Distribution and Habitat Characteristics of the Kit Fox (*Vulpes macrotis*) in Utah

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DISTRIBUTION AND HABITAT CHARACTERISTICS OF THE KIT FOX (*VULPES MACROTIS*) IN UTAH

by

John C. McGrew

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of

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ABSTRACT

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Major Professor: Dr. J. Juan Spillett
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Stepwise discriminant analysis was performed on groups of skulls representing the three nominal subspecies of *V. macrotis* reported to occur in Utah (*V. m. nevadensis*, *arsipus*, and *neomexicana*). The skulls were judged to represent three distinct populations significantly different from each other in at least seven skull characteristics. Six specimens from eastern Utah and western Colorado were tentatively assigned to *V. m. nevadensis*.

Throughout their range in the state kit foxes are generally associated with desert soils and desert shrub vegetation, elevations below 5,500 feet (1,676 m), and relatively mild winters. Winter severity is apparently a limiting factor on kit fox distribution in the northern part of Utah.

Kit foxes are common in west-central and east-central portions of the state. Trapping and hunting are probably important mortality factors in local areas, but the impact of predator control has been greatly reduced by the ban on the use of toxicants on public lands. A method of monitoring kit fox abundance and population trends in areas with rapidly increasing human populations would be advisable, and a program to promote the nonconsumptive use of kit foxes is recommended.

(92 pages)

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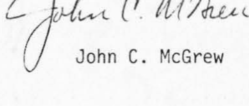

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CHAPTER I

INTRODUCTION

Interest in the kit fox (Vulpes macrotis) in Utah is a direct result of two responsibilities assigned to the Department of Interior in the late 1960's. The first, the Endangered Species Preservation Act of 1966, authorized the Secretary of Interior to declare any native animal "threatened with extinction" if, among other things, its habitat is in imminent danger of destruction or drastic modification (U.S. Department of Interior 1973). The second responsibility is a mandate for the preservation of predatory species which resulted from a reorganization of predator control policies.

One of the first mammals to be considered under the Endangered Species Act was the San Joaquin kit fox (V. m. mutica). This subspecies had been declared a protected furbearer by the state of California in 1965 after studies indicated its habitat was being converted to industrial and agricultural uses at an alarming rate (Leach 1971). The Secretary of Interior concurred with these findings and placed V. m. mutica on the Endangered Species List in 1966.

Reorganization of predator control in the western United States resulted from public pressure for a review of control policy on public lands. The "Leopold Report" (Leopold et al. 1964) maintained that, although control of some predatory species in local areas is necessary, it is also true that all native animals are of inherent interest and value to the public. Basic policy should thus reflect husbandry of all forms of wildlife.

Members of a later study panel, the "Cain Committee" (Cain et al. 1972) agreed with this philosophy. They advocated a broader approach to the whole predator control program in addition to upgrading personnel and methods. Among their recommendations were long-term studies of ecological problems associated with predator control, and special measures to protect all species of predators placed on the Endangered Species List.

Pursuant to these responsibilities, the U.S. Fish and Wildlife Service recommended that the Utah Cooperative Wildlife Research Unit study the kit fox in Utah. After consultations with the Utah Division of Wildlife Resources, it was decided to undertake a project to:

1. Study distribution and relative abundance of the kit fox in Utah.

2. Evaluate habitat characteristics of the kit fox and develop a description of habitat characteristics for management purposes.

3. Make suggestions for management of Utah's kit foxes.

CHAPTER II

REVIEW OF LITERATURE

The kit fox is a unique carnivore, found only in the desert and semi-arid regions of western North America. It is the smallest native member of the family Canidae with a body length ranging from 15 to 20 inches (38-50 cm) plus a tail from 9 to 12 inches (23-30 cm) in length. Weights vary from 3 to 6 pounds (1.4 to 2.8 kg). A related species, the swift fox (V. velox) occupies the semi-arid grasslands of the Great Plains in the United States and Canada (Snow 1973).

Because of its nocturnal habits, isolated distribution and limited economic value, the kit fox has received little attention from man. The original description comments: "It is not a little surprising that so large a mammal as a fox, inhabiting so well explored a region as California, should have escaped attention till the present time ..." (Merriam 1888). Fewer than 12 studies of the kit fox are reported in the literature. Snow (1973) reviewed these articles, and an annotated bibliography of kit and swift foxes is in preparation (Egoscue and McGrew, unpublished manuscript).

Taxonomy and Distribution

Eight extant subspecies of V. macrotis are currently recognized (Hall and Kelson 1959), but the Mexican subspecies (devia, tenuirostris, and zinseri) are known only from a handful of specimens (Figure 1). Three of the subspecies have been reported in or near Utah. Hardy (1945) referred to kit foxes in Washington County as V. m. arsipus.

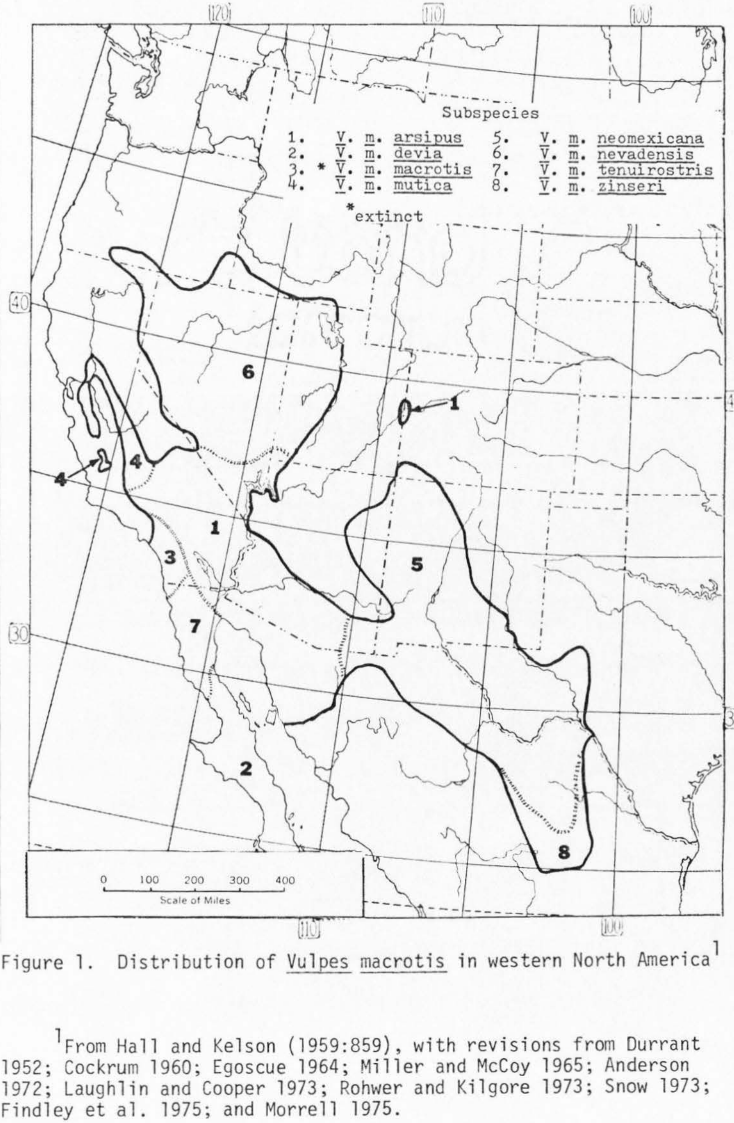


Figure 1. Distribution of Vulpes macrotis in western North America[1]

[1]From Hall and Kelson (1959:859), with revisions from Durrant 1952; Cockrum 1960; Egoscue 1964; Miller and McCoy 1965; Anderson 1972; Laughlin and Cooper 1973; Rohwer and Kilgore 1973; Snow 1973; Findley et al. 1975; and Morrell 1975.

Stock (1970) assigned three specimens from Washington County to arsipus on the basis of dorsal pelage coloration and skull measurements. Miller and McCoy (1965) assigned two skulls from Mesa County, Colorado, to *V. m. arsipus* despite the fact that Mesa County is several hundred miles east of the nearest known *arsipus* population. Armstrong (1972) concurred with this identification. Durrant (1952) assigned all kit foxes in the state to *V. m. nevadensis*, but suggested that *arsipus* and *nevadensis* may be only one subspecies, as implied by Hall (1946). Egoscue (1964) identified two skulls from Montezuma County, Colorado, as *V. m. neomexicana*.

Several specimens collected since 1952 suggest that kit foxes occur in much of eastern Utah (Figure 2). A kit fox was collected in Carbon County (University of Utah specimen UU #22903) and another was shot along U.S. Highway 6-50 in Grand County (UU #15128). Ranck found a roadkill along U.S. 6-50 "... 31 miles west of Grand Junction, Mesa County, Colorado ..." (unpublished field notes, 1968). This location is only a few miles from location reported by Miller and McCoy (1965). Harris (1963) and Findley et al. (1975) examined a number of kit fox specimens from San Juan County (northwestern New Mexico).

Ecology and Habitat Characteristics

Egoscue (1956, 1962, 1975) reported most of what is known of the natural history and ecology of *V. m. nevadensis*. His 25-square mile (6,475 ha) study area in Tooele County had a resident population of four or five pairs, plus one or more unpaired adults--a population density of about one fox per 2-square miles (one fox/1,036 ha). Foxes denned on sparse greasewood (*Sarcobatus vermiculatus*) or shadscale (*Atriplex*

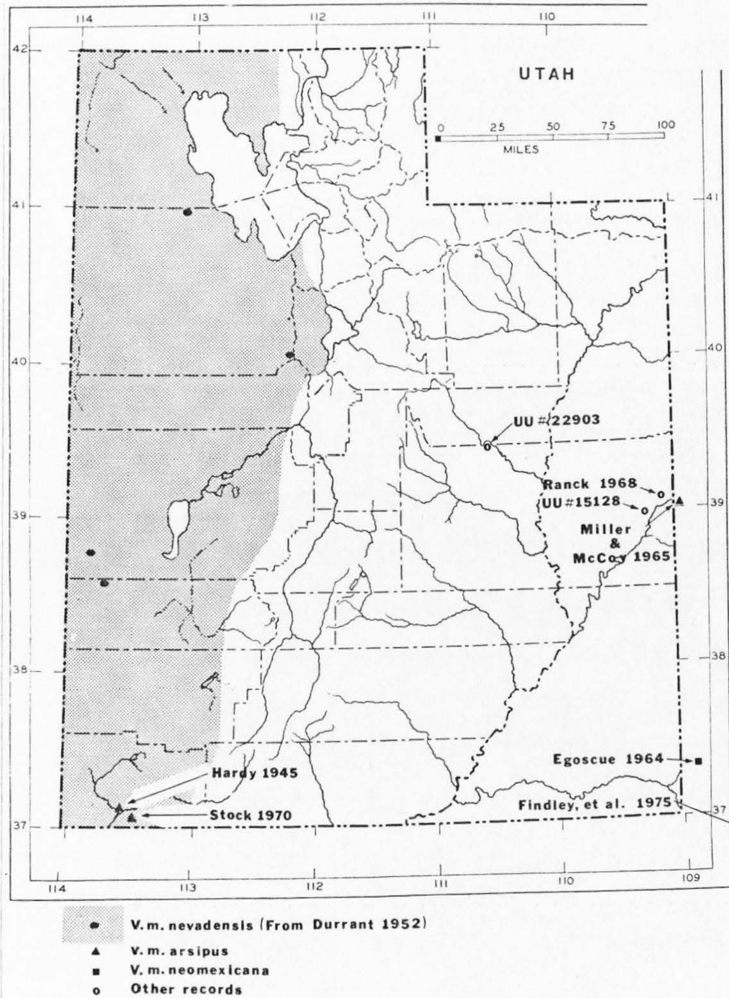


Figure 2. Records of Vulpes macrotis in Utah

confertifolia) flats, and dens were located in groups with many dens unoccupied at any given time.

Morrell (1972) studied the life history of the San Joaquin kit fox on a 2-square mile (518 ha) study area in Kern County, California. The dominant vegetation of the region was saltbrush (Atriplex polycarpa) with several annual grasses (Bromus rubens, Festuca reflexa, and F. megalura). The soil was a sandy clay, similar to that of Egoscue's site in Utah. Most dens were on level ground or slight slopes. Open areas with grass or scattered brush were preferred over heavy brush for den sites.

Using radiotelemetry equipment Morrell determined that foxes hunted sporadically throughout the night. No specific hunting territory was defended by foxes. Dens were numerous, and individual foxes often used several dens during the summer months. Population density was about six adult foxes per square mile (259 ha), a density higher than that reported for Tooele County (Egoscue 1962). This may have been atypical since Laughrin (1970) estimated the average density in this general area of California at about one fox per square mile.

Mortality Factors

Chief among the factors contributing to the decline of the San Joaquin kit fox is the conversion of native habitat to agricultural and industrial uses (Jensen 1972, Morrell 1972). Laughrin (1970) estimated the loss in native habitat between 1959 and 1969 at 34 percent. This trend is continuing, and even accelerating as more irrigation water becomes available in the San Joaquin Valley (Morrell 1975).

Morrell (1972) felt that illegal shooting was the greatest threat to the survival of kit foxes on his study area. Jensen (1972) listed night-hunting and all-terrain vehicle use as major causes of the reduction of the kit fox in the Panoche Hills. He also suggested that secondary poisoning due to indiscriminant use of toxicants for rodent control could be a mortality factor. Schitoskey (1975) found that the acute oral LD_{50} to the kit fox for compound 1080 is equivalent to an amount that could be consumed by a kangaroo rat in a field baiting program. However, Swick (1973) observed no kit fox mortality due to poisoning in a test of aerially applied 1080 baits for ground squirrel control. Kit foxes hunted in the treated area within hours of the application, but no ill-effects were noted during a two-week surveillance after the test.

Kit foxes are particularly vulnerable to predator control programs because of their curiosity and tolerance of humans (Egoscue 1956). They are easily taken with traps or M-44 cyanide guns and readily accept poison baits. However, the impact of predator control on kit foxes has been lessened in recent years. The use of toxic agents on public lands is currently prohibited, and modern predator control methods have very limited effects on nontarget carnivores (D. Hawthorne, personal communication).

CHAPTER III

DISTRIBUTION

Methods and Procedures

About 50,000-square miles (130,000-square km) were included in the study. Much of this area is essentially devoid of permanent human habitation. However, the state is served by a number of governmental agencies (i.e., the U.S. Fish and Wildlife Service [USFWS], the National Park Service [NPS], the Bureau of Land Management [BLM], the Soil Conservation Service [SCS], and the Utah Division of Wildlife Resources [UDWR]), each with professional wildlife personnel on their staff.

Indirect methods

Questionnaires. Dr. Bradley Parlin helped prepare a questionnaire for mailing to wildlife personnel in the state. The purpose was threefold:

a) to inform recipients of the kit fox project;

b) to obtain information about present abundance and distribution of the kit fox in Utah;

c) to record all kit fox sightings during a selected month (February in 1975; April in 1976).

The recipient was also asked to describe mortality factors affecting kit foxes. Sixty-eight questionnaires were sent in 1975, and 109 were sent in 1976 (see Appendix for a complete mailing list).

Two other indirect methods were also used to reach wildlife professionals and interested private citizens. A newsletter article describing the kit fox and the objectives of the project was published in the UDWR weekly newsletter, Wildlife Report (April 19, 1976). Also, a project progress report was presented at the 1976 meeting of the Utah Chapter of the Wildlife Society.

Museum information. Inquiries were sent to 45 museums requesting information about *V. macrotis* specimens from Utah, Colorado, New Mexico, and Arizona. Institutions selected (see Appendix for the mailing list) were those with mammal collections in excess of 50,000 specimens or with extensive collections from the Southwest (Choate and Genoways 1975).

Direct methods

Interviews, personal letters. Information about kit foxes in specific areas was obtained from interviews and written correspondence with UDWR Conservation Officers, BLM Wildlife Specialists, and Animal Damage Control District Field Assistants (USFWS). About 140 people were interviewed between January, 1975, and July, 1976, and over 200 letters were sent during this same period.

Western Predator Survey. The 16 Western Predator Survey lines in Utah provide annual indices of predator abundance in the state (Linhart and Knowlton 1975). Copies of data sheets showing kit fox visits were obtained from the USFWS.

Purchase of skulls. With the cooperation of the UDWR, a $5.00 reward was offered for kit foxes taken in southern or eastern Utah during the winter of 1975-1976. The requirements for payment were that the skull be undamaged and the carcass labeled with sex, and date and location of capture.

Spotlighting from highways and county roads, trapping with live traps modified from Cushwa and Burnham (1974), and direct observations made in the early morning and evening were the primary field methods used for finding kit foxes.

Results

The data are presented by regions that correspond broadly with the Great Basin, Mohave, and Painted deserts (Jaeger 1957), and the Uinta Basin. The four regions are as follows (also see Figure 3):

1) The West Desert (= Great Basin)--Box Elder, Tooele, Juab, Millard, Beaver, and Iron counties, plus parts of Weber, Davis, Salt Lake, Utah, Sanpete, Sevier, Piute, and Garfield counties.
2) Washington County (= Mohave Desert).
3) The East Desert (= Painted Desert)--Carbon, Emery, Grand, Wayne, western Garfield, Kane, and San Juan counties.
4) The Uinta Basin--Uintah and Duchesne counties.

Many of the kit fox sightings gathered during the study, plus the Western Predator Survey lines, are plotted on distribution maps (Figures 4 and 5 below). It should be noted that the locations are closely correlated with highways and human population centers, since many sightings were made by wildlife personnel during their normal duties. All of the sightings reported during the study are listed in the Appendix.

Distribution in the West Desert

There are few recent records of the kit fox in northwestern Utah. Questionnaire returns indicated that kit foxes are rarely seen in Box Elder County (Table 1). Only one or two kit foxes are represented in over 15 years of trapping records from Curlew Valley (F. Wagner,

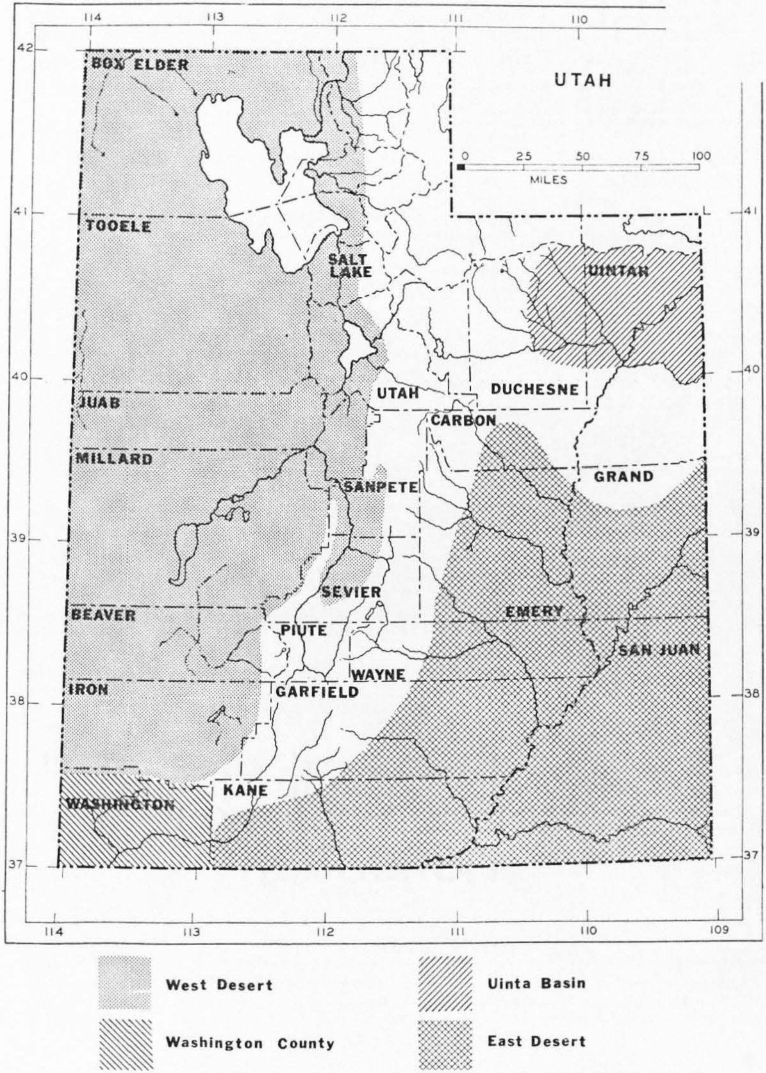


Figure 3. Approximate extent of the four regions of Utah where kit fox sightings were collected

Table 1. Frequency of kit fox sightings in the West Desert from questionnaire returns

County	1975	1976
Box Elder, Weber, Davis, Salt Lake		
Number of responses	2	9
Frequency of sightings:[a]		
Numerous	--	--
Occasional	--	1
Rare	2	6
Never	--	2
Tooele, Juab (western), Millard		
Number of responses	9	11
Frequency of sightings:		
Numerous	1	1
Occasional	6	6
Rare	2	4
Never	--	--
Beaver and Iron		
Number of responses	4	6
Frequency of sightings:		
Numerous	--	--
Occasional	2	1
Rare	1	4
Never	1	1
Utah, Juab (eastern), Sanpete, Sevier, Garfield (western)		
Number of responses	3	8
Frequency of sightings:		
Numerous	--	1
Occasional	1	--
Rare	2	5
Never	--	2

[a]On the questionnaire, "rarely seen" was defined as fewer than five foxes seen per year; "occasionally seen" was five to ten seen per year; "numerous" was greater than ten foxes seen per year.

unpublished data), and Western Predator Survey Lines 1 and 2 had no kit fox visits in 1973 through 1975 (Table 2). The only recent sighting from northern Box Elder County was from Hansel Valley (Figure 4: C30).

Kit foxes are periodically sighted on the migratory bird refuges on the east shore of the Great Salt Lake (C1, C3, C6), but apparently are not permanently established on any of the refuges. They are also found along the margins of the salt flats south and west of the lake. Unfortunately, most of western Box Elder and Tooele counties are part of Hill and Wendover Bombing Range or Dugway Proving Grounds, all of which have restricted access for field work.

Kit foxes are common in the central portion of the West Desert. Most questionnaire respondents saw five to ten foxes per year (Table 1). The broad, flat valleys in western Juab, Millard, and Beaver counties all have good populations of kit foxes. Western Predator Survey Lines 13 and 14, located along the Nevada--Utah boundary in Millard and Beaver counties, and Lines 15 and 16 in north central Millard County, recorded numerous kit fox visits in 1972 through 1975 (Table 2). Kit foxes are also common in the Sevier and Black Rock deserts (eastern Millard County). Active dens (A3, A16) were visible in 1974, 1975, and 1976 at the highway junction east of Deseret. Dens were also noted along Utah 257 north of Milford (A10, A11).

No recent reports were obtained from Beaver County south of Milford, or from Iron County, and no field work was conducted in this area. Questionnaire returns described the kit fox as "rarely seen" (Table 1).

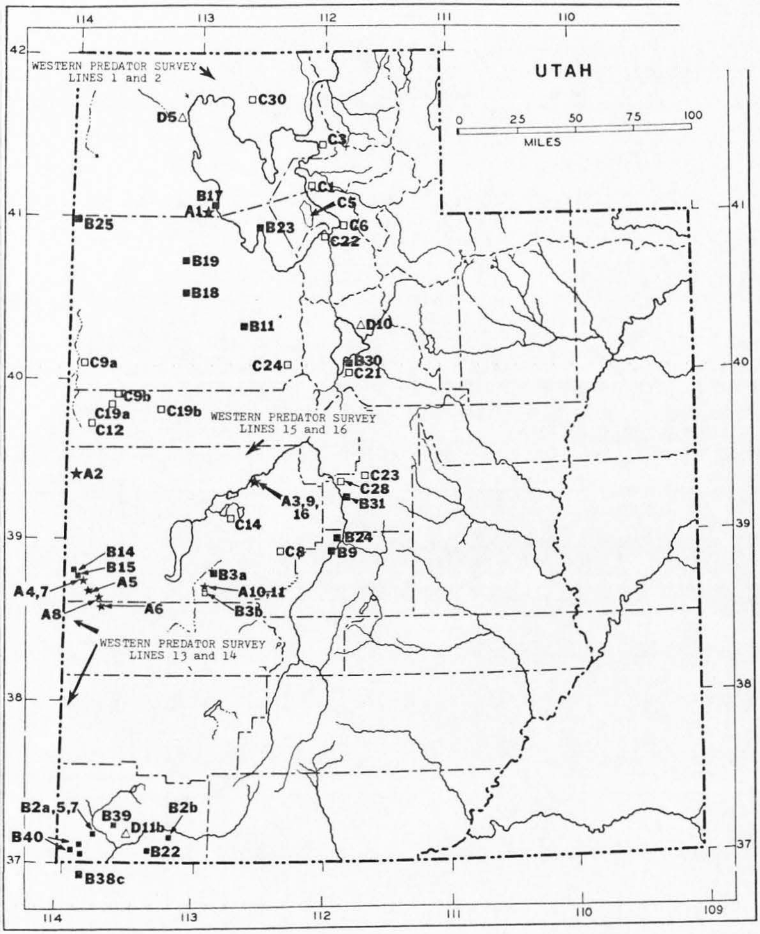
Utah, Sevier, and Sanpete counties were included in the West Desert region, although physiographically they are part of the Colorado

Table 2. Western Predator Survey kit fox indices for Utah

Region/county	Line number and location		Number of visits/index[a] 1972	1973	1974	1975
West Desert						
Box Elder	1	Curlew Valley	--	0/0	0/0	0/0
Box Elder	2	Curlew Valley	--	0/0	0/0	0/0
Millard	13	Antelope Valley	104/26	12/3	116/29	17/4
Beaver	14	Pine Valley	4/1	4/1	46/11	13/3
Millard and Juab	15	North of Sugarville	44/11	52/13	16/4	40/6
Millard and Juab	16	Parallel to 15, 8 miles west	64/16	28/7	8/2	0/0
East Desert						
Grand	7	Westwater Canyon	64/16	20/5	0/0	0/0
Grand	8	South of Cisco	143/30	100/25	0/0	0/0
Emery	9	Southwest of Green River city	26/4	36/9	48/12	35/7
Emery	10	Northwest of Temple Mountain	--	92/23	96/24	53/12
Uinta Basin						
Uintah	5	North of Bonanza	0/0	0/0	0/0	0/0
Uintah	6	Southwest of Vernal	0/0	0/0	0/0	0/0

[a]The index is calculated as follows: $\text{Index} = \frac{\text{Total kit fox visits}}{\text{Total operative station nights}} \times 1{,}000$

Thus, Line 13 had 104 kit fox visits and a visitation index of 26 in 1972.



★A Personal sighting

■B Reliable sighting

□C Less reliable sighting

△D Historical record (before 1970)

Figure 4. Kit fox reports from the West Desert and Washington County, 1974-1976

Plateau (Hunt 1974). Sightings (B9, B30, B31) and questionnaire returns (Table 1) indicated that kit foxes are found throughout the low valleys in these counties. These sightings are consistent with Rasmussen (1958), who reported kit foxes in the arid section of the lower Sanpete Valley, and the location is an eastward extension of kit fox range as delineated by Durrant (1952).

Distribution in Washington County

Washington County is divided north-to-south by the Beaver Dam Mountains. Sightings were reported from the Beaver Dam Wash (B40) and the Virgin and Santa Clara river valleys (B39) west and east of the divide, respectively. This agreed with earlier accounts (Hardy 1945, Stock 1970). Conservation Officer D. Kay and the SCS District Conservationist described the kit fox as "rarely seen," but E. Coombs (UDWR Biologist) felt they were common in the area.

Kit foxes were also reported in the Virgin River Valley north and east of St. George. G. Blackburn (USFWS) described the kit fox as common around Virgin (Figure 4: B2b), and G. McKell (UDWR) reported that they are "seen occasionally" near Hurricane.

Distribution in the East Desert

Field work, questionnaire returns, and Western Predator Survey data indicate that the kit fox is widely distributed in eastern Utah, despite the lack of published accounts from this area. Kit foxes were found throughout the low areas of Emery County (Table 3, Figure 5). They were observed on several occasions along U.S. Highway 6-50 southeast of Price (A12 through A15) and in Castle Valley southwest of Price (B33, D1). Kit fox tracks were reported on Western Predator Survey

Table 3. Frequency of kit fox sightings in the East Desert from questionnaire returns

County	1975	1976
Carbon and Emery		
Number of responses	2	5
Frequency of sightings:[a]		
Numerous	--	--
Occasional	2	1
Rare	--	4
Never	--	--
Kane		
Number of responses	6	8
Frequency of sightings:		
Numerous	--	--
Occasional	--	--
Rare	3	5
Never	3	3
San Juan (northern)		
Number of responses	7	9
Frequency of sightings:		
Numerous	--	--
Occasional	--	--
Rare	5	1
Never	2	8

[a]For explanation see Table 1.

Lines 9 and 10 in the San Rafael Desert in 1973, 1974, and 1975 (Table 2). The identity of these tracks was initially doubted because kit foxes had not been reported in eastern Utah. However, the capture of a pair of adult kit foxes approximately 1 mile (1.6 km) south of Line 10 (location A17) strongly supported the prior reports. Several other

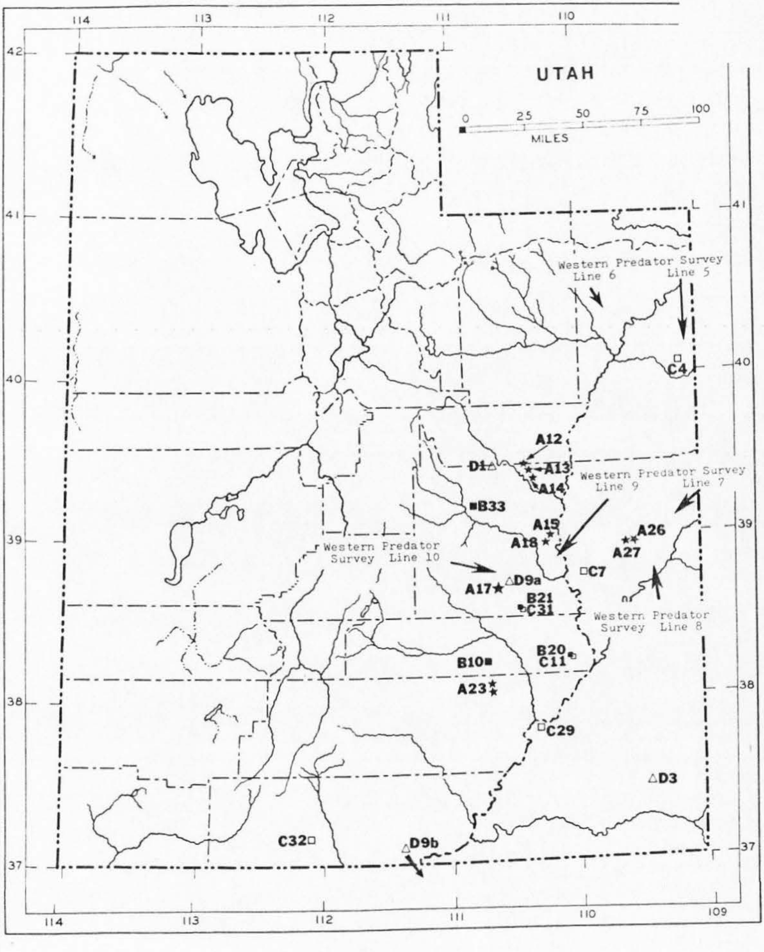


Figure 5. Kit fox reports from the East Desert and Uinta Basin, 1974-1976

sightings (A23, B21, C31) were collected from the San Rafael Desert during the project.

There were few reliable sightings south of A23 in Garfield County. Much of this vast region is extremely rough, and only a few roads penetrate the area. Questionnaire returns from Kane County suggested that kit foxes are rarely seen in southern Utah (Table 3). Only two sightings (C29, D3) were reported south of the Colorado River. Questionnaire returns (Table 3) indicated that kit foxes are rare or absent in northern San Juan County. However, J. Antonio, Navajo Nation Fish and Wildlife Department, indicated that kit foxes are not uncommon in the southern third of the county, and that two of his trappers had taken kit foxes on the Navajo Reservation. Egoscue (1964) examined two kit fox carcasses taken a short distance from the Reservation in Colorado. Attempts to contact Mr. Antonio for further information were unsuccessful.

Although kit foxes had not been reported in the desert east of the Green River (Grand County), the findings of Miller and McCoy (1965) suggested that they might occur in this area. Reports collected during this study confirmed this suggestion. Kit fox tracks were reported on Western Predator Survey Lines 7 and 8 in 1972 and 1973 (Table 2). However, the USFWS employee who ran these lines in 1974 and 1975 identified similar tracks as those of the grey fox. Accounts collected during the present study (e.g., Ranck 1968 and UU #15128, Figure 2; A26 and A27, Figure 5) would appear to support the 1972 and 1973 reports. Unfortunately, no questionnaire returns were available from this area.

Distribution in the Uinta Basin

Because the predominant vegetation in the Uinta Basin is desert and salt-desert shrub, Jaeger (1957) included the area in the Great Basin Desert. However, the Uinta Basin is isolated from the Great Basin in Utah, and was treated as a separate region in this study.

Olsen (1973) listed the swift fox (V. velox) as fairly common in the Utah Oil Shale Area (OSA) of Uintah County (C4: Figure 5), based on interviews with USFWS personnel. His use of V. velox instead of V. macrotis probably resulted from the distribution map in Hall and Kelson (1959) which erroneously includes eastern Wyoming and northeastern Utah within the range of V. velox (Egoscue 1973).

Several attempts were made to verify Olsen's report. During the week of August 11, 1975, state and federal wildlife personnel from the Uinta Basin were interviewed concerning kit foxes in the area. The following information seemed to contradict Olsen's account:

1) J. Grandison (UDWR) had seen no sign of kit foxes on his 20,000 acre (8,100 ha) study site near the White River.

2) M. Perry, Utah Museum of Natural History in Vernal, conducted two Environmental Impact studies on the OSA and reported no kit fox sign.

3) VTN Corporation, a private consulting firm involved in environmental studies in the OSA, had no records of kit foxes.

4) V. Hackford and R. Dickson (USFWS) had not encountered kit foxes during their animal damage control activities, and the USFWS had no record of kit foxes being trapped in the area.

5) Neither L. Nickel nor D. Thomas, retired Conservation Officers with a total of over 80 years accumulative experience in the Uinta Basin, had ever seen a kit fox in the Basin, although both men had trapped extensively.

6) Western Predator Survey Lines 5 and 6 have never recorded a kit fox visit (Table 2).

On his 1976 questionnaire return, S. Cranney (UDWR) summarized his findings: "In extensive talks with local trappers, I have concluded that kit foxes are not present in the Uinta Basin." Although questionnaire returns do not unanimously support this conclusion (Table 4), it is more likely that foxes sighted in the Basin are grey foxes (Urocyon cinereoargenteus) instead of kit foxes. Olsen did not collect any kit fox specimens during his study in the Uinta Basin, and he was unable to add any further information about their distribution in this area (personal communication).

Table 4. Frequency of kit fox sightings in the Uinta Basin from questionnaire returns

County	1975	1976
Uintah and Duchesne		
Number of responses	7	8
Frequency of sightings:[a]		
Numerous	--	--
Occasional	2	--
Rare	3	4
Never	2	4

[a]For explanation see Table 1.

CHAPTER IV

TAXONOMY

Methods and Procedures

The extension of known kit fox range into eastern Utah underlined the need to assess the taxonomic status of the species in the state. Accordingly, morphometric characteristics of kit fox skulls from the West Desert, Washington County, and New Mexico were studied. The objectives were to characterize the three populations and then to compare these characteristics with those of specimens from the East Desert.

Four groups of skulls were examined:

1) Twenty-four skulls from the West Desert (deposited in the Museum of Natural History, University of Utah) served as the reference group for V. m. nevadensis.

2) Sixteen skulls from Washington County, purchased from trappers in 1976, served as the reference population for V. m. arsipus.

3) Thirteen specimens from the Museum of Southwest Biology (University of New Mexico) were the reference population for V. m. neomexicana.

4) Specimens from three collections comprised the unknowns. Included in this group were: #7579 and #7980, Museum of Natural History, the University of Colorado (Miller and McCoy 1965); PC #17 and #18 (Emery County); and UU #22903 and UU #15128. Unfortunately, specimens from Montezuma County, Colorado, (Egoscue 1964) were unavailable for examination, and the skull found by Ranck (Figure 2) was broken and unusable.

A total of 34 skull and mandible characteristics were measured on each of 59 specimens (Figure 6). Four characteristics (numbers 11, 22, 33, and 34) were eventually discarded because of difficulties experienced in obtaining consistent measurements. Measurements were taken with dial calipers to the nearest 0.1 millimeter (0.025 in.). Skulls missing one or more measurements were not used in the analysis. Since the sex of most of the specimens was unknown, the sexes were not treated separately. Hildebrand (1954) found that sexual dimorphism in canids rarely exceeds 3 percent, so this was a relatively minor source of error.

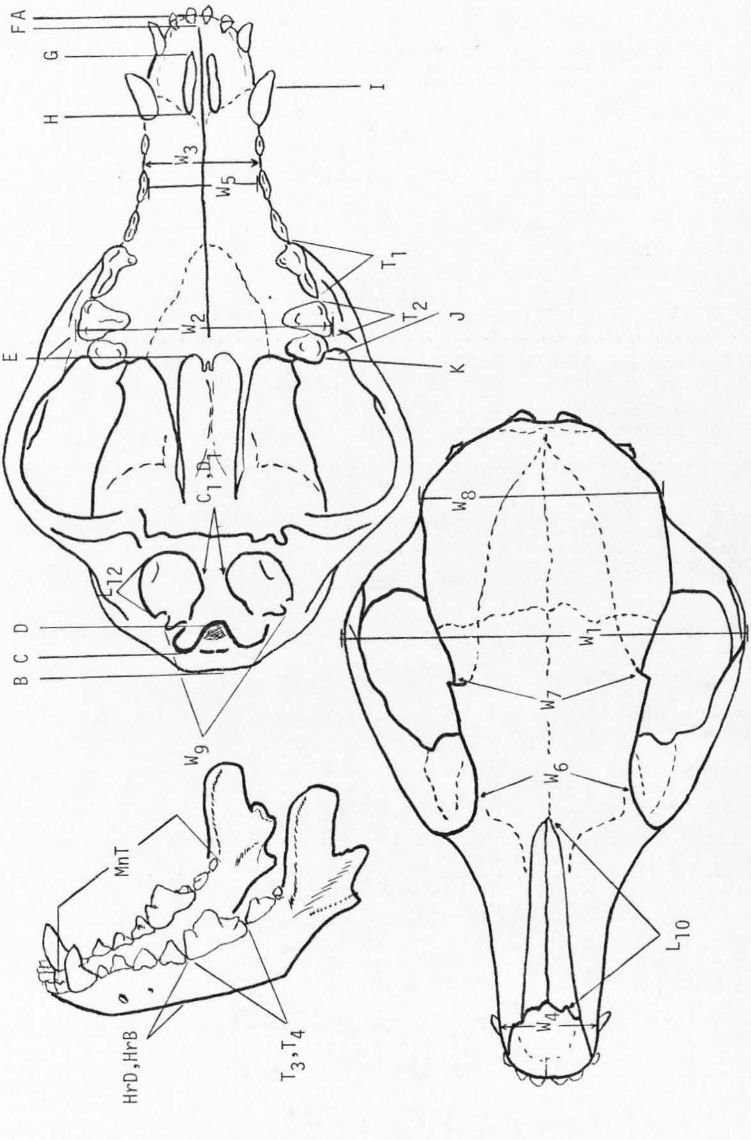
Variables were analyzed using the BMD-07M stepwise discriminant analysis program. In general, stepwise discriminant analysis selects an optimal set of variables that provide maximum separation between reference groups and can be used to classify unknown specimens (Baker et al. 1972, Bowers 1974). This is accomplished by transforming linear combinations of the original variables into uncorrelated principal axes. The first principal axis accounts for the maximum amount of variation in the data, and so on. Usually most of the information contained in the many measurements can be expressed in a two- or three-dimensional plot of the principal component scores (Rohwer and Kilgore 1973).

Results

The 30 variables were evaluated in a stepwise manner using $F = 3.2$ to enter and delete variables. The program stopped when the F-value was insufficient for further computations. Seven significant variables were identified (Table 5). Stepwise analysis with these variables caused three "mistakes" in classifying reference specimens--one in the *arsipus*

Variable number		Designation	Variable number		Designation
1	A-C	Condylobasal length	18	W_5	Palatal width inside Pm^2
2	A-D	Basal length	19	W_6	Interorbital width
3	A-B	Greatest length of skull	20	W_7	Least width of braincase
4	A-E	Palatal length	21	W_8	Greatest width of braincase
5	H-E	Length of palatal bridge	22	W_9	Width at paraoccipital processes
6	F-E	Palatar length	23	C_1	Width between bullae
7	E-D	Postpalatal length	24	D_1	Depth of bullae
8	E-C	Palate-occipital condyle length	25	T_1	Alveolar length of Pm^4
9	H-C	Incisive foramen to occipital condyle	26	T_2	Crown length of M^1
10	L_{10}	Nasal length	27	T_3	Length of M_1
11	G-H	Incisive foramen length	28	T_4	Breadth of M_1
12	L_{12}	Auditory bulla length	29	I-K	Length of maxillary tooth row
13	I-J	Rostrum length	30	MnT	Length of mandibulary tooth row
14	W_1	Zygomatic breadth	31	HrD	Horizontal ramus depth
15	W_2	Palatal width at M^1	32	HrB	Horizontal ramus breadth
16	W_3	Breadth of rostrum	33	H_1	(height of auditory meatus) and
17	W_4	Outside breadth of rostrum	34	T_5	(canine tooth) not shown

Figure 6. Kit fox skull characteristics measured for analysis


F A
G
H
I
W_3
W_5
T_1
T_2
J
E
K
W_2
C_1, D_1
L_{12}
B C D
W_9
W_8
W_1
W_7
W_6
MnT
L_{10}
HrD, HrB
T_3, T_4
W_4

group and two in nevadensis (Table 6). Three unknowns were classified V. m. arsipus, and three were classified V. m. nevadensis. Note that the unknowns were scattered among the nevadensis and arsipus specimens (Figure 7).

Canonical variables are computed in such a way that the variance between groups is maximized relative to the variance within the groups. It is possible to determine which of the seven significant variables account for the variation found within each canonical variable by computing the standardized canonical variate (SCV) coefficient. This is done by multiplying the coefficient for the canonical variable in question by the pooled standard deviation for the proper skull measurement. The SCV's with the highest coefficients make the greatest contribution to the discriminant power of their respective canonical variable (Davis and Baker 1974). Table 7 gives the SCV's for the first three canonical variables and the canonical variate coefficients evaluated at group means. Canonical variable I (with greatest width of the brain case, palate-occipital condyle length, and crown length of M^1 contributing most of the variation) separates neomexicana from the other three groups (Figure 8). Variable II (palatal width at M^1, palatal width inside Pm^2, and depth of bullae) separates arsipus from nevadensis, and Variable III (length of the nasal bones) separates the unknowns from arsipus.

Discussion

The morphometric differences between V. m. arsipus, nevadensis, and neomexicana are significant (Figures 7 and 8), but multivariate analysis is required to show the separation. For example, arsipus and

Table 5. Seven significant variables as determined by stepwise discriminant analysis of 30 kit fox skull variables

Step		Variable	F-value[a]
1	8	Palate-occipital condyle length	165.13
2	24	Depth of bullae	19.51
3	15	Palatal width at M^1	10.35
4	18	Palatal width inside Pm^2	13.20
5	21	Greatest width of braincase	6.34
6	26	Crown length of M^1	6.57
7	10	Nasal length	4.92

[a]F = 3.2 to enter and delete variables; $p < 0.05$, df = 2,40.

Table 6. Number of kit fox specimens classified into each taxonomic group and posterior probabilities of each unknown specimen belonging to each reference group

Group	arsipus	nevadensis	neomexicana
arsipus	15	1	0
nevadensis	2	22	0
neomexicana	0	0	13
unknown	3	3	0
Specimen		Probabilities	
UC #7579	100.0	--	--
UC #7580	4.7	95.3	--
PC #17	94.2	5.8	--
PC #18	2.3	97.7	--
UU #22903	45.3	54.7	--
UU #15128	97.7	2.3	--

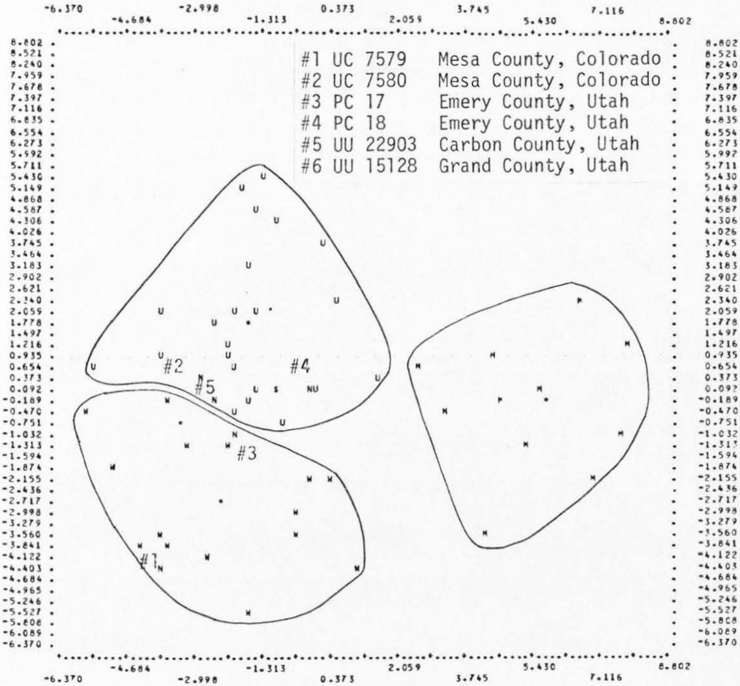


Figure 8. Fifty-five kit fox specimens projected on the first two canonical variables[1]

[1] Symbols: U = <u>nevadensis</u> group
W = <u>arsipus</u> group
M = <u>neomexicana</u> group
N = <u>unknown</u> group
* = group means
$ = overlap

Table 7. Standardized canonical variate coefficients for the seven significant variables and the canonical variate coefficients evaluated at group means

Original variable[a]	Canonical variables[b] I	II	III
Palate-occipital length	1.905	0.802	-1.697
Depth of bullae	0.512	1.222	0.119
Palatal width at M^1	0.129	1.703*	1.218
Palatal width inside Pm^2	-0.528	-1.433	-0.326
Braincase width	2.340*	-0.644	-0.270
Crown length of M^1	1.705	-0.311	0.014
Length of nasals	-0.621	-0.966	1.966*
Groups	Groups means[c]		
arsipus	-2.28	-2.59	0.00
nevadensis	-1.62	1.88	0.00
neomexicana	5.80	-0.28	0.00
unknown	-3.37	-0.83	1.33

[a]For identification of variables, see Figure 6.

[b]Asterisks indicate characters best explaining variation.

[c]Plotted on Figure 8.

nevadensis are significantly different when the seven variables are considered jointly, but they overlap with respect to each of the same seven variables considered individually (Figure 9). Only palate-occipital condyle length (variable 8) separates neomexicana from arsipus and nevadensis without any other measurements, and variable 8 would

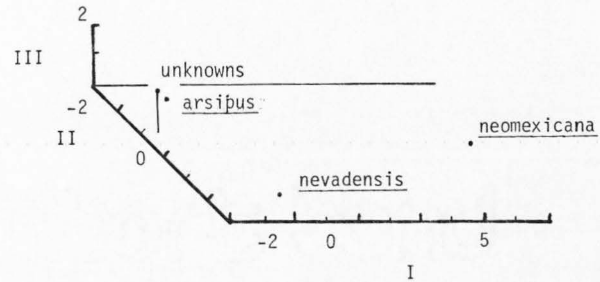


Figure 8. Three-dimensional projection of the first three canonical variables evaluated at group means

misclassify two nevadensis reference specimens as neomexicana. The East Desert skulls (unknowns) are more similar to the arsipus/nevadensis group. This implies 1) gene transfer with the West Desert and/or Washington County and 2) isolation from the New Mexico subspecies. The Colorado River has apparently provided the genetic barrier.

Conclusions

Sample sizes were small for analysis by accepted systematic methods (i.e., Lidicker 1962, Mayr 1969), but the data presented above

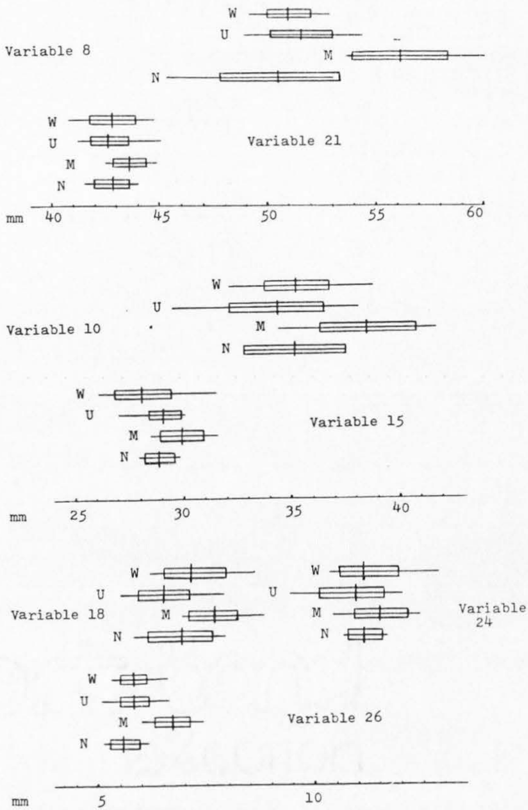


Figure 9. Range, means, and standard deviations of the seven significant kit fox skull variables[1]

[1]The horizontal line represents the range, the vertical line the mean, and the rectangle one standard deviation. Note the overlap of all of the variables except number 8 (palatal-occipital condyle length). For identification of the other variables see Figure 6.

W = the arsipus group (Washington County); U = nevadensis group (West Desert); M = neomexicana group (New Mexico); N = unknowns (East Desert).

suggest that the reference groups for arsipus, nevadensis, and neomexicana represent distinct populations that are significantly different from each other in some characteristics, especially the size of the braincase and rostrum. Until further collecting and analysis is completed, the three groups should be considered valid subspecies, at least in Utah, on the basis of their habitation of definite geographical areas, partial isolation from each other, and the results of the multivariate analysis. The East Desert foxes (i.e., the unknowns) are tentatively assigned to V. m. nevadensis.

CHAPTER V

HABITAT CHARACTERISTICS

Methods and Procedures

In response to a request for his opinion on possible factors limiting kit fox distribution in the state, Egoscue wrote:

> ... I have finally come to believe that the flatness of the terrain and sparseness and or height of the vegetation limit kit foxes more than type of soil, which is (of) secondary importance. Distribution in Utah is mainly limited to the Bonneville Basin. (personal communication)

Egoscue also noted that he had never encountered kit foxes above 5,000 feet (1,524 m) in elevation. It was decided to investigate kit fox habitat in terms of these general characteristics, and to use environmental data available from state and federal agencies in Utah.

A total of 92 sightings at 82 locations were plotted on a 1: 1,000,000 scale base map (see Appendix for locations). This map was then used as an overlay on a vegetative cover map provided by the Soil Conservation Service and on the soil map from Wilson et al. (1975). Cover type and soil type were recorded for each location, along with elevations determined from U.S. Geological Survey topographic maps (200 feet/61 m contour intervals). Other habitat information was derived from SCS Range Site Descriptions and from Shelford (1963).

Ten locations, chosen subjectively to represent specific regions and "typical" communities within each region, were examined in the field for comparison with the description developed above. The dominant plant species were identified, and the average height of the vegetation and percent ground cover were determined by the line-intercept method

(Canfield 1941). Soil samples were taken from the surface and from 10 to 20 cm below the surface. Finally, each site was described in terms of land use, proximity to human activity, and surface features in the immediate vicinity. Correspondence with the general description was judged to be sufficient to allow the use of the method to develop a habitat description applicable to the entire state (see Appendix for summary).

Results

Soils

Kit foxes were recorded on eight of the 19 broad soil groups and 17 of the 67 soil associations recognized in Utah by Wilson et al. (1975). Ninety-seven percent of the sightings were on the seven associations identified as desert soils or land types. The desert soils are light-colored and typically in the loam textural class, with high percentages of sand and silt. Most are moderately deep to deep, permeable, and well-drained. Annual precipitation averages less than 14 inches (35 cm), and Mean Annual Soil Temperature and Mean Summer Soil Temperature (Table 8) separate these associations from more mesic soils. Many of these soils have a gravelly or rocky surface layer (desert pavement) and a hardpan from 6 to 20 inches (15-50 cm) below the surface.

Vegetation

Three plant communities--shadscale (Atriplex confertifolia), sagebrush (Artemesia tridentata), and pinyon-juniper (Pinus and Juniperus spp.)--cover about 75 percent of the Intermountain Region (Cronquist et al. 1972). A fourth community, creosote bush (Larrea tridentata) enters Utah at altitudes below 4,000 feet (1,220 m) in Washington County.

Table 8. Soil types associated with kit fox sightings in Utah

Soil groups and associations[a]	MAST[b]	MSST[c]	Number of sightings
G. Dark soils of lake terraces, alluvial fans, and valley bottoms. West front of the Wasatch Mountains south to Levan	47-59° F (8-15° C)	>59° F (15° C)	
Associations: 26 and 27			3
M. Light-colored desert soils. Extensive in western Utah	47-59° F (8-15° C)	>59° F (15° C)	
Associations: 47 through 50			12
N. Light-colored desert soils. West-central Utah and widely separated areas in eastern Utah	47-59° F (9-15° C)	>59° F (15° C)	
Associations: 51 through 55			24
O. Light-colored desert soils. Southwestern Utah only	--	>59° F (15° C)	
Associations: 56 through 59			9
P1. Sodic-saline soils. River bottoms and flood plains in larger valleys of western Utah	--	--	
Association: 60			11

Table 8. Continued

Soil groups and associations[a]	MAST[b]	MSST[c]	Number of sightings
P2. Highly erodable soils of eastern and southeastern Utah in Colorado and Green River drainages	--	--	
Association: 63			11
P3. Dominantly sandy soils	--	--	
Associations: 65 and 66			11
Q. Miscellaneous desert land types:			
Rockland. Colorado and Virgin river drainages	--	--	
Association: 68			4
Playas. Great Basin, especially the Great Salt Lake Desert and other parts of the Bonneville Basin	--	--	
Association: 71			7
		Total	92

[a]For detailed descriptions of the soil groups and associations see Wilson et al. (1975).

[b]Mean annual soil temperature

[c]Mean summer soil temperature

All kit fox sightings in Washington County were in either creosote bush or shadscale (Table 9). None of the sightings were in the higher blackbrush (Colegyne ramosissima) association. Kit foxes were found throughout the shadscale zone in both the East and West deserts. This zone is a mosaic of plant associations including shadscale, greasewood (Sarcobatus vermiculatus), and winterfat (Eurotia lanata). Sagebrush and sagebrush-bunchgrass replace shadscale in deep, salt-free soils, generally beginning above 5,000 feet (1,524 m). There were nine kit fox sightings in this zone. Much of the irrigated farmland in the Intermountain Region was originally vegetated with sagebrush, and patches of brush are often found adjacent to cultivated fields. No kit foxes were reported from the pinyon-juniper zone, which generally begins above 5,500 feet (1,676 m) on rocky hillsides.

The most important characteristic of the vegetation seemed to be the structure of the plant community, especially the percent of ground cover and the average height of the vegetation. Even in sagebrush, which can be tall and rank, kit foxes were only seen where the plants were widely scattered.

Elevation

The average elevation of kit fox sightings in the West Desert was about 4,800 feet (1,463 m), with 78 percent of the sightings at or below 5,000 feet (1,524 m). East Desert sightings averaged about 100 feet (30.5 m) higher (Table 10). Only about 52 percent of the East Desert locations were at 5,000 feet or less; 87 percent were less than 5,500 feet (1,676 m). The Washington County sightings averaged 3,500 feet (1,068 m). Of 92 sightings for the state, 68 (74 percent) were at 5,000 feet or less, and 83 (90 percent) were 5,500 feet or less.

Table 9. Distribution of kit fox sightings in Utah by vegetative cover type

Region	Vegetative cover type[a]									
	S	Sd	Sg	B	G	D_1	D_2	I_1	I_2	W
West Desert	--	33	9	3	4	1	2	1	4	1
Washington County	10	1	--	--	--	--	--	--	--	--
East Desert	5	12	--	2	4	--	--	--	--	--
	15	46	9	5	8	1	2	1	4	1

[a]Cover types as follows:

S = southern desert shrub (Larrea, Colegyne)
Sd = salt desert shrub (shadscale zone)
Sg = sagebrush
B = barren
G = grasses and forbs
D_1,D_2 = non-irrigated cropland
I_1 = irrigated cropland
W = wet meadow

Table 10. Elevations of kit fox sightings

Region	Number of sightings	Elevation (feet/meters)		
		Mean	s.d.	Extremes
West Desert	58	4,836/1,475	± 458/140	4,200-6,100/1,248-1,860
Washington County	11	3,518/1,073	± 525/160	2,400-4,500/ 732-1,373
East Desert	23	4,922/1,501	± 481/147	3,800-5,800/1,158-1,768

Climate

Kit fox habitat in Utah is hot and dry. Summer temperatures for much of the West Desert and Washington County often exceed 100° F (Table 11), and mean annual precipitation is less than 12 inches (30 cm). In the East Desert the mean annual precipitation is less than 10 inches (25 cm). Snowfall is limited in all three regions, although blizzards in the West Desert occasionally drop large amounts of snow in short periods.

The Freeze-Free Season (the average period, in days, at 50 percent probability level, between the last spring frost and the first fall frost) identifies broad areas of the state with similar climates (Ashcroft and Richardson 1975). The FFS for the 92 sightings was determined (Appendix, Table 20), and the results are summarized in Table 12. Ninety percent of the kit fox sightings were in areas with an FFS of 120 days or more, and no kit foxes were reported from any area with a FFS less than 100 days or an average annual minimum temperature of less than -15° F.

Table 11. Mean temperature maximums and minimums for January, July, and the year in Utah

Region[a]	January mean, °F		July mean, °F		Annual
	Maximum	Minimum	Maximum	Minimum	Mean
West Desert	32-40	12-16	88-94	52-60	49.1
Washington County	52	24	100	64-68	60.9
East Desert	32-44	8-20	92-96	56-66	51.4

[a]Data from Jeppson et al. (1968)

Table 12. Distribution of kit fox sightings in Utah by length of the Freeze-Free Season

Freeze-Free Season (days)[a]	Number of sightings: West Desert	Washington County	East Desert	Annual minimum temperature (°F)[b]
100-119	9	--	--	-15
120-139	24	1	8	-10
140-159	19	2	2	- 5
160-179	6	1	11	0
180-199	--	2	--	+ 5
200-219	--	5	2	+10

[a]From Ashcroft and Richardson (1975)

[b]Richardson, unpublished manuscript

The Winter Severity Index (S_w) is a further description of winter climate. S_w for any location is calculated as follows (Richardson, unpublished manuscript):

$$S_w = \frac{(100 - T_a)}{68} + \frac{S_t}{75} + \frac{D_o}{90} \times 100$$

where winter is defined as December, January, and February, and

T_a = average winter temperature,

S_t = total winter snowfall, and

D_o = number of days during the winter with a temperature of 0° F or less

Figure 10 gives the S_w for several weather stations and shows approximate winter severity zones for the state.

S_w for most of the 92 kit fox sighting locations was less than 150, but for the six stations in the Uinta Basin, S_w averaged almost 170. This is significantly higher than the mean for either the East Desert or

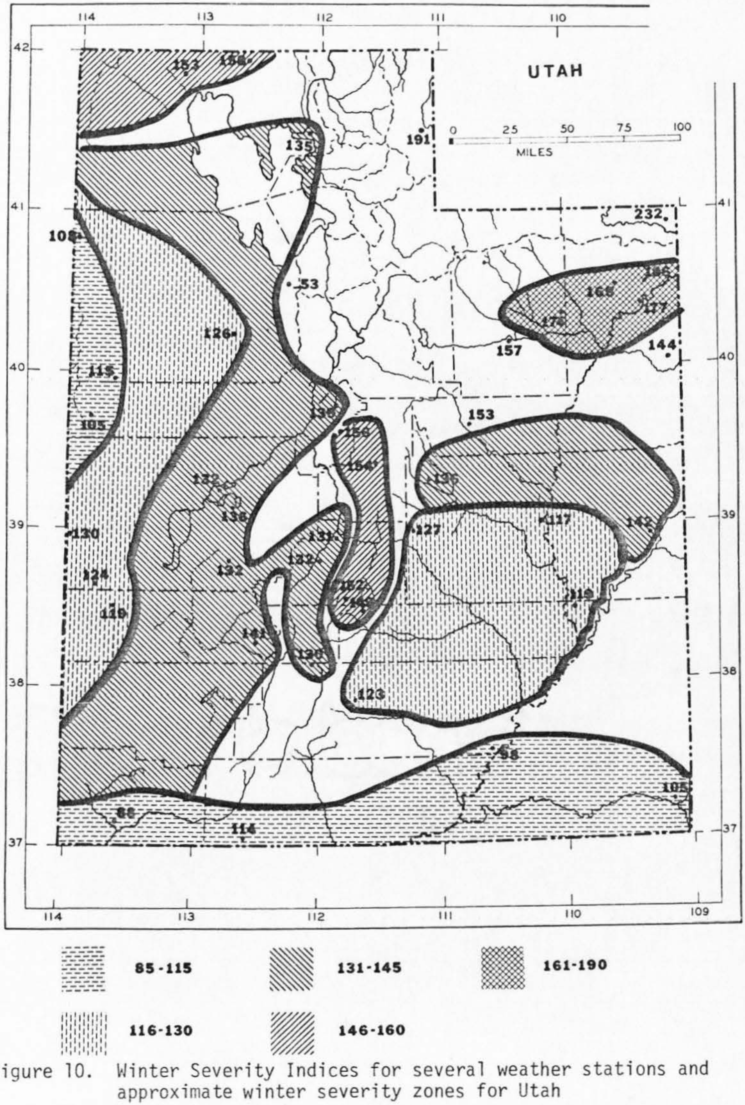


Figure 10. Winter Severity Indices for several weather stations and approximate winter severity zones for Utah

the West Desert ($t = 5.6$ and 4.6, respectively; $p < 0.01$), due largely to the lower average winter temperature and more days with a minimum temperature less than 0° F (Table 13).

Other factors

The kit fox has been described as a weak digger (Grinnell et al. 1937). If this is true, the desert pavement and hardpan must constitute a formidable barrier to denning. Observations made during the present study suggest that kit foxes depend on other burrowing animals for dens. The badger (Taxidea taxus) is a primary source of kit fox dens. Every den examined in the West Desert was an enlarged badger hole. Most were on level ground, but one (A10) was dug into the road bed of the Union Pacific railroad north of Milford. Other burrows may also be remodeled by kit foxes. Den A18 was an abandoned prairie dog (Cynomys leucurus) mound.

When the soil is unsuitable for burrowing, kit foxes find other underground refuges. Dens A17 and A24 were wood rat (Neotoma spp.) dens located under a caprock at the top of a mesa. Neighboring holes were still occupied by woodrats. At Knolls (B19) a female kit fox denned in an old wooden culvert under a dune of drift sand. The most unusual den was a muskrat (Ondrata zibethicus) "house" used by a pair of kit foxes at Ogden Bay Refuge in 1971.

Kit foxes apparently do not need free water. They avoid heat stress by remaining inactive in the den during the day, and appear to have physiological adaptations for water conservation (Denver Wildlife Research Center 1975). Many of the sightings reported in the present study were several miles from the nearest water.

Table 13. Test for the difference between means of average winter temperature, total snowfall, days with a minimum temperature below 0° F, and the Winter Severity Index using Student's t-test

Region	Number of weather stations	Means			
		T_a	S_t	D_o	S_w
West Desert	19	30.9	17.5	8.1	134
Washington County	1	41.9	2.0	0.0	88
East Desert	11	31.8	12.3	6.0	123
Uinta Basin	6	20.9**	15.3	28.0**	168**

**Means for T_a, D_o, and S_w in the Uinta Basin were significantly different ($p < 0.01$) than corresponding values for both the West Desert and the East Desert.

Discussion

Information from the 92 sightings agreed with Egoscue's description (see page 34 above) in principle, but not in specific values. Elevation, for instance, was important, but the 5,000 feet (1,524 m) altitudinal limit suggested by Egoscue included only 74 percent of the sightings, while a 5,500 feet (1,676 m) limit included 90 percent.

Desert shrub vegetation was also important. Eighty-two percent of the sightings were in salt desert, southern desert, or sagebrush cover types, or on "barren ground" (sparsely vegetated playas or salt flats in the West Desert and rocklands in the East Desert). The most important feature of the vegetation seemed to be the ground cover--both horizontal and vertical--as suggested by Egoscue's description.

In contrast to Egoscue's statement that soils are of secondary importance, the data suggested that desert soils do have characteristics that are significant to kit foxes. Over 95 percent of the sightings occurred on the seven desert soil groups or desert land types. The reason may be related to the structure of the soil: it must be fine and allow the construction of some sort of burrow.

Taken together, a 5,500 feet altitudinal limit, desert shrub vegetation, and desert soils were associated with 73 percent of the sightings. Also, the six sightings in the West Desert with elevations greater than 5,500 feet (B14 and B15; A4, 5, and 6; A8, A20) had soils and vegetation similar to those of lower locations. Several other cover types are related to the desert shrub types. The desert east of the Green River (Grand County) is mapped "G" (grasses and forbs) by the Soil Conservation Service, but also contains scattered salt-desert shrubs. Similarly, cover types I_2, D_1, and D_2 still have scattered patches of natural vegetation along the margins of the cultivated fields. Morrell (1975) found that San Joaquin kit foxes can survive in these remnant patches of natural vegetation even after most of the land is converted to agriculture.

This general description does not explain why kit foxes do not occur in the Uinta Basin. In terms of elevation, soil type, and vegetation, much of the Basin should be ideal kit fox habitat. Geographical isolation is undoubtedly a factor, but foxes have overcome similar barriers in entering the East Desert.

The data suggest that severity of winter weather is probably a limiting factor in the Basin. The effect may be indirect, such as limitations of the prey of the kit fox or of vegetation that supports the prey. Kangaroo rats (Dipodomys spp.) and jackrabbits (Lepus spp.) are the principal items in the kit fox diet (Egoscue 1962, Laughrin

1970). Only one species of each occurs in the Basin, as compared to two or three species of each in the other regions (Hall and Kelson 1959, Sparks 1974).

The limitation may also be direct. The kit fox is a relatively small animal (average weight: 4 pounds/1.8 kg) with no specializations for cold climates. Its mobility would be limited by deep or persistent snow, and because of its small size, it might have difficulty thermoregulating in sustained frigid weather.

Winter weather may also explain kit fox occurrence in Box Elder County. Foxes are rarely seen in the northern part of the county where S_w exceeds 150 (Park Valley = 153, Snowville = 158). They are more common along the edges of the Great Salt Lake where the winter weather is mild by comparison (S_w for Bear River Refuge = 135) due to the moderating influence of the water.

Conclusions

In considering this habitat description, two points should be recognized. First, the four characteristics are not physical or physiological barriers (with the possible exception of winter severity). Rather, the description expresses a probability of finding kit foxes in areas of the state with these characteristics, based on the findings of this study.

Also, the habitat characteristics are not necessarily listed in order of importance, and, in fact, may not even be the determining factors. It is more likely that the prey base ultimately determines the distribution of the kit fox in the state, a relationship best expressed as follows:

climate--soil--vegetation--herbivores--kit foxes

A statewide survey of food habits of the kit fox would be necessary to confirm this relationship.

The validity and usefulness of the habitat description was demonstrated by two weeks of field work conducted in the East Desert after formulation of the description. Sightings A17, A18, and A23 through A25 (Emery and Wayne counties) and sightings A26 and A27 (Grand County) collected during this period came from areas with the proper habitat characteristics but no previous reports.

CHAPTER VI

DISCUSSION--THE KIT FOX IN UTAH

Distribution

Kit fox distribution in Utah prior to European settlement is unknown, but it is possible to infer potential distribution from the habitat description and from the taxonomic and distribution information gained in this study. Potential kit fox distribution (Figure 11) is based on 115 sightings reported from 1974 to 1976 plus the four components of the habitat description. "Known" distribution is derived from confirmed sightings and is thus analogous to distribution maps in Durrant (1952) or Hall and Kelson (1959). Range extensions in central Utah and in Carbon, Emery, Grand, Wayne, and Garfield counties added approximately 4,600-square miles (12,000-square kilometers) to the known range of the kit fox in the state.

In addition to the confirmed distribution, the kit fox probably inhabits a large area of San Juan County. This area has the proper habitat characteristics and is contiguous with known distribution in Colorado (Egoscue 1964) and New Mexico (Findley et al. 1975). Two unconfirmed sightings were reported in this area during 1976 (Figure 5: C29, D3). Kit foxes would probably be found in most of the canyons on the Navajo Reservation, and would likely be referable to _V. m. neomexicana_.

"Possible" distribution is inferred from the habitat description and morphometric characteristics of the eastern Utah specimens. Occurrence in Kane County is speculative. Surveys of the Glen Canyon

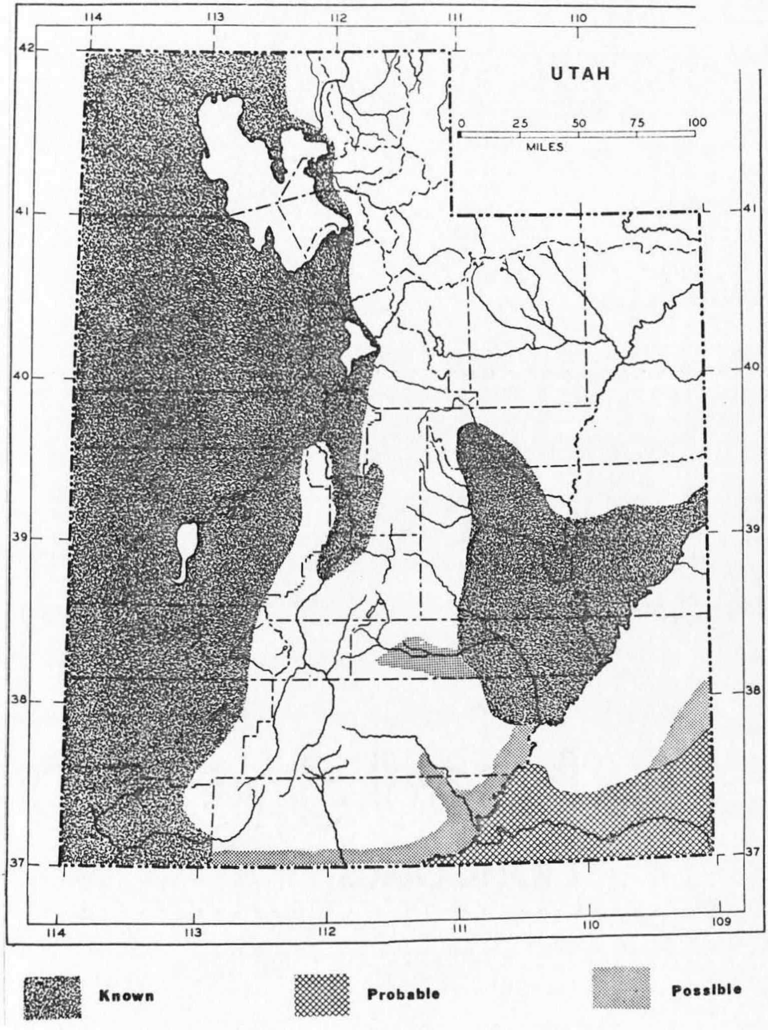


Figure 11. Potential kit fox distribution in Utah

conducted by the University of Utah (Woodbury 1958, 1959) did not mention kit foxes in either the contemporary fauna or archaeological sites, although both the red fox (V. vulpes) and grey fox were noted. Questionnaire returns suggested that kit foxes are not common in the area, but some residents of Kane County insist that kit foxes were abundant until a few years ago. They attribute the decline to competition from grey foxes.

The Glen Canyon studies were primarily concerned with the part of the canyon to be flooded by Lake Powell and may have overlooked the kit fox. Dr. Durrant, project mammalogist, collected numerous small mammals, but accounts of larger species were based on "sign" and chance observations. Nocturnal kit foxes would be less likely to be seen than the more crepuscular red and grey foxes.

Cronquist et al. (1972) described the part of Kane County in question as an extension of the floristic community of Washington County. Kit fox occurrence in this corridor and along the north bank of the Colorado River would explain the similarity of three East Desert specimens to the arsipus (Washington County) reference group, but would do little to explain the nevadensis characteristics of the other three specimens. There are two possible explanations for these nevadensis characteristics: either nevadensis has successfully invaded the East Desert from the Great Basin or the nominal subspecies arsipus and nevadensis are, in fact, a single subspecies whose members differ slightly in size at the geographic extremes of its range.

Invasion of the East Desert from the west seems unlikely. Foxes would have to withstand harsh winters and pass through conifer forests at elevations greater than 7,000 feet (2,100 m). There have been reports of kit foxes near Loa and Capitol Reef National Park (eastern Wayne County), but these have not been confirmed. On the other hand, discriminant analysis separated the *arsipus* and *nevadensis* reference groups, suggesting the Washington County and West Desert kit foxes are distinct populations. Three specimens from Milford, only 100 miles (161 km) north of Washington County, had typical *nevadensis* characteristics and little affinity to *arsipus*.

Further field work would be necessary to resolve the taxonomic status of the East Desert foxes. Collecting along possible invasion routes would test the invasion hypothesis. If kit foxes were found, their morphological characteristics would indicate their subspecific identity. Discriminant analysis of skulls collected along north-south lines in Nevada and western Utah would reveal any trend from *nevadensis* to *arsipus* characteristics, and thus test the second hypothesis.

Status

Except in local areas, the threat of large scale conversion of native habitat to agricultural and industrial uses does not exist in Utah. Over 75 percent of the thousands of square miles of kit fox habitat in Utah are public lands used primarily for grazing. Kit foxes are abundant in western Tooele, Juab, and Millard counties in the West Desert, and in Carbon, Emery, and Grand counties in eastern Utah. Soils in most of these areas are too alkaline for crops. There is insufficient water for irrigation, and availability of irrigation water in the near future is unlikely. In areas where the desert has been converted to agriculture (e.g., eastern Millard County), kit foxes live in patches of natural vegetation along the edges of cultivated fields.

Kit fox populations near centers of human population are under greater pressure. New housing developments near St. George and Washington are being built in prime kit fox habitat. Intensive agriculture and the completion of U.S. Interstate 15 in Box Elder and Weber counties may have reduced kit fox populations in that area. Energy development in eastern Utah probably will not affect kit fox populations directly since most coal and oil shale deposits do not coincide with kit fox habitat. However, the indirect effects (i.e., ORV's, night hunting, highway and home construction) resulting from increased human populations may become important.

Field workers agreed almost unanimously (95 percent) that kit foxes are about the same or are less common than in past years (Table 14). This is a subjective judgment based largely on chance sightings, but it is a fairly good sample since most wildlife workers keep records that are sufficiently detailed to compare sightings from year to year.

The same subjective elements exist in opinions of mortality factors, but again, the people contacted are familiar with their areas. About half of the questionnaire returns agreed that hunting is an important mortality factor (Table 14). Unfortunately, hunters and trappers are not required to report their kills, so there is no way to document their impact.

Importance of road kills and coyote trapping were probably exaggerated by the questionnaire returns. Fewer than a dozen road kills were seen in two years and approximately 20,000 miles (32,200 km) of driving on this project. Coyote control is also limited in its impact since the ban on the use of toxicants on public land. Control efforts

Table 14. Kit fox abundance trends and mortality factors from questionnaire returns

Question	Replies--number and percent 1975		1976	
Would you say that kit foxes are				
more common	1	4	2	5
less common	10	37	12	30
about the same	16	59	26	65
this year as compared to past years?				
Would you say that any of the following are important mortality factors in your area?[a]				
varmint/night hunters	10	42	16	57
road kills	7	29	9	32
fur trapping	17	71	14	50
coyote control	6	25	11	39

[a]Based on 25 respondents in 1975 and 28 respondents in 1976. Respondents could mark more than one factor.

are now concentrated on aerial gunning which has no deleterious effect on non-target predators (D. Hawthorne, personal communication).

Management

At the present time there are no special statutes or management policies relating to the kit fox in Utah, and apparently none are needed. Kit foxes are abundant in at least some parts of the state, and they are unlikely to become threatened as a species anywhere in the state in the foreseeable future. However, it would be advisable to establish a system for monitoring population levels in areas where human pressures are increasing rapidly (e.g., Emery and Washington counties). This could be accomplished by permanent spotlight transects (Morrell 1975), annual reports from trappers and furbuyers, or questionnaires similar to those used in this project.

Kit foxes do present an unusual opportunity for non-consumptive use, namely "fox watching." They are easily approached and can provide hours of fascinating observations. Unfortunately, the public is usually unaware of this opportunity. The UDWR, cooperating with other agencies, could prepare educational programs for parks and recreation areas to acquaint people with this interesting canid. Yuba Lake State Recreation Area, the BLM Little Sahara Recreation Area (Juab County), and Goblin Valley State Reserve (Emery County) would be ideal locations for such a project.

LITERATURE CITED

Anderson, S. 1972. Mammals of Chihuahua/taxonomy and distribution. Bull. Am. Mus. Nat. Hist. 148(2):149-410.

Anonymous. 1972. Kit fox. Dinny's Digest 1(12):12. Calgary Zool. Soc., Calgary, Alberta.

Armstrong, D. M. 1972. Distribution of mammals in Colorado. Monogr. No. 3., Mus. Nat. Hist., Univ. Kansas. 415 p.

Ashcroft, G. L., and E. A. Richardson. 1975. Freeze-Free Season. State of Utah. Utah Agric. Exp. Stn. Bull. 486. Map.

Baker, R. J., W. R. Atchley, and V. R. McDaniel. 1972. Karyology and morphometrics of Peters' tent-making bat, Uroderma bilobatum Peters (Chiroptera, Phyllostomatidae). Syst. Zool. 21:414-429.

Bowers, J. H. 1974. Genetic compatibility of Peromyscus maniculatus and Peromyscus melanotis, as indicated by breeding studies and morphometrics. J. Mammal. 55(4):720-737.

Cain, S. A., J. A. Kadlec, D. L. Allen, R. A. Cooley, M. G. Hornocker, A. S. Leopold, and F. H. Wagner. 1972. Predator control--1971. Inst. for Environ. Qual., Univ. Michigan, Ann Arbor. 207 p.

Canfield, R. H. 1941. Application of the line intercept method in sampling range vegetation. J. For. 39:388-394.

Choate, J. R., and H. H. Genoways. 1975. Collections of recent mammals in North America. J. Mammal. 56(2):452-502.

Cockrum, E. L. 1960. The recent mammals of Arizona: their taxonomy and distribution. University of Arizona Press, Tucson. 276 p.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal. 1972. Intermountain flora. Vol. one. Hafner Publ. Co., New York. 270 p.

Cushwa, C. T., and K. P. Burnham. 1974. An inexpensive live trap for snowshoe hares. J. Wildl. Manage. 38(4):939-941.

Davis, B. L., and R. J. Baker. 1974. Morphometrics, evolution, and cytotaxonomy of mainland bats of the genus Macrotus (Chiroptera: Phyllostomatidae). Syst. Zool. 23(1):26-39.

Denver Wildlife Research Center. 1975. Annual report--Research highlights. U.S. Fish and Wildl. Serv., Denver. 21 p. (mimeogr.)

Durrant, S. D. 1952. Mammals of Utah/taxonomy and distribution. Univ. Kansas Publ., Mus. Nat. Hist. 6:1-549.

Egoscue, H. J. 1956. Preliminary studies of the kit fox in Utah. J. Mammal. 37(3):351-357.

-----. 1962. Ecology and life history of the kit fox in Tooele County, Utah. Ecology 43(3):481-497.

-----. 1964. The kit fox in southwestern Colorado. Southwest. Nat. 9(1):40.

-----. 1973. Kit fox critique. 1/15/73. Available from the Conservation Library, Denver Public Library. 6 p. (typed)

-----. 1975. Population dynamics of the kit fox in western Utah. Bull. South. Calif. Acad. Sci. 74(3):122-127.

----- and J. C. McGrew. An annotated bibliography of Vulpes macrotis--Vulpes velox literature. Unpubl. ms.

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque. 360 p.

Grinnell, J., J. S. Dixon, and J. M. Linsdale. 1937. Furbearing mammals of California. Vol. 2. University of California Press, Berkeley. 777 p.

Hall, E. R. 1946. Mammals of Nevada. University of California Press, Berkeley. 710 p.

----- and K. R. Kelson. 1959. Mammals of North America. Two vols. Ronald Press, New York. 1,083 p.

Hardy, R. 1945. The influence of types of soil upon the local distribution of some mammals in southwestern Utah. Ecol. Monogr. 15(1): 71-108.

Harris, A. H. 1963. Ecological distribution of some vertebrates in the San Juan Basin, New Mexico. Mus. New Mexico Pap. Anthropol. No. 8. 63 p.

Hildebrand, M. 1954. Comparative morphology of the body skeleton in recent Canidae. Univ. California Publ. Zool. 52:399-470.

Hodge, M. W., and D. S. Haverty. 1974. Survey of the mammals of Antelope Island State Park. Proc. Utah Acad. Sci., Arts, and Letters 5(1):62-65.

Hunt, C. B. 1974. Natural regions of the United States and Canada. W. H. Freeman, San Francisco. 725 p.

Jaeger, E. C. 1957. The North American deserts. Stanford University Press, Stanford. 308 p.

Jensen, C. C. 1972. San Joaquin kit fox distribution. U.S. Bur. Sport Fish. and Wildl., Div. Wildl. Serv., Sacramento. 22 p.

Jeppson, R. W., G. L. Ashcroft, A. L. Huber, G. V. Skogerboe, and J. M. Bagley. 1968. Hydrologic atlas of Utah. Utah Water Resour. Lab., Utah Agric. Exper. Stn., Logan. 306 p.

Jolicoeur, P. 1959. Multivariate geographical variation in the wolf Canis lupus L. Evolution 13(3):283-299.

Laughlin, J. M. and A. L. Cooper. 1973. A range extension of the kit fox in Oregon. Murrelet. 54(2):23.

Laughrin, L. 1970. San Joaquin kit fox: its distribution and abundance. California Dept. Fish and Game, Wildl. Mgmt. Admin. Rep. 70-2. 20 p.

Leach, H. 1971. Slow squeeze on the San Joaquin kit fox. Outdoor California 32(1-2):26-27.

Leopold, A. S., S. A. Cain, C. M. Cottam, I. N. Gabrielson, and T. L. Kimball. 1964. Predator and rodent control in the United States. Trans. N. Am. Wildl. Nat. Resour. Conf. 29:27-49.

Lidicker, W. Z., Jr. 1962. The nature of the subspecies boundaries in a desert rodent and its implications for subspecific taxonomy. Syst. Zool. 11:160-171.

Linhart, S. B., and F. F. Knowlton. 1975. Determining relative abundance of coyotes by scent station lines. Wildl. Soc. Bull. 3(3): 119-124.

Mayr, E. 1969. Principles of systematic zoology. McGraw-Hill Co., New York. 428 p.

Merriam, C. H. 1888. Description of a new fox from southern California. Proc. Biol. Soc. Washington 4:135-138.

Miller, P. H., and C. J. McCoy, Jr. 1965. Kit fox in Colorado. J. Mammal. 46(2):342-343.

Morrell, S. 1972. Life history of the San Joaquin kit fox. California Fish and Game 58(3):162-174.

-----. 1975. San Joaquin kit fox distribution and abundance in 1975. California Fish and Game, Wildl. Manage. Branch Admin. Rep. 75-3. 27 p.

Olsen, P. F. 1973. Wildlife resources of the Utah oil shale area. Utah Div. Wildl. Resour. Publ. No. 74-2. 146 p.

Ranck, G. L. 1968. Unpublished field notes. Available from the National Fish and Wildlife Laboratory, Fort Collins, Colorado, Field Station.

Rasmussen, D. I. 1958. Mammals of the Wasatch Plateau area. M.S. Thesis, Univ. Utah, Salt Lake City. 159 p.

Richardson, E. A. Calculation of Winter Severity Indices. Unpubl. ms.

Rohwer, S. A., and D. L. Kilgore, Jr. 1973. Interbreeding in the arid-land foxes, Vulpes velox and V. macrotis. Syst. Zool. 22(2): 157-165.

Schitoskey, F., Jr. 1975. Primary and secondary hazards of three rodenticides to kit fox. J. Wildl. Manage. 39(2):416-418.

Shelford, V. E. 1963. The ecology of North America. University of Illinois Press, Urbana. 610 p.

Snow, C. 1973. Habitat management series for endangered species/ Report No. 6. San Joaquin kit fox Vulpes macrotis mutica. U.S. Bur. Land Manage. Tech. Note. 23 p.

Sparks, E. A. 1974. Checklist of Utah mammals. Utah Div. Wildl. Resour. Publ. No. 74-3. 33 p.

Stock, A. D. 1970. Notes on mammals of southwestern Utah. J. Mammal. 51(2):429-433.

Swick, C. D. 1973. San Joaquin kit fox: an impact report of secondary hazards aerial application of 1080 grain baits for ground squirrel control in San Luis Obispo County. California Dept. Fish and Game Wildl. Invest. Prog. Rep. W-54-R. 14 p.

U.S. Department of the Interior. 1973. Threatened wildlife of the United States. U.S. Bur. Sport Fish. and Wildl., Resour. Publ. 114. 289 p.

Wilson, L.. M. E. Olsen, T. B. Hutchings, A. R. Southard, and A. J. Erickson. 1975. Soils of Utah. Utah Agric. Exp. Stn., Logan. Bull. 492. 94 p.

Woodbury, A. M. 1958. Preliminary report on biological resources of the Glen Canyon reservoir. Univ. Utah Anthropol. Pap. No. 31. 219 p.

-----, biol. ed. 1959. Ecological studies of flora and fauna in Glen Canyon. Univ. Utah Anthropol. Pap. No. 40. 226 p.

APPENDIX

Table 15. Kit fox questionnaire mailing list, 1975-1976

City[a]	Agency[b]					
	UDWR	BLM	SCS	NPS	Sheriff	Other
Tremonton	75 76		75 76			
Snowville	75 76					
Brigham City	75 76				75 76	76-Bear Refuge
Hooper	76					
Hill AFB						76
Farmington	76					
Salt Lake City	76	75 76				
Murray	75 76					
Tooele	75 76		75 76		75 76	75 76-Tooele Army Depot
Dugway						75 76-Dugway Proving Gnd.
Provo	76		75			
Payson	76					
Santaquin	75 76					
Fish Springs						75 76-USFWS
Mona	76					
Nephi			75		75 76	
Fairview	76					
Delta	75 76					
Manti	76		76		76	
Fillmore	76	75 76	75 76		75 76	
Salina	76					
Richfield	76	75 76	76		76	
Milford	75 76					
Beaver	75		75 76		75 76	
Junction					76	
Paragonah					76	
Parowan	75 76					
Panguitch	76		76		76	
Cedar City	76	75 76	75 76		75 76	
Bryce Canyon				75 76		
LaVerkin	75 76					
Zion				75 76		
St. George	76		75 76		75 76	
Helper	76					
Price	76	75	75 76		76	
Dragerton	75 76					
Castle Dale	76		76		76	
Hanksville	75					
Loa			76		76	
Capitol Reef				75 76		
Bullfrog Basin	75					
Kanab		75 76	75	75	76	
Moab	75 76	76		75 76	75 76	
Monticello	75 76	75 76	75 76		75 76	

Table 15. Continued

City[a]	Agency[b]					
	UDWR	BLM	SCS	NPS	Sheriff	Other
Blanding	75 76			75 76		
Page	75 76			75 76		
Vernal	75 76	75 76	75 76		75 76	
Dinosaur, Colorado				75 76		
Roosevelt	75 76		75 76			
Duchesne	75 76					

[a]Cities are arranged generally from north to south in western Utah, then north to south in eastern Utah, then the Uinta Basin

[b]UDWR = Utah Division of Wildlife Resources
BLM = Bureau of Land Management
SCS = Soil Conservation Service
NPS = National Park Service
USFWS = U.S. Fish and Wildlife Service

Table 16. Museum questionnaire mailing list

Museum and institution	Location
Arizona State University	Tempe
Grand Canyon National Park	Grand Canyon, AZ
Museum of Northern Arizona	Flagstaff
Northern Arizona University	Flagstaff
Organ Pipe Cactus Natl. Mon.	Ajo, AZ
Southwest Research Station, American Museum of Natural History	Portal, AZ
University of Arizona Archaeological Center	Tucson
University of Arizona, Department of Biology	Tucson
California Academy of Sciences	San Francisco
Milton Hildebrand Collection, U. C. Davis	Davis
San Diego Museum of Natural History	San Diego
University of California	Berkeley
University of California	Davis
University of California	Los Angeles
University of Colorado	Boulder
National Fish and Wildlife Laboratory	Denver, CO
National Museum of Natural History	Washington, D.C.
Field Museum of Natural History	Chicago, IL
University of Illinois	Urbana
Ft. Hays State College	Hays, KN
University of Kansas, Museum of Natural History	Lawrence
Harvard University	Cambridge, MA
Michigan State University	East Lansing
University of Michigan	Ann Arbor
University of Nevada	Las Vegas
Eastern New Mexico University	Portales
New Mexico State University	Las Cruces
University of New Mexico	Albuquerque
Western New Mexico University	Silver City
American Museum of Natural History	New York
Cleveland Museum of Natural History	Cleveland, OH
Oklahoma State University	Stillwater
Carnagie Museum	Pittsburgh, PA
Philadelphia Academy of Natural Science	Philadelphia
Angelo State University	San Angelo, TX
Midwestern University	Wichita Falls, TX
North Texas State	Denton
Texas A & M	College Station
Texas Tech	Lubbock
University of Texas	El Paso
Wayland Baptist College	Plainview, TX
Brigham Young University	Provo, UT
University of Wyoming	Laramie

Table 17. Relationship of sites examined in the field to the habitat description

Location[a]	Principle vegetation[b]	Percent ground cover[c]	Average vegetation height	Soil type[d]
1. Preliminary description	S: Dixie grass galleta; creosote bush, mormon tea, snakeweed	5-10	12-20 in. (30-51 cm)	59: old stream terraces and alluvial fans; mostly sandy loams
Validation site: Welcome Springs Wash (T43S, R19W, Sec. 13)	Creosote bush	8	40 cm	sandy
2. Preliminary description	S: see above	5-10	Less than 12 in. (30 cm)	58: hills and low mountains; loamy or clay-loam
Validation site: about T42S, R14W, Sec. 35	Red brome, snakeweed, mormon tea	11	25 cm	sandy with rocks
3. Preliminary description	Sd: Indian ricegrass, greasewood, shadscale, winterfat	5-15	5-15 in. (13-38 cm)	60: valley bottoms, flood plains; loams, silt-loams, clay loams
Validation site: All (17.3 mi./27.8 km N. of Milford)	Greasewood, shadscale, rabbit brush	19	20.5 cm	clay-loam

Table 17. Continued

Location[a]		Principle vegetation[b]	Percent ground cover[c]	Average vegetation height	Soil type[d]
4.	Preliminary description	Sd: Indian ricegrass, black sage, bud sage, shadscale, winterfat	15-20	5-15 in. (13-38 cm)	55: alluvial fans, terraces, mesas; sandy-, silty-, and clay-loams
	Validation site: A20 (23 mi./37 km S. of Garrison)	Indian ricegrass, halogeton, winterfat, <u>Chrysothamnus</u>	7.5	12 cm	clay-loam with gravel and rock pavement
5.	Preliminary description	Sd: as above plus big sagebrush	15-25	Varies: 10 to 25 in. (25-64 cm)	65: terraces and uplands; sand and sandy-loam
	Validation site: A22 (4 mi./6.4 km SE of Delta)	Greasewood, shadscale, halogeton, desert molly	19	41 cm	sandy-loam
6.	Preliminary description	Sd: as above plus galleta, western wheatgrass	15-20	5-15 in. (13-38 cm)	60: valley bottoms, flood plains; deep silty or silty-clay with desert pavement
	Validation site: A2 (22 mi./35.4 km N of U. S. Highway 6-50 on the Gandy Road)	Halogeton, winterfat, shadscale, rabbitbrush, bud sage	7	14 cm	silt-clay with an almost solid pavement of gravel and rocks

Table 17. Continued

Location[a]	Principle vegetation[b]	Percent ground cover[c]	Average vegetation height	Soil type[d]
7. Preliminary description	Sg: Needle-and-thread, Indian ricegrass, big sage, juniper	20-30	Varies: 3 layers of vegetation present	66: sand dunes and rock outcrops
Validation site: B11 (1 mi./1.6 km S. of Willow Springs)	Indian ricegrass, Sporobolus spp., big sagebrush	18	45 cm	sandy
8. Preliminary description	Sd: Galleta, black and bud sage, Indian ricegrass, needle-and-thread	15-20	5-15 in. (13-38 cm)	55: alluvial fans, terraces, mesas; sand and sand-clay loam
Validation site: A23 (13 mi./20.9 km S. of Hanksville)	Galleta, Sporobolus, Mormon tea, Artemesia fillifolia	8	18 cm	sandy clay bank
9. Preliminary description	B: barren	--	--	63: silt loam and silty-clay loam
Validation site: A18 (6.5 mi./10.5 km E. of the Hanksville--I-70	Barren except for very scattered shadscale and grey	<5	--	clay flats

Table 17. Continued

Location[a]		Principle vegetation[b]	Percent ground cover[c]	Average vegetation height	Soil type[d]
	Interchange on I-70 eastbound)	horsebrush			
10.	Preliminary description	Sd: Grama, Sporobolus, Indian ricegrass, bitterbrush, sagebrush, shadscale	15-25	Varies: 10-25 in. (25-64 cm)	65: Terraces and uplands; sand and loamy sand
	Validation site: A17 (about T25S, R11W, Sec. 13)	Indian ricegrass, Mormon tea, big sagebrush, Sporobolus	10	20 cm	sandy with gravel and rock outcroppings

[a]Locations may be found on Figures 4 and 5.

[b]Abbreviations: S = Southern Desert Shrub
Sd = Salt Desert Shrub
Sg = Sagebrush/Grass
B = Barren

[c]Ground cover percentages for the preliminary descriptions are occular estimates from the SCS Range Site Descriptions. Ground cover at validation sites was determined by the line intercept method (Canfield 1941).

[d]Soil types are described in Table 8.

Table 18. Kit fox observations from the West Desert and Washington County, 1974-1976

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
A1	Lakeside Military Area, about 12.5 miles (20 km) S. of Lakeside	Box Elder	J. McGrew	1/11/75
A2	22 miles (35 km) N. of U.S. 6-50 on the Gandy Road	Millard	J. McGrew	3/10/75
A3	7.5 miles (12 km) SE of Delta on Utah 26	Millard	J. McGrew	6/ 1/75
A4	14.5 miles (23 km) S. of Garrison on Utah 21	Millard	J. McGrew	6/ 4/75
A5	20 miles (32 km) S. of Garrison on Utah 21	Millard	J. McGrew	6/ 4/75
A6	30 miles (48 km) S. of Garrison on Utah 21	Beaver	J. McGrew	6/ 4/75
A7	15.5 and 21.5 miles (25 and 35 km) S. of Garrison on Utah 21 (two spotlighted sightings)	Millard	J. McGrew	6/ 4/75
A8	Desert Range Experimental Station	Millard	J. McGrew	6/ 4/75
A9	Same as A3	Millard	J. McGrew	7/ 8/75
A10	18.5 miles (30 km) N. of Milford on Utah 257	Millard	J. McGrew	7/10/75
A11	17.3 miles (28 km) N. of Milford on Utah 257	Millard	J. McGrew	7/10/75
A16	6.5 miles (10 km) S. of Delta on Utah 26	Millard	J. McGrew	8/25/75

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
A19	Same as A10 (roadkill)	Millard	J. McGrew	7/ 7/76
A20	23 miles (37 km) S. of Garrison on Utah 21	Millard	J. McGrew	7/ 8/76
A21	Junction of Utah 26 and Utah 125 E. of Delta	Millard	J. McGrew	7/ 8/76
A22	Milepost 4, Utah 26 SE of Delta	Millard	J. McGrew	7/ 9/76
B2a	"Apex area"	Washington	G. Blackburn (USFWS)	12/17/74
B2b	Near Virgin	Washington	G. Blackburn (USFWS)	12/18/74
B3a	4 miles (6.4 km) NW of Blackrock	Millard	C. Poulson (USFWS)	12/31/74
B3b	4 miles (6.4 km) SW of Blackrock	Millard	C. Poulson (USFWS)	12/31/74
B5	"Apex area"	Washington	G. Blackburn (USFWS)	1/14/75
B7	"Apex area"	Washington	G. Blackburn (USFWS)	2/10/76
B8	3 miles (4.8 km) W. of Delta on U.S. 6-50	Millard	F. Pannunzio (UDWR)	3/ 3/75
B9	North edge of Aurora	Sevier	B. Lowry (BLM)	3/ 6/75
B11	1 mile (1.6 km) S. of Willow Spgs., 8 miles (13 km) E. of Dugway	Tooele	J. Ekins (UDWR)	3/20/75

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
B13	Milepost 67, U.S. 6-50 W. of Delta	Millard	V. Warnick (USFWS)	5/21/75
B14	SE1/4 Sec. 27, T.23S, R.19W	Millard	G. Cropper (BLM)	6/25/75
B15	NW1/4NE1/4 Sec. 14, T.24S, R.19W	Millard	G. Cropper (BLM)	6/25/75
B17	Same as A1	Box Elder	B. Turnbow (USAF)	7/21/75
B18	2 miles (3.2 km) NE of the Wildcat Mtns., Wendover Bombing Range	Tooele	USAF personnel, Lakeside Mil. Area	7/21/75
B19	1 mile (1.6 km) E. of Knolls	Tooele	Restaurant owner	7/21/75
B22	T.43S, R.14W, Sec. 17	Washington	J. Gebhardt (BLM)	2/20/76
B23	Badger Island (NW end of Standsbury Island)	Tooele	T. Boner (USFWS)	4/ 7/76
B24	1 mile (1.6 km) SW of Salina	Sevier	R. Isham (UDT)	5/23/76
B25	About 17 miles (48 km) N. of Interstate 80, Wendover exit	Tooele	Maj. McNarie (USAF)	5/24/76
B26a	One mile (1.6 km) SE of Hurricane	Washington	D. Johnson (reported	12/26/75 5/27/76)
B26b	Fillmore Interstate 15 exit	Millard	D. Johnson (reported	4/18/76 5/27/76)
B27a	Utah 26 and Deseret Road intersection	Millard	F. Pannunzio (UDWR)	6/ 5/76

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
B27b	Same as A21	Millard	F. Pannunzio (UDWR)	6/ 5/76
B28	5 miles (8 km) S. of Callao	Juab	A. Johnson (UDWR)	3/--/76
B29	Baker Lab, Dugway Proving Grounds	Tooele	Unidentified biologist	5/19/76
B30	Lincoln Bench Road, West Mountain	Utah	D. Gurley (UDWR)	5/13/76
B31	3 miles (4.8 km) S. Yuba Lake	Sanpete	N. Bingham (UDWR)	5/ 9/76
B32a	T.27S, R.14W, Sec. 7	Beaver	J. Farrell (BLM)	6/ 2/76
B32b	T.21S, R8W, Sec. 3 and 8 (two sightings)	Millard	J. Farrell (BLM)	6/ 2/76
B32c	Little Sahara Recreation Area	Juab	J. Farrell (BLM)	6/ 2/76
B32d	T.17S, R.6W, Sec. 2	Millard	J. Farrell (BLM)	6/ 2/76
B34	Thomas Range Well, 12 miles (19 km) E. of Fish Springs	Juab	M. Perkins (USFWS)	3/20/76
B35	5 miles (8 km) E. of St. George	Washington	V. Lunceford (BLM)	9/--/75 (reported 5/17/76)
B36	Ogden Bay Waterfowl Management Area	Weber	N. Nelson (UDWR)	3/--/75 (reported 5/ 3/76)
B37	Gravel pit one mile (1.6 km) W. of the Gunlock Road	Washington	D. Kay (UDWR)	5/13/76
B38a	Near the first trough, Welcome Spgs.	Washington	E. Coombs (UDWR)	6/10/76

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
B38b	Woodbury turnoff, U.S. 91	Washington	E. Coombs (UDWR)	5/19/76
B38c	2 miles (3.2 km) S. of the Utah border on U.S. 91	Mohave (AZ)	E. Coombs (UDWR)	6/ 1/76
B39	T.42S, R.16W, Sec. 1 (road kill) and T.42S, R.16W, Sec. 2 (active den)	Washington	E. Coombs (UDWR)	5/--/76
B40	Several active dens: T.42S, R.19W, Sec. 36 T.43S, R.18W, Sec. 18, 32 T.43S, R.19W, Sec. 11, 16, 20, 36	Washington	E. Coombs (UDWR)	--/--/76
C1	Ogden Bay Waterfowl Management Area	Weber	N. Nelson (UDWR)	9/27/74
C3	Bear River Migratory Bird Refuge	Box Elder	L. Gunther (USFWS)	10/ 4/74
C5	Angelope Island	Davis	Hodge & Haverty (1974)	--/--/74
C6	Farmington Bay Waterfowl Management Area	Davis	T. Provan (UDWR)	1/21/75
C8	By the Interstate 25 overpass S. of Fillmore	Millard	D. Nielsen (SCS)	3/ 5/75
C9a	Ibapah area	Tooele	M. Perkins (USFWS)	3/ 6/75
C9b	Callao area	Juab	M. Perkins (USFWS)	3/ 6/75

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
C12	Warm Creek Ranch--15.5 miles (25 km) S. of Callao	Juab	M. Perkins (USFWS)	3/22/75
C14	18 miles (29 km) S. of Delta on Utah 257	Millard	D. Alm (UDWR)	2/22/75
C15	See D4			
C16	See D1			
C19a	1 mile (1.6 km) S. of the Boyd Pony Express Station	Juab	R. Hoffman(through M. Perkins USFWS)	4/17/75
C19b	.5 mile (.8 km) S. of the Callao CCC Camp	Juab	R. Hoffman(through M. Perkins USFWS)	4/17/75
C21	South of West Mtn., near Genola	Utah	D. Gurley (UDWR)	2/ 7/76
C22	Associated Duck Club, Salt Lake City	Salt Lake	Anonymous source, WLS Meeting	2/ 7/76
C23	"West of Ephraim"	Sanpete	Anonymous source, WLS Meeting	2/ 7/76
C24	2 miles (3.2 km) S. of the Johnson Pass Road, near Benmore	Tooele	Anonymous source, WLS Meeting	2/ 7/76
C27	25 miles (40 km) S. of Garrison on Utah 21	Millard	L. Rowley (USFWS)	5/ 8/76
C28a	1 mile (1.6 km) SW Yuba Lake State Park ranger station	Juab	C. V. Fairbourne	5/10/76
C28b	S. of Yuba Lake Narrows	Sanpete	C. V. Fairbourne	5/10/76

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
C28c	Sevier River below Utah 15	Juab	C. V. Fairbourne	5/10/76
C30	12-13 miles (19-21 km) S. of Interstate 15 in the Hansel Valley	Box Elder	L. Price	5/25/76
D5	Hogup Point, west side	Box Elder	V. Montgomery (USNM #287981)	11/10/58
D6	Gold Hill	Tooele	F. Pomel (USNM #287985)	1/26/59
D7	Fish Mountain, 15 miles (25 km) E. of Callao	Juab	F. Pomel (USNM #287986)	12/13/58
D8	Silver Island, 20 miles (32 km) NE of Wendover	Tooele	F. Pomel (USNM #287987)	12/16/58
D10	"In the fall, a new male was obtained ... from Orem, Utah"	Utah	Anonymous (1972)	--/--/72
D11	7 miles (11.2 km) SE of St. George	Washington	Stock (1970)	--/--/70

[a]Kit fox reports were recorded in a journal as they were received. Reports were categorized as follows:

A--personal sightings of foxes or active dens
B--sightings from reliable sources
C--sightings that were less reliable, usually because of incomplete data
D--historical records (i.e., before 1970)

[b]Locations are given as accurately as possible. Locations in quotations are verbatim from the original account.

Table 18. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year

[c]Most of the authorities are identified by their agencies. In alphabetical order:

- BLM--Bureau of Land Management
- NFWL--specimen from the National Fish and Wildlife Laboratory, Ft. Collins, CO
- NPS--National Park Service
- SCS--Soil Conservation Service
- UDT--Utah Department of Transportation
- UDWR--Utah Division of Wildlife Resources
- USA--U.S. Army
- USAF--U.S. Air Force
- USFWS--U.S. Fish and Wildlife Service
- USNM--specimen from the U.S. National Museum
- UU--specimen from the Museum of Natural History, University of Utah

Authorities with no designation are private citizens, and those followed by a date are literature citations.

Table 19. Kit fox observations from the East Desert and Uinta Basin, 1974-1976

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
A12	19 miles (30.5 km) SE of Price on U.S. 6-50	Carbon	J. McGrew	7/28/75
A13	25 miles (40 km) SE of Price on U.S. 6-50	Emery	J. McGrew	7/28/75
A14	Between 32 and 35 miles (52 and 56 km) SE of Price on U.S. 6-50 (3 sightings)	Emery	J. McGrew	7/28/75
A15	About 51 miles (82 km) S. of Price on U.S. 6-50	Emery	J. McGrew	7/30/75
A17	T.25S, R.11E, Sec. 12	Emery	J. McGrew	6/ 4/76
A18	6.5 miles (10.5 km) E. of the Interstate 70--Hanksville interchange	Emery	J. McGrew	6/ 4/76
A23	13 and 17 miles (21 and 27 km) S. of Hanksville on Utah 95 (2 active dens)	Wayne	J. McGrew	7/14/76
A24	T.25S, R.11E, Sec. 12	Emery	J. McGrew	7/14/76
A25	6.1 miles (9.8 km) E. of the Interstate 70--Hanksville interchange	Emery	J. McGrew	7/14/76
A26	16.4 miles (26 km) W. of the Cisco--Interstate 70 interchange (on the westbound lane)	Grand	J. McGrew	7/14/76
A27	18.8 miles (30 km) W. of the Cisco--Interstate 70 interchange (on the median)	Grand	J. McGrew	7/14/76

Table 19. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
B10	10 miles (16 km) S. of Hanksville on Utah 95	Wayne	J. McGrew	3/ 6/75
B16	About 25 miles (40 km) SE of Price on U.S. 6-50	Emery	G. Clevinger	7/ 8/75
B20	Roost Flats area	Wayne	J. Walker (NPS)	7/31/75
B21	3 miles (4.8 km) E. of Jeffrey Wells on the Flint Trail Road	Emery	L. Dalton (UDWR)	9/ 6/75
B33	Buckhorn Reservoir	Emery	R. Hanson (USFWS)	11/--/75
C4	"... swift foxes are rather common and are regularly taken in the Oil Shale Area in traps set for coyotes."	Uintah	Olsen (1973)	--/--/--
C7	"Four skinned carcasses near the head of Ten Mile Canyon"	Grand	Unidentified wildlife specialist (BLM)	3/ 5/75
C10	"One-quarter mile (.4 km) S. of the Neck" (Canyonlands Natl. Park)	San Juan	R. Boulter (NPS)	1/ 1/75
C11	Same as B20	Wayne	J. Walker (NPS)	2/19/75
C20	See D3			
C26	See D2			
C29	West end of the bridge that crosses White Canyon, S. of Hite Crossing	San Juan	T. Adams (NPS)	5/22/76

Table 19. Continued

Number[a]	Location[b]	County	Authority[c]	Mon/Day/Year
C31	Near Big Flat Top	Emery	M. Salamacha (NPS)	6/ 1/76
C32	"Saw one kit fox in Buckskin Gultch E. of Kanab"	Kane	P. Winn	8/--/75
D1	"3 miles (4.8 km) NE Olsen Reservoir	Carbon	M. Morgan (UU #22903)	7/16/66
D2	"31 miles (49.6 km) W. of Grand Junction, Colorado"	Grand	G. Ranck (NFWL)	8/ 5/68
D3	Between Blanding and Bluff, just past the Aneth turnoff	San Juan	J. Pederson (UDWR)	7/--/67
D4	"Shot along highway 6-50, 4 miles"	Grand	N. Denan (UU #15128)	7/16/59
D9a	"... about 5 miles (8 km) N. of the Temple Mtn. turnoff"	Emery	W. Donaldson	6/--/70
D9b	"Den of five foxes between Wah-Weep Marina and the UDWR biological station near Page"	Coconino (AZ)	W. Donaldson	7/--/70

[a,b,c] See Table 18 for explanations.

Table 20. Characteristics associated with the 92 kit fox sightings used in the habitat description

Sighting[a]	Elevation (feet/meters)	Soil Type[b]	Vegetative Cover Type[c]	Freeze-Free Season[d]
A1, B17	4,500/1,372	52	Sd	140-160
A2	5,000/1,524	60	Sd	120-140
A3, 9, 16	4,600/1,417	55	Sd	140-160
A4	5,600/1,707	55	Sd	120-140
A5	6,000/1,829	52	Sd	120-140
A6	5,300/1,615	52	Sd	100-120
A7	5,665/1,727	55	Sd	120-140
A8	5,200/1,585	55	Sd	100-120
A10, 11, 19	4,900/1,494	60	Sd	120-140
A12	5,400/1,646	63	Sd	140-160
A13	5,200/1,585	63	Sd	120-140
A14	5,200/1,585	63	Sd	120-140
A15	4,600/1,402	63	Sd	160-180
A17	5,200/1,585	65	Sd	120-140
A18, 25	4,500/1,372	63	B	160-180
A20	6,100/1,860	52	Sd	120-140
A21, B32d, B27b	4,600/1,402	65	Sd	140-160
A22	4,650/1,417	65	Sd	140-160
A23	5,800/1,462	55 & 68	Sd & S	160-180
A24	5,200/1,585	65	Sd	120-140
A26	4,500/1,372	63	G	160-180
A27	4,700/1,433	63	G	160-180
B2b	3,600/1,097	58	S	180-200
B3a	5,000/1,524	55	G	120-140
B8	4,600/1,402	51	I_2	120-140
B9	5,200/1,585	48	I_2	120-140
B10	4,800/1,462	55	Sd	160-180
B11	5,000/1,524	66	Sg	120-140
B13a	4,800/1,463	60	Sd	120-140
B14	5,600/1,707	52	Sd	120-140

Table 20. Continued

Sighting[a]	Elevation (feet/meters)	Soil Type[b]	Vegetative Cover Type[c]	Freeze-Free Season[d]
B15	5,600/1,707	52	Sd	120-140
B18	4,240/1,292	71	B	100-120
B19	4,240/1,292	71	B	100-120
B20	5,800/1,768	65	G	120-140
B21	5,300/1,615	65	Sd	120-140
B22	3,200/ 975	56	S	140-160
B23	4,200/1,280	71	Sd	160-180
B24	5,200/1,585	48	G	120-140
B25	4,300/1,310	71	Sd	140-160
B26a	3,800/1,158	56	S	180-200
B26b, C8	5,500/1,676	27	D_2	140-160
B28	4,600/1,402	55	Sd	120-140
B29	4,800/1,463	60	Sg	160-180
B30	4,500/1,372	49	Sg	120-140
B31	5,200/1,585	48	Sg	100-120
B32a	5,000/1,524	52	Sd	120-140
B32b	4,600/1,402	60	Sd	140-160
B32c	4,800/1,462	65	B	140-160
B33	5,800/1,768	63	Sd	120-140
B34	5,500/1,372	60	Sd	140-160
B35	4,500/1,372	60	Sd	120-140
B37	2,400/1,097	57	S	140-160
B38a	4,000/1,220	59	S	200-220
B38c	2,400/ 732	59	S	200-220
B39	3,400/1,036	59	S	160-180
B40	3,500/1,067	59 & 68	S	200-220
C1	4,200/1,280	71	W	160-180
C3	4,220/1,286	71	G	160-180
C5	4,500/1,372	50	G	160-180
C6	4,200/1,280	71	Sd	160-180

Table 20. Continued

Sighting[a]	Elevation (feet/meters)	Soil Type[b]	Vegetative Cover Type[c]	Freeze-Free Season[d]
C7	4,500/1,372	52	S	160-180
C9a	5,400/1,646	49	Sg	100-120
C9b	4,400/1,341	51	I_2	120-140
C12	4,700/1,433	51	I_2	120-140
C14	4,600/1,402	60	Sd	120-140
C19a	4,600/1,402	60	Sd	140-160
C19b	4,600/1,402	51	Sd	120-140
C21	4,500/1,372	48	Sg	140-160
C28a	5,000/1,524	49	Sg	100-120
C28b & c	5,000/1,524	48	Sg	100-120
C29	5,400/1,646	68	S	200-220
C30	4,300/1,310	47	D_1	140-160
D1	5,200/1,585	63	Sd	120-140
D2	4,900/1,494	63	Sd	140-160
D3	4,800/1,463	55	S	160-180
D4	4,300/1,311	63	G	160-180
D5	5,000/1,524	60	Sd	140-160
D9b	3,800/1,158	68	S	---
D10	4,500/1,372	26	I_2	120-160
D11b	3,200/ 975	59	S	200-220

[a]Kit fox sightings were categorized as follows: A--personal sightings of foxes or active dens; B--sightings from reliable sources; C--sightings that were less reliable, usually because of incomplete data; D--historical records (i.e., before 1970). For locations, see Tables 18 and 19.

[b]Soil groups and associations (in parentheses) from Wilson et al. (1975):

Dark, alluvial soils. West front of Wasatch Mountains to Levan (26 and 27)
Light-colored desert soils. Western Utah (47 through 50)

Table 20. Continued

Sighting[a]	Elevation (feet/meters)	Soil Type[b]	Vegetative Cover Type[c]	Freeze-Free Season[d]

Light-colored desert soils. West-central and some eastern locations (51 through 55)
Light-colored desert soils. Southwestern Utah only (56 through 59)
Sodic-saline soils. Western Utah (60)
Highly erodable soils. Eastern and southeastern Utah (63)
Dominantly sandy soils. West central, southern, and southeastern Utah (65 and 66)
Rocklands. Colorado and Virgin river drainages (68)
Playas. Great Basin (71)

[c]Vegetative cover types from the Soil Conservation Service:

S = southern desert shrub (especially Larrea, Colegyne)
Sd = salt desert shrub (shadscale, greasewood, winterfat)
Sg = sagebrush
G = grasses and forbs
D_1 and D_2 = non-irrigated cropland
I_1 = irrigated cropland
W = wet meadow
B = barren

VITA

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