Winters are cool with an average minimum temperature of 4°C. Most precipitation occurs as snow in the winter and early spring.

The monument is approximately 18,600 ha. It is part of the Modoc Plateau, a high lava plateau that resulted from the build up of basalt lava flows (Alt and Hyndman 1975). It lies on the northern flank of a shield volcanoe, the Medicine Lake Highlands, which erupted approximately 100,000 yrs ago. The terrain rises gradually from 1250 m in the Tule Lake Basin at the northeastern boundary, to 1700 m in the southwestern corner (Figure 2). The incline in elevation continues outside the monument to over 2100 m in the Medicine Lake Highlands (Figure 2). The soil is of volcanic origin. Cinder cones, lava flows and lava tubes are scattered throughout the area and result in a rough, broken terrain.

The northern two-thirds of the monument is characteristic of a shrub-steppe habitat (Figure 3). Dominant shrubs in that section include mountain big sagebrush (Artemesia tridentata), rabbitbrush (Chrysothamnus nauseosus and C. viscidiflorus), and horsebrush (Tetradymia canescens). Common native bunchgrasses include bluebunch wheatgrass (Agropyron spicatum), neddlegrasses (Stipa thurberiana and S. occidentalis), Sandberg's bluegrass (Poa sandbergii), squirreltail

Figure 2. USGS map of study area. (1:250000)
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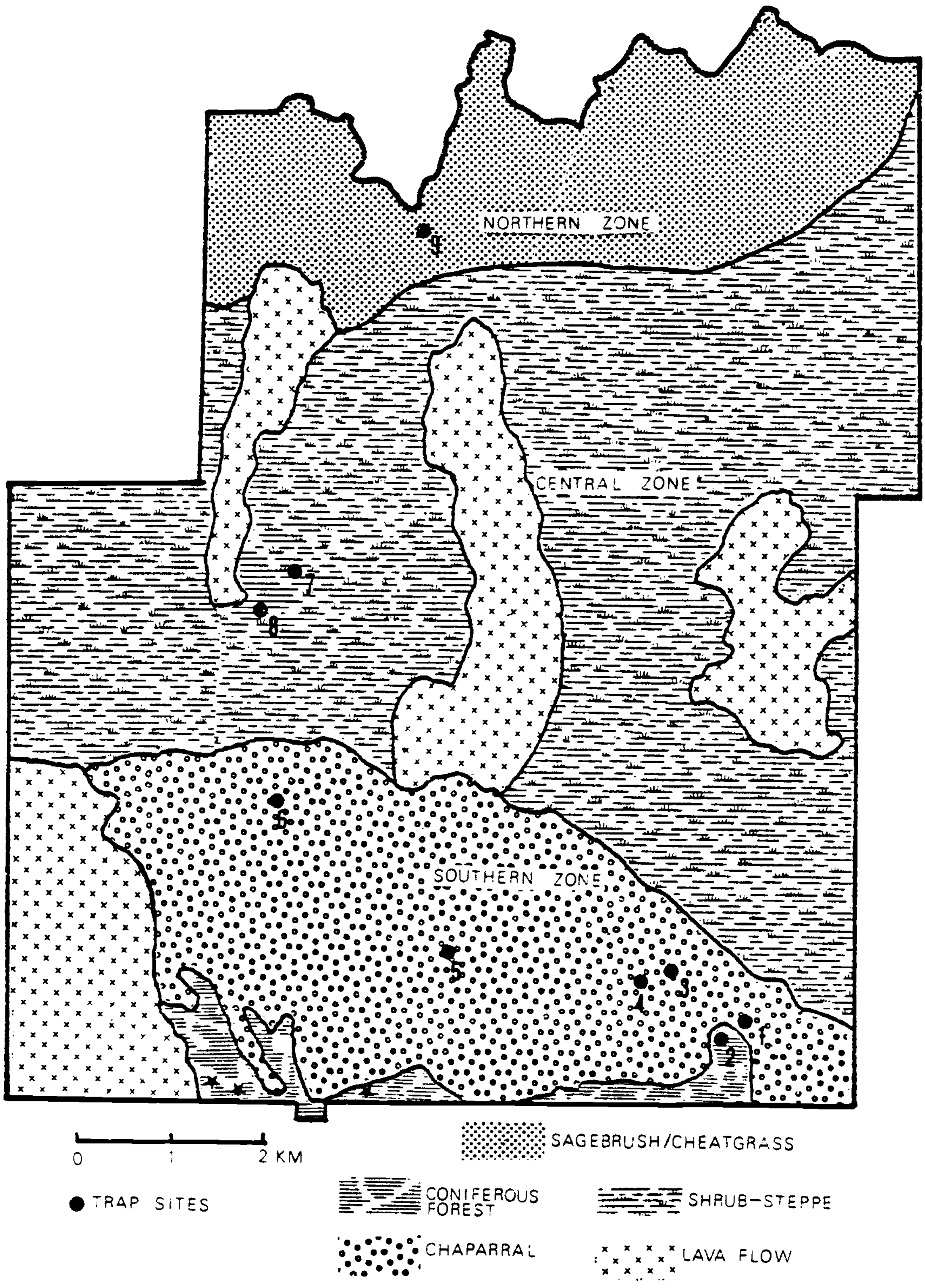

Figure 3. Vegetation zones and trap sites in Lava Beds National Monument. (Revised from Schnoes 1978).

(Sitanion hystrix), and Idaho fescue (Festuca idahoensis). Cheatgrass (Bromus tectorum) and tumbling mustard (Sisymbrium altissimum) are the most abundant introduced annuals.

The southern portion of the monument supports a western juniper (Juniperus occidentalis) and curlleaf mountain mahogany (Cercocarpus ledifolius) chaparral. Associated shrubs are mountain big sagebrush, bitterbrush (Purshia tridentata), and rabbitbrush. The extreme southern portion of the monument supports a coniferous forest of ponderosa pine (Pinus ponderosa), white fir (Abies concolor) and incense cedar (Libocedrus decurrens). The understory is comprised predominantly of bitterbrush, snowbrush (Ceanothus velutinus), and greenleaf manzanita (Arctostaphylus patula).

Schnoes (1978) divided the monument into three zones that reflected the type of vegetation and forage available to deer (Figure 3). The southern zone coincides with the juniper/mahogany chaparral and the coniferous forest. The 1973 wildfire (200 ha), and the 1976 West Crescent (25 ha) and 1977 Caldwell (65 ha) prescribed burns, occurred in that zone (Figure 4). Juniper and mountain mahogany are less common in the central zone, however bitterbrush and sagebrush are common along with the bunchgrasses. The prescribed burn at Fleener Chimneys (140 ha) was conducted in that zone in 1976 (Figure 4). Sagebrush and rabbitbrush dominate the northern zone; cheatgrass and tumbling mustard are frequent also. The Hovey Point prescribed burn (170 ha) occurred in that zone in 1976 (Figure 4).

Based on migration routes of migratory does, the migration corridor for deer that winter in Lava Beds extends south of the monument from the Sand Buttes to the lower hills of the Medicine Lake Highlands (Figure 2). Within the corridor, bitterbrush and mountain big sagebrush dominate the hills southwest of the monument with mountain mahogany and juniper. The ponderosa pine forest extends southwest into the higher elevations of the Highlands. Sagebrush, rabbitbrush, horsebrush, western needlegrass and cheatgrass are common on the plain surrounding the Sand Buttes, southeast of the monument.

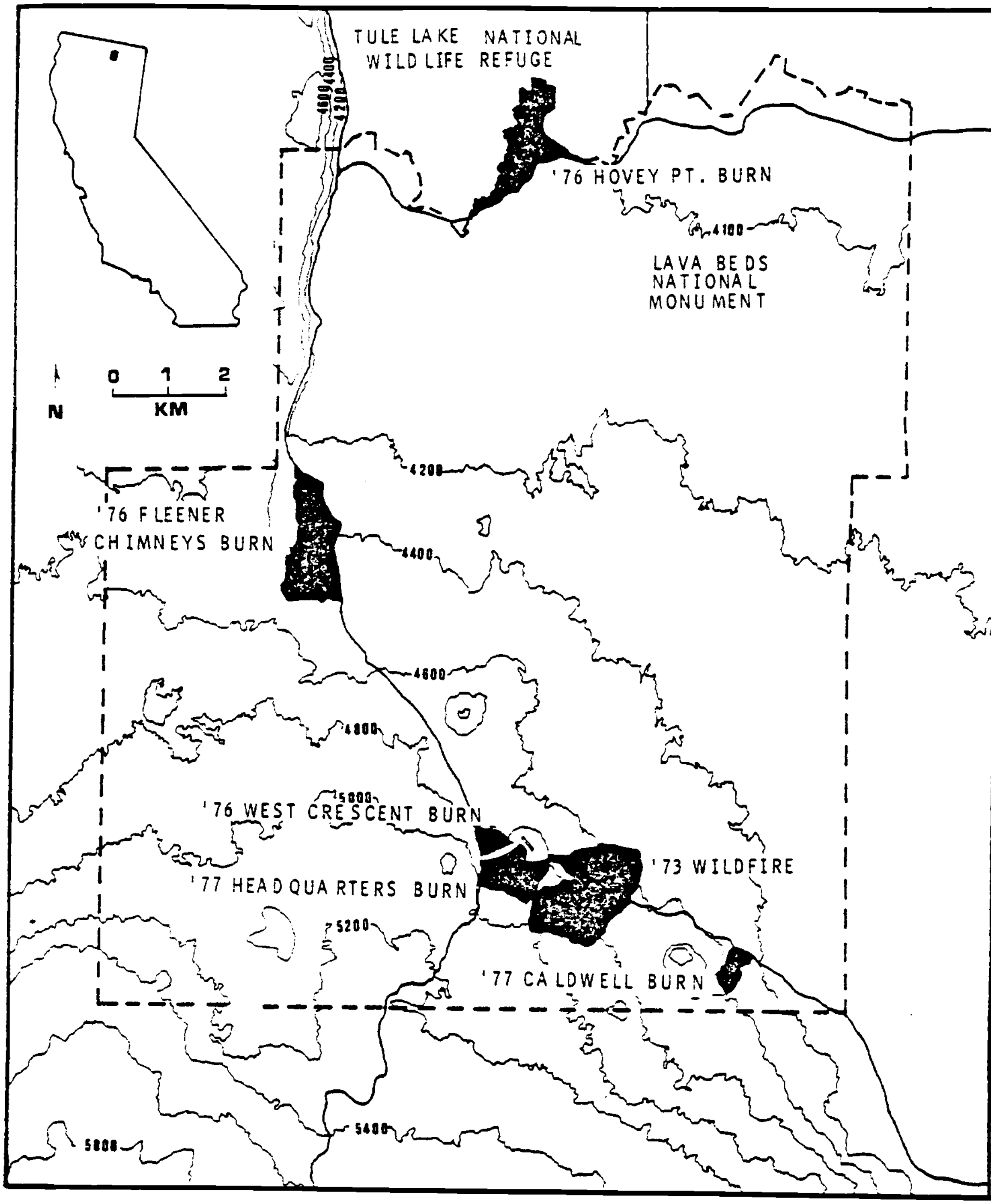

Figure 4. Location of study burns in Lava Beds National Monument.

The summer range used by migratory does that were monitored during 1977 and 1978 is approximately 24 km south of Lava Beds in the Modoc and Shasta-Trinity National Forests (Figure 2). The summer climate is hot and dry. Mean maximum and minimum temperatures during summer are 33°C and 11°C, respectively, based on weather data from Happy Camp Ranger Station, 18 km east of the area. The topography is flat east of the Highlands. Elevation rises from 1300 m east of the Long Bell State Game Refuge to 1500 m at the base of the Highlands (Figure 2). A ponderosa pine forest similar to that in the southern portion of the monument characterizes lower elevations of the summer range. Lava reefs and ridges are interspersed throughout the area. Curlleaf mountain mahogany and cherries (Prunus virginianus and P. emarginata) comprise the brush component in such areas, in addition to snowbrush and manzanita. Serviceberry (Amelanchier alnifolia), current (Ribes cereum) and gooseberry (R. velutinum) are also present but are less abundant. Common native perennial grasses include western needlegrass, squirreltail, mountain brome (Bromus carinatus) and bluebunch wheatgrass. Cheatgrass is also abundant throughout the area. Common forbs include Phlox spp., Vicia spp., Castelleja spp., Penstemon spp., Eriogonum spp., Mimulus spp., Cryptantha spp., Delphinium spp., Madia spp., Astragalus spp., Monitia spp., Phacelia spp., Senecio spp., Sidalcea spp., and Conyza spp.

Higher elevation of the Highlands support a mixed white fir forest with ponderosa pine, incense cedar and sugar pine (Pinus lambertiana). The highest elevations, those above 2100 m, support white fir and lodgepole pine (P. contorta).

Agriculture, domestic livestock, and fire have played important roles in shaping the present ecosystem of the monument and the summer range to the south. Early in the twentieth century, the southern portion of Tule Lake was drained and converted to cropland. The lake was reduced from approximately 40,500 ha to its present 5,300 ha. After the Modoc Indian war in 1873, large numbers of cattle and horses were brought into the area. At the turn of the century, the number of cattle declined but were replaced by domestic sheep. Overgrazing by domestic livestock played a major role in allowing the establishment of cheatgrass, particularly in the northern part of the monument (Cronemiller 1935, Knox 1953). Livestock grazing is presently prohibited within Lava Beds however, grazing allotments for domestic sheep exist on the deer summer range to the south.

Fire has been a dominant force in shaping the plant communities in the general area (Johnson and Smathers 1976). A policy of fire suppression was enforced in the monument prior to the initiation of prescribed burning. That policy has permitted the encroachment of juniper and the increase of sagebrush in the central portion of the monument (Johnson and Smathers 1976). In the southern portion of the monument, fire suppression has resulted in an increase of mountain mahogany, bitterbrush, and juniper. Portions of those brush communities are senescent and have resulted in a high fire fuel load (Johnson and Smathers 1976). Similar senescent shrub communities are evident also in several areas on the summer range south of Lava Beds.

METHODOLOGY

Field research was initiated in late March 1977 and continued through May 1978. Seasonal movements data were obtained from relocations of ear-tagged and radio-collared deer. Fifty-three deer were ear-tagged during the winters of 1976 and 1977. Four of these 53 deer were radio-collared in the winter of 1977 (Schnoes 1978). Seven additional does had radio-collars and ear tags attached in the spring of 1977. In the winter of 1978, seven more deer were ear-tagged; one of these received a radio-collar. Thus, by late spring of 1977, there were 11 radio-collared does. By mid fall 1977, two radio-collared does had died and transmitters had failed on two other does. The majority of information reported herein was obtained from the remaining eight radio-collared does. To prevent problems that may have resulted from the swollen necks of bucks during the rut, only does were radio-collared.

Deer marked in the spring of 1977 and the winter of 1976 were captured using Oregon single-gate traps (Oregon Department of Fisheries and Wildlife) baited with alfalfa, or darted using a mixture of Rompun (Xylazine) and M-99 (Etorphine). Drugs were administered with a CO_2 powered Cap-Chur gun (Palmer Chemical Company). Deer were weighed and a metal numbered eartag (California Department of Fish and Game) with colored plastic backing was attached. A summary of deer capture data from spring 1977 through winter 1978 is included in Appendix 2.

Telemetry equipment was purchased from AVM Instrument Company. Radio-collars were constructed of a double layer of neoprene-impregnated nylon machine belting. Transmitters were encapsulated in dental acrylic. The completed collars weighed 0.5-1.0 kg. Radios transmitted at 164.24-164.75 mhz; the theoretical life expectancy was approximately 1.5 yrs. Monitoring equipment included an AVM LA-12 receiver, 4-element hand-held yagi antenna, and a truck-mounted null-peak antenna.

The null-peak system consisted of twin yagi antennas attached to a three m mast with a compass rose and pointer attached at midpoint on the mast.

The maximum tracking range of the null-peak antenna was 24 km. Radio-collared deer were located by triangulation from two or three of several stations located throughout the study area. Locational error that may have resulted from truck alignment at those stations and mapping problems was estimated to be ± 2-4°. The time that elapsed between bearings ranged from 3-10 min. Locational error caused by an animal moving was probably minimal due to the relatively close proximity of deer to observer, usually less than three km.

Radio-locations of deer were plotted on United States Geological Survey maps (scale = 1:62500). X-Y UTM grid coordinates were assigned to those locations with an SAC Ultrasonic Digitizer. Model S50 Telemetry data on deer movements were analyzed using the Cyber 70, Model 73 computer at Oregon State University.

During spring and summer 1977, migratory does occasionally were monitored from an aircraft. Yagi antennas were attached to the steps of a Cessna 182 aircraft and the general location of migratory radio-collared does was obtained in flight. Specific locations of these deer were determined on the ground with the null-peak or hand-held antenna.

Radio-collared does were located at random throughout a 24 hr period. Each deer was usually located three times each day. The small number of relocations of ear-tagged deer provided an index to home range size however, movements data from radio-collared does provided the most complete information on home ranges.

Two methods were employed to estimate home ranges of radio-collared does. The outer-most locations of an animal were connected to obtain the minimum polygon home range. Numerous researchers have used the minimum polygon method (Mohr 1947, Odum and Kunzler 1955, Southwood 1966). It provides a consistant measure of home range size.

Koepple et al. (1975) described a statistical measure of home range size that constructed an ellipse based on variability within the locational data. Incorporating an adjustment for sample size and the F-statistic into the formula, a 95% confidence ellipse can be drawn about an animal's locations. This technique requires that locational data follow a bivariate normal distribution.

When tested, locational data for most does did not conform to a bivariate normal distribution. Violation of the assumption prevented statistical testing for shifts in the location of home ranges and centers of activity between seasons and years. Overlap of minimum polygon home ranges was used to roughly determine if does returned to and used the same home ranges each year on the winter range. However, the use of home range ellipses was retained in this study since they demonstrated variability in an animal's movements that was not evident from size or shape of minimum polygon home ranges. Unless specifically mentioned, home range size in the text refers to minimum polygon home ranges.

Seasonal home ranges were constructed also. Seasons were delineated as follows: summer, June-August, fall, September-November, winter, December-February, and spring, March-May. This division reflected the general change in temperature and moisture patterns which in turn, influenced the phenology of vegetation and deer movement patterns throughout the year.

Two-way analysis of variance (Neter and Wasserman 1974) was conducted to determine the influence of season and individual deer on home range size and minimum daily distance moved (distance moved within a 22-26 hr period). A t-test was used to determine if seasonal home ranges of deer in the central and northern zones of the monument were significantly larger than those of deer that occupied the southern zone. The least significant difference multiple comparison test was used to test for significant differences in the mean minimum daily distance moved between seasons. Because this multiple comparison test allows frequent rejection of the null hypothesis, the significance level for this test was set at $P < 0.01$. The statistical significance level for all other statistical tests was set at $P < 0.05$.

Radio-collared does were recorded as active or inactive from fluctuations in the radio signal. Signal fluctuations resulted whenever the orientation of the collar antenna changed in relation to the receiving antenna (null-peak or hand-held antenna). An active signal could be obtained while a doe was travelling, or from head movement while a doe was bedded or standing, but not travelling. As a result, activity data were biased toward the active classification. Nevertheless, distinct periods of activity versus inactivity were evident and the data provided an index to daily activity patterns of deer.

For analysis of daily activity, the day was divided into eight three hour periods, corresponding to early morning, late morning, early afternoon, and late afternoon periods of the day, and the same quarterly periods of the night. Each day began at the time of sunrise at midpoint in a season. The chi square statistic (Downie and Heath 1974) was used to determine if activity varied from that expected if deer were active equally throughout all periods of the day. Daily activity patterns were similar among radio-collared does, thus data from all individuals were pooled and analyzed by season.

The same methodology was used to analyze the daily use of burns by deer. Since daily use of burns varied greatly among individual does, data for each doe were analyzed by season.

The chi square statistic also was used to determine the seasonal selectivity or avoidance of burned areas by radio-collared does. Locational data for each animal was analyzed by season. A (0) indicated that the number of locations in a burn for an individual deer was in proportion to availability of the burn within the animal's composite polygon home range. If a deer was located in a burn significantly ($P < 0.05$) greater or less than expected from availability of the burn, selection (+) or avoidance (-) was indicated.

RESULTS AND DISCUSSION

Migration and Summer Ranges

There is minimal documentation of the migratory habits of deer in Lava Beds. The past contention of Park Service personnel was that deer in the monument migrated to higher elevations of the Medicine Lake Highlands (Lahr 1960, Wunner 1964, Blaisdell, personal communication 1977). In a study of deer movements, Ashcraft (1961) found that some tagged deer from the McCloud Flats region (Figure 2) moved to winter range near or within the monument.

Spring Migration

Eight radio-collared does in the southern half of the monument migrated in the spring of 1977 (Table 1). Four of these does were monitored again during the 1978 spring migration (Table 1). In both years, deer migrated 3-4 wks after the last major snow storm in the monument. On March 25, 1977, 7.6 cm of snow fell and radio-collared does migrated between April 16 and April 27 that year. In April 1978, the monument received a total of 36.8 cm of snow, of which 6.4 fell on April 20 and 21. The four radio-collared does mointored that spring left the monument between May 6 and May 12.

There was no direct evidence to indicate that migratory deer in Lava Beds made "test trips" to higher elevation to test the suitability of forage conditions as described by Bertram and Rempel (1977). One doe was located 2.4 km east of her southern-most location on April 18, 1978. She spent less than 12 hrs in that area. Whether or not that trip was a start toward the summer range could not be determined. Unlike deer in Bertram and Rempel's study, the migratory routes of radio-collared does in Lava Beds did not take them to higher elevation.

Table 1. Summary of spring migration of radio-collared does in 1977 and 1978.

Deer	Last Location in Monument		Absence Confirmed		Holding Area	Period of Delay	First Location on Summer Home Range
	Date	Time	Date	Time			
A	4/22/77	1500	4/23/77	0800	----------	----------	5/5/77
	5/10/78	0530	5/10/77	0700	[1]Cougar Burn	5/10-5/11	5/11/78
S	4/24/77	2030	4/25/77	0600	----------	----------	5/5/77
	5/9/78	0245	5/9/78	0800	----------	----------	5/10/78
Y	4/20/77	2100	4/21/77	0600	----------	----------	5/5/77
	5/6/78	0700	5/7/78	1400	----------	----------	5/7/78
L	4/16/77	0830	4/16/77	1200	----------	----------	5/5/77
	5/13/78	1835	5/13/78	1935	[1]Valentine Cave	5/12-5/13	
					Cougar Burn	5/13-5/15	
					[1]Lower Bench Rd.	5/15-5/?	5/17/78 monitoring terminated
E	4/22/77	2400	4/23/77	0700	Valentine Cave	4/22-4/23/77	
					[1]SE Timber Mt.	4/23/77 last located	
X	4/28/77	1900	4/29/77	1000	[1]SE Round Mt.	5/5/77	6/77 sighting reported 65 km S of Lava Beds
C & T	4/22/77	1500	4/23/77	0700	Valentine Cave	4/22-4/23/77	5/29/77
					[1]N boundary of Long Bell Refuge	5/15/77	5/29/77 doe T's collar found

[1]See Figure 5 for locations of holding areas.

Elevation of the migration corridor and summer range was similar to that on the winter range. Plants on transitional ranges south of the monument probably initiate spring growth at approximately the same time as similar plants in the monument and this may be the reason "test trips" were not evident in this study.

Does migrated from the monument in a south, southeasterly direction. Most deer moved through the ponderosa pine forest or juniper-mahogany chaparral along low ridges of the Medicine Lake Highlands (Figure 5). A few deer moved through the flat terrain near the Sand Buttes, southeast of the monument (Figure 5). Migratory does remained below 1500 m en route to the summer range.

The distances traveled by migratory radio-collared does ranged from 19.1 km to 65 km (Table 2). Some continued to travel through the night and arrived on their summer home ranges in the early morning. Two does traveled minimum distances of 25.2 and 29.6 km within a 24 hr period in 1978 (Tables 1 and 2).

Holding areas, as described by Bertram and Rempel (1977), were used extensively by one doe (doe L, Table 1). However evidence suggested that other does also used holding areas. Most deer did delay briefly during spring migration in 1977 and 1978. Deer with home ranges north of monument headquarters (does L-T, Table 1) delayed overnight near Valentine Cave (Figure 5). Some deer delayed for longer periods further south. Two does (does C and T, Table 1) were located once near the northern boundary of the Long Bell State Game Refuge prior to their first location on their summer home ranges. Lack of additional locations for those does during migration precluded conclusions on the duration of their stay in that area. The radio-signal of another doe (doe X, Table 1) was received south of Timber Mountain (Figure 5) on April 29, 1977 and southeast of Round Mountain (Figure 5) one wk later. Monitoring was terminated after doe L remained in a holding area for two days during spring 1978 (Table 1).

Migratory does are on transitional ranges during the latter part of the third trimester of gestation, when energy and protein requirements are increased (Moen 1973). Recent investigations (Holl et al.

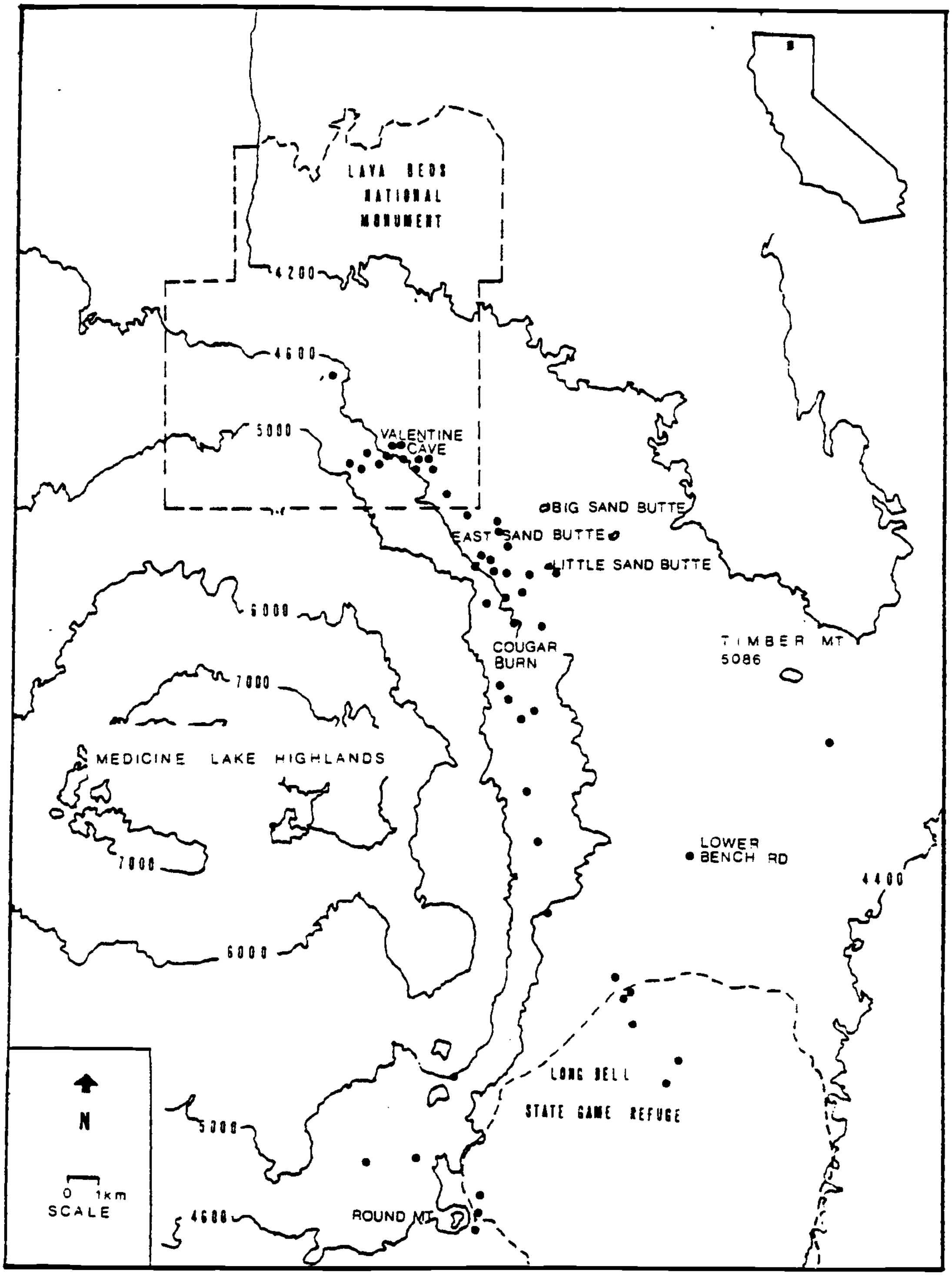

Figure 5. Locations of radio-collared migratory does during spring migration, 1977 and 1978.

Table 2. Straight line distances in km traveled by radio-collared migratory does to home ranges on the summer range during spring migration 1977 and 1978.

Deer	1977	1978
A	19.1	18.3
S	31.2	25.2
Y	33.2	29.6
L	34.0	23.3[1]
C	30.3	
T	29.8	
X	65.0	
E	20.0[2]	

[1]Distance traveled to southern holding area (Lower Bench Rd., Figure 5)

[2]Approximate distance traveled to general area from which radio-signal last received.

1979, Salwasser 1979) have indicated that deficiency of high quality forage in the diets of does while they are on spring transitional ranges can adversely affect fawn survival. Thus, alterations that affect the nutritional characteristics of the spring transitional range can affect the population level of deer in the monument.

Summer Movements and Home Ranges

The concept of home range has been reviewed and discussed by numerous researchers (Burt 1943, Dice 1952, Jewell 1966, Tester and Siniff 1973). Home range was defined by Burt (1943:351) as "that area transversed by the individual in its normal activities of food gathering, mating, and caring for young." That definition was used in this study.

Non-migratory Does

During summer 1977, marked deer of the northern half of the monument remained in Lava Beds. Five of seven marked deer (71%) from this area were sighted in the monument during the summer period. Only one doe in the southern zone did not migrate (doe O).

Movements of most radio-collared, non-migratory does were restricted in late May and early June. Two of these does were observed with fawns in the second week of June (does B and O). Their movements remained restricted throughout the summer, particularly those of doe B (Figure 6). She used 15% of the area that she occupied the previous winter-spring period during which she traveled without a fawn (Schnoes 1978). During the first week of June, doe O traveled 2.4 km north of her usual area of activity (Figure 6). That early summer trip to a possible fawning site, extended the size of her summer home range.

In contrast, the summer movements of doe W were extensive as indicated by her large summer home range ellipse (Table 6). She was not associated with a fawn during the summer. Her large movements

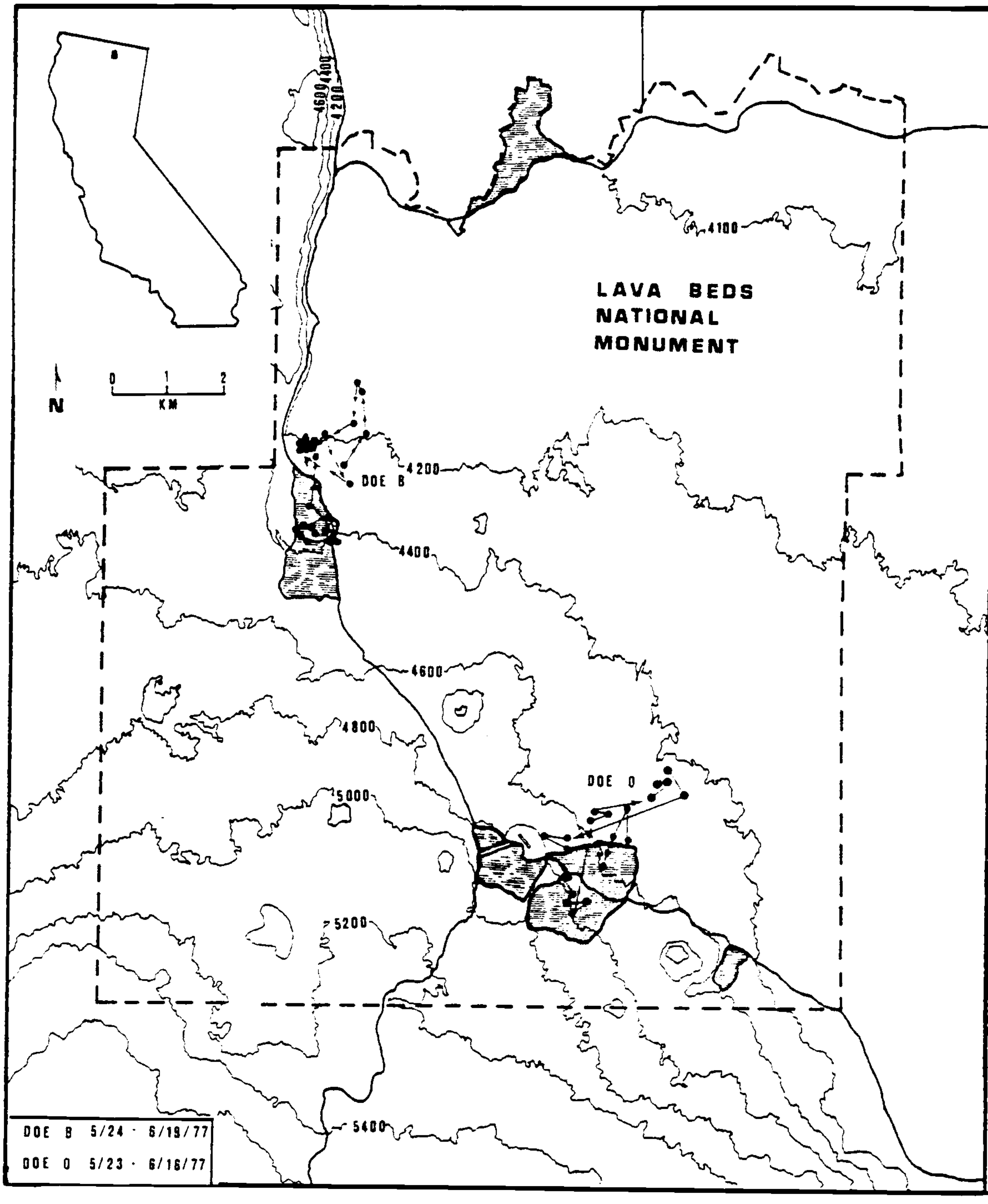

Figure 6. Late spring and early summer movements of radio-collared does B and O, 1977.

continued through late summer and early fall when she traveled with two additional does, also without fawns. Miller (1970) reported an extensive home range for a barren black-tailed deer doe during the summer months in northwestern Oregon. It was not definitely known that doe W or the does with which she traveled were barren. However, the fact that they were not associated with fawns most likely permitted them to travel such distances.

In the monument, radio-collared does with fawns confined their movements to sagebrush-juniper communities in early June. Thus, these plant communities may be important as fawning sites for deer that remain in the monument in summer. Swickard and Conrad (1975) indicated that cover characteristics of vegetation were extremely important in selection of fawning habitat by deer. Sheehy (1978) reported that communities of mountain big sagebrush combined with other shrub species, or mountain big sagebrush alone, were preferred communities for fawning in southeastern Oregon.

While radio-collared does with fawns used shrub communities in late spring-early summer, they used burned areas within their home ranges heavily throughout the remainder of the summer. The habitat use pattern of an ear-tagged doe, 3505, who also had fawns, was similar to that of radio-collared does with fawns. Doe 3505 occupied the central zone of the monument and was observed in the sagebrush-bunchgrass community south of the Fleener Chimneys burn in late May, and in the burn in three subsequent sightings of her and her fawns in July.

Julander et al. (1961) noted the importance of adequate quantity and quality of forage for deer on summer ranges. The nutritive quality of vegetation on a burned site is usually improved since heating and combustion transforms nitrogen on the site into a form readily available for plant growth (Christensen, 1973). Increased quantity (Champlin and Winward 1979), and the probable improved quality of herbaceous forage provided by burns in the monument during spring and summer may benefit fawn survival of non-migratory deer in Lava Beds.

Migratory Does

Five of eight radio-collared does summered adjacent to or in the Long Bell State Game Refuge. A sixth doe summered five km north of the refuge at the eastern base of Black Mountain (Figure 7). One doe was sighted during summer 1977 by personnel of the California Department Fish and Game south of the McCloud Flats area, 65 km south of Lava Beds (Figure 2).

Dense vegetation made prolonged visual observations of deer difficult on the summer range south of the monument. Two of the five does for which detailed information was obtained were definitely associated with fawns (Table 3). While the remaining does were sighted with doe-fawn groups later in the summer, observations of these does were too infrequent and brief to draw conclusions regarding the integrity of the groups. Due to that uncertainty and the affects of drought conditions on deer movements, the influence that fawns may have had on summer movements and home ranges of their dams could not be determined.

Summer home range ellipses (see Table 6) reflected the extensive movements of migratory does on the summer range. A drought prevailed in that area for a second year in 1977 (Appendix 3) and was probably the major influence in the extensive movement of does.

Trips to higher elevation (an elevational change of over 400 m) were made by three does (Figure 7). The brief trips of doe A greatly inflated the size of her summer home range (Figure 7). Her trips in June and early July appeared similar to those of does occupying higher elevations in the North Kings herd (Bertram and Rempel 1977). Bertram and Rempel as well as others (Taber and Dasman 1958), postulated that such movements result from does seeking vegetation of an earlier phenological stage.

Monitoring does for one summer only, precluded any definitive conclusions regarding yearly consistancy of late summer shifts, such as those exhibited by does S and Y (Figure 7). These two does moved to higher elevation in the Highlands (over 400 m) in early August

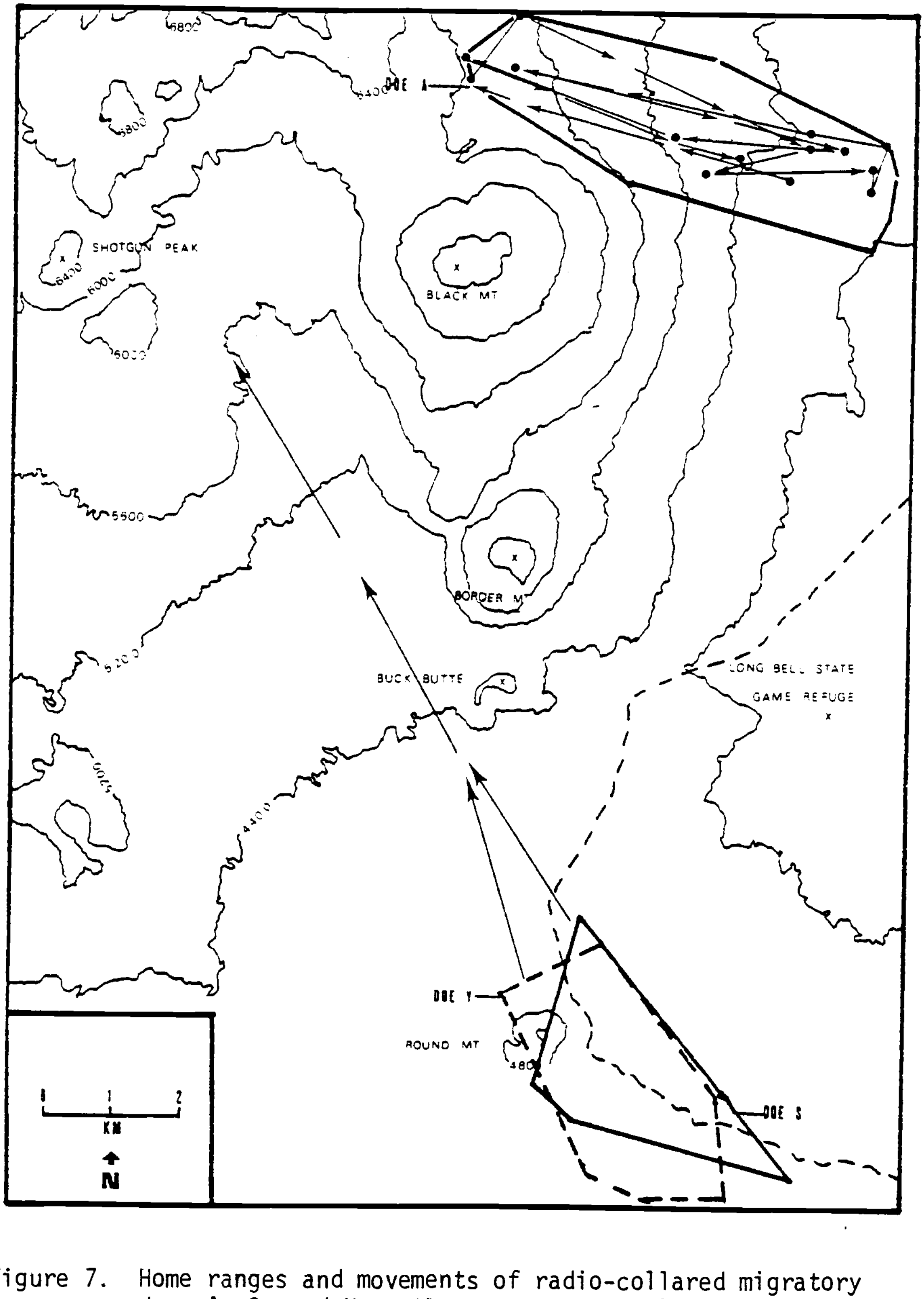

Figure 7. Home ranges and movements of radio-collared migratory does A, S, and Y on the summer range, 1977.

Table 3. Time period on summer range and fall holding areas in 1977 for radio-collared, migratory does.

Deer	With Fawn	First Location on Summer Home Range	Final Location on Summer Home Range	Holding Area	Period on Holding Area	Date of Return to Winter Range
A	+	5/5/77	12/16/77	----------	----------	12/17-1/2/78
S	?	5/5/77	9/27/77	----------	----------	9/30/77
Y	?	5/5/77	9/27/77	----------	----------	9/30/77
L	?	5/5/77	9/16/77	Lower Bench Rd. Cougar Burn	9/30-10/21/77 10/24-11/21/77	 11/22/77
X	?			SW of Round Mt.	11/1/77	11/7/77
C	+	5/29/77	9/14/77 died	----------	----------	----------
T	-	5/29/77 died		----------	----------	----------

and remained there until late September. It is conceivable that drought induced early dry forage conditions at lower elevations in 1977 and that deer moved to higher elevations for less mature, more succulent forage.

The effects of drought on deer movements were apparent particularly in the late summer and early fall. Drought conditions caused a late summer concentration of deer near available water at the Long Bell guard station. In early August a radio-collared doe made frequent trips for water to the station, located 4.8 km west of her usual area of activity (Figure 8). In late August and early September, she watered with domestic sheep grazing near her usual area of activity. Upon the removal of domestic sheep from the forest, she returned to water at Long Bell where she eventually succumbed from hoofrot (William Clark, personal communication).

The southern portion of Siskiyou and Modoc counties in California has a history of the hoofrot epizootic (Spherophorus necrophorus). Previous outbreaks of the disease have been reported in 1925, 1932, and 1945 (Rosen 1951). Personnel of the California Department of Fish and Game estimated that 100 deer in the Long Bell area died from hoofrot in the summer of 1977 (Douglas Thayer, personal communication). In addition to the death of doe C, an autopsy of doe 3501, found dead in the monument in the winter of 1977, revealed that she had hoofrot among other maladies (Schnoes 1978).

A few deer probably die each year from hoofrot on the summer range. However, years of highest mortality are characterized by drought conditions, which cause a concentration of deer at remaining sources of water. The temporary crowding provides an optimal situation for the transmission of the bacterial organism among the population. Presently, there is no effective treatment for the disease in deer. Its occurrence is mentioned here due to its potential impact, particularly in drought years, on migratory deer from the monument.

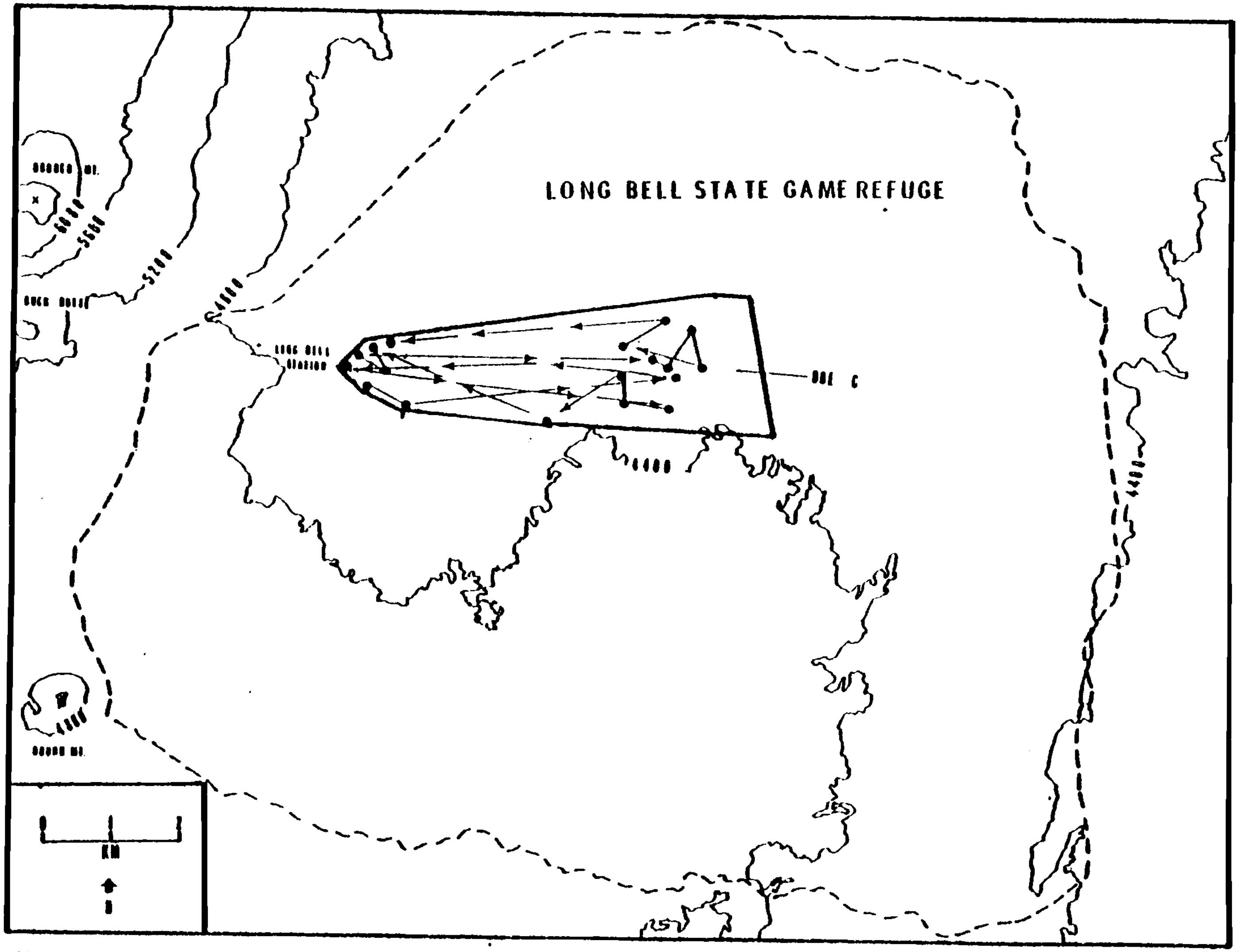

Figure 8. Home range and movements of radio-collared doe C on the summer range, August-mid September, 1977.

Fall Migration

Five does were monitored during the fall migration in 1977 (Table 3), which extended over a period of 2.5 months. The earliest arrival of radio-collared does in the monument was September 30, 1977; the latest arrival was between December 17, 1977 and January 2, 1978 (Table 3). Does that summered in or adjacent to the Long Bell State Game Refuge initiated their fall migration before the end of September (does S, Y, and L, Table 3). Ashcraft (1961) reported a similar early migration of deer that summered in the McCloud Flats as a result of drought conditions in 1955.

Doe L was the only doe for which detailed information was obtained during the fall 1977 migration (Table 3, Figure 9). She used the same holdings areas during her spring 1978 and fall 1977 migration (Tables 1 and 3). Her delaying pattern of 3-4 wks in each area during fall was similar to that found for does in the North Kings herd (Bertram and Rempel 1977). Other monitored does returned to the monument within a period of a week or less (Table 3).

It appears that migratory does leave and return to the winter range in Lava Beds thorough the same migration corridor. Doe L's use of the same holding areas in spring and fall may indicate that holding areas are site-specific areas within the migration corridor that are used when habitat or environmental conditions dictate.

Lactation makes a considerable demand on the energy reserves of does (Moen 1973) during the summer. However, does need considerable energy reserves to survive fall and winter periods (Bertram and Rempel 1977) and must regain lost reserves in late summer and fall. The quality and accessibility of forage on the fall transitional ranges may therefore effect breeding success of does and winter fawn losses of migratory deer.

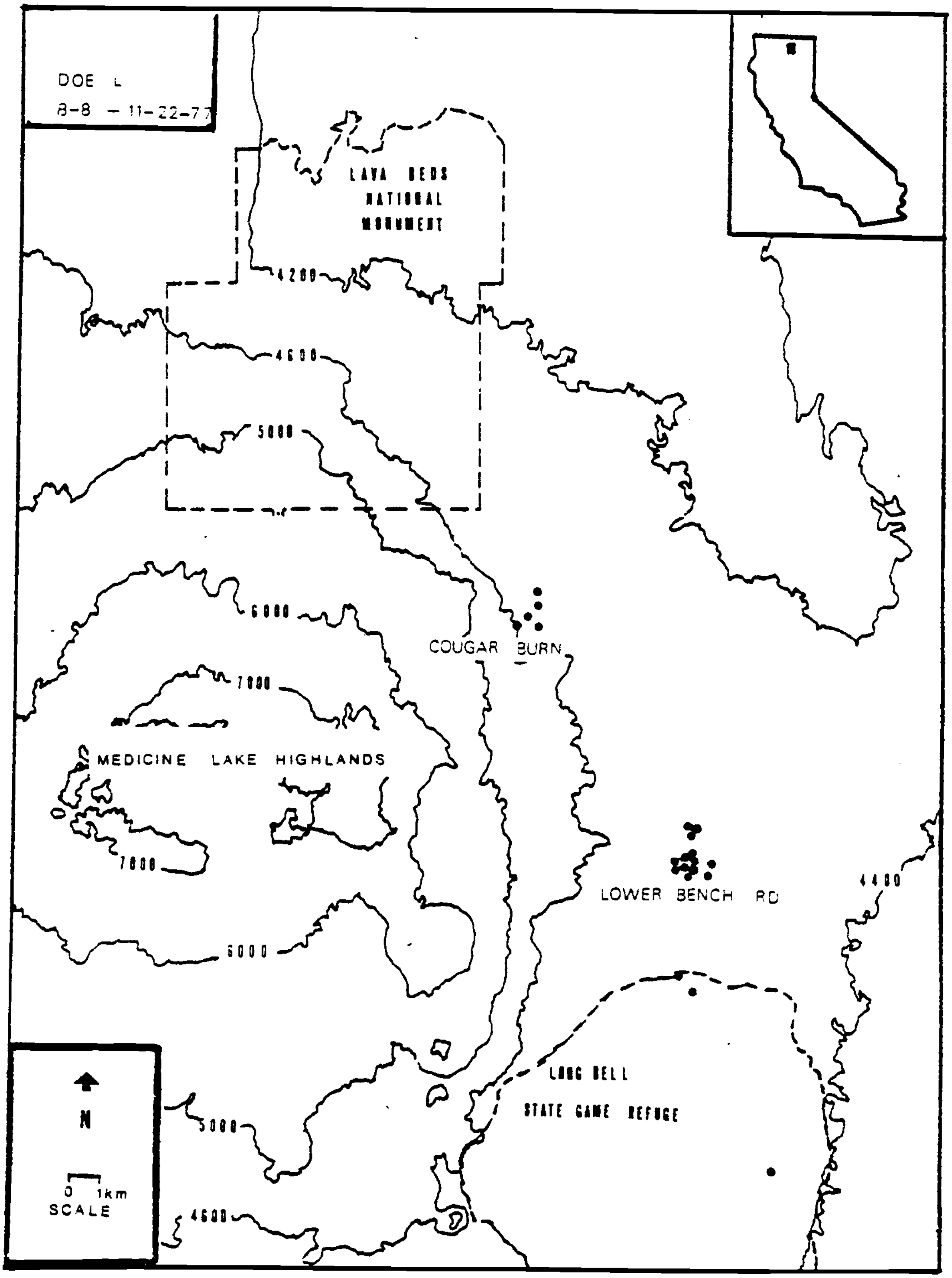

Figure 9. Movements and holding areas of radio-collared doe L., fall 1977.

Composite and Seasonal Home Ranges--General Patterns

The home range diameters of 14 ear-tagged deer averaged 1.3 km ± 0.8 km based on observations of those deer during April 1977 through May 1978 (Table 4). Those data agree with the mean home range diameter of 1.7 km for ear-tagged deer in the winters of 1976 and 1977 (Schnoes 1978). The small number of males tagged and relocated prevented comparison of home range size between sexes.

The mean diameter of the 1977-78 composite home ranges of eight radio-collared does was 5.7 km ± 3.3km (Table 5). Areas of composite home ranges average 1414 ha ± 1619 ha (Table 5).

There is considerable variation in size of winter home ranges of mule deer reported in the literature. Clark (1953) found a mean home range diameter of 3.7 km for mule deer in arid southern Arizona. His findings were supported by those of Hansen and McCulloch (1955) who reported a mean home range diameter of 3.3 km for desert mule deer (Odocoileus hemionus crookii) that wintered in Arizona brushlands. Winter home ranges of deer of the Jawbone herd in dense chaparral on on the west slope of the Sierra Nevada, averaged 0.29 and 0.69 km in diameter for females and males respectively (Leopold et al. 1951). Terrel (1973) found the mean home range radius of nine radio-collared does to be 1.0 km in a pinyon-juniper woodland in Utah. Robinette (1966) attributed variation in home range size of deer to numerous factors including sex, age, heredity, population density topography, season, availability of food, cover, and water, and rutting activities.

Home range size is affected also by the number of relocations for an animal. The large number of telemetry relocations for does on the winter range may have been partially responsible for the large home range size of radio-collared does in this study. The home range diameters of ear-tagged deer however, appeared comparable to others home range diameters found in the literature (Leopold et al. 1951, Terrel 1973).

Composite home ranges of deer in the central and northern zones were larger than those of deer in the southern zone. This pattern was apparent in the seasonal home ranges of radio-collared deer as well as the home range diameters of ear-tagged dear (Tables 4 and 5). Schnoes (1978) noted a similar difference in the movements of four radio-collared does in the two areas during the winter of 1977.

Two-way analysis of variance was conducted to determine the influence of season and individual deer on home range size. Summer and fall home ranges of 1977, and winter and spring home ranges of 1978 were used in the analysis. No significant difference was noted in the size of home ranges among seasons. However, the analysis showed a significant difference ($P < 0.05$) in the home range size of six does (Table 6). A t-test confirmed the hypothesis that seasonal home ranges of deer in the central and northern zones were significantly larger ($P < 0.05$) than seasonal home ranges of deer in the southern zone.

A pattern evident in home range size from the above literature cited is that deer occupying open shrubland have larger home ranges than those that occupy more densely vegetated habitat. Sanderson (1966:219) noted that "habitat affects size of home range but it is difficult to separate the effects of the availability of food and cover." In the monument, forage and cover for deer in the southern zone varied greatly from that in the central and northern zones. Percentage of tree and shrub cover in the juniper/mahogany chaparral of the southern zone was greater than that provided by the more open shrub steppe communities that dominated the central and northern zones (Erhard 1979). Density of bitterbrush and mountain mahogany, the browse species most selected by deer in the previous two winters (Schnoes 1978), also were greater in the southern zone than in the central and northern zones (Erhard 1979).

Thus, the smaller home ranges of deer in the southern zone could be associated with the greater plant cover and greater density of bitterbrush and mahogany in this zone. Data from pellet-group transects located throughout the monument indicates that the deer herd is concentrated in the southern part of the monument (Schnoes 1978).

Table 4. Home range diameters of ear-tagged deer observed between April 1977 and March 1978.

Deer	Sex	Number of Relocations	Maximum Distance Between Observations (km)
Deer in southern zone			
4301	F	11	1.6
4304	F	5	0.6
4305	F	4	0.5
4306	M	5	2.1
3912	F	4	0.8
3522	M	2	0.2
3509	F	2	1.5
3504	F	2	2.0
13	F	4	2.0
11	F	3	0.2
Deer in central and northern zones			
3902	F	2	2.3
3901	M	4	1.5
3505	F	17	2.8

$\bar{X}$ Diameter in southern zone = 1.1 km

S.D. = 0.9 km

$\bar{X}$ Diameter in central and northern zone = 2.3 km

S.D. = 0.7 km

Total $\bar{X}$ Diameter = 1.3 km

S.D. = 0.8 km

Table 5. Composite home range area in has, and diameters in km, of radio-collared does.

Deer	Sampling Period	Home Range Ellipse	Minimum Polygon Home Range	Home Range Diameter	N
Deer in southern zone					
A	1/77-4/77	512	659	4.6	188
A	1/78-5/78	683	700	4.6	129
S	4/77-5/78	588	726	4.3	320
Y	4/77-5/78	677	636	4.8	301
L	4/77-5/78	182	287	2.7	235
O	4/77-5/78	483	463	3.5	419
Deer in central and northern zones					
B	1/77-4/78	5012	2873	10.0	233
B	1/78-5/78	2999	1917	7.0	154
B	4/77-5/78	2835	2563	7.6	402
W	4/77-5/78	3939	5022	13.0	437
J	1/78-5/78	904	922	4.4	152
Total 4/77-5/78	$\bar{X}$ =	1286 ha	1414 ha	5.7 km	
S.D.	=	1345 ha	1619 ha	3.3 km	

Table 6. Areas of seasonal home range in km of radio-collared does.

Deer	Summer Ellipse	Summer Polygon	Summer N	Fall Ellipse	Fall Polygon	Fall N	Winter Ellipse	Winter Polygon	Winter N	Spring Ellipse	Spring Polygon	Spring N
Deer in southern zone												
[1]A 1977	2618	1542	48	----	----	---	553	605	105	454	369	83
1978	----	----	--	----	----	---	827	483	41	633	581	88
[1]S 1977	2077	584	22	600	491	91	----	----	---	261	152	37
1978	----	----	--	----	----	---	584	424	72	849	566	109
[1]Y 1977	834	747	27	376	318	96	----	----	80	92	67	27
1978	----	----	--	----	----	---	515	346	80	664	581	97
L 1978	----	----	--	----	----	---	99	217	82	160	251	120
[1]O 1977	351	289	67	171	186	137	----	----	---	554	354	63
1978	----	----	--	----	----	---	141	101	99	154	85	81
C 1977	2103	755	34	----	----	---	----	----	---	289	209	23
T 1977	----	----	--	----	----	---	----	----	---	---	114	16
Deer in central and northern zones												
[1]B 1977	577	406	72	1942	1811	121	5135	2227	91	3510	2126	132
1978	----	----	--	----	----	---	1634	1026	98	3245	1648	72
[1]W 1977	3040	747	64	6686	4313	121	----	----	---	1157	889	83
1978	----	----	--	----	----	---	1351	1643	95	1080	1287	71
J 1978	----	----	--	----	----	----	889	623	71	1211	749	81
[1]$\bar{X}$ used in analysis of variance		719 ha			1424 ha			671 ha			791 ha	
S.D.		443 ha			1741 ha			565 ha			569 ha	
$\bar{X}$ seasonal home range areas in southern zone		485										
S.D.		348										
$\bar{X}$ seasonal home range areas in central and northern zones		1610										
S.D.		1195										

Table 7. Mean minimum daily distance moved in km by five radio-collared does.

Deer	Fall	N	Winter	N	Spring	N
Deer in southern zone						
S	1614	25	1250	21	877	42
Y	786	30	1193	24	1216	28
O	576	42	339	3	453	16
Deer in central and northern zones						
B	1273	35	534	34	862	21
W	1812	37	859	30	780	23
$\bar{X}$ =	1182		775		868	
S.D. =	1113		647		702	

Prescribed fire in the southern zone will probably have the greatest impact on the deer population in the monument because of greater plant cover, smaller home ranges and greater density of deer in this zone.

Seasonal Home Ranges on the Winter Range

Fall Movements and Home Ranges

All radio-collared migratory deer returned to their respective home ranges on the winter range within the monument in the fall of 1977. Fall home ranges averaged 1424 ha ± 1741 ha (Table 6). Although the size of home ranges did not vary significantly among seasons, mean minimum daily distance traveled by does in the fall was significantly greater ($P < 0.05$) than in spring or winter of 1978 (Table 7).

Does in the central and northern zones of the monument traveled extensively throughout the fall. Early fall movements of does in those zones occurred prior to the first fall rains in mid-September. During the first two weeks of September, doe W traveled from the northern edge of the 1973 wildfire to the Tule Lake National Wildlife Refuge (Figure 10). Doe B and her fawn also moved to the refuge during that period. Green succulent vegetation was available along irrigation ditches in the refuge and both does were observed feeding near these ditches while in the refuge. During this time dry forage conditions existed in the monument. These conditions occurred only for the first two weeks of September in 1977 and this is the usual time for the start of fall rains. Early fall shifts by does in the central zone to the Tule Lake refuge prior to these rains may be a typical seasonal pattern of movement and partially responsible for the increased size of fall home ranges for does in the central and northern zones.

After mid September, does W and B remained in the central zone of the monument until late October. Doe B made two brief trips to

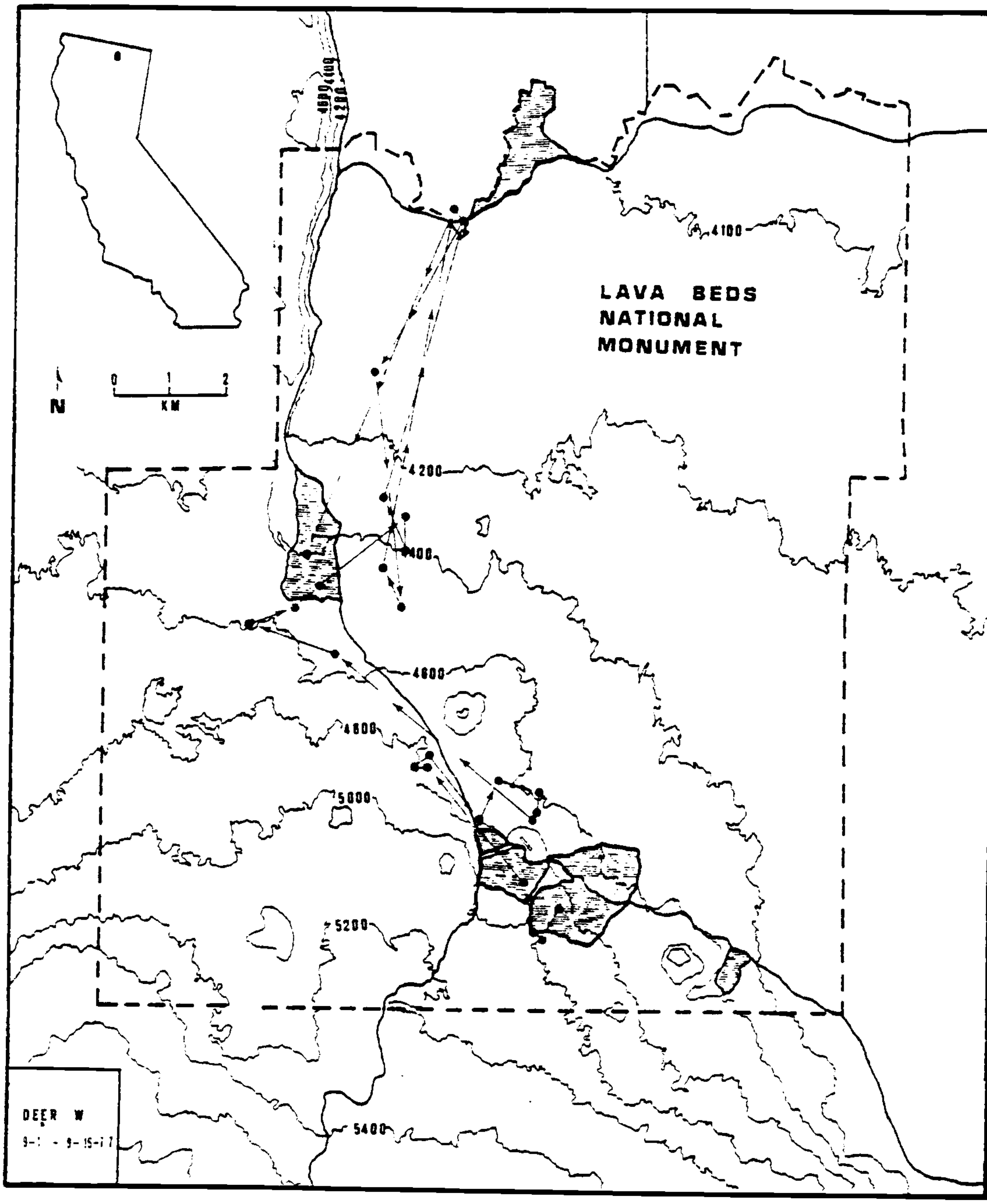

Figure 10. Movements of radio-collared doe W in early September, 1977.

the refuge and Hovey Point Burn (less than two days) during the interim period. In late October, she moved to the northern boundary and remained there through November and early December with the exception of two trips back to the central zone. Throughout November, doe W traveled between the central and northern zones (Figure 11). Four point bucks were observed in pursuit of both does while they were in the northern zone.

Extensive movements of does during the rut have been reported in the literature (Dasman and Taber 1956). Richardson and Petersen (1974) noted that bucks frequently pursue does tenaciously whether or not the doe is in estrus. Such behavior also was observed frequently during the rut in this study, and may be partially responsible for the frequent movements of radio-collared does between the central and northern zones during fall.

Daily movements of does also increased in the southern zone of the monument during the fall (Table 7). Does traveled between the 1973 wildfire and coniferous forest south of the burn however, this pattern also typified her movements during the winter and spring and may or may not have been associated with the rut. Some migratory does remained south of the monument (does A and X, Table 3) and may have bred prior to their return to Lava Beds in the fall.

Winter and Spring Movements and Home Ranges

The mean winter home range size of six radio-collared does in 1978 was 671 ha ± 565 ha; spring 1978 home range size averaged 791 ha ± 567 ha (Table 6). While spring home ranges tended to be larger than winter home ranges, the difference was not significant ($P < 0.05$). Mean minimum daily distance moved by does also did not differ significantly ($P < 0.05$) between winter and spring 1978 (Table 7).

Deer in the central and northern zones of the monument reduced their home ranges and movements during the winter and spring of 1978 (Tables 6 and 7). In January doe B remained in the central zone; she

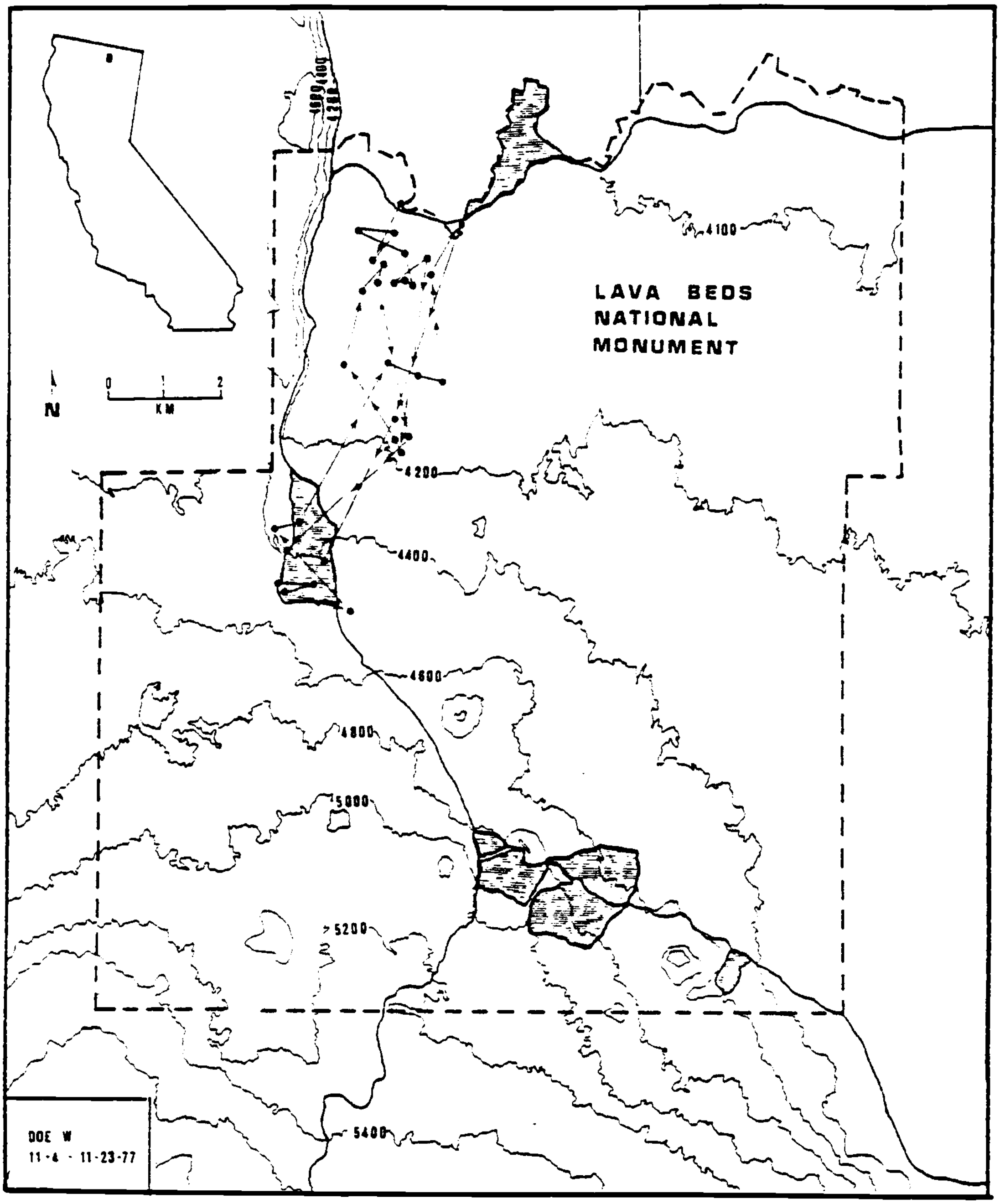

Figure 11. Movements of radio-collared doe W in November, 1977.

moved to Hovey Point using the Hovey Point Burn and the Tule Lake National Wildlife Refuge from mid February through mid April. In mid April, she again moved south to the central zone. Does W and J (collared in January 1978) traveled together throughout the winter and spring and restricted their movements to the central zone. A two day trip was made by doe W to the refuge in late February and early March. The significance of this trip is not known but it extended the size of her winter and spring home ranges (Figure 12).

Except for one doe (doe L), radio-collared migratory does in the southern zone made frequent trips of 2-4 km into the coniferous forest. The duration of the trips ranged from one day to two weeks. There was no association between weather and the southward trips and the significance of these trips remains uncertain. However, the trips resulted in the linear shape of home ranges for those does (Figures 13-15).

The mild, relatively snowless winter of 1978 may have enabled the heavy use of the coniferous forest. Leckenby (1968) also reported that mule deer on the Silver Lake range, Oregon spent more time in ponderosa pine forest during mild winters. The Interstate Deer Herd Committee (1949) reported that the Glass Mountain herd remained at higher elevations in the pine forest during the mild winter of 1947. In 1948, severe winter weather forced the herd to concentrate at lower elevations (Interstate Deer Herd Committee 1950). Other investigators as well, have reported that deer reduce movements or concentrate in smaller areas during severe winters (Loveless 1964, Moen 1976). Drolet (1976) noted that home ranges of deer were significantly smaller in a severe winter with heavy accumulation of snow than in a mild, snowless winter. Thus, ranges of radio-collered does in Lave Beds may approximate a maximum size used by does.

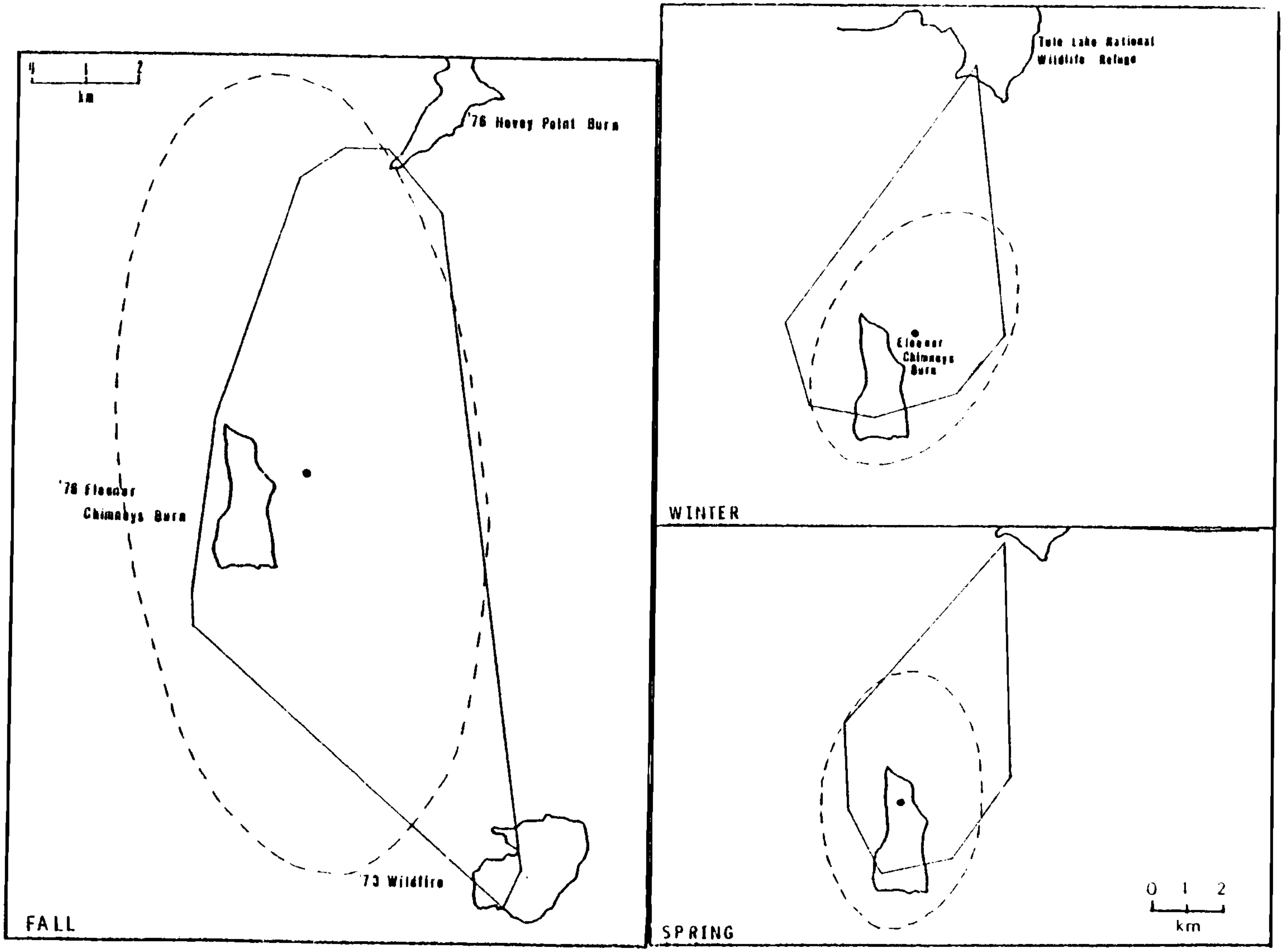

Figure 12. Seasonal home ranges of doe W, 1977-1978.

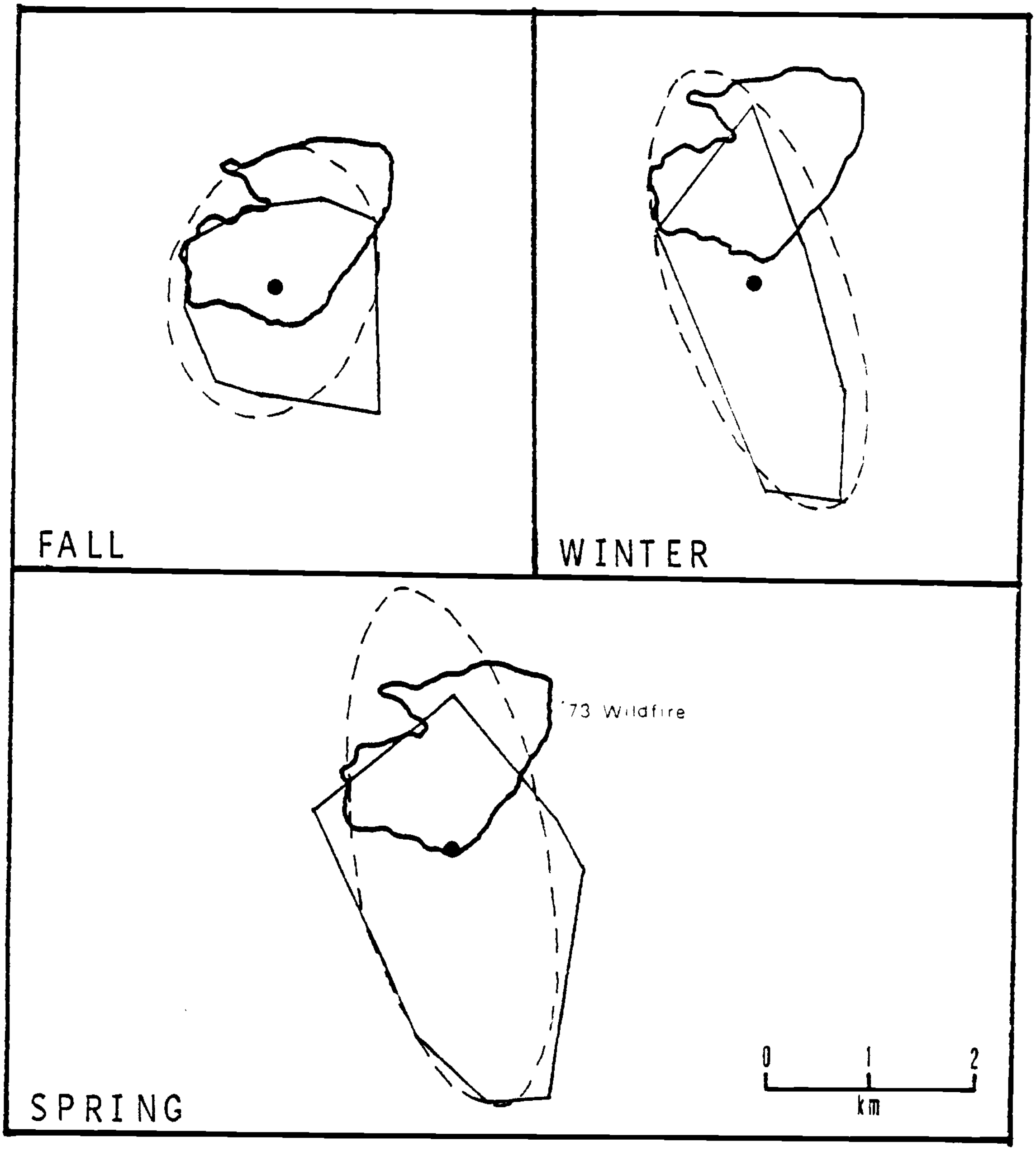

Figure 13. Seasonal home ranges of radio-collared doe Y, 1977-1978.

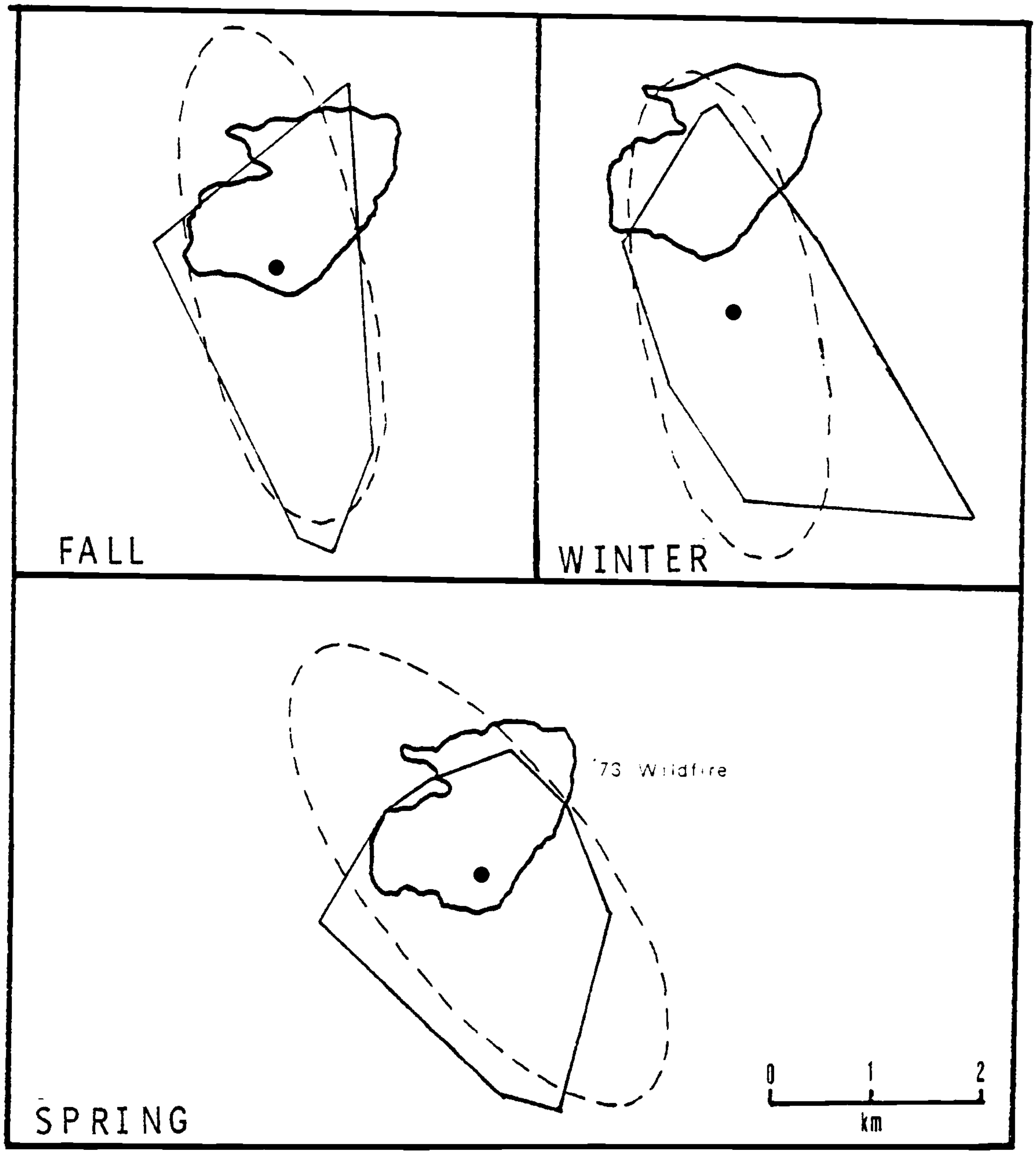

Figure 14. Seasonal home ranges of radio-collared doe S, 1977-1978.

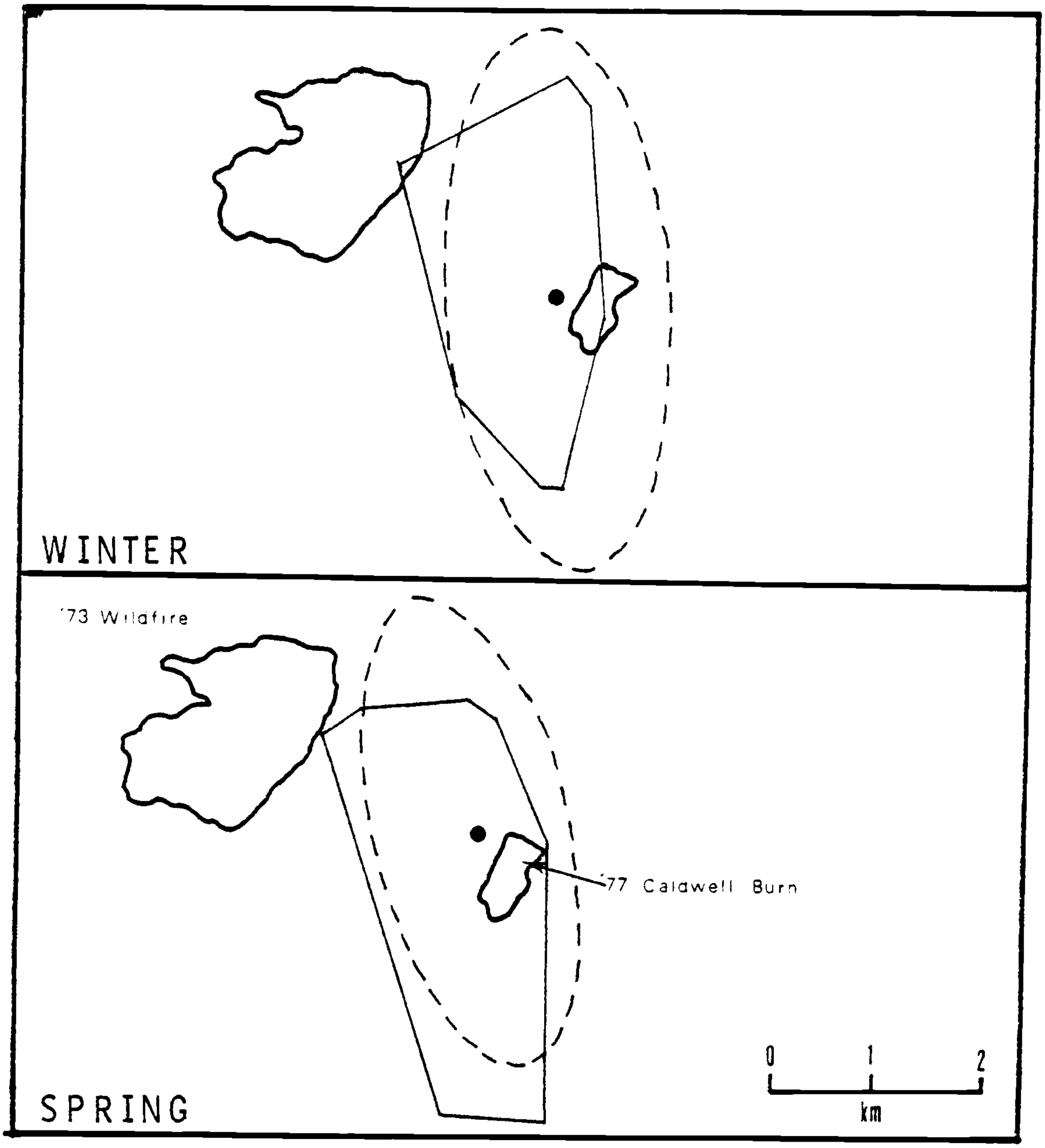

Figure 15. Seasonal home ranges of radio-collared doe A, 1978.

Seasonal and Yearly Shifts in Centers of Activity

Distances between seasonal centers of activity varied greatly among individual does and seasons. While on the winter range, shifts were greatest for does in the central and northern zones of the monument (Table 8). Burns and meadows provided herbaceous forage for deer during all seasons and appeared to have the greatest influence on seasonal shifts in centers of activity. The implications of those shifts are discussed in the section on deer movements in response to burns.

Individual does used essentially the same home ranges during the winter-spring periods of 1977 and 1978. Areas of concentrated use within individual home ranges varied between years. Such shifts were indicated by changes in the centers of activity between 1977 and 1978 (Figure 16).

The mild winter weather in 1978 appeared to indirectly influence shifts in centers of activity between years. Mild temperatures and plentiful rain resulted in an early green-up, particularly at lower elevations in the north. Does in the central and northern zones moved into burns, meadows, and the Tule Lake National Wildlife Refuge with the onset of the warming trend and subsequent green-up in mid February. Deer continued to use those areas heavily through the spring. The early and extended use of burns, meadows and the refuge in 1978 resulted in the northward shift in centers of activity of deer in the northern half of the monument (Figure 16).

Centers of activity of migratory does in the southern half of the monument shifted to the south in 1978 (Figure 16). Those shifts were a result of the southward trips into the coniferous forest discussed previously.

Table 8. Distance in km between seasonal centers of activity of radio-collared does.

Season	Deer in southern zone					Deer in central and northern zones		
	A	S	Y	L	O	B	W	J
Winter 1977 / Spring 1977	0.3	---	---	---	---		---	---
Spring 1977 / Summer 1977	18.8	31.5	32.5	34.2	0.5	3.2	1.2	---
Summer 1977 / Fall 1977	---	31.3	32.3	---	0.5	2.2	1.9	---
Fall 1977 / Winter 1978	17.3	0.8	0.7	21.0	0.3	1.3	0.5	---
Winter 1978 / Spring 1978	0.2	0.9	0.2	0.2	0.2	0.8	0.7	0.6

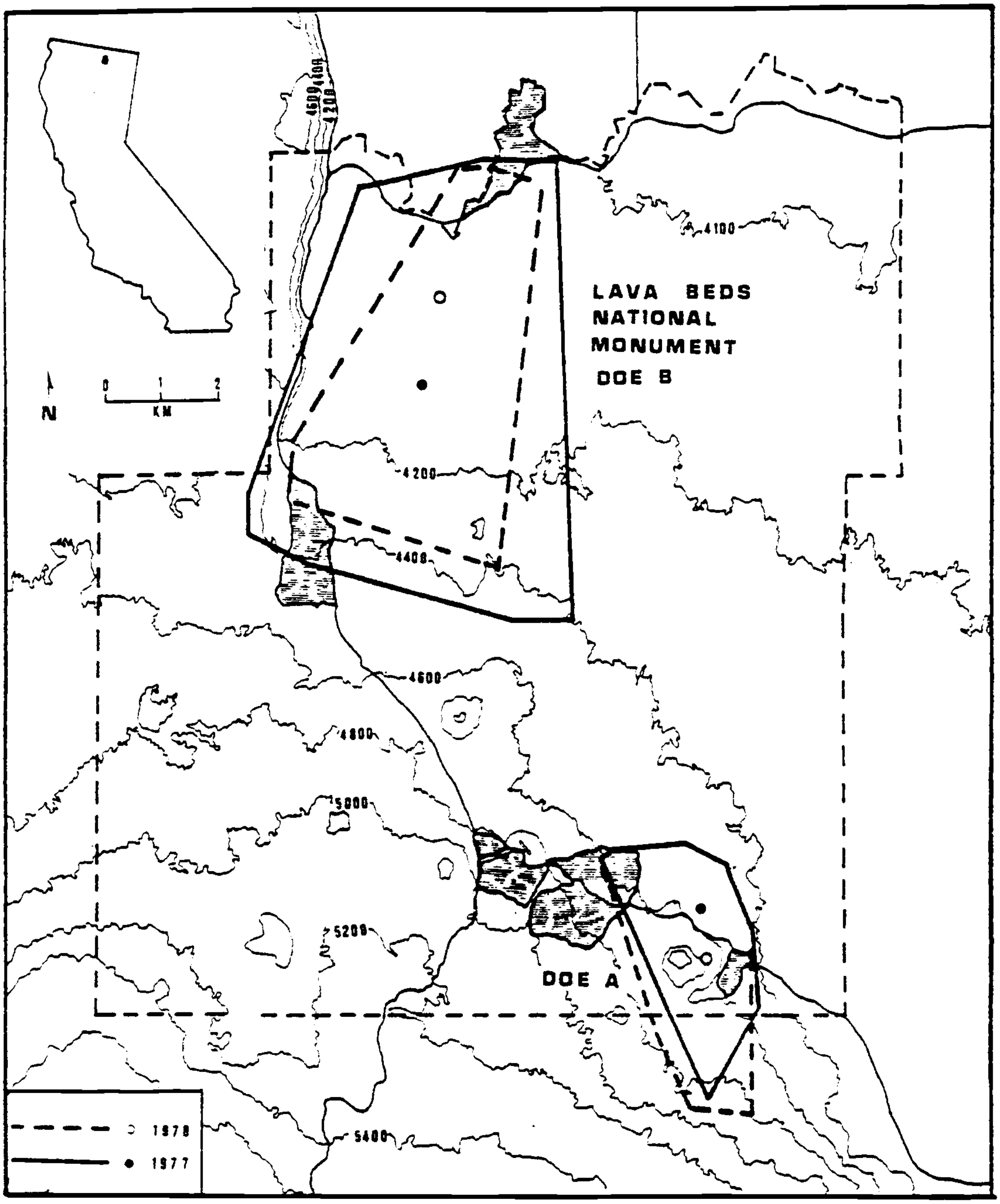

Figure 16. Home ranges and centers of activity of radio-collared does B and A in the winter-spring period of 1977 and 1978.

Movements in Response to Burns

Daily Activity Patterns and Use of Burns

Chi square analyses of activity dates showed a significant ($P < 0.05$) association between activity and time of the day. During all seasons, peak periods of activity occurred in the first three hr period of the day and in the afternoon or evening periods prior to midnight (Figure 17). Feeding was the most frequent behavior observed during peak periods of activity. The results of this study are similar to those of Mackie (1970), who found mule deer most active during 3-4 hr periods in the early morning and late afternoon. Such a diurnal pattern of activity has been indicated for other ungulate species as well (Harper 1962, Montgomery 1963, Kammermeyer and Marchington 1977).

The mean percentage of active readings was lowest in winter (41%). During winter and spring, activity was reduced during night periods except for a peak in activity prior to midnight in winter (Figure 17). During summer and fall, activity remained high during evening and night periods (Figure 17). Silver et al. (1969) reported indications of depressed fasting metabolism for white tailed deer (Odocoileus hemionus virginianus). Her work was supported by Moen's (1978) recent report on seasonal activity rythms in white-tailed deer. Moen (1973) suggested that diurnal patterns in the basal metabolic rate exist in deer as well. In this study, reduced activity of deer in winter and spring, particularly during night periods, may have reflected the seasonal and diurnal rhythems to which deer have become attuned physiologically and which serve as an energy conservation mechanism.

During the winters of 1976 and 1977, use of the 1973 wildfire and the Hovey Point Burn - Tule lake Refuge by deer was linked to time of the day (Schnoes 1978). Deer moved from shrub cover into the burns (or at Hovey Point, the burn and refuge) in the evening, and back into shrub cover in the morning. Except for doe 0 in fall 1977 there was no significant association ($P > 0.05$) between time of day

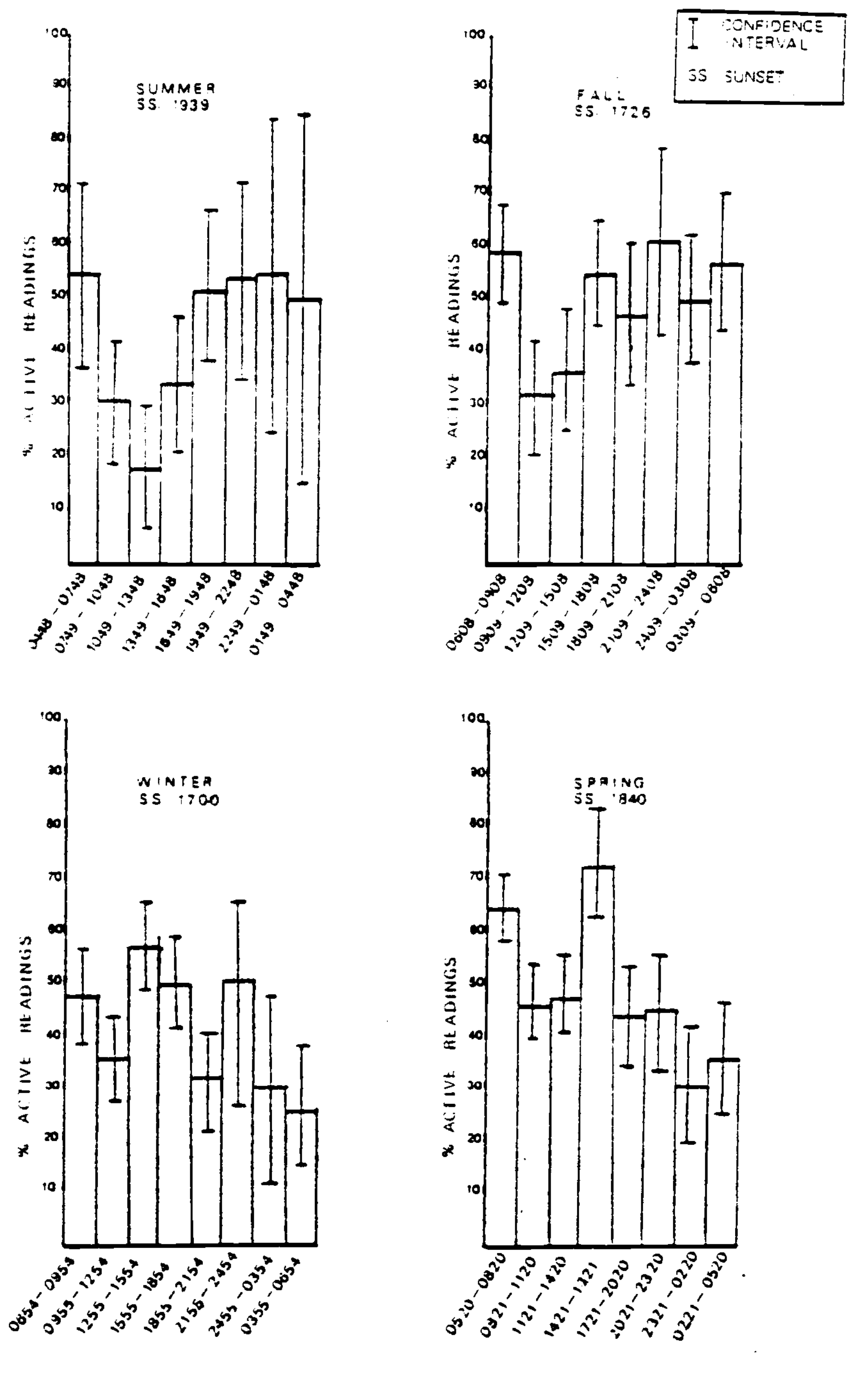

Figure 17. Daily activity patterns of radio-collared does.

and use of burns by radio-collared deer in 1977-78 (Tables 9 A-D). Observations of deer feeding and bedding in burns at mid day supported radio-telemetry data. Telemetry data was further supported by the lack of association between peak periods of activity and peak periods in use of burns for individual deer.

The distinct morning and evening movement pattern of deer in the area of Hovey Point and the 1973 wildfire noted by Schnoes was observed also in the winter of 1978. However, telemetry data indicated that deer were using burns throughout the day as well as during the morning and evening periods. Since activity patterns were found to be associated with time of the day, but there was no significant association between the use of burns and time of the day, prescribed burns conducted thus far do not appear to have caused a disruption in the normal daily activity patterns of deer.

Seasonal Use of Burns

Results of chi square analyses on the seasonal use of burns are presented in Table 10. With the exception of doe L. radio-collared does selected for or used burns in proportion to their availability (Table 10). All deer increased their use of burns in their home ranges in the spring of 1978 from that in the winter. An increased use of the 1973 wildfire by some does in the southern zone was evident also in the fall. Increased use of burns in the fall and spring was significant ($P<0.05$) for most radio-collared does. The higher use of burns during those seasons resulted in a shift in the seasonal centers of activity towards the burns (Figure 18).

The period during which deer were on the winter range in 1977 and 1978 was exceptionally mild (Appendix 4). Herbaceous forage was available throughout the winter in open grass fields and burned areas. While in such areas, deer fed predominantly on herbaceous vegetation. Schnoes (1978) also found that deer feeding in burns selected herbaceous shoots when they became available in the winters of 1976 and 1977. Herbaceous vegetation in burns appeared to be the primary factor that influenced frequent use of burns by deer, particularly during the spring.

Tables 9 A-D. Percentage of locations in burns for each three hour period of the day for radio-collared does.

Table 9-A. Summer 1977

Deer	0448 0748	N	0749 1048	N	1049 1348	N	1349 1648	N	1649 1948	N	1949 2248	N	2249 0148	N	0149 0448	N	χ^2 [1]
<u>Deer in southern zone</u>																	
O	77	9	91	11	80	5	50	14	81	16	67	6	100	4	100	2	5.73
<u>Deer in central and northern zones</u>																	
B	44	9	46	13	44	9	33	9	25	12	56	16	0	2	0	3	6.73

Table 9-B. Fall 1977.

Deer	0608 0908	N	0909 1208	N	1209 1508	N	1509 1808	N	1809 2108	N	2109 2408	N	2409 2408	N	0309 0608	N	χ^2 [1]
<u>Deer in southern zone</u>																	
S	47	19	53	15	40	10	38	13	45	11	67	3	50	10	54	11	1.58
Y	57	21	36	14	50	10	53	15	67	9	50	4	80	10	60	10	6.89
O	59	29	62	20	53	15	95	21	86	14	100	8	73	15	86	14	17.30
<u>Deer in central and northern zones</u>																	
B	15	26	14	14	11	18	21	24	9	11	14	7	29	14	17	12	3.35
W	27	26	22	17	17	18	28	18	27	11	20	10	46	13	53	9	4.21

[1] Chi square values greater than 14.07 are significant at $P < 0.05$.

Table 9-C. Winter 1978.

Deer	0654 0954	N	0955 1254	N	1255 1554	N	1555 1854	N	1855 2154	N	2155 2454	N	2455 0354	N	0355 0654	N	χ^2 [1]
<u>Deer in southern zone</u>																	
S	8	13	13	15	10	10	31	13	25	12	25	4	0	0	17	6	3.82
Y	33	3	7	15	33	15	29	17	33	9	0	2	50	2	29	7	6.51
O	74	19	64	14	65	20	62	13	93	15	57	7	33	3	88	8	8.46
<u>Deer in central and northern zones</u>																	
B	36	11	11	19	24	21	6	16	23	13	17	6	33	3	17	6	5.40
W	8	13	27	22	15	20	19	16	23	13	0	5	0	3	33	6	5.32
J	18	11	24	17	20	15	23	13	17	6	25	4	0	1	25	4	0.62

Table 9-D. Spring 1978.

Deer	0520 0820	N	0821 1120	N	1121 1420	N	1421 1720	N	1721 2020	N	2021 2320	N	2321 0220	N	0221 0520	N	χ^2 [1]
<u>Deer in southern zone</u>																	
S	54	26	48	21	45	27	71	21	70	10	67	6	43	7	50	6	5.51
Y	25	20	17	24	33	15	25	12	57	7	50	8	60	5	50	8	10.80
O	76	17	82	17	77	13	78	18	50	2	100	4	100	4	100	5	4.99
<u>Deer in central and northern zones</u>																	
B	17	18	11	18	9	11	9	11	17	6	0	1	0	1	0	3	1.68
W	20	15	47	15	45	11	71	14	50	4	50	3	33	3	33	6	12.80
J	18	11	24	17	20	15	23	13	17	6	0	1	25	1	25	4	12.45

Table 10. Percent of locations in burned area of home range in relation to percent of composite home range burned for radio-collared does.

Season	Deer				
	S	Y	O	A	L
Deer in souther zone					
% of composite home range burned	27	16	26	6	32
Winter 1977	---	---	---	5 (0)	---
Spring 1977	69 (+)[1]	78 (+)	39 (+)	6 (0)	---
Summer 1977	---	---	---	---	---
Fall 1966	48 (+)	57 (+)	82 (+)	---	---
Winter 1977-78	20 (0)	25 (+)	72 (+)	2 (0)	9 (-)
Spring 1978	60 (+)	32 (+)	71 (+)	9 (0)	21 (-)
	B	W	J		
Deer in central and northern zones					
% composite home range burned	4	7	15		
Winter 1977	4 (0)	---	---		
Spring 1977	7 (0)	31 (+)	---		
Summer 1977	39 (+)	4 (0)	---		
Fall 1977	18 (+)	29 (+)	---		
Winter 1977-78	19 (+)	19 (+)	23 (0)		
Spring 1978	10 (+)	47 (+)	42 (+)		

[1] (+) indicates selection for burn, (-) indicates selection against burn, (0) indicates use of burn in proportion to its availability.

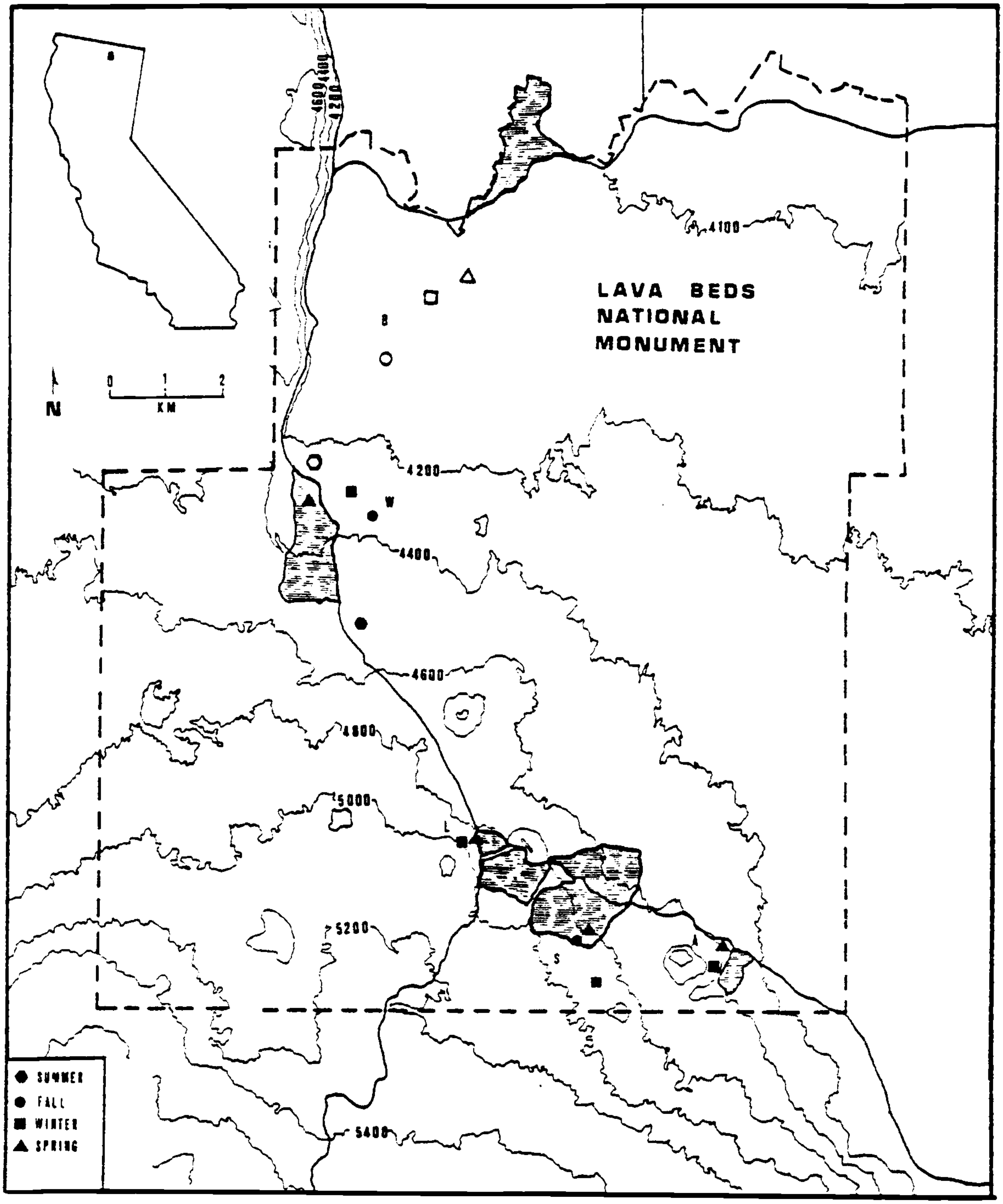

Figure 18. Shifts in seasonal centers of activity for radio-collared does, 1977 - 1978.

Effects of Burns on Home Ranges

All radio-collared migratory does returned to their winter home ranges of the previous year. Migratory and non-migratory does were not displaced by recent burns within their home ranges. Furthermore, they did not extend their home ranges to include the new burns. The prescribed Headquarters Burn, conducted the summer of 1977, did not attract does S and Y whose home ranges in the monument were adjacent to it.

Doe O, a non-migratory doe, had a small corner (2%) of her composite home range burned by the 1977 Headquarters Burn. Her use of the newly burned portion of her home range significantly increased ($P < 0.05$) from her use of that area the previous year. She did not extend her home range however, to include a greater portion of the burn. Her spring home range of 1978 was much smaller than that in 1977 (Table 6). She restricted her movements to the new burn and a small area surrounding monument headquarters that included part of the 1973 wildfire. It appeared that the new burn caused a reduction of her 1978 spring home range.

Doe A exhibited a different response to a similar situation. The 1977 Caldwell Burn affected a small portion (4%) of her 1978 composite home range. In contrast to doe O, she did not change her use of the burned area from the previous year. She used the Caldwell Burn and the 1973 wildfire in proportion to their availability (Table 10); her movements in 1978 seemed unaffected by the presence of the new burn within her home range.

Thus, adult does showed a strong fidelity to their home ranges in the monument and the occurrence of burns did not induce an extension or abandonment of those home ranges the years following the burns. Migration data in the spring of 1978 also suggest that deer return to site-specific holding areas on transitional ranges and home ranges on the summer range. These data support Schnoes (1978) hypothesis of site-specific home ranges for individual deer.

CONCLUSIONS AND RECOMMENDATIONS

Migratory does in Lava Beds were found to migrate from the monument in a south-southeasterly direction and move to low elevation summer range in the Modoc and Shasta-Trinity National Forests. The summer range of migratory deer extended from an area approximately 18 km south of the monument to south of the McCloud Flats region, approximately 65 km south of the monument.

Since the majority of deer in Lava Beds migrate, their numbers can be affected by natural or man-caused alterations on transitional and summer ranges south of the monument. If an undesirable change should occur in the population level of deer in Lava Beds, it should be known whether that change is a result of conditions within the monument or on seasonal ranges south of the monument. Thus action in the proper area can be taken to reverse the undesirable trend.

Personnel of the California Department of Fish and Game conduct herd composition counts of the Glass Mountain herd in fall (bucks: fawns:does) and spring (adults:fawns). These counts provide an index to fawn survival and thus herd recruitment and population trends. Personnel in the monument should keep informed of these counts since they will provide information on the response of migratory deer to changing conditions on the winter range (spring counts) and on seasonal ranges south of Lava Beds (fall counts).

Also, data should continue to be obtained from pellet-group transects already established in the monument. Although pellet-groups counts will not provide an accurate estimate of herd size, they will reflect general population trends on the winter range within the monument. Furthermore, they will continue to provide information on distribution of deer in Lava Beds.

Migratory does used essentially the same home ranges within the monument in 1978 as in 1977. Prescribed burns conducted to date do not appear to have adversely affected the movement patterns of deer whose home ranges were near or overlapped burned areas. This may have been due partially to the mosaic of burned and unburned vegetation remaining after the prescribed fires and the relatively small size of the burns (less than 200 ha). Since radio-collared does return to site specific home ranges, it is probable that only does whose home ranges overlap burned areas will be affected as Schnoes (1978) suggested.

Studies have shown that deer reduce their movements and concentrate in smaller areas in severe winters (Drolet 1976, Loveless 1964). In view of the mild winter weather that occurred in 1977-78, home ranges on the winter range may approximate maximum areas rather than minimum areas used by does. In a more severe winter, deer in the monument may reduce their home ranges and burns would incorporate a larger percentage of individual home ranges. Comcomitantly, herbaceous vegetation would not be as available, and the importance of thermal cover would increase. In a harsh winter, large, intense block burns may have a detrimental effect on deer particularly in the southern zone where there are greater numbers of deer, smaller home ranges and greater plant cover.

Schnoes (1978) suggested that burns with a minimum diameter in any direction of less than two km (approximately 300 ha) would not totally encompass the home ranges of a significant number of deer. Burns that exceed this guideline are probably best delayed until the opportunity arises to observe the response of the deer population following a winter of above average severity.

Most does selected burned areas within their home ranges during fall 1977 and spring 1978, and all deer, with the exception of one, used the burned areas at least in proportion to their availability during winter 1978. Mild weather prevailed during the winter of 1977-78 and placed minimal stress on deer during that period.

Plentiful rainfall produced herbaceous growth in meadows and burns that remained available for the entire period that deer were on the winter range. The frequent use of burns by does appeared to be associated with availability of herbaceous vegetation in the burns.

The spring period, March-May, corresponds to the final three months of fetal development in pregnant does. Pregnancy demands additional energy and protein particularly in the last trimester of gestation, due to the rapid growth rate of the fetus (Moen 1973). Numerous studies have indicated that nutritional deficiencies in does during the last trimester of pregnancy result in increased neo-natal mortality of fawns (Murphy and Coats 1966, Thompson and Thompson 1953, Verme 1963, Verme 1977 and others). Results from a production study conducted on the Fleener Chimneys burn site showed an increased production in bunchgrasses on the burn site for two years following the burn (Champlin and Winward 1979). Other investigations also have documented increased quantity and quality of herbaceous growth for 2-5 years following burns in chaparral habitat (Christensen 1973, Sampson 1944).

Radio-collared migratory deer in Lava Beds remained in the monument through mid spring in 1977 and through late spring in 1978. An examination of weather records for the monument over the past 18 years indicates that spring warming trends typically occur in March (Appendix 4). Thus it appears that migratory deer will have access to herbaceous forage in meadows and burns during the initial half of the third trimester of gestation. The increased quantity and quality of herbaceous vegetation on burn sites may increase fawn survival of deer in the monument.

Burns ranging from 400-34800 ha, and numerous smaller fires have occurred on the transitional and summer ranges of migratory deer, concomitantly with prescribed burns in Lava Beds. Those wildfires are pertinent since migratory deer are on these ranges for the last half of spring through fall. The quality of habitat on seasonal ranges south of the monument can influence the survival of fawns over summer and winter periods. As succession proceeds in the burns south of the monument, a seral stage of optimal cover and forage for deer will be reached. The large area affected by those burns most likely will affect a significant segment of the migratory deer population in Lava Beds. Burns on the transitional and summer ranges are likely to have the greatest influence on productivity and fawn survival 5-10 yrs after they occur (Salwasser 1979).

Because of nutritional benefits that may be provided by new forage in burned areas in the monument and on seasonal ranges south of the monument, an increase in the deer population in Lava Beds seems probable. However, this study has investigated deer movements and the response of deer to burns for one year only, a year during which mild weather persisted for a third consecutive winter. As a result, the movements and home range patterns of deer and their response to burns during severe winter conditions is still lacking. Continued monitoring of the deer population with pellet-group counts and fall and spring herd composition counts is advised. Prescribed burns should remain conservative in size (less than 300 ha) until the response of the deer population can be monitored during a winter of above average severity.

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APPENDIX

Appendix 1. Herd composition counts of the Glass Mountain herd and estimated percent of fawns lost over summer and winter.

Year	Fall FF/100 DD	Spring FF/100 DD	[1]Potential Fawns Born/100 DD	% Fawns Lost Over Summer	% Fawns Lost Over Winter
1960	52	43	192	72.9	6.4
1961	53	39	189	72.0	6.8
1962	72	40	189	61.9	6.9
1963	91	62	207	56.0	4.8
1964	77	93	248	59.0	0.0
1965	56	57	203	72.4	8.1
1966	62	48	196	68.4	3.9
1967	45	37	187	75.9	12.8
1968	71	27	181	60.8	8.6
1969	66	53	200	67.0	9.9
1970	48	51	198	75.8	7.5
1971	41	27	179	77.1	10.6
1972	60	30	182	67.5	6.1
1973	51	28	180	71.7	17.6
1974	40	22	175	77.1	16.1
1975	55	27	179	69.3	7.4
1976	46	33	184	75.0	12.3
1977	46	30	182	74.7	8.7
1978	41	33	184	77.7	7.1
1979	50	29	181	72.4	6.5

[1]Potential fawns born/100 DD = (Breeding age does/100 DD)(Fetal Rate)(% Pregnancy)

Breeding age does/100 DD = 100/100 + .5 (Spr FF/100 DD) (Salwasser 1976)

Fetal Rate = 1.69, % Pregnancy = 93% (Reproductive data obtained for the Interstate Herd in 1975, by Salwasser [1979]. Reproductive data for the Glass Mountain herd is assumed to be similar since the two herds are subject to similar ecological conditions on summer and winter ranges).

Appendix 2. Summary of deer capture data in spring 1977 and winter 1978.

Tag #	Sex	Age	Approximate Weight km	Capture Site[1]	Capture Method	Capture Date	% of Relocations
18[2]	F	A	61	3	Drug	4/11/77	419
19	F	Y	45	6	Drug	4/2/77	23
20[2]	F	A	57	3	Drug	4/12/77	232
4301	F	Y	45	3	Trap	12/13/77	11
4302	F	A	55	2	Trap	1/5/78	0
4303[2]	F	A	61	7	Trap	1/5/78	152
4304	F	Y	50	3	Trap	1/7/78	5
4305	F	Y	48	3	Trap	1/6/78	4
4306	M	F	36	3	Trap	1/24/78	5
4307	F	A	55	3	Trap	1/26/78	0

[1]Location of trap sites displayed on Figure 3.

[2]Fitted with radio-collar.

Appendix 3. Climatic conditions during the summer in the study area.

Year	Lava Beds National Monument June-August $\bar{X}$			Summer Range June-August $\bar{X}$		
	$\bar{X}$ Temp	$\bar{X}$ Precip	Total Annual Precipitation	$\bar{X}$ Temp	$\bar{X}$ Pricip	Total Annual Pricipitation
1960	19.7	0.2	30.7	22.9	0.3	144.7
1961	19.9	0.5	32.5	23.5	0.9	145.6
1962	17.3	0.2	45.0	21.9	0.2	131.0
1963	16.0	1.4	33.3	20.9	0.9	145.3
1964	15.6	3.1	43.7	21.8	0.8	166.0
1965	16.1	4.0	47.5	21.5	3.1	156.4
1966	16.8	2.5	34.8	21.1	2.0	156.4
1977	19.3	1.0	33.0	21.5	0.2	149.4
1968	17.8	0.7	38.6	21.5	0.2	149.4
1969	17.8	2.1	45.4	21.8	0.2	133.1
1970	18.9	2.3	42.7	22.9	0.3	180.1
1971	17.9	1.5	36.3	s1.4	0.1	142.8
1972	18.7	0.8	31.8	22.3	0.3	138.2
1973	18.5	0.6	40.6	22.0	0.1	169.2
1974	19.0	1.3	36.0	s1.5	0.4	133.7
1975	19.0	1.3	36.0	21.5	0.4	133.7
16 year $\bar{X}$	17.8	1.5	38.1	22.1	0.6	142.6
1976	17.1	3.5	20.6	19.9	0.3	50.5
1977	18.8	2.0	33.0	23.0	0.2	58.4

Appendix 4. Climatic conditions during winter and early spring in Lava Beds National Monument, California.

Year	December		January		February		March		3 Month $\bar{X}$		Annual Snowfall cm
	$\bar{X}$ Temp (°C)	Total Snow cm	$\bar{X}$ Temp (°C)	Total Snow cm	$\bar{X}$ Temp (°C)	Total Snow cm	$\bar{X}$ Temp (°C)	Total Snow cm	$\bar{X}$ Temp (°C)	Total Snow cm	
1959-60	1.1	8.9	-1.4	5.8	0.3	T	5.1	10.2	1.3	6.2	15.2
1960-61	---	---	3.3	1.3	2.6	10.6	2.8	7.9	2.9	6.5	19.6
1961-62	-0.6	13.5	-2.1	25.4	0.5	19.1	1.9	27.4	-0.1	21.4	71.9
1962-63	2.2	0.0	0.5	2.5	5.8	3.8	2.6	26.4	2.9	8.1	32.8
1963-64	2.1	6.4	-1.2	43.9	-0.2	6.4	1.2	39.4	0.5	24.2	89.7
1964-65	0.3	31.9	0.1	88.9	2.1	10.2	5.8	0.7	2.1	32.7	91.2
1965-66	-0.7	5.1	-0.7	-10.9	-0.3	15.7	3.2	8.1	0.4	10.0	43.2
1966-67	0.7	35.3	-0.1	23.6	3.1	8.9	1.8	70.4	1.4	34.6	102.9
1967-68	-2.0	22.0	-1.6	19.1	3.8	0.0	4.9	11.9	1.2	13.3	31.0
1968-69	-2.1	44.5	-2.2	55.6	-1.2	60.5	2.4	6.1	-0.8	42.7	141.5
1969-70	0.9	18.5	0.2	15.0	3.4	5.3	3.1	7.9	1.9	11.7	75.4
1970-71	2.7	52.8	0.1	9.1	1.6	12.2	1.3	3.3	1.4	19.4	63.0
1971-72	-3.3	66.8	-2.8	24.1	1.7	25.4	6.6	16.8	2.2	33.3	49.5
1972-73	-3.3	23.1	-2.4	37.8	1.4	21.4	2.1	5.3	-0.6	21.9	91.4
1973-74	---	---	-3.3	20.1	-0.5	23.9	1.9	50.0	-0.6	31.3	94.5
1974-75	0.2	23.3	-1.1	25.9	-1.1	143.5	0.7	17.3	-0.4	48.1	185.7
16 Yr $\bar{X}$	-0.5	25.1	-1.4	25.6	1.0	22.9	3.0	19.3	0.5	23.2	74.9
1975-76	1.4	9.7	1.0	10.2	1.4	26.6	1.2	21.8	1.3	17.1	60.2
1976-77	1.8	11.4	-3.1	30.7	0.4	4.6	0.8	27.9	0.0	18.7	63.2
1977-78	1.5	1.3	2.0	0.8	3.6	2.8	4.8	5.1	1.5	2.5	76.3