LONG-DISTANCE MOVEMENTS OF BLACK-TAILED JACKRABBITS

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Abstract: During an intensive demographic study of black-tailed jackrabbits (*Lepus californicus*) in Curlew Valley, Utah, USA, we noted unexpected large displacements among 30% of our study animals. Although understanding movement patterns—especially long-distance movements—should be an essential element for programs studying and managing wild populations, reports of such events among jackrabbits are rare. We describe aspects of long-distance movements within 1 jackrabbit population. We placed radiotransmitters on 393 black-tailed jackrabbits and accumulated 28,945 animal-days of data during 5 study periods between 1979 and 1984. In 146 instances, we documented hares moving ≥5.0 km, typically within 2–10 days. Although 3 hares moved ≥25 km (longest = 35 km), 63% of such movements were ≤10 km. Long movements occurred in all seasons but on an animal-day basis were most frequent February–April (24%) and October–December (52%). Vectors between north and east comprised 66% of long-distance movements documented between March and May. However, 65% of such movements during summer and 83% during fall and winter involved vectors between south and west. These movements appeared to represent migrations to and from traditional wintering areas. Despite the magnitude of these movements, the Curlew Valley jackrabbit population appears to be demographically closed, but if timing of movements varies among sex and age classes, demographic analyses on geographic units that do not encompass the entire valley could be affected. Efforts to mitigate jackrabbit depredations on growing crops or stored forages should incorporate information about seasonal movement patterns as well as the areas potential management programs might affect.

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Black-tailed jackrabbits are a common native herbivore throughout the Great Basin as well as much of western North America. They are prey for medium to large carnivores (Clark 1972, Wagner 1981, MacCracken and Hansen 1987) and raptors (Howard 1975, Steenhof and Kochert 1988), and pose economic risks to some agricultural interests during periodic irruptions in abundance (Marsh and Salmon 1981, Knight 1994) or when they congregate around growing or stored forage crops (Fagerstone et al. 1980). They also serve as hosts for a variety of vectors of human and animal diseases, such as Rocky Mountain spotted fever, hydatid disease, and tularemia (Davis et al. 1970). Despite their abundance and distribution, significant aspects of their biology and behavior remain undocumented. We report on an unexpected aspect of jackrabbit movements relevant to depredation control programs as well as studies of jackrabbit demographic patterns.

Aspects of jackrabbit home range movement patterns in Curlew Valley, Utah, USA, were reported by Smith (1987, 1990), which are generally consistent with reports by Vorhies and Taylor (1933), Lechleitner (1958), Rusch (1965), and Haug (1969). In 1979, we were alerted to the possibility of extended movements among jackrabbits when, in the midst of the reproductive season, a female we were radiomonitoring moved 7 km from a known home area. Six weeks after moving from that home area (about the length of gestation for black-tailed jackrabbits), she returned to the former area. Other than Porth (1995), who reported 17 instances of black-tailed jackrabbits moving substantial distances ($\bar{x}$ = 12 km), there are scant references to movement patterns atypical of home range activities. With a substantially larger data set, we can examine long-distance movement patterns of jackrabbits in greater detail.

STUDY AREA

Curlew Valley, located along the Utah–Idaho border in Box Elder County, Utah, and Cassia and Oneida counties, Idaho, is within the Great Basin. The valley floor slopes from about 1,500 m on the west, north, and east to 1,280 m in the south near

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the border with the Great Salt Lake. Our study area encompassed 1,400 km^2 in the Utah (southern) portion of Curlew Valley, between Utah Highway 30 and the Great Salt Lake. The area is semiarid with precipitation most abundant during winter and spring. Annual precipitation for the years of our study, as measured at Snowville, Box Elder County, Utah (about 15 km northeast of our study site), varied between 31.3 and 62.0 cm, averaging 43.4 cm (National Oceanic and Atmospheric Administration 1979–1984). During the same period, mean daily temperatures in Curlew Valley varied from –6 °C in January to 21 °C in July, with summer maxima of around 38 °C and winter minima of around –30 °C (National Oceanic and Atmospheric Administration 1979–1984).

Topography and vegetation were described in detail by Gross et al. (1974) and Hoffman (1979). We recognized 4 major vegetative associations within the area: (1) areas of big sagebrush (*Artemisia tridentata*) with forbs covering about 50% of the area; (2) salt-desert vegetation composed primarily of shadscale (*Atriplex confertifolia*) and sickle saltbush (*Atriplex falcata*) is scattered but widespread and occupies about 25% of the area; (3) greasewood (*Sarcobatus vermiculatus*) covering about 10% of the area in the more saline soils just north of the Great Salt Lake; and (4) scattered stands of Utah juniper (*Juniperus osteosperma*) at higher elevations also covering 10% of the area. Agricultural areas, such as irrigated alfalfa (*Medicago sativa*) and plantings of crested wheatgrass (*Agropyron desertorum*), are locally important vegetative constituents.

METHODS

As part of a demographic study, we captured black-tailed jackrabbits by nightlighting and netting (Griffiths and Evans 1970), assessed their sex and age, equipped them with 50-g radiotransmitters, and released them at their respective capture locations. We determined sex by examination of external genitalia and estimated age from body size as well as color and relative eye size (L. C. Stoddart, unpublished data). The collars used to attach the transmitters were designed to minimize neck-chafing (Wywialowski and Knowlton 1983). Periodically, additional animals were caught and radiocollared to replace those that died. During winter monitoring sessions, some jackrabbits were captured in live traps. These animals were handled similarly to those captured by netting. Jackrabbits were given a 2-week postcapture adjustment period before they were considered part of the study sample to avoid potential problems associated with capture myopathy or adjustment to the collars (Wywialowski and Knowlton 1983, Keith et al. 1984).

We monitored jackrabbits during 5 periods: 1 April to 1 October 1979, 5 June to 16 October 1980, 16 December 1981 to 24 March 1982, 14 November 1983 to 25 April 1984, and 15 May to 27 November 1984. These periods spanned a fluctuation in jackrabbit abundance (Fig. 1) from midway through an increase in density, to a peak in 1980, and a subsequent decline to a low density by 1984 (Stoddart 1987, Knowlton and Stoddart 1992). During 1979, we only monitored adults; during 1980, only juveniles (3+ months old); while during 1984, both adults and juveniles were monitored. We considered all jackrabbits radiomarked for winters 1981–1982 and 1983–1984 to be adults.

We checked radio frequencies associated with individual animals at least every other day. Over 95% of the time we were able to monitor all instrumented jackrabbits and obtain locations from combinations of 3 fixed stations on the Wildcat Hills, which are central to the study area. When we could not identify transmitter locations from the fixed stations, we searched for transmitter signals from other prominent topographic points in and around Curlew Valley with portable antennas and receivers until we were confident of the animal's location. At the conclusion of the 1979 and 1983–1984 tracking sessions, we also used aircraft to search for animals that may have moved extensive distances. During the 1979, 1980, and 1981–1982 tracking sessions, jackrabbit locations were estimated within 0.5 km and recorded on individual maps of the study area. During winter

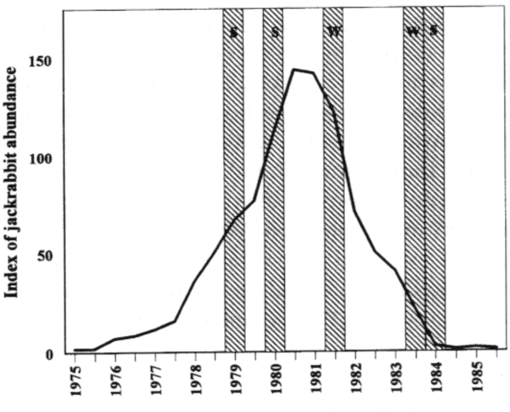

Fig. 1. The 5 study sessions (shaded bars) superimposed on trends in jackrabbit abundance in Curlew Valley, Utah, USA, 1975–1985 (from Stoddart 1987, Knowlton and Stoddart 1992). April–October (S) and November–April (W) monitoring periods are identified.

Table 1. Number of radiomarked black-tailed jackrabbits (*n*), accumulated days of monitoring, and distribution among males and females for 5 monitoring periods in Curlew Valley, Box Elder County, Utah, USA, 1979–1984.

	Year (season)[a]					
Parameter	1979 (S)	1980 (S)	1982–1983 (W)	1983–1984 (W)	1984 (S)	Overall
Sample (*n*):	119	60	72	79	63	393
% Female	39.5	46.7	54.2	55.7	71.4	51.6
% Male	60.5	53.3	45.8	44.3	28.5	48.3
Number of animal-days monitored:						
Females	4,599	2,419	1,847	1,556	2,840	13,261
Males	8,903	2,718	1,529	1,264	1,270	15,684
Total	13,502	5,137	3,376	2,820	4,010	28,945

[a] S = Apr through Oct, W = Nov through Apr.

1983–1984 and summer 1984, locations were determined more precisely (±200 m) by taking simultaneous azimuths from 2 or more locations (Smith 1987, 1990) and calculating jackrabbit locations via triangulation. We used displacement of 5 km from point of capture, or previously established home area, as a lower threshold for defining long-distance movements. We measured displacement distances ≥5 km to the nearest kilometer from topographic maps, and noted the timing and direction of such movements. We considered jackrabbits to be part of our sample up to the day radio contact was lost, the animal was determined to be dead, or the particular study period ended.

Although we searched throughout the study area for jackrabbits to radiocollar, they were more commonly captured in some locations than others. Some analyses may be skewed because directional options available at some locations were limited by topographic features (e.g., Great Salt Lake). Similarly, different sample sizes among study periods, as well as changing sample sizes as individual animals entered or left the study, limited our ability to accurately discern the fraction of the population engaged in long-distance movements.

RESULTS

We included 393 jackrabbits in our study with an accumulated total of 28,945 animal-days of monitoring (Table 1). At the end of our study, only 30 jackrabbits (7.7%) remained unaccounted for, which suggested that our monitoring system was effective and experimental error was low. Overall, samples were evenly distributed between males (48.3%) and females (51.6%), but the fraction comprised of males declined systematically from 60.5% to 28.5% as the study progressed from 1979 through 1984 (Table 1). Because males predominated in the first study period when the sample size was nearly double that of subsequent samples, we accumulated nearly 2,500 more days of monitoring males than females (Table 1). We collected 146 movements ≥5 km, involving 118 different jackrabbits (some jackrabbits moved ≥5 km as many as 4 times). This included 35% of the females and 24% of the males (Table 2). The frac-

Table 2. Number of long-distance (≥5 km) movements recorded for radiomarked black-tailed jackrabbits during 5 monitoring periods in Curlew Valley, Box Elder County, Utah, USA, 1979–1984.

	Year (season)[a]					
Parameter	1979 (S)	1980 (S)	1982–1983 (W)	1983–1984 (W)	1984 (S)	Overall
Number of hares monitored (*n*)	119	60	72	79	63	393
Number of movements ≥5 km recognized	38	19	20	33	36	146
Number of hares making long movements	21	18	16	31	32	118
Fraction of females involved	0.23	0.29	0.23	0.45	0.53	0.35
Fraction of males involved	0.14	0.31	0.21	0.31	0.44	0.24
Mean distance (km)	10	12	9	10	12	11

[a] S = Apr through Oct, W = Nov through Apr.

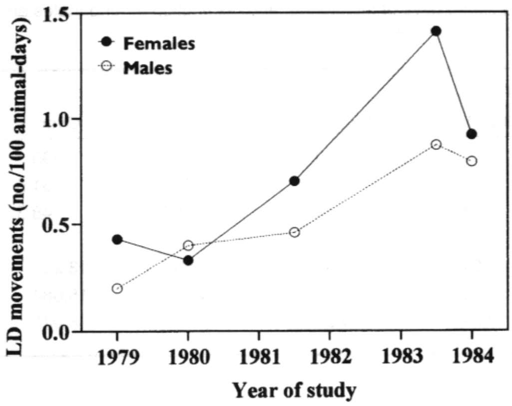

Fig. 2. Relative frequency of 146 long-distance (LD) movements, expressed as the number per 100 animal-days of monitoring, among female and male black-tailed jackrabbits in Curlew Valley, Utah, USA, during 5 study periods between 1979 and 1984.

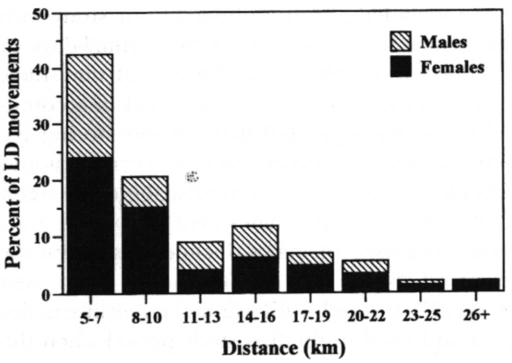

Fig. 3. Relative frequency distribution of distances moved for 146 long-distance movements recorded among black-tailed jackrabbits in Curlew Valley, Utah, USA.

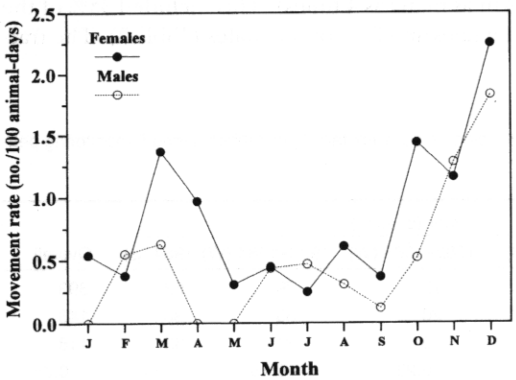

Fig. 4. Relative frequency on a monthly basis of 146 long-distance movements (expressed as the number of movements per 100 animal-days of monitoring) among male and female black-tailed jackrabbits in Curlew Valley, Utah, USA.

tion of hares with long-distance movements increased over the course of the 5 monitoring periods 2.3- and 3.1-fold among females and males, respectively (Table 2). In addition, over the 5 monitoring periods, we noted a 3-fold increase in the frequency with which long-distance movements were detected, from about 0.3 long-distance movements per 100 animal-days of monitoring during the first study session to 1.0 long-distance movements per 100 animal-days during winter 1983–1984 (Fig. 2).

Distances Moved

More than 43% of movements ≥5 km were between 5 and 7 km, with an additional 21% identified as 8 to 10 km (Fig. 3). Decreasing percentages of jackrabbits were involved at progressively greater distances. On 3 occasions, we noted movements >25 km (27, 28, and 35 km, respectively). Females outnumbered males in most distance categories (Fig. 3).

Seasonal Aspects of Movements

Timing.—We noted long-distance movements in all months, but they were most common during March–April and October–December (Fig. 4). In most months, we noted 1 such movement for every 200 animal-days of monitoring. During spring and late fall–winter, the frequency increased to 1 for every 50 to 75 animal-days of monitoring. Males were less inclined to make such movements (Fig. 4).

Direction.— There was a strong seasonal component to the long-distance movements we observed. During spring (Mar–May), vectors between north and east predominated, contributing 66% of the observed long-distance movements (Fig. 5). Starting in summer (May–Sep), the flow shifted, with vectors south to west accounting for 65% of our observed long-distance movements. This trend was emphasized during late fall and winter when 83% of the movements we noted were on vectors between south and west (Fig. 5).

DISCUSSION

We documented that 30% of 393 black-tailed jackrabbits in Curlew Valley moved ≥5 km at least once during the time they were monitored. This is an underestimate of long-distance movement because none of the jackrabbits were monitored for an entire year, and many died during the study from predation and other causes (Smith 1987). The seasonal directionality of these movements suggests that they may represent migrations to and from traditional wintering areas at lower elevations near the Great Salt Lake where accumulated winter snow depths are typically less than in other portions of the valley. Many of the movements toward these wintering areas were initiated during midsummer (Fig. 5). Displacements by females during the reproductive season lead us to speculate whether some such movements might also represent a form of forced weaning of 1 litter prior to the birth of the next.

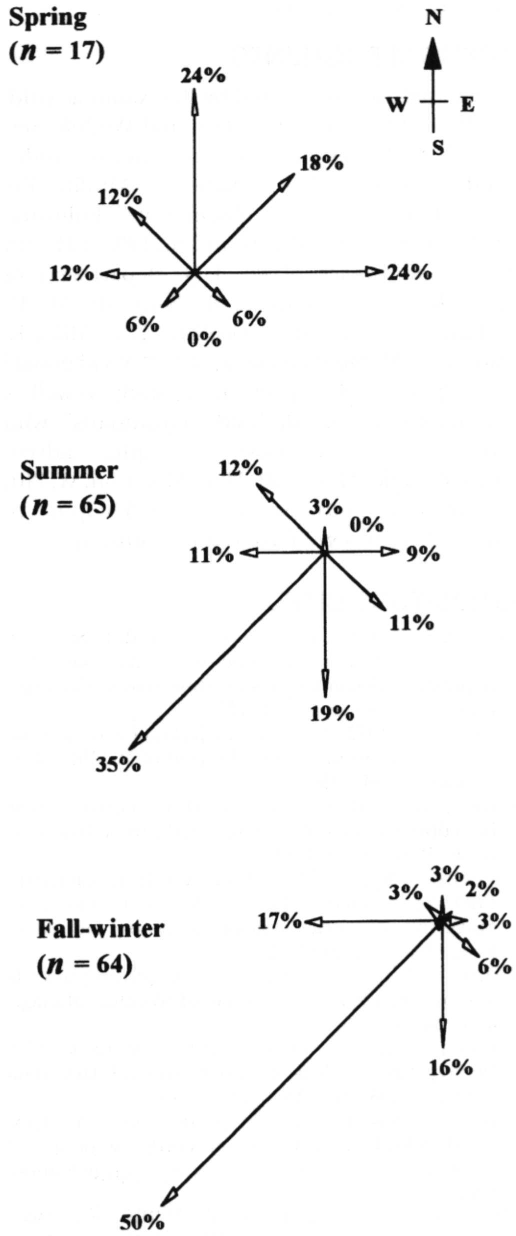

Fig. 5. Comparison of the directional component of long-distance movements of black-tailed jackrabbits in Curlew Valley, Utah, USA, during spring (Mar–May), summer (Jun–Sep), and fall–winter (Oct–Feb).

Other researchers (Rusch 1965, Tiemeier 1965, Haug 1969, Gross et al. 1974) reported some long-distance movements of black-tailed jackrabbits. Porth (1995), who worked about 200 km north of Curlew Valley, documented 17 long-distance movements among 41 black-tailed jackrabbits, with a mean displacement of 12 km. He noted long-distance movements among both males and females in all seasons, but movements were more common in fall (39%), compared with 28% in summer and 17% in winter. With substantially larger samples in all seasons, we were able to document peak periods of movements among the jackrabbits both in spring and fall–winter. We are aware of reports of seasonal shifts in home range areas for only 1 other species of North American hare. Hearn et al. (1987) reported arctic hares (*Lepus arcticus*) in southwestern Newfoundland shifting about 2.5 km between summer and fall ranges, with a maximum distance of 3.2 km.

Behavioral Significance

During spring, summer, and fall, jackrabbits are found throughout Curlew Valley, although they are more common in some areas than others. The high incidence of long-distance movements in fall and early winter coincides with jackrabbits concentrating near denser stands of greasewood, particularly in the southern and lower portions of Curlew Valley near the Great Salt Lake where weather is typically more mild and snow accumulations less. By early to mid-winter, major portions of Curlew Valley are almost devoid of jackrabbits. Rusch (1965) similarly recovered 3 of his marked jackrabbits after they had moved up to 18 km to wintering areas in the southern portion of Curlew Valley. As the snow receded in March and April, we observed jackrabbits repopulating most of Curlew Valley. Movements primarily are south and west during fall and early winter and mainly north and east during March and April, a pattern suggesting an annual migration. Unfortunately, the expected life of our transmitters did not permit us to follow individual hares throughout an annual cycle to determine whether the same individuals were involved in movements in both directions.

The increased frequency of long-distance movements among jackrabbits during the latter portion of this study may reflect our increased vigilance and detection of such movements, but it seems unlikely this would account for a 3-fold increase. Other possible explanations include 2 of the last 3 study periods being in late fall and winter when greater proportions of the population appear to move to wintering areas, and perhaps a density-dependent component related to jackrabbit abundance (Fig. 1). The weather severity may also have had an influence. The winter of 1983–1984, with nearly double the frequency of long-distance movements, was more severe with mean temperatures 2.3 °C lower and precipitation 17% higher than that of 1981–1982 (National Oceanic and Atmospheric Administration 1981–1984). Within wintering areas, jackrabbits respond to fresh snow by concentrating within very small areas and constructing networks of trails (Smith 1987). During the latter part of the study when the population was sparse, longer movements may have been required to achieve an optimum density either to facilitate creating trails that give jackrabbits greater mobility in deep snow or to enhance survivorship in the presence of territorial predators (Mech 1984, Messier and Barrette 1985). Seasonal movements toward wintering areas apparently start in midsummer (Fig. 5), several months before winter weather begins to constrain jackrabbit mobility.

Demographic Implications

We documented that 25–50% ($\bar{x}$ = 35%) of the radiocollared black-tailed jackrabbits we studied moved >5 km, and sometimes as much as 25 km. Movements of this magnitude could have important implications for understanding population processes, including whether or not an open or closed population is involved, estimating demographic parameters such as population size, reproductive patterns, rates and causes of mortality, population structure, and dispersal patterns. Only 5 of the radiocollared jackrabbits are known to have emigrated out of Curlew Valley. In addition, movement patterns of Curlew Valley jackrabbits do not fit the theories of dispersal as reviewed by Boutin et al. (1985). Assuming patterns of immigration and emigration are similar, the Curlew Valley jackrabbit population appears to be geographically closed. However, the extent and pervasiveness of movements of jackrabbits within the valley suggest that analyses of some demographic characteristics, such as sex and age ratios, population estimates based on mark–recapture procedures, and mortality estimates, may be misleading if differential movements occur among subsets of the population and sampling is not appropriately distributed throughout the valley.

Since long-distance movements occurred among both males and females, and differences were not great, we suspect there are not important implications for determining sex and age ratios or the social structure of Curlew Valley jackrabbits. Such movements might become relevant for sampling schemes if there are temporal differences when specific population components engage in such long-distance movements.

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LITERATURE CITED

Boutin, S., B. S. Gilbert, C. J. Krebs, A. R. E. Sinclair, and J. N. M. Smith. 1985. The role of dispersal in the population dynamics of snowshoe hares. Canadian Journal of Zoology 63:106–115.

Clark, F. W. 1972. Influence of jackrabbit density on coyote population change. Journal of Wildlife Management 36:343–356.

Davis, J. W., L. H. Karstad, and D. O. Trainer. 1970. Infectious diseases of wild mammals. Iowa State University Press, Ames, USA.

Fagerstone, K. A., G. K. LaVoie, and R. E. Griffiths. 1980. Black-tailed jackrabbit diet and density on rangeland and near agricultural crops. Journal of Range Management 33:229–233.

Griffiths, R. E., and J. Evans. 1970. Capturing jackrabbits by night-lighting. Journal of Wildlife Management 34:637–639.

Gross, J. E., L. C. Stoddart, and F. W. Wagner. 1974. Demographic analysis of a northern Utah jackrabbit population. Wildlife Monographs 40.

Haug, J. C. 1969. Activity and reproduction of the black-tailed jackrabbit in the coastal cordgrass prairie of Texas. Thesis, Texas A&M University, College Station, USA.

Hearn, B. J., L. B. Keith, and O. J. Rongstad. 1987. Demography and ecology of the arctic hare (*Lepus arcticus*) in southwestern Newfoundland. Canadian Journal of Zoology 65:852–861.

Hoffman, S. W. 1979. Coyote–prey relationships in Curlew Valley during a period of low jackrabbit density. Thesis, Utah State University, Logan, USA.

HOWARD, R. 1975. Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho. Thesis, Utah State University, Logan, USA.

KEITH, L. B., J. R. CARY, O. J. RONGSTAD, AND M. C. BRITTINGHAM. 1984. Demography and ecology of a declining snowshoe hare population. Wildlife Monographs 90.

KNIGHT, J. E. 1994. Jackrabbits. Pages D-81–D-80 *in* S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Institute of Agriculture and Natural Resources, Lincoln, USA.

KNOWLTON, F. F., AND L. C. STODDART. 1992. Some observations from two coyote–prey studies. Pages 101–121 *in* A. H. Boer, editor. Ecology and management of the eastern coyote. Wildlife Research Unit, University of New Brunswick, Fredericton, Canada.

LECHLEITNER, R. R. 1958. Movements, density and mortality in a black-tailed jackrabbit population. Journal of Wildlife Management 22:371–384.

MACCRACKEN, J. G., AND R. M. HANSEN. 1987. Coyote feeding strategies in southeastern Idaho: optimal foraging by an opportunistic predator? Journal of Wildlife Management 51:278–285.

MARSH, R. E., AND T. P. SALMON. 1981. The control of jackrabbits in California agriculture. Pages 706–719 *in* K. Myers and C. D. MacInnes, editors. Proceedings of the world lagomorph conference. University of Guelph, Ontario, Canada.

MECH, L. D. 1984. Predators and predation. Pages 189–202 *in* L. K. Halls, editor. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

MESSIER, F., AND C. BARRETTE. 1985. The efficiency of yarding behavior by white-tailed deer as an antipredator strategy. Canadian Journal of Zoology 63:785–789.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. 1979–1984. Climatological data: Utah, 81–86:1–13. National Climatic Data Center, Asheville, North Carolina, USA.

PORTH, A. T. 1995. Movements of black-tailed jackrabbits (*Lepus californicus*) and effects of high population densities on the nitrogen budget of sage-brush steppe. Thesis, Idaho State University, Pocatello, USA.

RUSCH, D. 1965. Some movements of black-tailed jackrabbits in northern Utah. Thesis, Utah State University, Logan, USA.

SMITH, G. W. 1987. Mortality and movement within a black-tailed jackrabbit population. Dissertation, Utah State University, Logan, USA.

———. 1990. Home range and activity patterns of black-tailed jackrabbits. Great Basin Naturalist 50:249–256.

STEENHOF, K., AND M. N. KOCHERT. 1988. Dietary responses of three raptor species to changing prey densities in a natural environment. Journal of Animal Ecology 57:37–48.

STODDART, L. C. 1987. Relative abundance of coyotes, jackrabbits and rodents in Curlew Valley, Utah. Annual report, Predator Ecology and Behavior Project. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Denver Wildlife Research Center, Colorado, USA.

TIEMEIER, O. W. 1965. The black-tailed jack rabbit in Kansas. Experiment Station Technical Bulletin 140. Kansas State Agricultural College, Manhattan, USA.

VORHIES, C. T., AND W. P. TAYLOR. 1933. The life histories and ecology of jack rabbits *Lepus alleni* and *Lepus californicus* spp. in relation to grazing in Arizona. University of Arizona Agricultural Experiment Station Technical Bulletin 49:467–587.

WAGNER, F. H. 1981. Role of lagomorphs in ecosystems. Pages 668–694 *in* K. Myers and C. D. MacInnes, editors. Proceedings of the world lagomorph conference. University of Guelph, Ontario, Canada.

WYWIALOWSKI, A. P., AND F. F. KNOWLTON. 1983. Effects of simulated radio-transmitters on captive black-tailed jackrabbits. Proceedings of the International Conference on Wildlife Biotelemetry 4:1–11.

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