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Home Range, Home Range Expansion, Dispersal, and Mortality of Juvenile Red Foxes in Southeastern South Dakota

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HOME RANGE, HOME RANGE EXPANSION, DISPERSAL, AND MORTALITY OF JUVENILE RED FOXES IN SOUTHEASTERN SOUTH DAKOTA

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

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Data from aerial and landowner surveys showed that red fox (Vulpes vulpes) families on the Sinai study area decreased from 13 (5.2 per township) in 1976 to 11 (4.4 per township) in 1977. The majority (88%) of the active red fox dens was located in pastures and idle lands although these cover types constituted only 24% of the available cover. Twenty-nine juveniles and 3 adults were captured and marked during spring, 1976. Trappers and hunters returned 62% of the tags placed on juvenile foxes. During spring, 1977, 15 juveniles and 2 adult red foxes were marked. Three juveniles were subsequently reported as harvested. Trapping (81%) and hunting (14%) accounted for 95% of the reported mortality. The pelt of one juvenile was reported by a furbuyer, but no information was provided concerning cause of mortality. Mean distance of dispersal.for juvenile males was 59.5 km (range 10.0 - 239.0 km). Mean dispersal distance for juvenile females was 37.6 km (range 18.0 - 54.8 km). Home ranges were determined from 919 locations of 9 red foxes. Mean home range size for adults was 1193 ha (sd ± 438.4 ha), 195 ha (sd ± 29.6 ha) for juvenile males, and 316 ha (sd ± 33.1 ha) for juvenile females.

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INTRODUCTION

Red foxes (Vulpes vulpes) have become highly prized by both hunters and trappers in South Dakota. Red fox pelts purchased by furbuyers within the state increased from 14,076 in 1970-71 to 56,070 in 1976-77 (fur harvest records compiled by the South Dakota Department of Game, Fish and Parks). The average price paid per pelt increased from $7.67 in 1970 to $48.29 in 1977. The concern by lay people that foxes prey on ring-necked pheasants (Phasianus colchicus) and the increased value of pelts necessitates availability of data for reaching management decisions concerning red fox in South Dakota.

Food habits, reproductive characteristics, and population dynamics of red foxes were studied in the prairie pothole region of eastern South Dakota (Drieslein 1967). Predation by red foxes with emphasis on ring-necked pheasant interactions was studied by Trautman and Fredrickson (1974). Population density, home range, and dispersal of red foxes in eastern South Dakota was investigated by Sweeting (1977).

My objectives were to gather additional data on the density of red foxes on a 234 km^2 study area, obtain data on dispersal and mortality, and determine home range and home range expansion of juvenile red foxes in relation to the home range of a parental adult.

DESCRIPTION OF THE STUDY AREA

The Sinai study area consisted of Lake Sinai Township (T109N, R52W), sections 3-10, 15-22, and sections 27-34 of Oslo Township (T109N, R51W); sections 31-36 of Bangor Township (T110N, R52W), and sections 31-34 of Volga Township (T110N, R51W) of Brookings County; and sections 1-12 of Nunda Township (T108N, R52W), and sections 3-10 of Summit Township (T108N, R51W) of Lake County.

A larger area with a 112 km radius and centered at Brookings, South Dakota (Fig. 1) was used for evaluation of movement and mortality of tagged red foxes. This larger study area encompassed the smaller one and was largely within the Coteau des Prairie physiographic area (Westin et al. 1967).

The Coteau des Prairie lies between the Minnesota-Red River Lowland on the east and the James River Lowland on the west (Westin et al. 1967). The topography within the study area is gently undulating to rolling (Schultz and Driessen 1973) with some areas of hilly to steep terrain (Westin et al. 1958). Elevation varies from 492.6 m above mean sea level on the east edge of the study area to 543.6 m on the west. Elevation at Sinai, South Dakota, near the center of the study area, is 534.9 m.

Soils of the study area are classified as the Chernozem zonal group, characterized by black surface horizons rich in organic matter. The surface horizons grade into a lighter colored soil and finally into a horizon of carbonate accumulation. These soils developed under tall and mixed grasses in a temperate to cool, subhumid climate (Westin et al. 1967). Mean annual precipitation and standard deviation for the

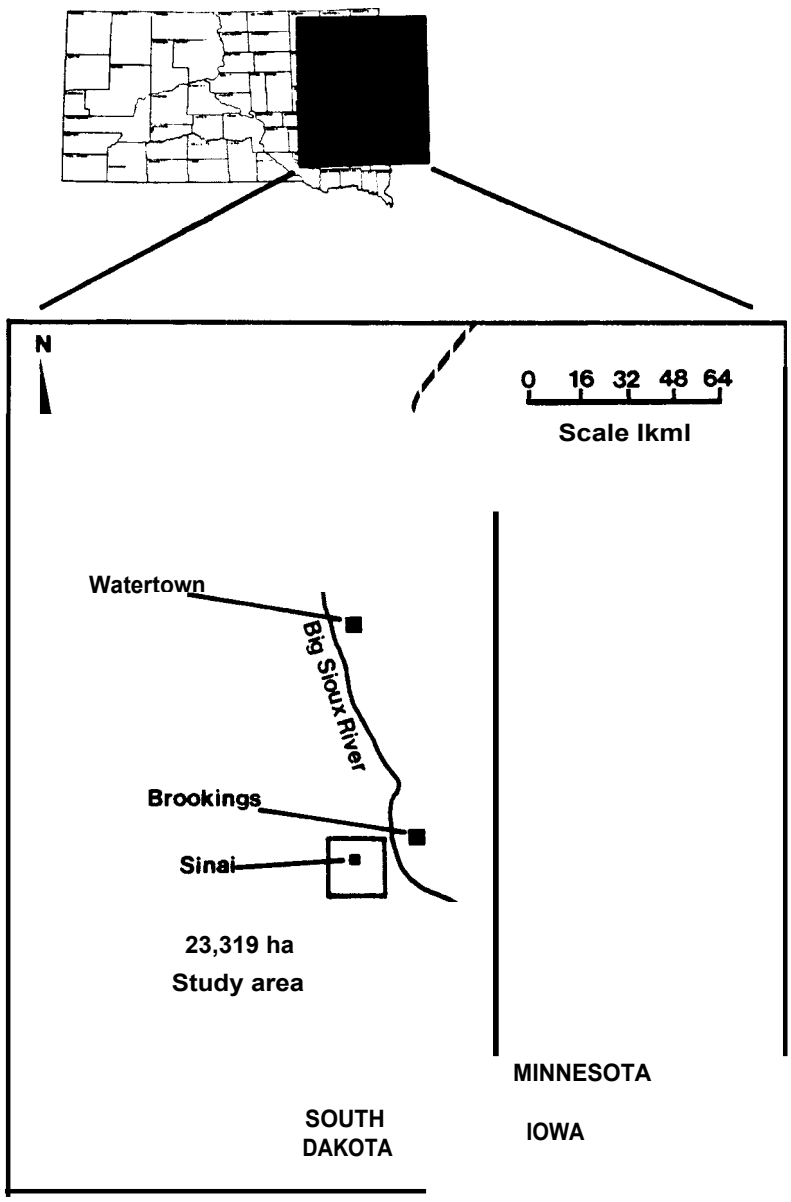


Figure 1. Location of extensive and intensive study areas where research involving the home range, home range expansion, dispersal, and mortality of juvenile red foxes was conducted in southeastern South Dakota, 1976-77.

Brookings vicinity for 30 years is 54.15 ± 13.11 cm. Precipitation in 1976 was 33.68 cm (U. S. Department of Commerce 1976).

Production of agricultural commodities is the predominant land use within the intensive study area. Major crops include corn, oats, wheat, flax, soybeans, and alfalfa. A representative portion of the study area, containing 9324 ha, consisted in 1975 of 82.0% cropland, 8.5% pasture, and 9.5% miscellaneous (shelterbelts, idle farmland, lakes, marshes, and building sites) (Olson and Flake 1975). Communication with personnel of the Agricultural Stabilization and Conservation Service, USDA, Brookings, South Dakota, indicates no significant changes in these percentages in the years of this study.

The native prairie vegetation of the study area was determined by soil type, slope, and drainage. Dominance by short, mid-, or tall grass prairie species was possible and depended on the specific site within the study area. Prairie potholes and accompanying marsh vegetation occurred on poorly drained soils (Westin et al. 1958).

METHODS AND MATERIALS

Estimation of Red Fox Population

Intensive systematic aerial surveys were conducted each spring to aid in the estimation of the red fox population on the study area. Surveys were conducted 17-27 May 1976, and 19 May-7 June 1977 following the method described by Sargeant et al. (1975). A single-engined, high-winged Cessna 172 aircraft was used. Three observers accompanied the pilot on each search. At least 1 of the observers on each flight was experienced in locating foxes and fox dens from the air.

The plane circled areas of dense vegetation or areas otherwise difficult to observe from the air. All searches commenced at 0700 and continued for 1-3 hours unless winds exceeded 32 km/h or rainfall had occurred within 24 hours. Twenty-four to 72 km^2 were searched each day. T)en sites identified from the air were recorded on township maps.

Criteria used for identification of active fox dens included presence of adult and/or juvenile foxes; dens with fan-shaped, packed mounds; presence of prey remains; and run-ways of matted vegetation connecting adjacent holes of the den. All suspected den sites were visited by a ground crew for verification.

Landowners and operators were interviewed concerning their knowledge of active fox dens within the study area. Landowners and operators farming approximately 98% of the study area were contacted. Additional dens identified during the landowner interviews were visited by study personnel for verification.

Sargeant et al. (1975) reported occasional movement of fox families to a different den during the season of counting and found that movement of fox families from 1 den to another ranged from less than 0.1 to 2.6 km (;7= 0.61 km). Approximately 4.2% of the fox families identified on Sargeant's North Dakota study area were double counted due to movements over 1.6 km. The number of dens identified on the Sinai study area was reduced by 4.2% when used to estimate families to compensate for movements greater than 1.6 km.

Three assumptions were used to expand fox family density to fox density. Fox families were assumed to consist of 2 adults and 5 juveniles (Scott and Selko 1939). An even sex ratio of adult foxes was assumed at the start of the breeding season (Sheldon 1950). Examination of fox uteri during February in northern Illinois and northern Iowa (Storm 1972) indicated 95% of 188 female fox breed successfully, and 5% were unsuccessful. Five percent of the males would also be non-breeding assuming an even sex ratio (Storm 1972).

Capturing and Marking Juvenile Foxes

Locations of active red fox dens within the extensive study area were solicited from April through July from Conservation Officers, farmers, hunters, and trappers in the expanded study area using notices, personal communication, and press releases to area newspapers. Juvenile foxes on the intensive study area were fitted with radio telemetry collars at dens located during the aerial and landowner surveys.

During May 1976, each den site was surrounded with a length of poultry fence and water was introduced into the opening. Pups were captured with long-handled dip nets as they emerged from the den (Sweeting 1977). Subsequent to May 1976, dens were either partially excavated or traps were placed in the immediate vicinity of the den to facilitate capture of the pups. If the den was to be partially excavated, passages were explored with a wire ferret (Storm and Dauphin 1965). At intervals of 1-2 m, holes were dug from ground level to the den passages in an effort to locate the pups. Once located, the pups were placed in burlap bags until measured, tagged, and released. All excavated dens were partially reconstructed to allow use by the fox families. If dens were inaccessible or excavation was prohibited, No. 1, single, long-springed traps were placed at or near the den entrances. Traps were checked and pups removed daily at 2400 and 0600 hours to prevent damage to the legs of captured animals.

Each fox was tagged with serially numbered No. 4 monel ear tags (National Band and Tag Co., Newport, KY) to facilitate identification. Each tag was stamped with the appropriate information to aid in return by collectors. Sex and standard body measurements were recorded for each fox and foxes were released at the original site of capture. Two foxes were released at another location at the request of the landowner.

Direction of travel during dispersal was determined by plotting the recovery locations for foxes that dispersed more than 8 km from points of release. Studies indicate that home ranges of non-dispersing red foxes are less than 8 km in diameter (Murie 1936, Scott 1943, Storm 1965, Ables 1969, Sargeant 1972).

Home Range Studies

Home ranges of 9 red foxes were determined from 919 telemetry locations (Appendix Table 1). Transmitters were placed on members of 2 red fox family groups in 1976 and 1 in 1977. Members of each family group included a parental adult fox, a juvenile male, and a juvenile female.

Each transmitter package consisted of a lithium chloride battery pack, transmitter, and nylon web collar. An expanding collar described by Sheldon (1949) and modified by the author to accept a 3.5 cm wide radio transmitter was attached to juvenile foxes. Each transmitter emitted a pulsed signal in the 150-151 mhz range. All radio equipment was manufactured by Davtron (Minneapolis, TIN).

Five element, directional yagi antennas and 12-channel receivers were used to locate and track foxes. A 1.8 m high platform constructed on the bed of a pick-up truck was used to increase radio reception capabilities. Two receivers were often used to allow simultaneous tracking of moving animals. Points throughout the study area that were readily identifiable on topographic maps were used to facilitate plotting locations of foxes. Radio locations were usually obtained at less than 1.2 km. Readings were accurate to 5° at 0.8 km from the transmitter source. Attempts were made to locate the foxes throughout the night at least 6 nights a week. No daytime locations were made.

Radio locations were plotted at 2-week intervals on enlarged topographic maps to evaluate changes in home ranges during the tracking period. Home range areas were delineated according to Mohr (1947). Home ranges areas were measured from the maps using a planimeter.

RESULTS AND DISCUSSION

Estimation of Red Fox Population in Spring

Thirteen families (5.2 families per township) resided on the Sinai study area during spring 1976 (Table 1). Eleven families (4.4 per township) were present in spring 1977. Sweeting (1977) estimated 23 families (9.2 families per township) present on the study area in spring 1974 and 19 families (7.6 per township) in spring 1975.

Ten den sites were overlooked during the aerial survey, 4 in 1976 and 6 in 1977. These dens were later identified in the landowner interviews.

South Dakota was affected by a drought prior to 1977. Runways from den holes were especially visible from the air and dry, short vegetation did not obscure the details of the dens. The drought ended in 1977, and spring conditions were wet. Rapid recovery of the vegetation made aerial observability of the dens more difficult.

Eighty-eight percent of the red fox dens were located in pastures and idle areas although these cover types represented only 24% of the available land area (Table 2). Sargeant (1972) and Sweeting (1977) also found a disproportionate percentage of red fox dens occurring in pasture and idle lands in relation to other cover. These areas receive less disturbance by man than intensively cultivated cropland.

Red fox dens located in 1976 and 1977 on the Sinai study area are illustrated in Appendix figures 1 and 2, respectively. Information relative to active dens located on the study area are recorded in Appendix tables 2 and 3.

Table 1. Adjustment factors affecting the red fox population estimates on the Sinai study area in southeastern South Dakota, 1976-77.

	1976		1977	
Total fox families identified from air	10		7	
Adjustment factors:				
Aerial observability of fox families[a]	4		5[b]	
Movement of red fox families over 1 mile (1.6 km)[c]	0.6		0.5	
Total adjustment	3.4		4.5	
Adjusted total fox families	13.4	(13)	11.5	(11)
Fox families per township	5.2		4.4	
Total adjustment (%)	28.6		41.7	

[a]Natal dens overlooked by air and located by ground reconnaissance and landowner interview.

[b]lncludes a fox family determined by radio telemetry.

[c]Subtract 4.2% of the total families for which dens were identified.

Table 2. Distribution of 25[a] red fox dens in relation to land use on the Sinai study area, 1976 and 1977.

Land use type	Percent of type availabl[b]	Number of dens
Cultivated cropland	44.0	1
Pasture	17.0	13
Idle farmland	6.9	9
Hayland	10.1	1
Other[c]	22.0	1[d]

[a]0ne den location was not observed, juvenile foxes were observed by spotlight.

[b]Data from T109N, R52W during 1973-74 (Olson 1975).

[c]lncludes roads, residential areas, farmyards, creeks, feedlots, Lake Sinai, fallow, marsh, shelterbelts, fencerows, and roadside.

[d]one den located in a road culvert.

Density and Population Changes

The estimated red fox population of the study area decreased from 92 (0.39 per km^2) in 1976 to 78 (0.33 per km^2) in 1977. This estimated population decline continued the trend indicated by Sweeting (1977) for this area.

High pelt value in the fur season of 1975-76 prompted several fur ranchers to purchase wild juvenile red foxes the following spring. Fur ranchers paid $6 per juvenile red fox if a landowner allowed the fur rancher to remove the foxes from his property. The purchase price was $12 per juvenile if the pups were delivered to the fur rancher. Juveniles were occasionally trapped on the den mounds, or flushed with exhaust fumes or water. Excavation of the den was the most frequently used method of pup removal by individuals selling juvenile foxes. This total destruction of the den made habitation by future fox families impossible.

Storm et al. (1976) found that dens not severely disturbed were often used for several consecutive years. Although Storm et al. (1976) made no effort to determine the number of years each of 509 dens visited in Illinois and Iowa were used, it was noted that of 33 dens active during spring 1966 in Carroll County, Illinois, at least 7 were active during at least 1 more year from 1967 to 1970. In Iowa, 35 dens were used for rearing young more than 1 year. Of those, 27 were used during 2 years, 6 during 3 years, and 2 during 4 years.

Three of the 13 family groups identified on the Sinai study area in 1976 had pups removed and sold. In 1 case, (den 15), a den was excavated and the pups removed without the landowner's permission. In 1976, a minimum of 15 juvenile red foxes was removed from the study area and sold. The South Dakota Department of Game, Fish and Parks Commission enacted a regulation in 1977 to prohibit the possession of more than 1 live, wild furbearer by any individual. In spite of this regulation, 1 adult female and 8 juveniles were illegally sold by a landowner in 1977. This adult female was ear-tagged, but the purchaser refused to divulge the number on the tag.

Mortality and Dispersal

Twenty-nine juveniles and 3 adult foxes were captured and marked during spring 1976. Trappers and hunters returned 18 (62.1%) of the tags from tagged juvenile foxes. One adult male was shot in January 1978 approximately 1.6 km from the point of original capture. During spring 1977, 15 juveniles and 2 adult red foxes were marked. Three of the juveniles were reported as harvested during the fur season. Neither of the adults was known to have been recaptured. Information relative to individual foxes tagged in this study is included in Appendix tables 4 and 5.

Only mortality related to hunting and trapping was reported in this study (Table 3). Mortality due to disease, parasites, or accidents was not determined. Trapping accounted for 81% (17 of 21) and hunting 14% (3 of 21) of the reported mortality. One juvenile (1 of 21) was reported by a furbuyer during the fur season of 1976

Table 3. Number of red foxes recovered by hunting or trapping, 1976-78.

Time of recovery	Number recovered	Mortality		
		Hunting	Trapping	Unknown
Summer 1976	1	-	1	-
Autumn-winter 1976-77	17	1	15	1[a]
Autumn-winter 1977-78	3	2	1	-
Combined years	21	3	17	1

[a]Juvenile reported by furbuyer in the fall, assumed to have been trapped or shot.

and was assumed shot or trapped. There was a significant difference between the recovery rate contributed by trapping as compared to hunting during the 2 years of the study ($x^2 = 7.00$, $P > 0.05$).

In a study conducted by Phillips et al. (1972), 926 red foxes were tagged in Illinois. Hunting and trapping accounted for 60% and 22%, respectively, of reported mortality. Hunting accounted for a greater percentage of reported mortality than trapping in Iowa (R. D. Andrews, personal communication). Storm et al. (1976) reported that a few fox were shot during October and November before hunting for fur and recreation is normally emphasized. During this period foxes are usually taken incidentally during the hunting of other species, primarily ring-necked pheasants. This incidental type of mortality was reported in 1 case during this study.

A movement of over 8 km between first and last capture was considered dispersal in this study. It was not determined when the juvenile red fox dispersed from their natal areas. In 1976, an adult female and a juvenile male and female fitted with transmitters were still within their summer home ranges on 2 September and 1 adult female was located within her summer range on 4 September 1977. A juvenile male and juvenile female from this adult were still within the area on 9 September. Storm et al. (1976) found that subadult red foxes did not begin to disperse until late September or early October. The juveniles were then about 7 months of age and nearly full grown.

Twelve of the 20 juvenile foxes for which tags were reported dispersed a distance greater than 8 km from the natal den. Distances of dispersal for juvenile males ranged from 18.0 to 239.0 km with a

mean of 59.5 km (N = 9, sd ± 66.33). The greatest previously reported distance of dispersal for a subadult male was 211 km (Storm et al. 1976). One juvenile male tagged in 1976 was trapped as an adult in October 1977 after moving 43.2 km from its natal den. Dispersal distances for juvenile females ranged from 10.0 to 54.8 km ($\bar{X}$ = 37.6 km, N = 3, sd ± 19.71). Small sample size may distort the true mean dispersal distance of juvenile females.

The straight line distances between points of first and last captures of marked juvenile foxes was significantly greater for males than females ($t = 1.76$, $P > 0.10$). The recovery distances for all juvenile males ranged from 2.8 to 239 km ($x = 53.9$). Recovery distances for all juvenile females ranged from 0 to 54.8 km ($x = 14.0$). Points of last capture were randomly distributed in relation to direction of travel ($P > 0.05$) (Table 4). Other studies (Arnold and Schofield 1956, Donahoo 1962, Phillips et al. 1972, and Storm et al. 1976), indicated that more foxes disperse to the north than the south. Butler (1951) and Macpherson (1964) indicated a tendency for a general northward migration, but evidence to support this hypothesis was inconclusive.

Home Range Studies

Adults -- Mean home range size of the 3 adult foxes was 1193 ha (range 620-1684 ha). An adult female (family 1) used the largest area, 1684 ha. An adult male (family 2), captured 17 June 1976 and tracked through 14 July 1976, was reported shot 21 January 1978 approximately 1.6 km west of the original capture site. Home ranges of the 3 adults are illustrated in Figs. 2 and 3.

Table 4. Distribution of tag recoveries by direction of movement of juvenile red foxes that dispersed more than 8 km from their natal range.

Test comparison	Number (N = 12) of animals	Tabular x2 = 0.05	Computed x2 value
All directions	NW NE SE SW 3 6 2 1	7.81473	4.5
North versus south	North South 9 3	3.84146	3.0
East versus west	East West	3.84146	1.33

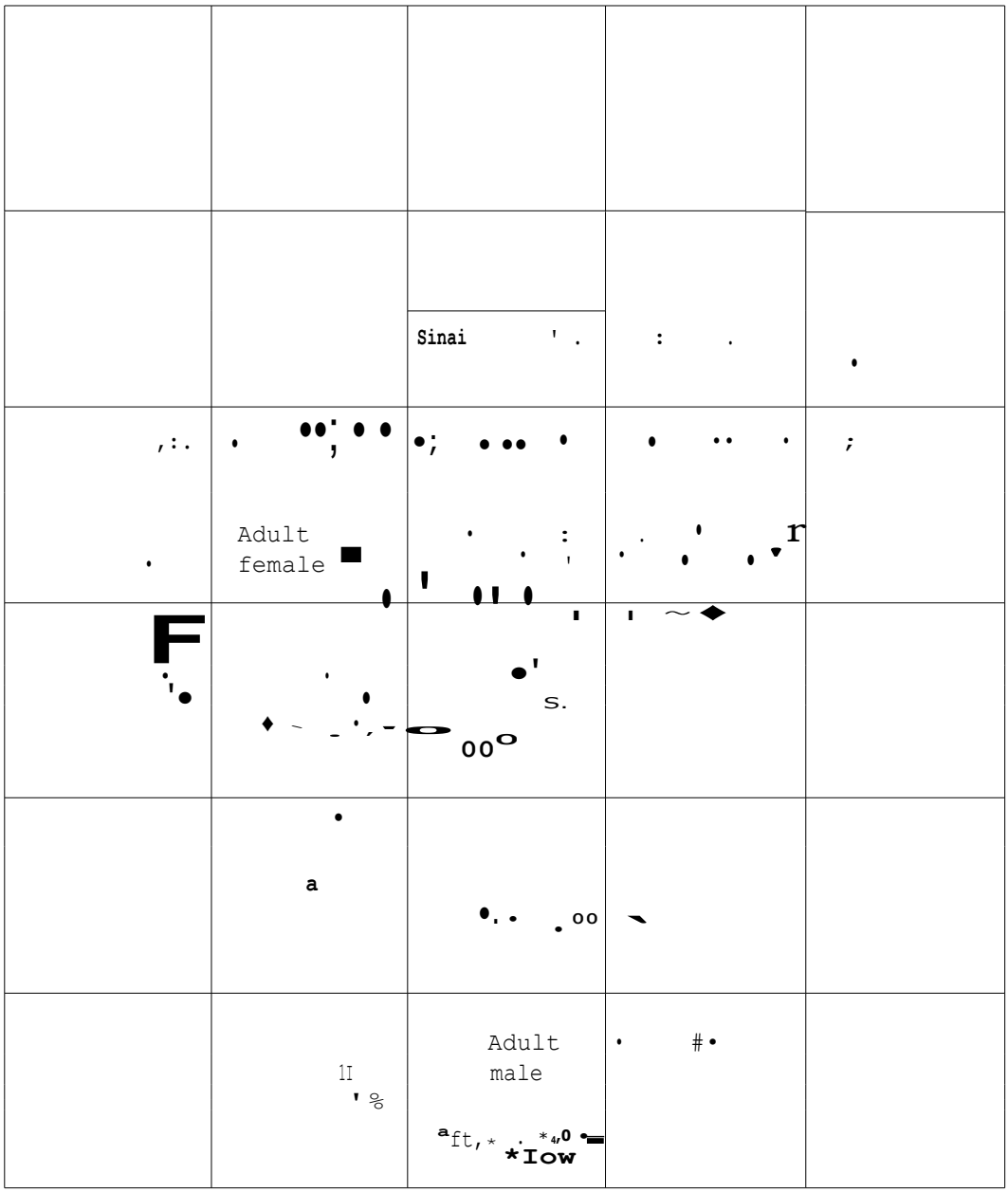


Figure 2. Spatial arrangement of home ranges of adult red foxes, as determined by radio telemetry, on the Sinai study area in southeastern South Dakota during the summer of 1976.

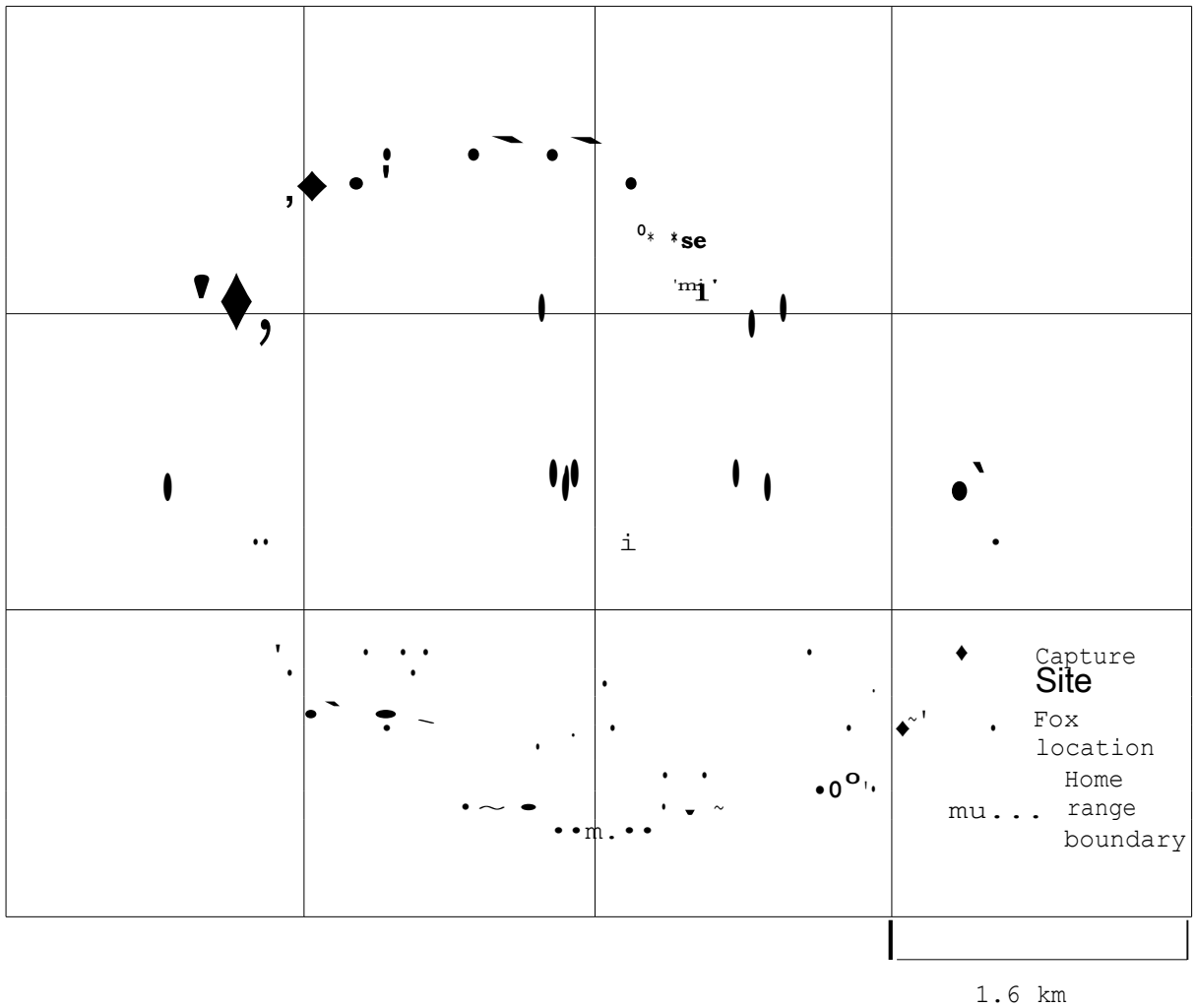


Figure 3. The home range of an adult female red fox, as determined by radio telemetry, on the Sinai study area in southeastern South Dakota during the summer of 1977.

Sweeting (1977) determined mean home range size of adult red foxes to be 648 ha during a period of higher densities within this study area. Ables (1969) found foxes using home range areas of 56.8 to 160 ha in a land area characterized by ecological diversity. Ables suggested if red fox are territorial such conditions would result in a contraction of home range size. Sargeant (1972) found that red fox population densities appear regulated by inherent species characteristics. Red fox families are territorial and occupy well-defined, non-overlapping, contiguous areas with boundaries that are maintained through non-aggressive behavioral mechanisms. As densities of red fox populations are diminished, territory size of the remaining animals increase and uninhabited areas develop between territories of adjacent families. Home range size in this study may have enlarged in a response to the low population density of the area.

Juveniles -- The juvenile red foxes were tracked during the dispersed use period (Sargeant 1972). Pup activity is widely dispersed in the den area and several dens are often used simultaneously during this period.

Six juvenile foxes, 3 males and 3 females, were fitted with transmitters and tracked during 1976 and 1977. Radio contact with 2 juveniles of family 1 was lost in late July 1976. Two juveniles of family 2 were tracked from mid-June through September 1976. In 1977, 2 juveniles of family 3 were tracked from late June through September.

Home ranges of juveniles were largely within the boundaries of the parental adults throughout the tracking period. In mid-June through late June, juvenile foxes occupied areas ranging from 15 to 51 ha (x = 32 ha). At the end of the final tracking periods, juvenile females used larger home range areas than juvenile males. Mean home range size for juvenile females was 316 ha (range 276-357 ha) in contrast to 195 ha for juvenile males (range 157-229 ha). Home range expansion for juveniles followed by radio tracking is summarized in Table 5.

Observation of fox tracks immediately after foxes crossed roads and entered new areas showed that drainageways and culverts were important travelways for foxes. Ables (1969) indicated use of home ranges by red foxes did not extend equally over the entire area, but contained sections of concentrated use. In this study, drainageways and culverts appeared to provide a rapid and secure means for foxes to travel from one area of concentrated use to another.

Storm (1972) concluded that at the age of 12 to 15 weeks, juveniles began to separate from their littermates and their parents, and to orient to specific parts of their parents' home range during the daytime. Storm hypothesized spacing of littermates may be adaptive in at least 2 ways. Spacing functions as an anti-predator mechanism by minimizing mortality due to other vertebrate predators. Spacing may also serve in orienting and familiarizing the juveniles with their physical environment.

All juveniles followed by radio telemetry within different family groups displayed spacing throughout their parents' home range in this study (Figs. 4-6 and Appendix figs. 3-22).

Table 5. Home range expansion (in hectares) of juvenile red foxes, as determined by radio telemetry, on the Sinai study area in southeastern South Dakota during the summers of 1976 and 1977.

Tracking period	1976				1977	
	Litter mates		Litter mates		Litter mates	
	Juvenile male	Juvenile female	Juvenile male	Juvenile female	Juvenile male	Juvenile female
Mid June-29 Jun	51	45	15		-	16
30 June-13 Jul	93	269	37	16	48	70
14 Jul-28 Jul	200	357	56	64	178	256
29 Jul-12 Aug			157	218	178	287
13 Aug-4 Sept			157	276	229	316

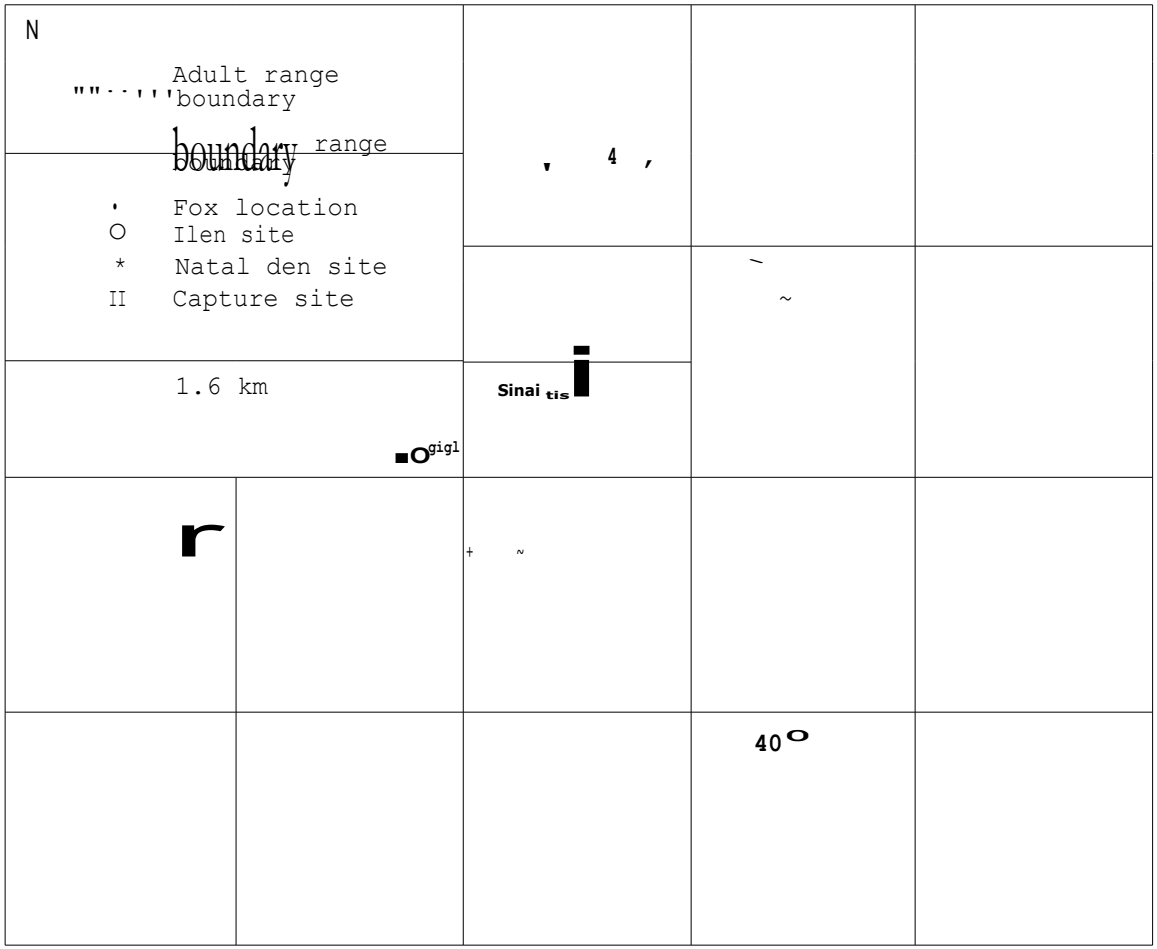


Figure 4. Home range of a juvenile male red fox in relation to its parental adult on the **Sinai** study area in southeastern South Dakota, 15 June-29 June 1976.

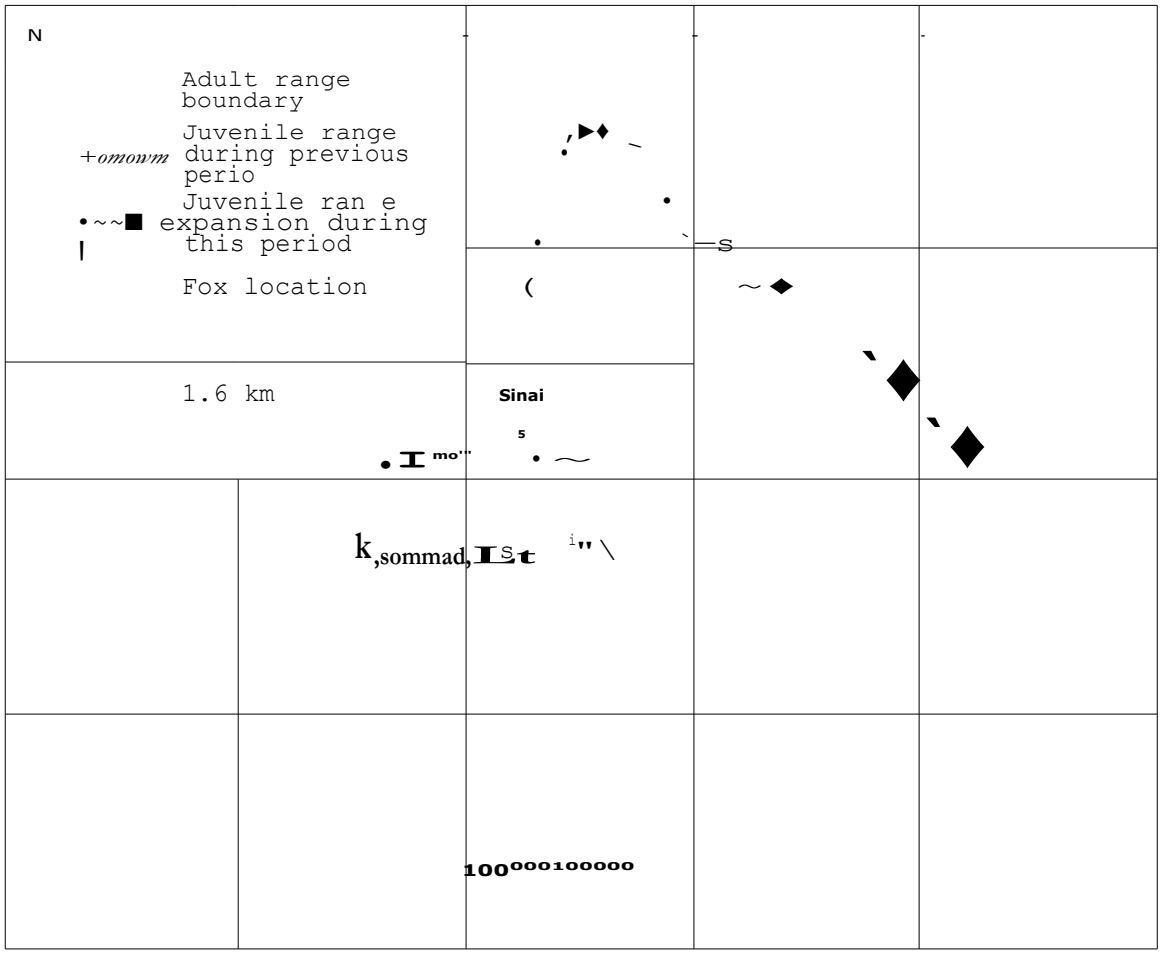


Figure 5. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 30 June-13 July 1976.

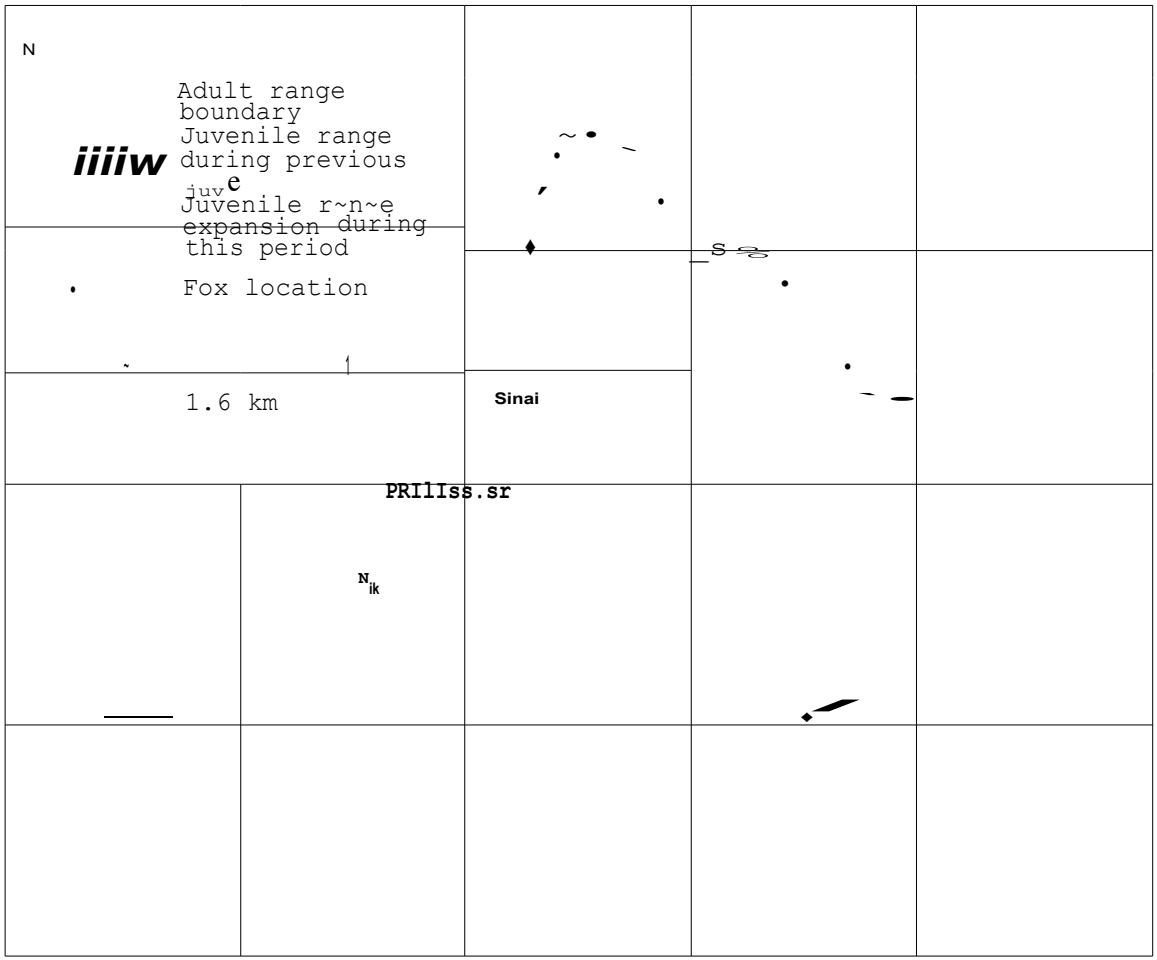


Figure 6. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 14 July-22 July 1976.

CONCLUSION

The red fox population of the Sinai study area decreased from 13 families in 1976 to 11 in 1977. Sweeting (1977) estimated the population on the study area to be 23 families in 1974. High fur prices and the increasing harvest pressure indicated by a 62.1% tag return rate in 1976 may explain this decreasing population trend. This trend is further substantiated by the large home ranges reported during this study (mean 1193 ha). Sargeant (1972) found areas of little or no use are often included in fox territories and uninhabited areas may develop between territories during periods of low density.

The management of red foxes in South Dakota has been based primarily on its role as a pheasant predator. Public sentiment and professional management during the past decade have shifted from a goal of fox population reduction to benefit the pheasant population to one of viewing the fox as a game animal in its own right. The South Dakota Department of Game, Fish and Parks has passed regulations to discourage the indiscriminate killing of foxes. Harvest of foxes now is viewed as an economic venture based on high fur prices. Red foxes, in the north central states, offer economic and recreational opportunities through trapping in the fall and hunting in the winter (Storm 1972). Management goals for red foxes should be based on their aesthetic and furbearer values, as well as their predatory nature.

LITERATURE CITED

Ales, E. D. 1969. Home range studies of red foxes (Vulpes vulpes). J. Mammal. 50(1):108-120.

Arnold, D. A., and R. D. Schofield. 1956. Home range and dispersal of Michigan red foxes. Pap. Mich. Acad. Sci., Arts Lett. 41-91-97.

Butler, L. 1951. Population cycles and color phase genetics of the colored fox in Quebec. Canadian J. Zool. 29(1):24-41.

Donahoo, D. G. 1962. Fox tagging study, North Dakota. U.S. Bur. Sport Fisheries and Wildl. 12pp. (Mimeo).

Drieslein, R. L. 1967. Fox-prey relationships in eastern South Dakota. M.S. Thesis. South Dakota State University. Brookings. 89pp.

Macpherson, A. H. 1964. A northward range expansion of the red fox in the eastern Canadian arctic. J. Mammal. 45(1):138-140.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Amer. Midl. Nat. 37(1):223-249.

Murie, A. 1936. Following fox trails. Univ. Michigan Museum Zool. Misc. Publ. 32. 45pp.

Olson, R. A. 1975. Nesting ecology of the ring-necked pheasant in eastern South Dakota. M.S. Thesis. South Dakota State University. Brookings. 59pp.

Olson, R. A., and L. D. Flake. 1975. Nesting of ring-necked pheasants in eastern South Dakota. Proc. S.D. Acad. Sci. 54:126-136.

Phillips, R. L., R. D. Andrews, G. L. Strom, and R. A. Bishop. 1972. Dispersal and mortality of red foxes. J. Wildl. Manage. 36(2):237-248.

Sargeant, A. B. 1972. Red fox spatial characteristics in relation to waterfowl predation. J. Wildl. Manage. 36(2):225-236.

, W. K. Pfeifer, and S. H. Allen. 1975. A spring aerial census of red foxes in North Dakota. J. Wildl. Manage. 39(1):30-39.

Schultz, L. D., and J. L. Driessen. 1973. Soil survey of Lake County, South Dakota. Soil Conservation Service, U.S. Dept. of Agric. U.S. Govt. Print. Off. 78pp.

Scott, T. G. 1943. Some food coactions of the northern plains red fox. Ecol. Monogr. 13(4):427-479.

, and L. F. Seiko. 1939. A census of red foxes and striped skunks in Clay and Boone counties, Iowa. J. Wildl. Manage. 3(2): 92-98.

Sheldon, W. G. 1949. A trapping and tagging technique for wild foxes. J. Wildl. Manage. 49(3):309-311.

. 1950. Denning habits and home range of red foxes in New York State. J. Wildl. Manage. 14(1):35-42.

Storm, G. L. 1965. Movements and activities of foxes as determined by radio tracking. J. Wildl. Manage. 29(1):1-13.

. 1972. Population dynamics of red foxes in north central United States. Ph.D. Thesis. University of Minnesota. St. Paul. 226pp.

, R. D. Andrews, R. L. Phillips, R. A. Bishop, D. B. Siniff, and J. R. Tester. 1976. Morphology, reproduction, dispersal and mortality of midwestern red fox populations. Wildl. Monogr. 49. 82pp.

, and K. P. Dauphin. 1965. A wire ferret for use in studies of foxes and skunks. J. Wildl. Manage. 29(3):625-626.

Sweeting, J. D. 1977. Population, home range, and dispersal of red foxes in east-central South Dakota. M.S. Thesis. South Dakota State University. Brookings. 68pp.

Trautman, C. G., and L. F. Fredrickson. 1974. Relationships of predators to populations of ring-necked pheasants and other prey. Trans. N. Amer. Wildl. Nat. Resources Conf. 39:241-252.

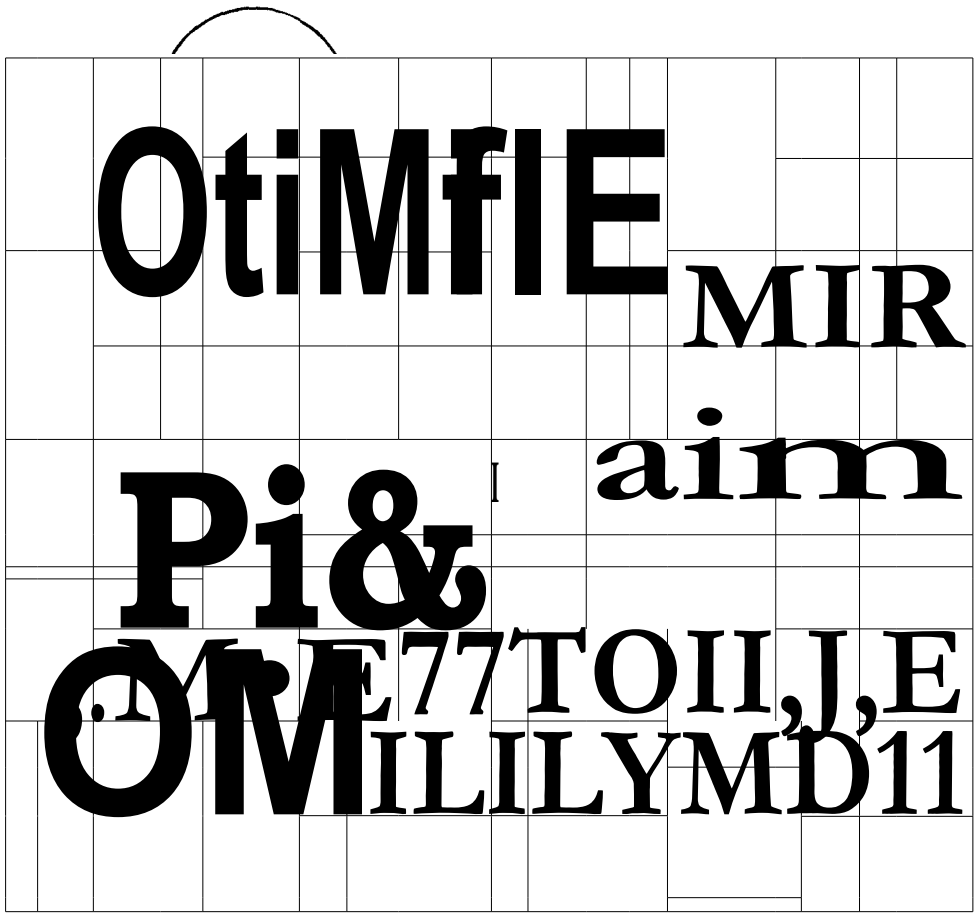
U.S. Department of Commerce. 1976. Climatological data: annual summary. National Oceanic and Atmospherical Administration. Vol. 81, No. 13. 18pp.

Westin, F. C., G. J. Buntley, F. E. Shubeck, L. F. Puhr, and N. E. Bergstreser. 1958. Soil survey, Brookings County, South Dakota. U.S. Govt. Print. Off., Washington, D.C. 87pp.

, L. F. Puhr, and G. J. Buntley. 1967. Soils of South Dakota. South Dakota State University Agric. Exp. Stn. Soil Surv. Ser. 3. 32pp.

APPENDIX

Appendix figure 1. Location of red fox dens on the Sinai study area in southeastern South Dakota, 1976.



Road

3.2 km

* Den (landowner sur7e¯)

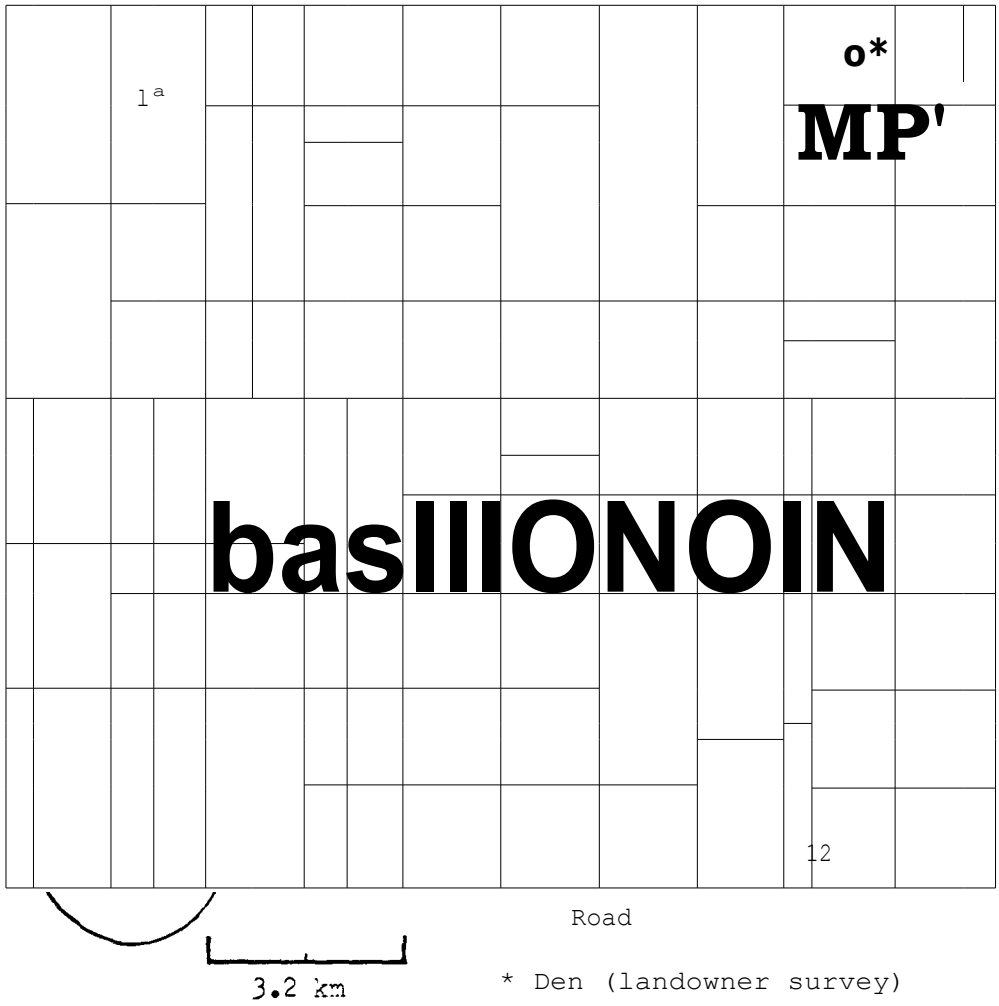
• Den (aerial survey

O Fox family

[a]Dens from which juveniles were removed and sold.

[b]Adult female shot here early in denning season by landowner, area not represented by a den.

Appendix figure 2. Location of red fox dens on the Sinai study area in southeastern South Dakota, 1977.



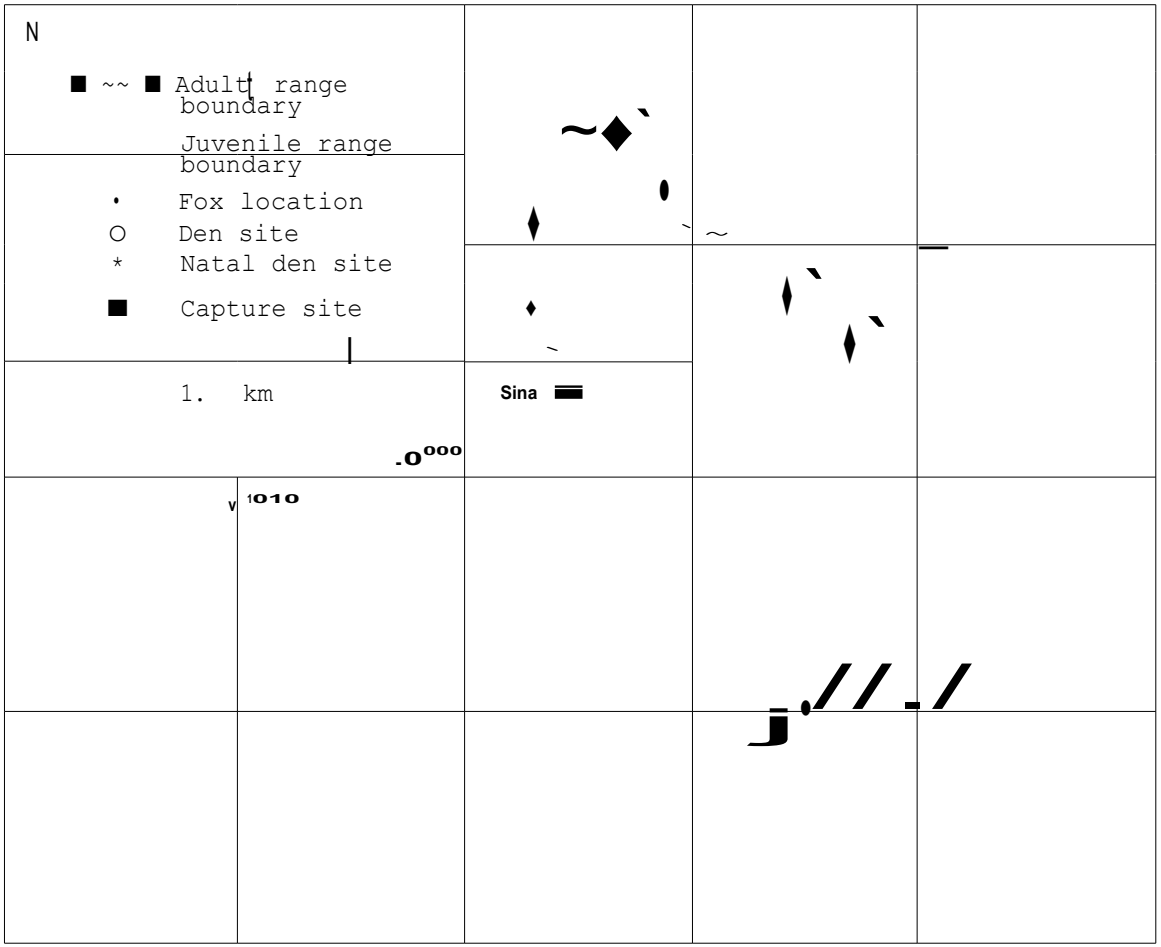
[a]Two juvenile foxes killed by landowner's dog.

[b]Den moved off study area, adult female and 8 juveniles illegally sold.

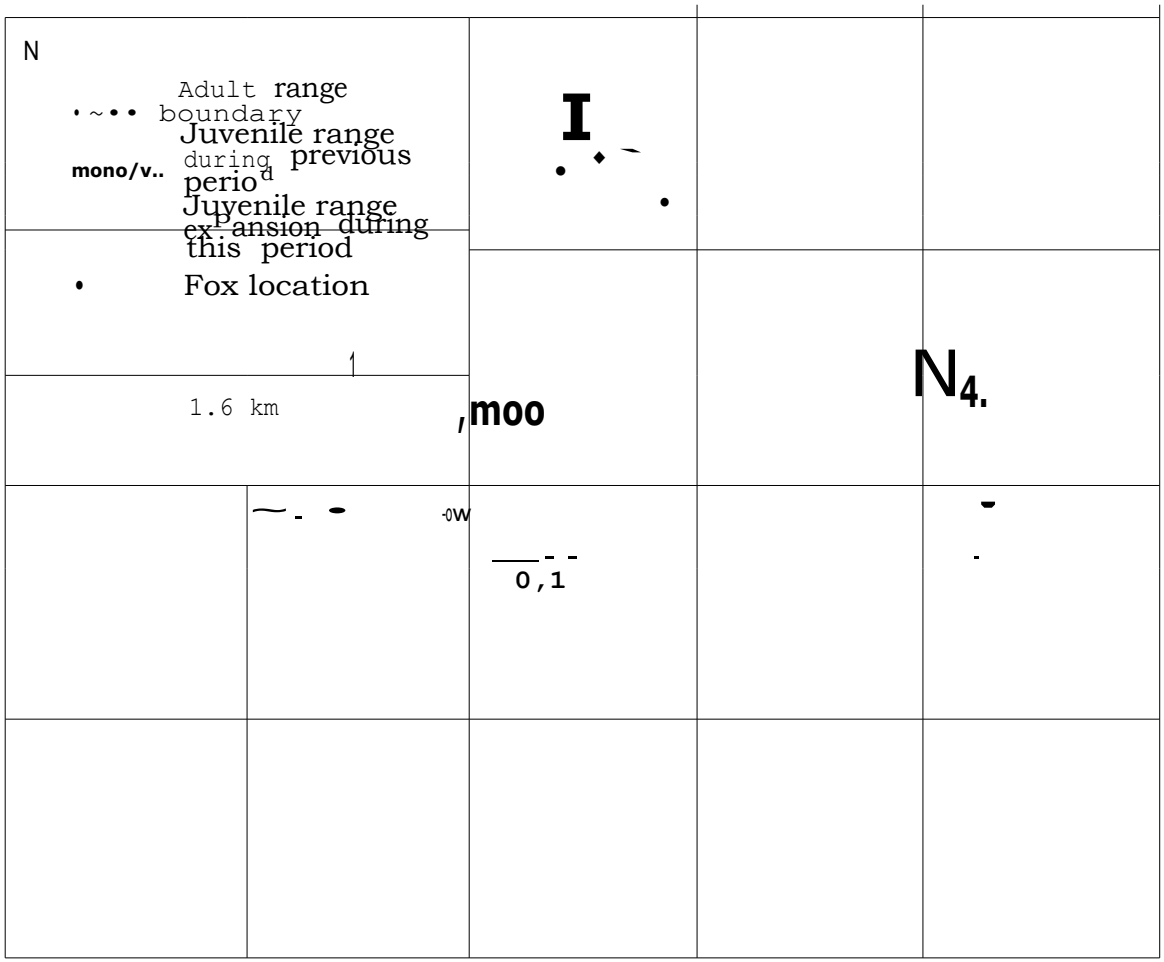
[c]Den not located (cultivated under), determined to be a separate den by trapping and radio telemetry.

[d]Den not located, juveniles observed by spotlighting.

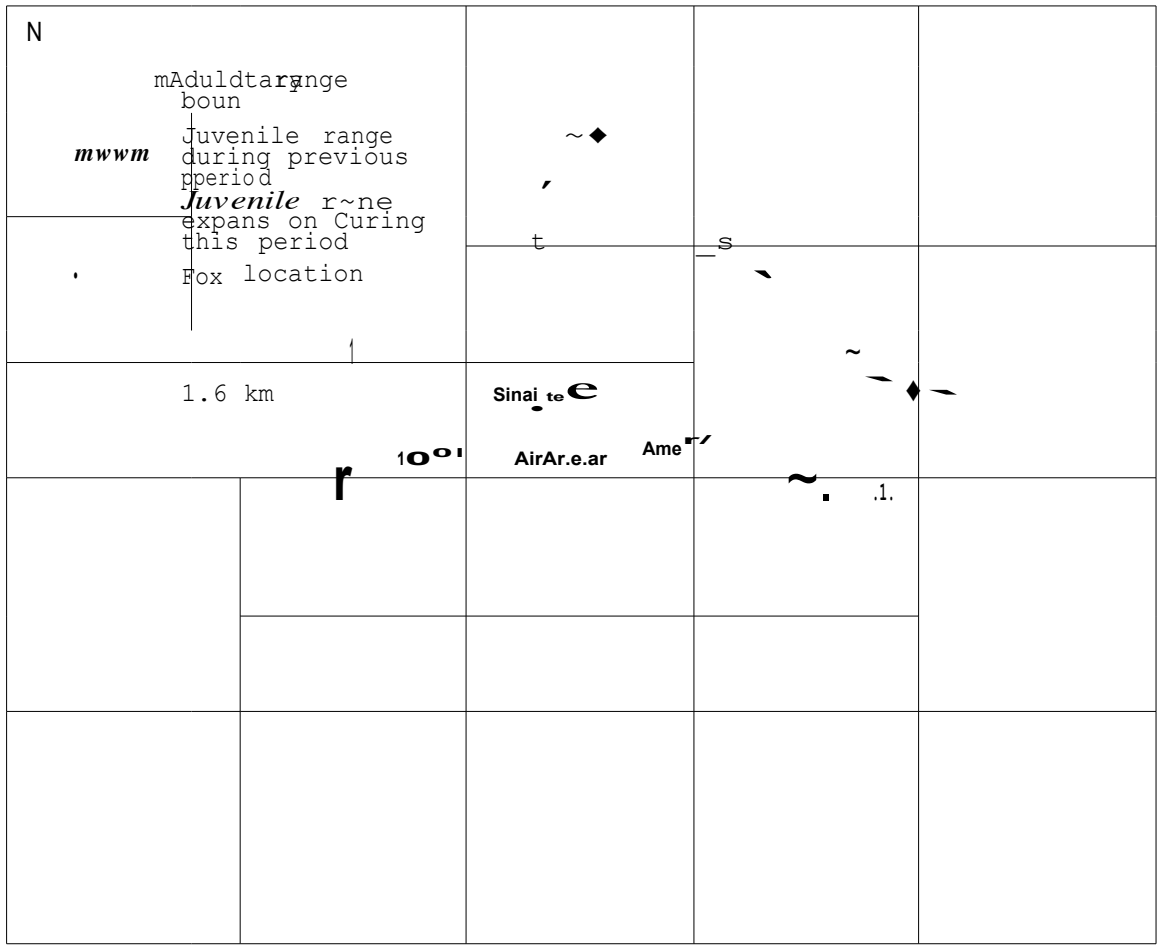
[e]Adult seen here by landowner, den or juveniles never located, assumed to be from Den 8.



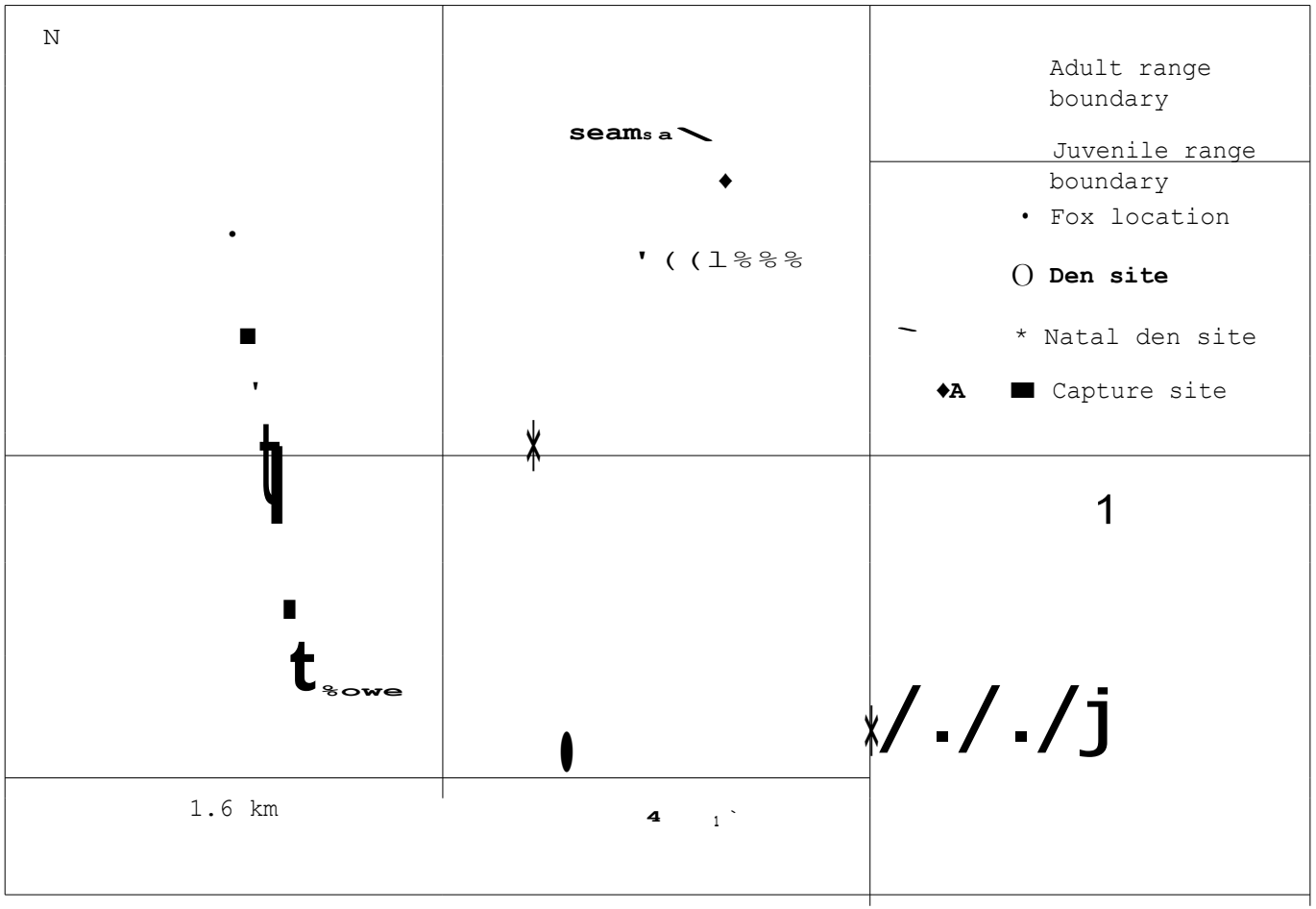
Appendix figure 3. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 15 June-29 June 1976.



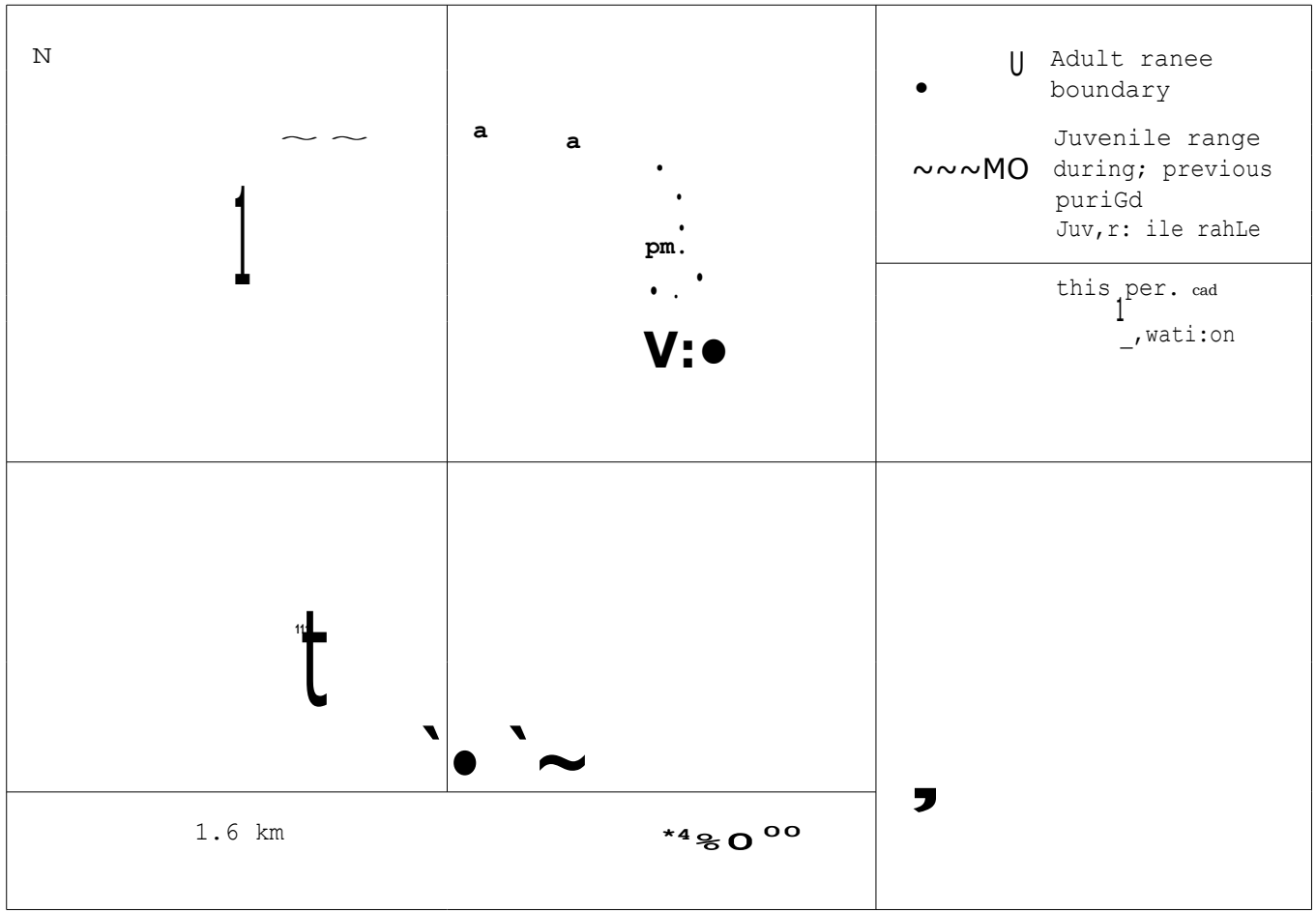
Appendix figure 4. Home range of a juvenile female red fox in relation to parental adult on the Sinai study area in southeastern South Dakota, 30 June-13 July 1976.



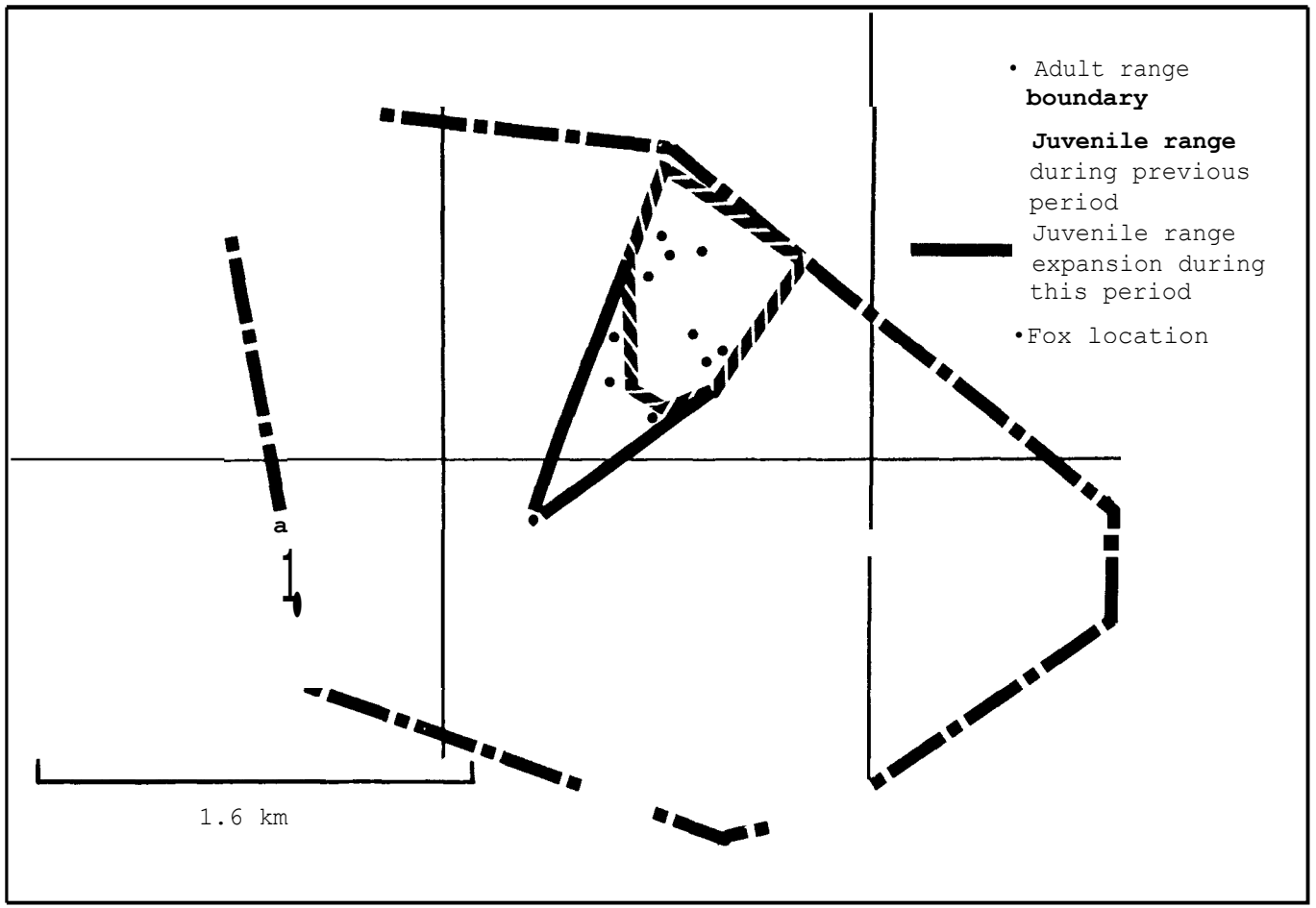
Appendix figure 5. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 14 July-19 July 1976.



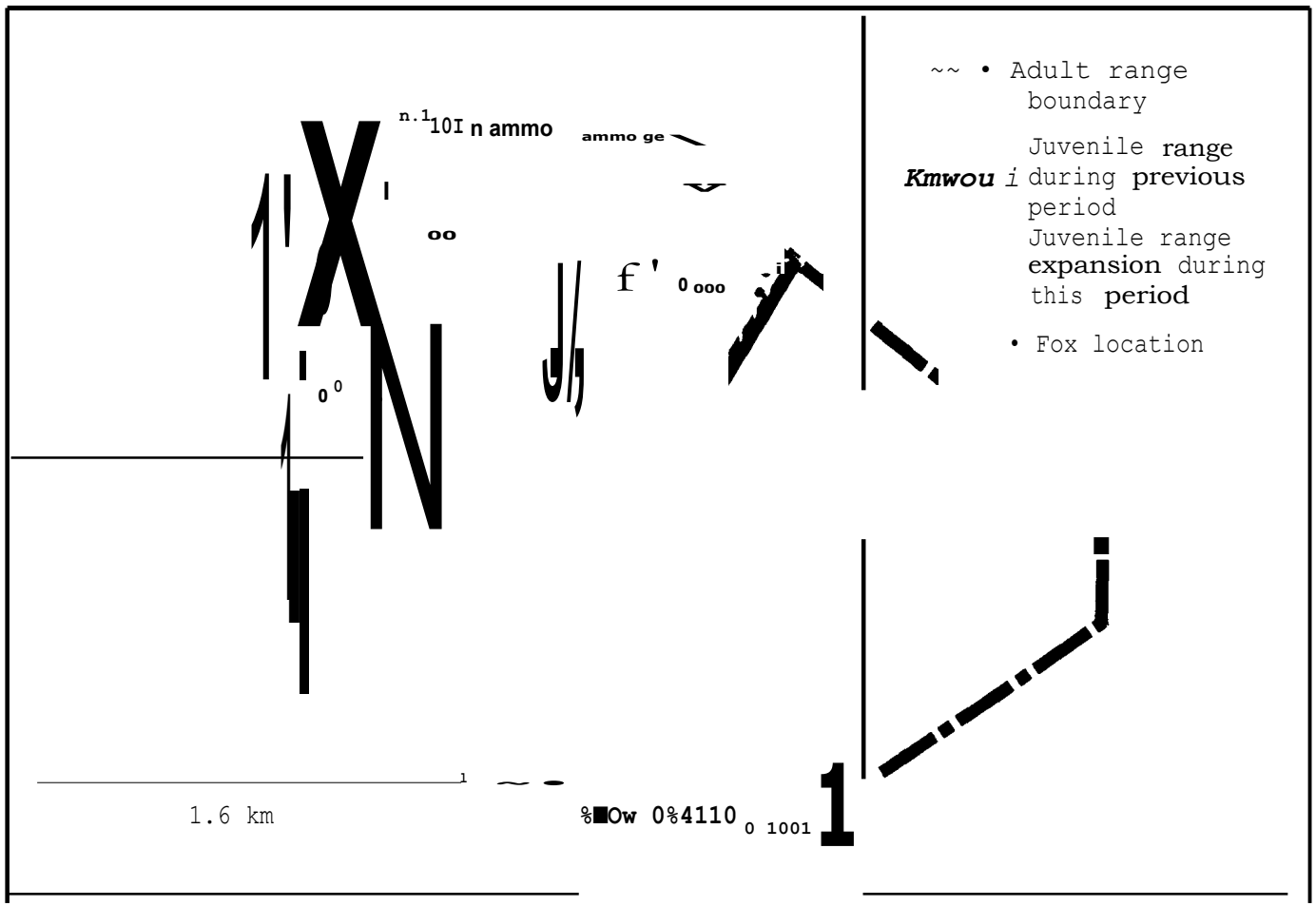
Appendix figure 6. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 18 June-29 June 1976.



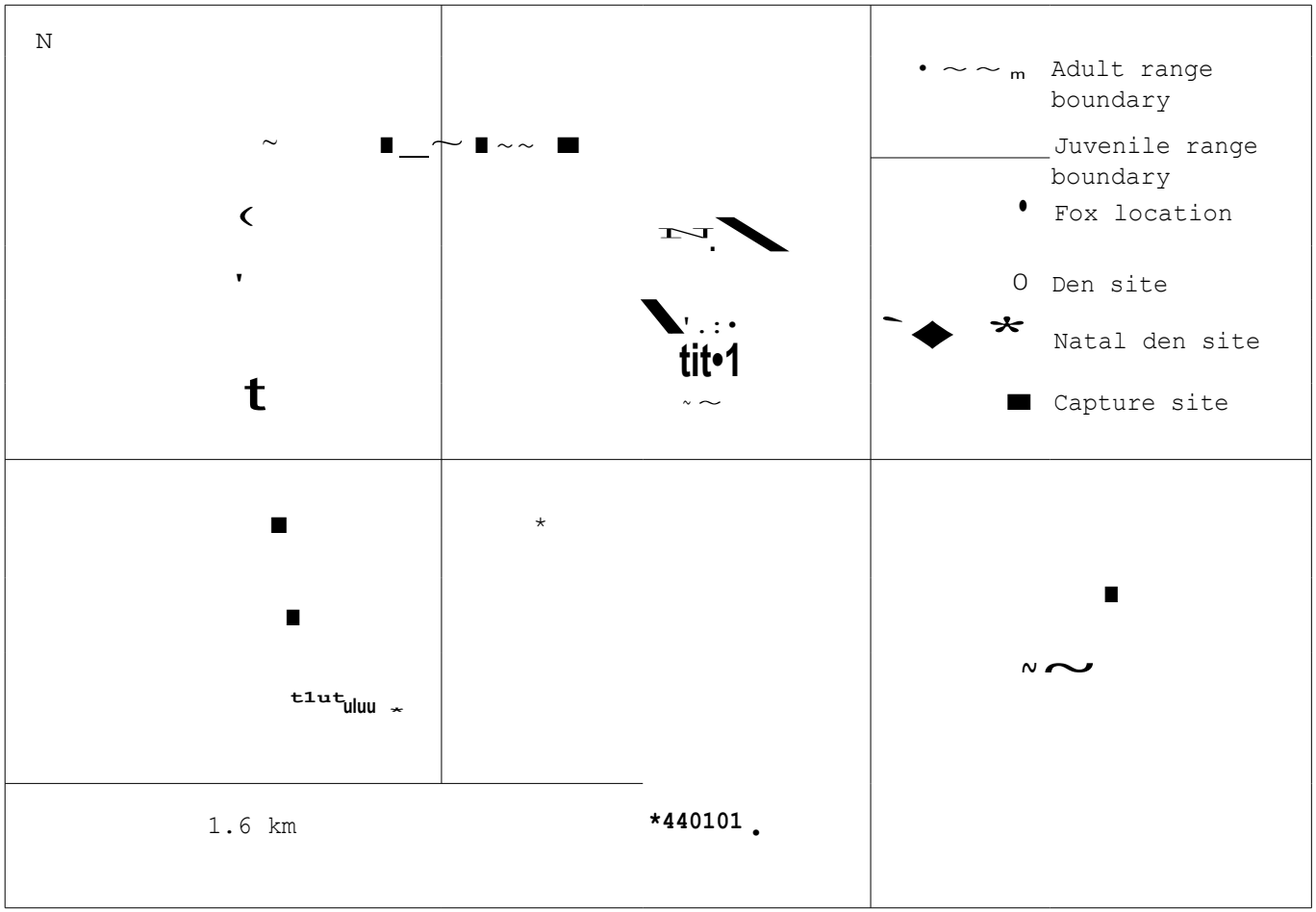
Appendix figure 7. **Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in** southeastern South **Dakota,** 30 **June-13 July 1976.**



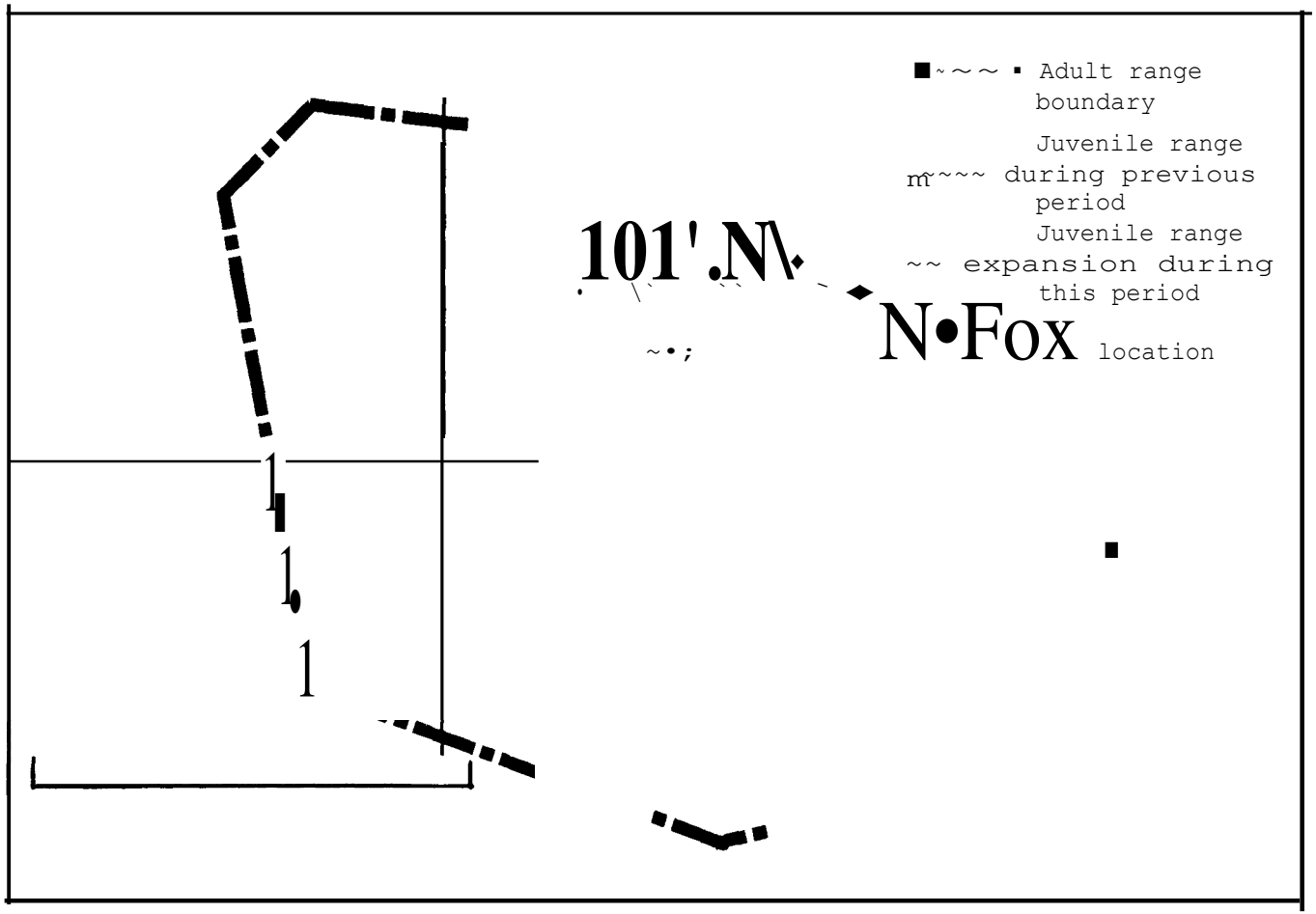
Appendix figure 8. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 14 July-28 July 1976.



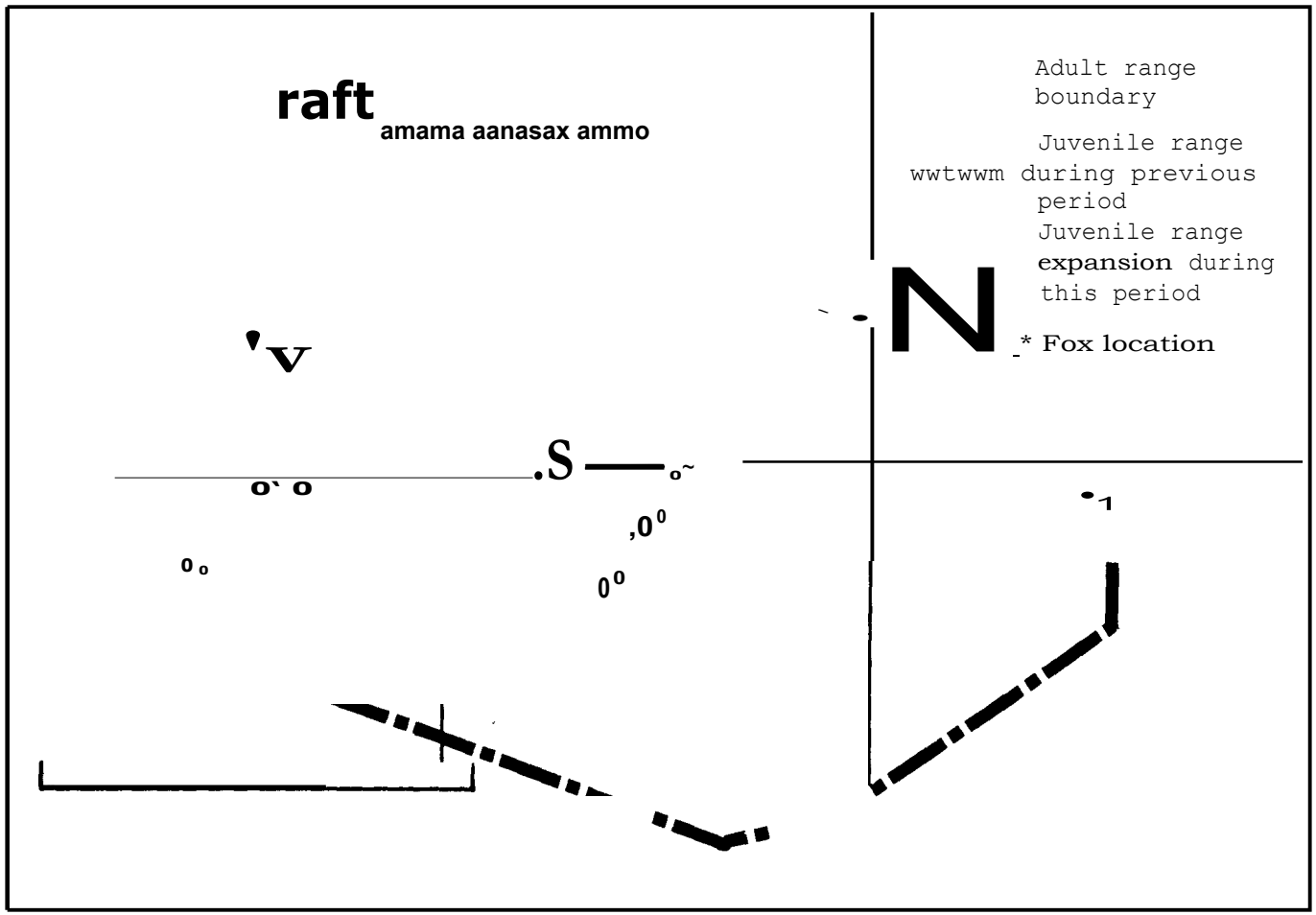
Appendix figure 9. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 29 July-2 September 1976.



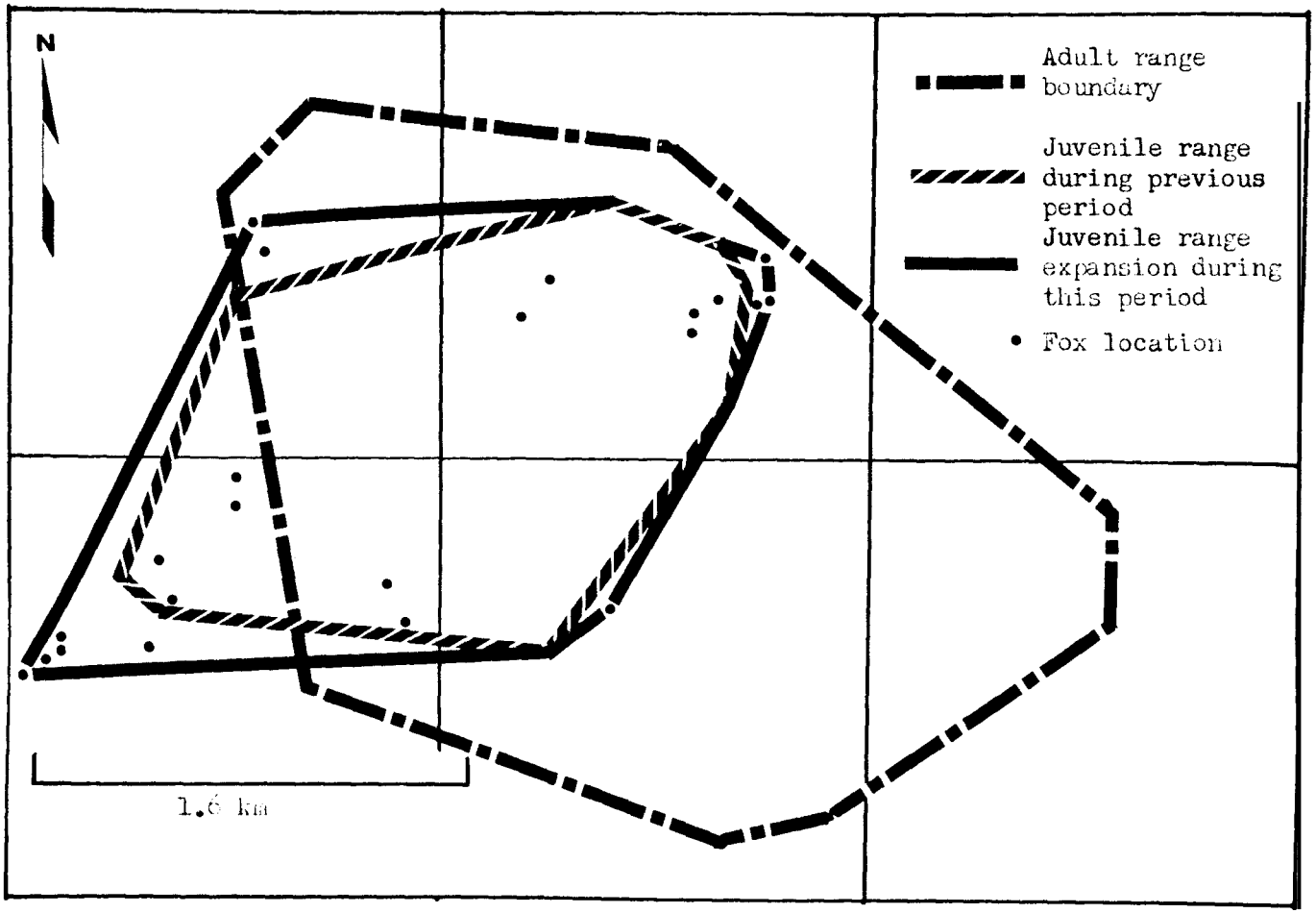
Appendix figure 10. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 30 June-13 July 1976.



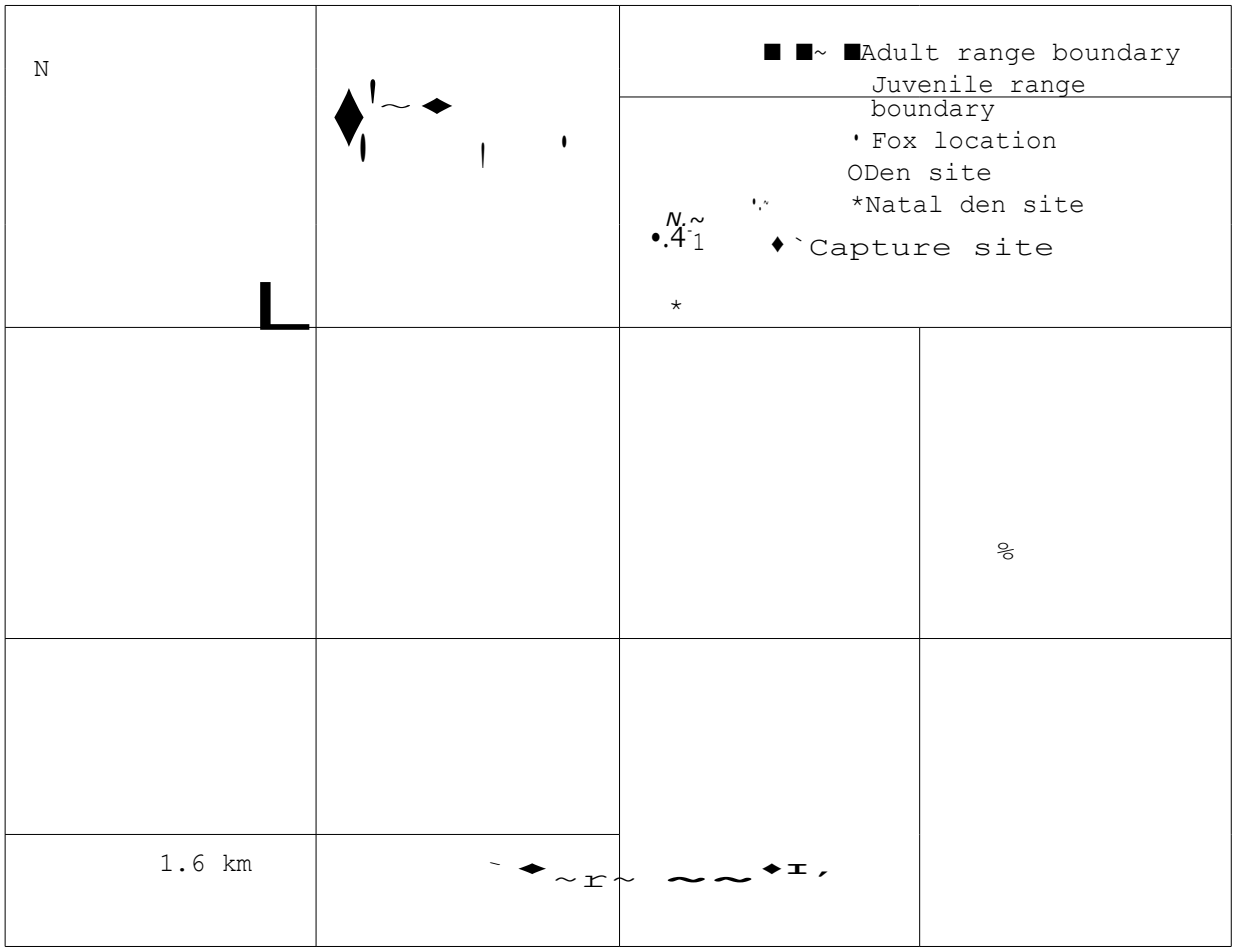
Appendix figure 11. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 14 July-28'July 1976.



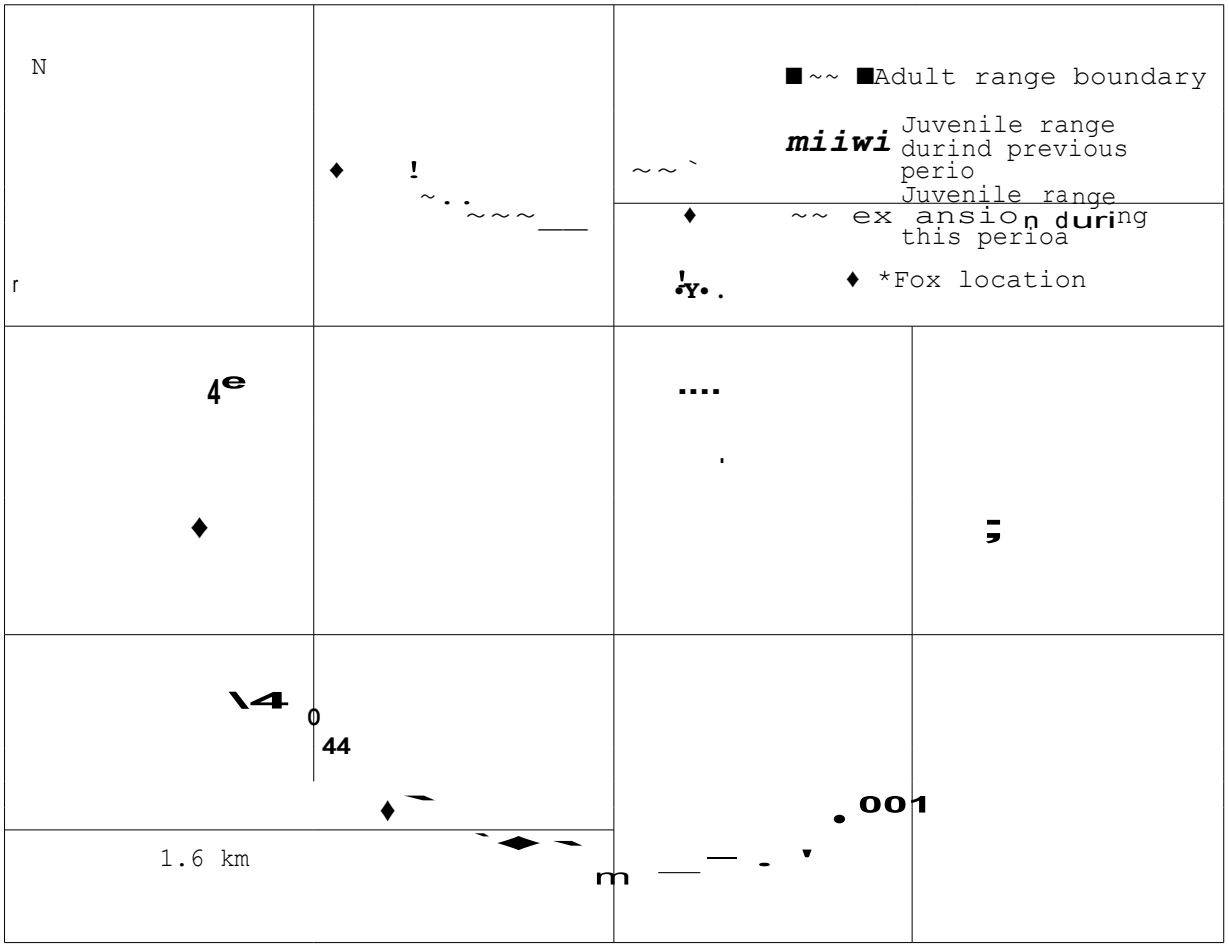
Appendix figure 12. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 29 July-12 August 1976.



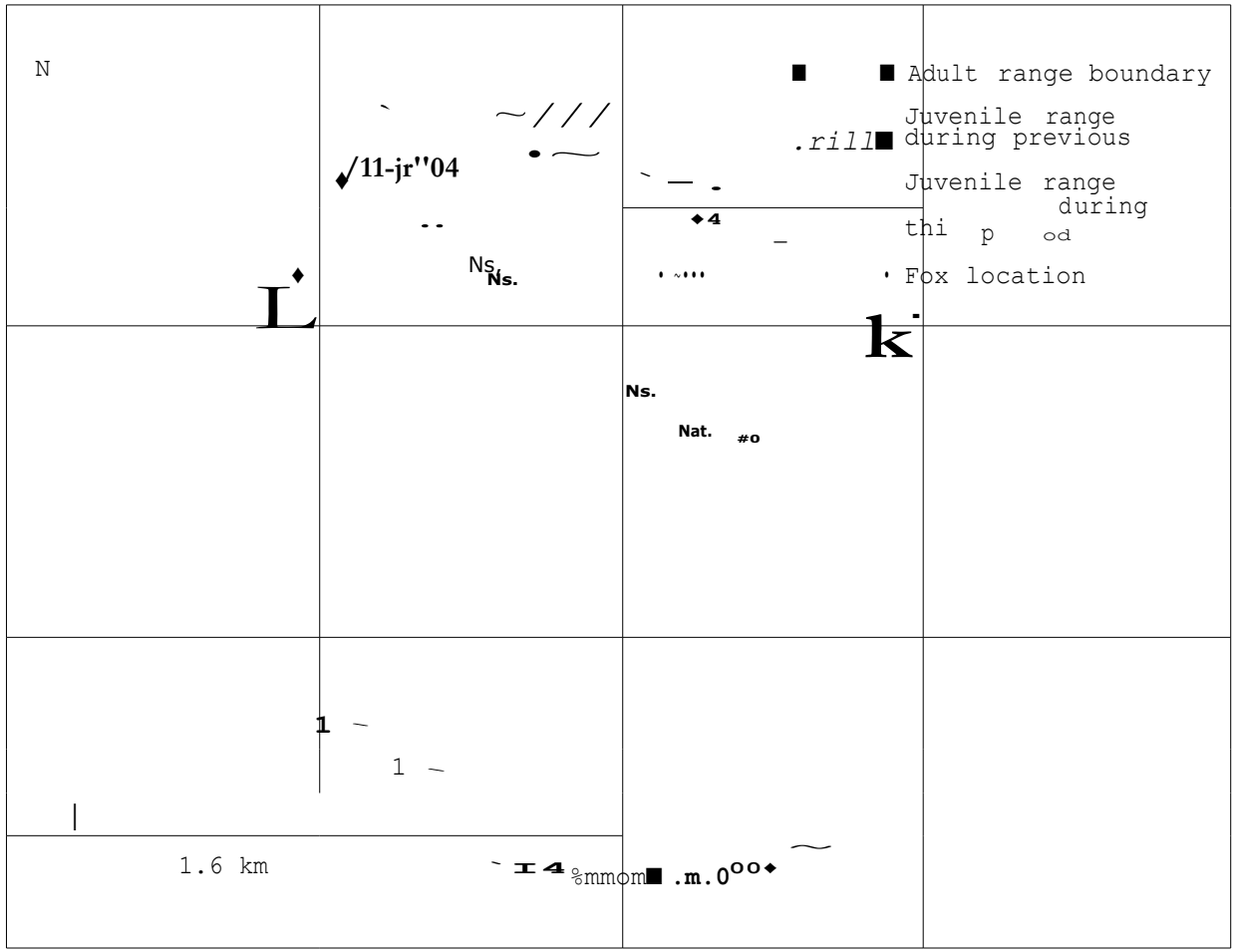
Appendix figure 13. Home **range of a juvenile female** red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 13 August-2 September 1976.



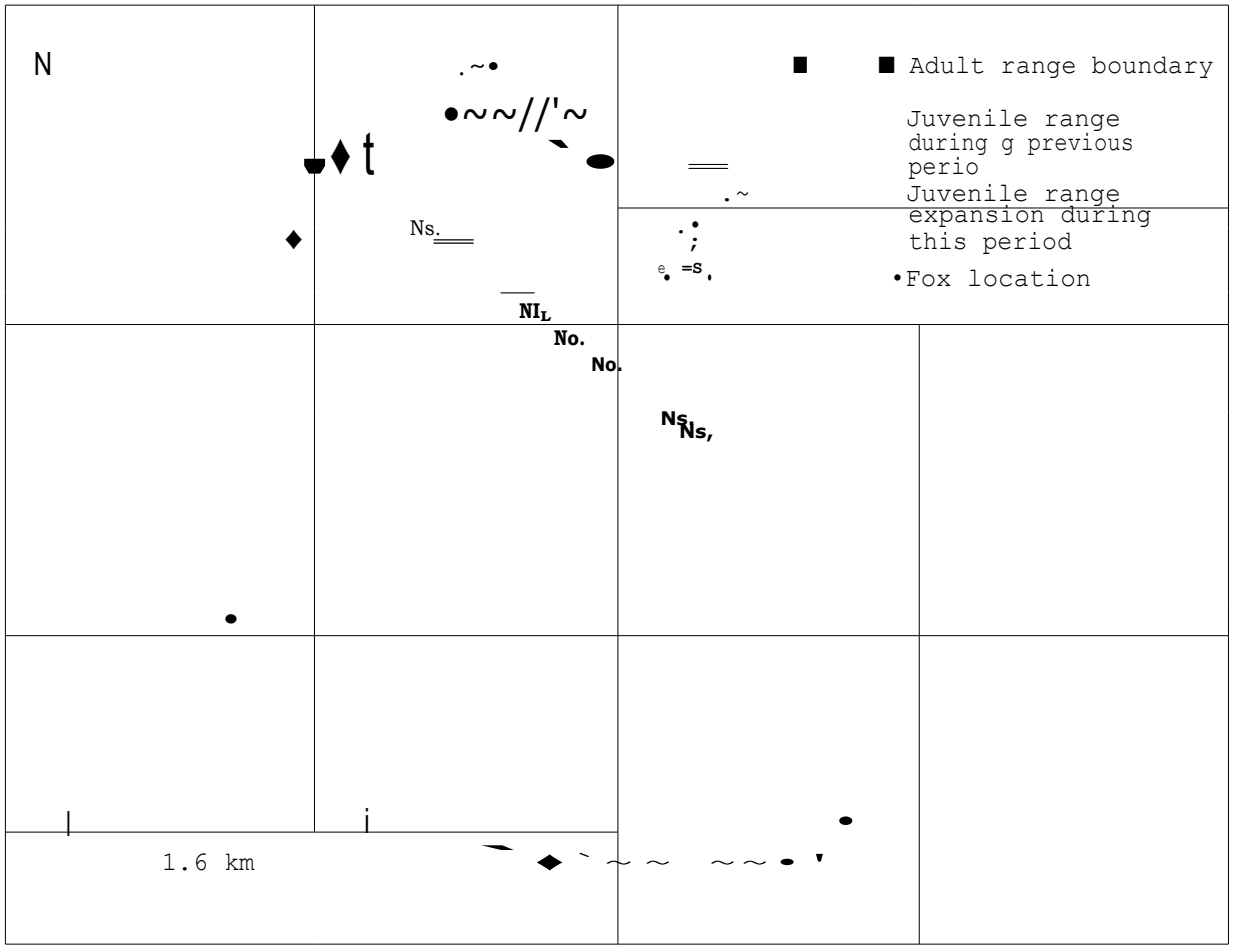
Appendix figure 14. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 25 June-13 July 1977.



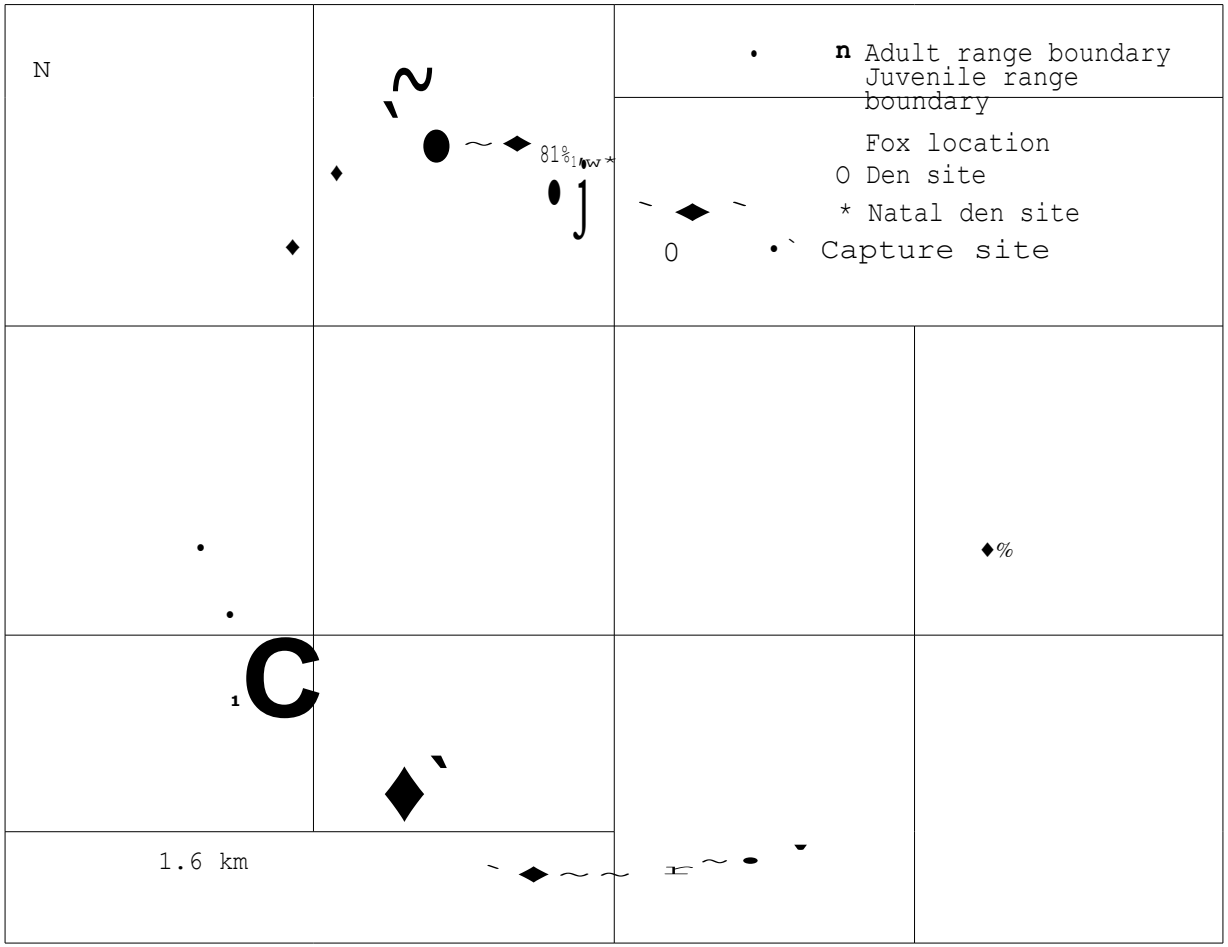
Appendix figure 15. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 14 July-28 July 1977.



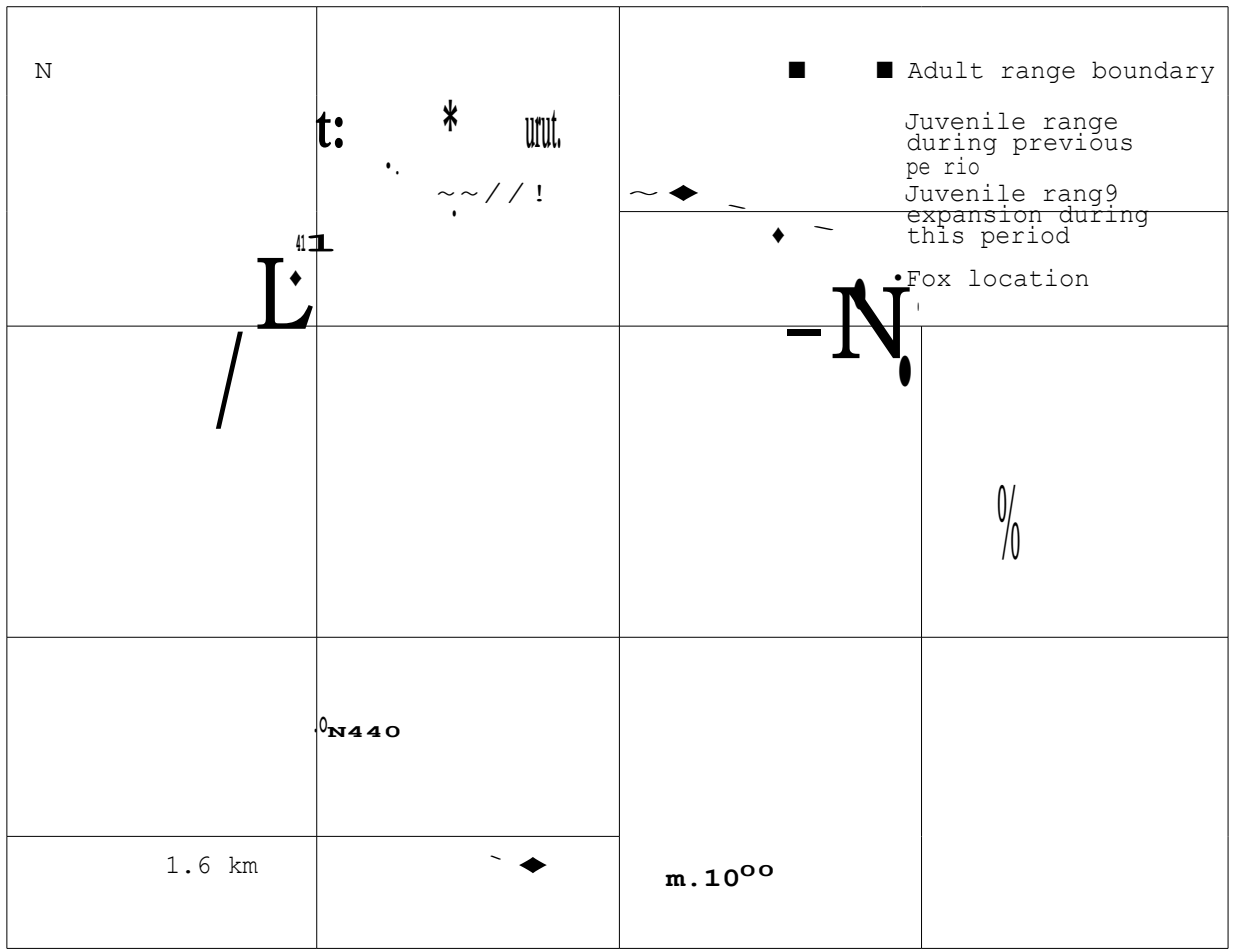
Appendix figure 16. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 29 July-12 August 1977.



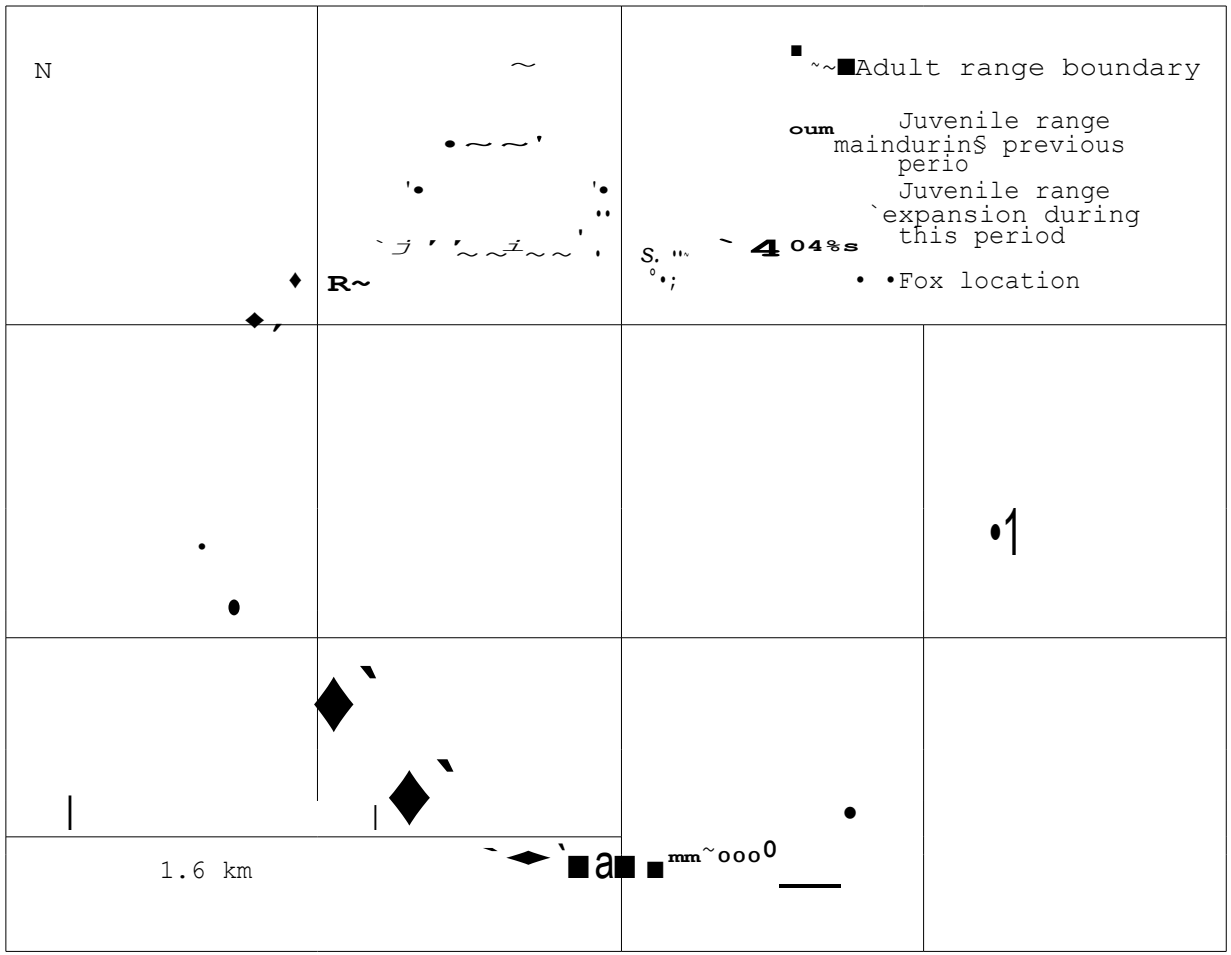
Appendix figure 17. Home range of a juvenile male red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 13 August-2 September 1977.



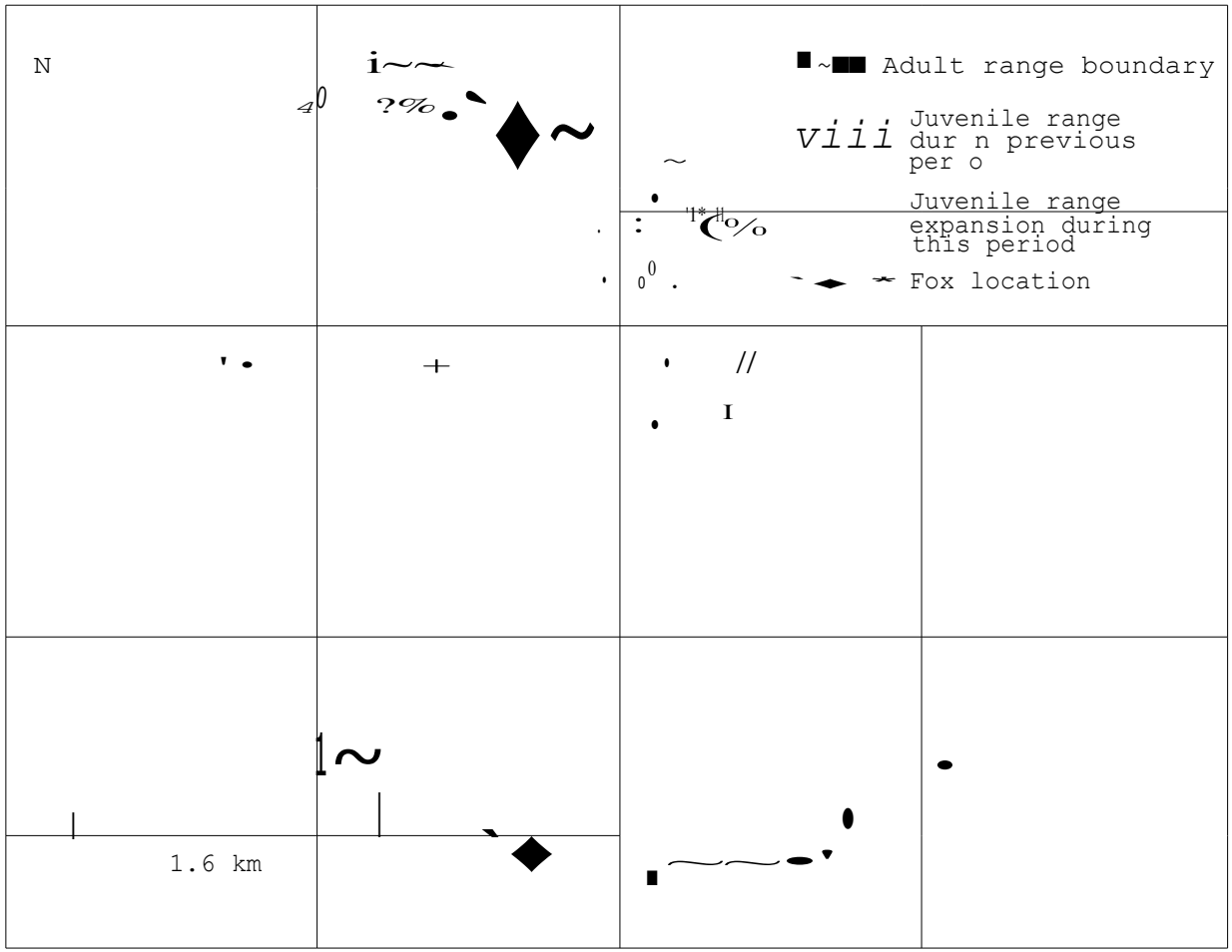
Appendix figure 18. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 25 June-29 **June** 1977.



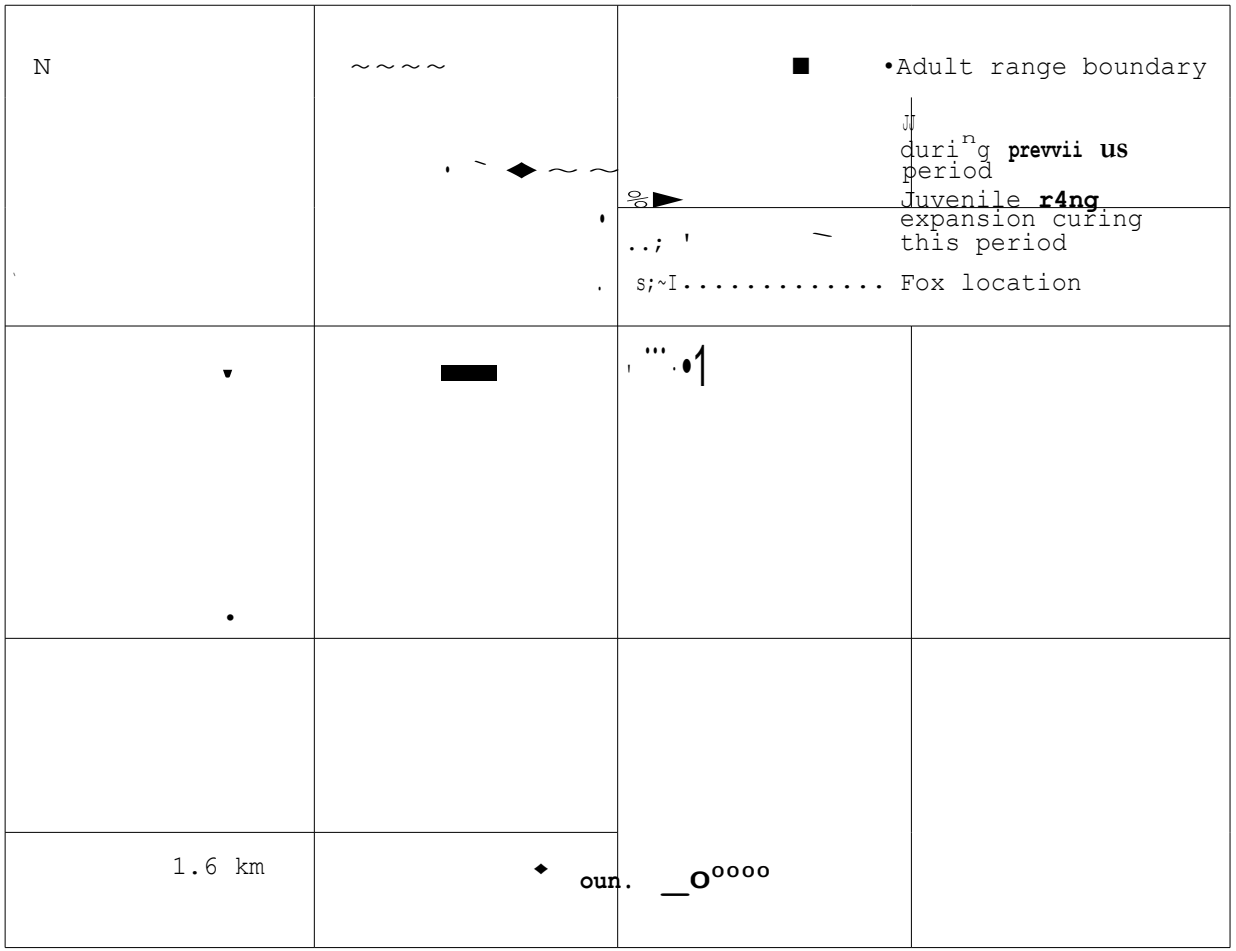
Appendix figure 19. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 30 June-13 July 1977.



Appendix figure 20. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 14 July-28 July 1977.



Appendix figure 21. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 29 July-12 August 1977.



Appendix figure 22. Home range of a juvenile female red fox in relation to its parental adult on the Sinai study area in southeastern South Dakota, 13 August-4 September 1977.

Appendix table 1. Information obtained from radio collared red foxes on the Sinai study area in southeastern South Dakota, Summer 1976 and Summer 1977.

	Fox	Capture date	Location of capture and release	Tracking dates	Number of radio fixes
Summer 1976					
	Adult female (429)	4-17-76	NE/ Section 22 T109N-R52W	6-16-76 9- 2-76	133
Family group one	Juvenile male (460)	6-10-76	NW1 Section 22 T109N-R52W	6-15-76 7-22-76	56
	Juvenile female (459)	6-10-76	NW4 Section 22 T109N-R52W	6-16-76 7-19-76	51
	Adult male (445)	6-17-76	NW4 Section 2 T108N-R52W	6-21-76 7-14-76	51
Family group two	Juvenile male (411)	6-18-76	S5! Section 35 T109N-R52W	6-21-76 9- 2-76	100
	Juvenile female (432)	6-26-76	SW% Section 35 T109N-R52W	7- 1-76 9- 2-76	104
Summer 1977					
	Adult female (440)	6-25-77	SEA Section 8 T108N-R52W	6-25-77 9- 4-77	125
Family group three	Juvenile male (554)	6-25-77	NE! Section 8 T108N-R52W	7- 1-77 9- 3-77	146
	Juvenile female (565)	6-25-77	NE¼ Section 8 T108N-R52W	6-27-77 9- 4-11	153

Appendix table 2. Information concerning red fox families located on the Sinai study area in southeastern South Dakota, 1976.

Family	Den location	Landowner knowledge of fox family	Method of location	Family indicator	Cover type around den
1	Section 33 T110N-R52W	yes	aerial	den	slough edge near pasture
2	Section 5 T109N-R52W	yes	aerial	den	pasture
3	Section 10 T109N-R52W	yes	landowner	den	pasture
4	Section 12 T109N-R52W	yes	aerial	den	idle hillside
5	Section 10 T109N-R51W	yes	aerial	den-adult-pups	alfalfa
6	Section 23 T109N-R52W	yes	aerial	den	idle area in grain field
7	Section 16 T109N-R51W	adult female shot in culvert early in denning season by landowner			
8	Section 30 T109N-R52W	yes	landowner	den	slough edge
9	Section 5 T108N-R52W	?	aerial	den-adult-pups	slough edge in pasture

Appendix table 2. Continued

Family	Den location	Landowner knowledge of fox family	Method of location	Family indicator	Cover type around den
10	Section 2 T108N-R52W	yes	aerial	den-adult	spoil bank in slough area near alfalfa field
11	Section 11 T108N-R52W	yes	aerial	**den**	idle area
12	Section 31 T109N-R51W	yes	landowner	den	pasture
13	Section 5 T108N-R51W		aerial	den-pups	Waterfowl Production Area
14	Section 9 T108N-R51W	yes	landowner	pups in culvert	culvert in road
15	Section 3 T108N-R51W	yes	aerial	adult	pasture

Appendix table 3. Information concerning red fox families located on the Sinai study area in southeastern South Dakota, 1977.

Family	Den location	Landowner knowledge of fox family	Method of location	Family indicator	Cover type around den
1	Section 32 T110N-R52W	yes	landowner	den	Waterfowl Production Area
2	Section 34 T11ON-R52W	no	passer-by	pups	pasture
3	Section 33 T110N-R51W	yes	aerial	den	pasture
4	Section 7 T109N-R52W	yes	aerial	den-pups	Waterfowl Production Area
5	Section 21 T109N-R52W	yes	aerial	den-pups	pasture
6	Section 21 T109N-R51W	yes	aerial	den	pasture
7	Section 34 T109N-R52W	yes	landowner		
8	Section 25 T109N-R52W	yes	landowner	den	pasture
9	Section 31 T109N-R51W	yes	landowner	den-pups	pasture

Appendix table 3. Continued

Family	Den location	Landowner knowledge of fox family	Method of location	Family indicator	Cover type around den
10	Section 8 T108N-R52W	yes	landowner	den	corn
11	Section 4 T108N-R52W	yes	aerial	den	idle slough edge
12	Section 8 T108N-R51W	yes	aerial	den-pups	pasture

Appendix table 4. Information collected from ear-tagged red foxes in southeastern South Dakota, 1976.

Date tagged	Tag number	Location of capture and release	Sex	Weight (gm)	Hind foot length (mm)	Total length (mm)	Tall length (mm)	Ear length (mm)	Date of capture	Method of capture	I)1tpersal distance (kin)	Dispersal direction	Location of capture
5-14-76	485 486	Section 26 T110N-R49W	F		100	625	200	62	10-18-76	trap	48	NE	Section 24 T11IN-R48W
	481 483		M		106	612	200	62	6-24-76	trap	2.8		Section 28 T107N-R50W
	(The above 2 juvenile red foxes were transplanted to Section 29 T107N-R50W at the landowner's request)												
5-21-76	501 502	Section 13 T106N-R52W	F	1792	125	706	219	62	6-16-76	trap	10	NW	Section 24 T106N-R53W
	506 507		M	2240	125	731	237	75					
	508 510		M	2072	125	669	244	62					
	513 514		M	2016	125	700	225	75					
	515 516	"	F	1848	125	690	228	75	(Reported by furbuyer, no cause of death given)				
	518 519		M	2184	125	725	237	75					
	520 522		M	2072	125	719	231	75	12- 1-76	trap	34.4	NW	Section 32 T110N-R52W
5-24-76	523 524	Section 29 T107N-R50W	M	2072	125	656	206	72	11-15-76	trap	29.2	NE	Section 28 T110N-R50W
	525 526		M	2128	122	700	212	69					
	527 528			2128	119	631	206	69	10-20-76	shot	20	NE	Section 21 T109N-R50W

Appendix table 4. Continued

Date tagged	Tag number	location of capture and release	Sex	Weight (gm)	Hind foot length (mm)	Total length (mm)	Tail length (nm)	Far length (mm)	Date of capture	Method of capture	Dispersal distance (km)	Dispersal direction	Location of capture
5-25-76	529 531	Section 36 T108N-R56W	F	2240	125	737	237	75	11-23-76	trap	0		Section 21 TI08N-R56W
5-28-76	542 546	Section 2 T107N-R49W	M	2016	119	669	237	75					
	538 549		M	2072	119	697	228	75					
	536 547		M	1848	119	725	231	75	12-23-76	trap	71.2	NE	Tll3N-R43W
	534 544		F	1904	119	662	237	69	12-21-76	trap	6.8	NE	Section 13 T108N-R49W
	535 541		F	1726	112	662	225	69	11-20-76	trap	54.8	SE	Section 30 T102N-R48W
	533 548		F	**Adult**									
6- 4-76	419 438	Section 13 T106N-R55W	F	1512	106	606	206	56	11- 1-76	trap	4	SW	Section 27 T106N-R55W
	414 444		M	1736	112	650	219	66	10-16-76	trap	20	NW	Section 18 T107N-R56W
	466 467		M	1904	112	644	212	66	10-25-76	trap	32.8	SE	Section 3 T102N-R54W
	437 462		F	1512	106	619	194	62	11- 1-76	trap	4	SW	Section 27 T106N-R55W
	413 472		F	1232	106	619	194	56					

Appendix table 4. Continued

Date tagged	Tag number	Location of capture and release	Sex	Weight (gm)	Hind foot length (mm)	Total length (mm)	Tail length (mm)	Ear length (mm)	Date of capture	Method of capture	Dispersal distance (km)	Dispersal direction	Location of capture
6-10-76	421 459	Section 22 T109N-R52W	F	2240	128	781	256	75	10-26-76	trap	3.2	SE	Section 24 T109N-R52W
	457 460		M	**2296**	137	778	253	75					
	573 574		F	**1960**	137	784	253	75					
4-17- 76	**429** 473		F	Adult									
6-18-76	411 465	Section 35 T109N-R52W	M	2576	144	825	275	84	10-31-77	trap	43.2	SE	Section 7 T108N-R47W
6-25-76	412 471	"	M	2464	144	897	312	87	10-29-76	trap	71.2	NW	Section 28 T116N-R52W
6-26-76	432 441		F	2576	144	862	306	84	10-31-76	trap	3.2	SW	Section 4 T108N-R52W
6-17-76	445 468	Section 2 T108N-R52W	M	Adult					1-21-78	shot	1.6	W	Section 3 T108N-R52W

Appendix table 5. Information collected from ear-tagged red foxes in southeastern South Dakota, 1977.

Date tagged	Tag number	Location of capture and release	Sex	Weight (gm)	Hind foot length (mm)	Total length (mm)	Tail length (mm)	Ear length (mm)	Date of capture	Method of capture	Dispersal distance (km)	Dispersal direction	Location of capture
5--14-77	415 436	Section 17 T102N-R51W	M	1904	101	625	187	66					
	442 452		F	1956	101	644	206	66					
	433 470		F	1680	101	631	212	66					
	593 595	"	F	Adult									
5-25-77	422 455	Section 5 T101N-R52W	M	2688	137	806	269	78					
	443 453		M	3080	137	806	262	78	10-26-77	trap	239	NE	Section 33 T124N-R49W
6- 7-77	572 576	Section 21 T109N-R52W	M	1960	137	825	312	87					
	570 578	"	M	2296	137	825	312	78					
	559 563		M	2352	137	850	312	81					
6-10-77	569 551	Section 18 T109N-R52W	F	2128	128	806	300	78	10-29-77	shot	6.2	S	Section 31 T108N-R52W
6-10-77	551 552	Section 34 T110N-R52W	F	2184	137	831	287	78					
	591 592		M	2072	137	800	287	81					

Appendix table 5. Continued

Date tagged	Tag number	Location of capture and release	Sex	Weight (gm)	**Hind** foot length (mm)	Total length (mm)	Tail length (mm)	Ear length (mm)	Date of capture	Method of capture	Dispersal distance (km)	Dispersal direction	Location of capture
6-25-77	565 567	Section 8 T108N-R52W	F	2912	131	**878**	275	78					
	554 555		M	3584	144	925	312	78					
	556 564		F	2688	131	**856**	306	78					
	440 4 56		F	4592	Adult								
8-14-77	**589** 590	Section 34 T109N-R50W	M		162	1087	400	92	12- -77	shot	18	SW	Section 11 T107N-849W