Investigation into the Habitat and Diet of Six Captive Swift Fox

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ABSTRACT

Swift Fox (*Vulpes velox*) are bred in captivity at the Cochrane Wildlife Reserve in Alberta, Canada. Six foxes are kept in a pen of substantially greater area than the pens used for the rest of the breeding colony. The habitat of this pen was found to be profoundly unlike that of the foxes natural habitat, with much of the pen being densely wooded; this was felt to be of limited importance however, given that the foxes are hunting, and therefore learning valuable life-skills in the pen. 97 scats were collected from the large pen over a six week period, and 74 of these scats were analysed at the Cochrane Wildlife Reserve. Remains of voles (*Microtus pennsylvanicus* and *M. longicaudus*) were found to be the primary constituent of 49% of the scats analysed, and to account for 33% of total occurrences in scat. Although insect remains formed the primary content of none of the scats, they were found to represent 12% of occurrences in scat. Recommendations for improving the accuracy of dietary predictions from remains in scat were discussed. Scat and pellets from local predators were analysed and were all found to indicate significant overlap of diet with the swift foxes in the large pen. 21 scats of recently released and wild swift foxes were collected from Grasslands National Park in Saskatchewan; these scats contained larger amounts of insect and mammalian prey remains than those analysed from the large pen. Prey-types were of similar sorts to those being consumed in the large pen, and included no birds or lagomorphs.

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INTRODUCTION

A breeding colony of swift fox (*Vulpes velox*) has been maintained at the Cochrane Wildlife Reserve near Cochrane, Alberta, since 1973. Foxes have usually been kept in breeding pairs, one pair per pen; the largest pens are approximately 0.04 acres in area. The foxes have been kept in pairs primarily because it was suggested (apparently on the basis of limited evidence) that they were not highly social animals. It was thought that placing more than two of the foxes in a pen together would lead to aggressive behaviour and injury. Unfortunately, keeping a large number of breeding pairs (the colony usually consists of 25 pairs) in separate pens, requires that the pens be of limited size, due to the logistical implications of feeding and pen-maintenance. This in turn restricts the possibility of the pens containing a useful prey base of natural prey items, hence reducing the opportunity for foxes which are to be released to learn vital hunting skills in their formative months.

Since November 1993, six foxes have been kept together in a larger pen, of approximately 20 acres in area. One of the major reasons for the use of the larger pen, was that the foxes would have more opportunity than those in the small pens, to develop a number of skills of importance for their release in the wild; principally, these included social interaction and hunting skills. In the time since the foxes were released into the pen, they have been observed to show a high degree of social behaviour and in early 1994, one pair bred successfully producing three cubs. It was not known whether the foxes were hunting to any degree (either to supplement or partially replace their diet of day-old chicks and horsemeat), or what was available for them to hunt. It was also suggested that the habitat in the large pen is so unlike the foxes' natural habitat, that life-skills developed in this pen may not be applicable in the wild. It was therefore decided to conduct a study on the large pen, in order to gain more information in two major areas:

1. **Habitat**: this would include both:

(i) a vegetation survey, aimed at gaining an overall view of the vegetation and terrain in the large pen (permitting comparison with the foxes' natural habitat); and

(ii) a survey of the fauna of the large pen, particularly as regards animals forming a possible prey base for the foxes.

2. **Diet**: this would involve several components:

(i) Study of the diet and scat of a fox in a small enclosure, where diet could be strictly regulated, and scat content could be directly related to known food-types;

(ii) Collection and analysis of scat from the large pen; and

(iii) Comparison of scat content with diets of wild foxes and other predators.

RESULTS

1. Habitat Analysis

(i) Vegetation Survey

a) Assessment of large pen layout and major habitat distribution:

The results of large pen mapping and habitat-type distribution assessment are shown on map 1.

b) Assessment of plant species in the large pen:

A full list of the plant species found in the large pen is located in appendix A. Species' relative abundance was found to vary spatially (with a high degree of zonation apparent in the distribution) and also temporally throughout June, July and August. Changes in the major species in each habitat were noted however.

In the grass/shrub areas, the grasses *Agropyron sp.*, *Koelaria macrantha* and *Elymus spp.* dominated earlier in the period of study, along with flowers such as *Achillea millefolium, Geum triflorum*, *Sisyrinchium angustifolium* and *Dodecatheon pauciflorum*; these were replaced by *Poa canbyi, Puccinella nuttalliana* and *Bromus spp.* later in the season, along with the flowers *Potentilla fruticosa, Ranunculus spp.*, *Lilium montanum, Zizia aptera, Zygadenus elegans* and *Galium boreale*; towards the end of the study period, the grass/shrub areas were dominated by the grass *Phleum pratense*, as well as the Leguminosae and many of the Compositae, especially *Aster spp.* and *Erigeron spp.* The main shrubs throughout, were *Betula glandulosa* and the *Salix spp.*

The aspen areas were of course dominated by the trees, which were almost exclusively *Populus tremuloides*. Below the canopy were mainly *Danthonia intermedia* and *Deschampsia sp.,* along with *Achillea millefolium* and *Hippuris vulgaris* early in the study period, with *Agrostis sp.* and *Festuca rubra* becoming dominant later in the season, as well as the Leguminosae, *Potentilla fruticosa* and *Castilleja sp*.

The spruce areas were almost solely populated by the spruce trees, *Picea glauca* and *Picea mariana*. Beneath these, the ground was so densely covered by fallen needles, and so deprived of sunlight, that very little was found to grow there. In the more open spruce areas however, grasses such as *Danthonia intermedia* and *Elymus spp*. were found, as well as *Hippuris vulgaris*. Towards the end of the study period, it was observed that many fungi also grew in the spruce areas.

Although some of the areas are described as bog, they were to a large extent dried up during July, August and September. These areas tended to be dominated by the shrubs *Betula glandulosa* and *Salix spp.*, throughout the entire study period. The wetter areas and bog centres were populated by reeds however, although these have not been identified.

Tree cover within the wooded aspen and spruce areas was also assessed and the results of this assessment are shown in appendix B. The results of sampling three 20'×20' quadrats in the aspen habitat, and three 20'×20' quadrats in the spruce habitat can be summarised as follows:

Table 1: Assessment of tree cover in Aspen Habitat

Tree type:	Aspen	Black Spruce	White Spruce	Jack Pine	Total
No. per acre:	1233	33	0	0	1266
% cover of habitat	1.56	0.05	0	0	1.61

Table 2: Assessment of tree cover in Spruce Habitat

Tree type:	Aspen	Black Spruce	White Spruce	Jack Pine	Total
No. per acre:	133	767	567	33	1500
% cover of habitat	0.34	0.41	0.44	0.56	1.75

(ii) Prey-base Survey

a) Snap-trapping results:

Table 3: Snap-trapping Record

Date	No. of Traps Set	Area of Trapping	Bait(s)	No. of animals trapped	Species
21.6.94	20	Close to house (Grass)	1,2	3	*Microtus pennsylvanicus*
23.6.94	20	By chicken pen and brush pile (Grass/brush)	1,2	5	*Microtus pennsylvanicus*
25.6.94	21	Spruce trees and brush pile (Grass/shrub)	1,2,3	11	*Microtus pennsylvanicus*
26.6.94	19	Around house (Grass)	2,3	2	*Microtus pennsylvanicus*
27.6.94	19	By T-shaped slew (Grass/shrub)	12	2	*Microtus pennsylvanicus*
12.7.94	19	By large slew (Grass/shrub)	4	1	*Microtus longicaudus*
20.7.94	19	Aspen woods by bird pens	4	1 1	*Microtus pennsylvanicus* *Microtus longicaudus*
29.7.94	19	Near charnel pit (Aspen)	4	0	
26.8.94	19	Near brush pile, chicken pen and T-shaped slew	4	1	*Sorex arcticus*
27.8.94	11	T-shaped slew	4	2	*Sorex arcticus*
28.8.94	12	Between house and T-shaped slew (Grass/shrub)	1	1	*Sorex arcticus*
29.8.94	10	Path to bison shed (Grass)	1	1 1	*Microtus pennsylvanicus* *Microtus longicaudus*
	9	By bird pens (Aspen)	2,3	1	*Microtus longicaudus* *Sorex arcticus*

				1	

Bait types: 1 = Jam / bread / milk paste; 2 = Bread; 3 = Cat biscuit; 4 = Peanut butter

b) Mammalian Collection:

Records of mammals trapped using snap-traps, as well as those obtained by other methods are given in appendix C. These are summarised below:

Table 4: List of small mammals acquired in the area

Order	Species	Common Name
INSECTIVORA	*Sorex arcticus*	Arctic shrew
	Sorex hoyi	Pygmy shrew
	Sorex monticolus	Dusky shrew
LAGOMORPHA	*Lepus townsendii*	White-tailed jack rabbit
RODENTIA	*Tamiasciurus hudsonicus*	Red squirrel
	Peromyscus maniculatus	Deer mouse
	Microtus pennsylvanicus	Meadow vole
	Microtus longicaudus	Long-tailed vole

Those retained as reference specimens are listed fully in appendix D, but a summary of these specimens follows:

Table 5: List of Specimens retained for reference

Collection Number	Species	Type of Specimen

1M	*Lepus townsendii*	Skin and skull
2M	*Microtus pennsylvanicus*	Skin and skull
3M	*Microtus pennsylvanicus*	Alcohol
4M	*Microtus pennsylvanicus*	Alcohol

Table 5 (continued)

Collection Number	**Species**	**Type of Specimen**
5M	*Microtus pennsylvanicus*	Alcohol
6M	*Tamiasciurus hudsonicus*	Skin and skull
7M	*Microtus longicaudus*	Skin and skull
8M	*Sorex monticolus*	Skin; body in alcohol
9M	*Peromyscus maniculatus*	Skin and skull
10M	*Sorex hoyi*	Alcohol
11M	*Sorex arcticus*	Skin and skull
12M	*Sorex arcticus*	Alcohol
13M	*Sorex arcticus*	Alcohol
14M	*Microtus pennsylvanicus*	Skeleton
15M	*Microtus longicaudus*	Skeleton

c) Other prey-types:

Insects deemed to be of sufficient size to be consumed by swift fox and to show up in scat, were collected from the following orders:

Coleoptera.... 2 species
Diptera..... 1 species
Odonata..... 1 species

Orthoptera.... 6 species

These were not identified, as it was discovered that where their remains did occur in scat, these were insufficient to make specific identifications.

A number of amphibians were also collected, but these were found to be of a single species, namely *Rana sylvatica* (Wood Frog). The wood frog was neither seen nor heard in the large pen throughout the course of the study, and hence no specimen was retained for reference. Photographs were taken of individuals caught however, and these have been retained with the collection.

2. **Dietary Analysis**

(i) Scat Pilot Study

This study took place over 16 days, resulting in 15 day's scats being collected and analysed. The full record of feeding and scat collection during this time has been included in appendix E; analytical reports of each day's scats have also been placed in this appendix. For more detail on the implications of this pilot study, see the discussion; some basic details of the study will be included here however.

Table 6: Basic summary of feeding of Dakota during scat pilot study

Food type	**Amount given during study/g**	**Amount uneaten during study/g**	**Percent Uneaten**
Day-old chicks	2600.0	94.6	3.64
Horse meat	1008.5	380.0	37.68
Iams	424.0	217.5	51.30
Microtus longicaudus	160.0	60.0	37.50
Microtus pennsylvanicus	39.0	0.0	0.00
Spermophilus richardsonii	710.0	186.0	26.20
Juvenile *Turdus migratorius*	40.0	20.0	50.00

Juvenile *Junco hyemalis*	15.0	10.0	66.67
Assorted orthoptera	32.9	0.0	0.00
Total	5029.4	968.1	30.33

The total amount of food given to Dakota during the study, was therefore 5029.4g.
This was a daily average of 314.3 ± (SD)53.3g.

The total amount of food uneaten during the study, was 968.1g.
This was a daily average of 60.5 ± (SD)71.4g.

The total amount of food eaten by Dakota during the study, was 4061.3g.
This was a daily average of 253.8 ± (SD)74.8g.

The total amount of scat collected during the study, was approximately 164.4g.
This was a daily average of approximately 11.0 ± (SD)6.1g.
Figures for these amounts are only approximate, due to the lack of sensitivity and precision of the scales used to weigh scat during the first week of study.

(ii) Large Pen Scat Study

The feeding and scat collection record for the large pen for the duration of the study, is given in appendix F; also contained in appendix F, are the analytical scat reports for all scats collected during the study. The food given over 41 days of study is summarised below.

Table 7: Basic summary of feeding of Large Pen foxes during scat study

Food Type	**Amount given during study/ g**	**Daily Average/ g ± SD**
Horse Meat	44225	1079 ± 260
Day-old Chicks	43450	1060 ± 231

Total	87675	2138 ± 392

220g of Iams were also fed on one occasion, as were 40g of house mice (Mus musculus), but it was felt that as these were not part of the regular diet, and would have little bearing on the daily averages, that it was not appropriate to include them with the summary figures.

A total of 97 scats were collected from the large pen over the 42 days of study.
The average number of scats collected per day was 2.3 ± (SD)1.2.
Of these, 94 scats were weighed; these had a total mass of 245.7g and an average mass of 2.6 ± (SD)1.8g.
74 of these scats were analysed at the Cochrane Wildlife Reserve, whilst the remaining 23 were sent to the University of Toronto, for analysis. Analysis of the 74 scats is summarised in table 8.

(iii) Other Predator Scat Study

Scats and pellets from other predators were analysed during the study. These included seven coyote (*Canis latrans*) scats collected from a neighbouring ranch, five red fox (*Vulpes vulpes*) scats collected from a red fox den site by a nearby road, and ten pellets from unknown raptors, eight of which were collected from the same ranch as the coyote scats, and two of which were found in the large pen at the reserve.

Reports on analysis of these scats and pellets are contained in appendix G but their contents are briefly summarised below.

Table 9: Summary of Coyote scat Contents

Field Number	**Primary Content**	**Present in any quantity**		
		1	**2**	**3**
1CS	1	/		
2CS	1	/		

3CS	1	/	/	
4CS	3	/	/	/
5CS	2	/	/	
6CS	2	/	/	
7CS	1	/	/	

Key: 1 = Deer (*Odocoileus spp.*); 2 = Vole (*Microtus spp.*);
3 = Richardson's ground squirrel (*Spermophilus richardsonii*)

Table 10: Summary of Red fox scat Contents

Field Number	**Identified as Present**			
	1	**2**	**3**	**4**
RF1	/			
RF2	/			
RF3	/	/	/	
RF4	/	/		
RF5	/			/

Key: 1 = Vole (*Microtine spp.*); 2 = Deer Mouse (*Peromyscus maniculatus*);
3 = Unknown Leporid; 4 = Unknown mammal

Table 11: Summary of Raptor Pellet Content

Field Number	**Identified as Present**		
	1	**2**	**3**
A1	/		/
A2			/

A3			/
A4	/		
A5		/	
A6		/	
A7		/	/
A8			/
A9		/	
A10	/		

Key: 1 = *Microtus pennsylvanicus; 2 = M. longicaudus; 3 = Peromyscus maniculatus*
Scats from recently released and wild-living swift fox were also collected from Grasslands National Park in Saskatchewan. In order to analyse these scats, some small mammal trapping was conducted in the area. The animals trapped have been included in the records in appendices C and D but a brief summary is included here:

Table 12: Summary of small mammals trapped in Grasslands National Park, Saskatchewan

Order	**Field No.**	**Collection No.**	**Species**	**Common Name**	**Specimen Kept**
INSECTIVORA	35	17M	*Microsorex hoyi*	Pygmy shrew	Alcohol
	36	18M	*Sorex cinereus*	Masked shrew	Alcohol
RODENTIA	34	16M	*Lagurus curtatus*	Sagebrush vole	Skull and hair sample
	37	-	*Microtus pennsylvanicus*	Meadow vole	-
	38	-	*Microtus pennsylvanicus*	Meadow vole	-
	39	19M	*Peromyscus maniculatus*	Deer Mouse	Skin, skull & skeleton

One other small rodent was trapped and this has been classified from external characteristics (including examination of hair), as the long-tailed vole (*Microtus longicaudus)*; however, the range of this rodent is not generally believed to extend into southern Saskatchewan, and hence it has been sent to the University of Toronto, for verification of its classification.

No specimen of *M. pennsylvanicus* was kept, as these animals were in poor condition, and considerable reference material already existed for this species. Hair samples from two lagomorphs of the area - one Lepus townsendii and one unidentified - were also retained for reference.

The trapped specimens which were retained, as well as the specimens already collected from the Cochrane area, were then used to analyse the content of the scats collected from Saskatchewan shortly after release of the captive-reared foxes. 21 scats from Grasslands National Park in Saskatchewan were analysed at the Cochrane Wildlife Reserve; the reports on this analysis are contained in appendix H and summarised in table 13. A similar number of scats from the same location were also sent to the University of Toronto for analysis.

Table 13: Summary of Analysis of Scats from Grasslands National Park, Saskatchewan

Field No.	Location	Primary Content	Present in any Quantity					
			1	2	3	4	5	6
S1a	Near natal den in East block	1	/			/		/
S1b	Near natal den in East block	2			/	/		/
S2a	Release site of large pen foxes	1	/	/		/		
S2b	Release site of large pen foxes	4	/			/		/
S3	Release site of Alaric & Dainty	5					/	/
S4a	Release site of Beth & Angus	4				/		/
S4b	Release site of Beth & Angus	4				/		/
S4c	Release site of Beth & Angus	4				/		/
S4d	Release site of Beth & Angus	4				/		/

S4e	Release site of Beth & Angus	3	/		/			/
S4f	Release site of Beth & Angus	1	/		/		/	/
S5	Release site of Betty & Bombadier	6	/					/
S6	Release site of Beth & Angus	6			/			/
S7a	Road near Lockhart's, East block	4			/	/		/
S7b	Road near Lockhart's, East block	4				/		
S7c	Road near Lockhart's, East block	3	/		/			/
S7d	Road near Lockhart's, East block	4				/		
S8a	Release site of Beth & Angus	6	/					/
S8b	Release site of Beth & Angus	6	/					/
S8c	Release site of Beth & Angus	6						/
S8d	Release site of Beth & Angus	4				/		/

Food types: 1 = *Microtus spp.*; 2 = *Lagurus curtatus*; 3 = *Peromyscus maniculatus;* 4 = Unknown mammals; 5 = Day-old chick; 6 = Insect

DISCUSSION

1. Habitat Analysis

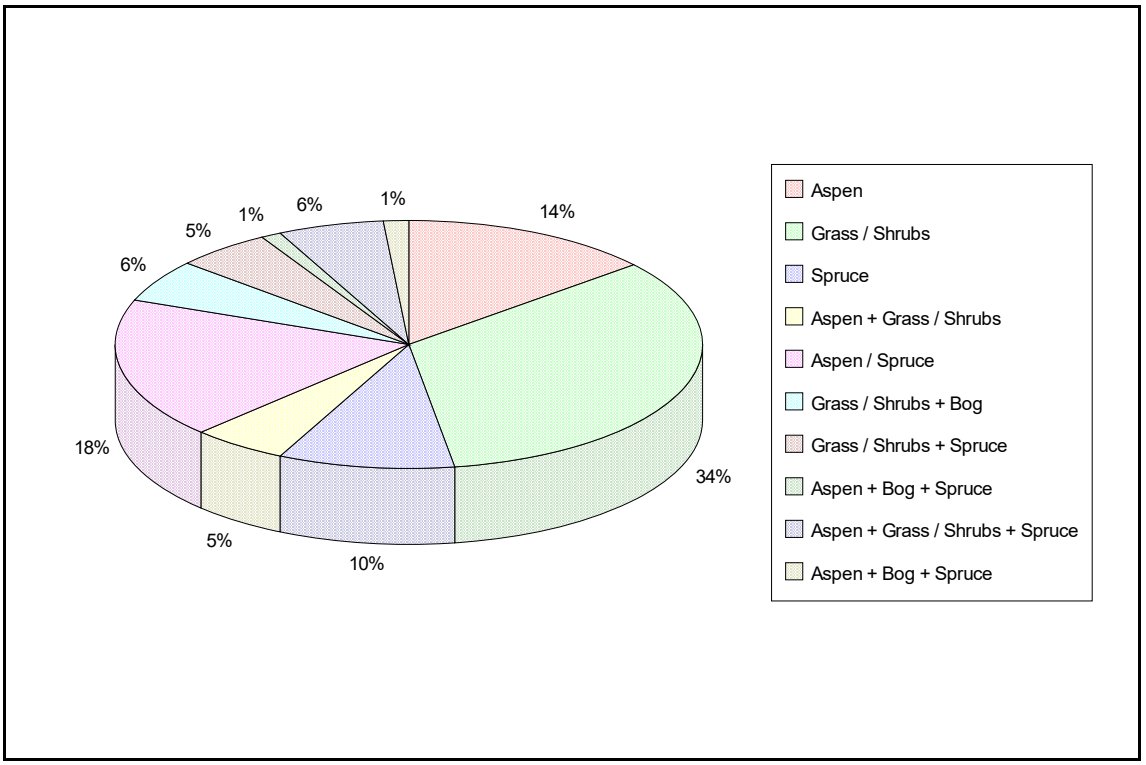
(i) Vegetation Survey

a) Assessment of large pen layout and major habitat distribution:

The area of the large pen was calculated to be 18.7 acres (or 7.6 hectares). Work by Fitzgerald *et al.* (1983) indicated that male swift fox in the Pawnee grasslands of Colorado had home ranges of about 200 hectares (or 2km5), whilst more recent work on a closely related species (the San Joaquin kit fox; *Vulpes macrotis mutica*) has suggested similar though larger figures (Zoellick *et al.*, 1989). It would appear therefore, that the large pen is only a fraction of the area that a swift fox would utilize in the wild, although it is almost 500 times the area of the largest pens in which foxes in the breeding colony have previously been kept.

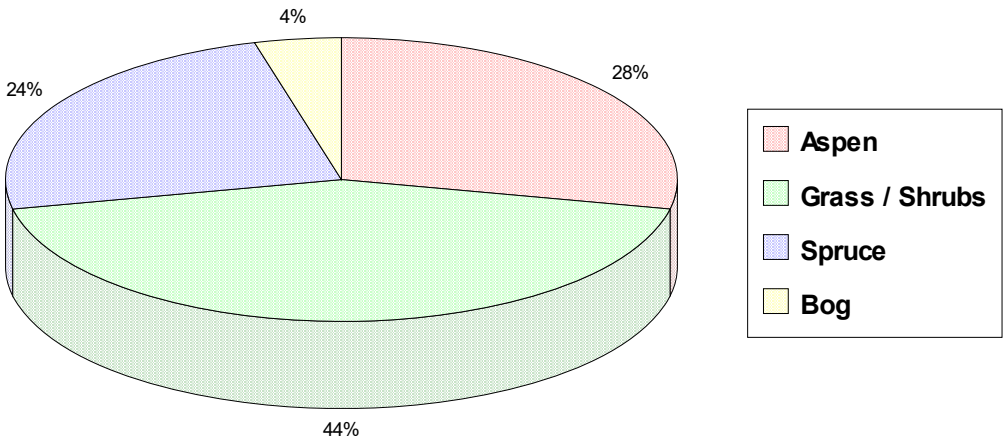
Map 1 shows the major distribution of habitat-types within the large pen. Relative quantities of each habitat-type within the pen are shown in Chart 7:

Chart 7: Division of habitat-types within the large pen



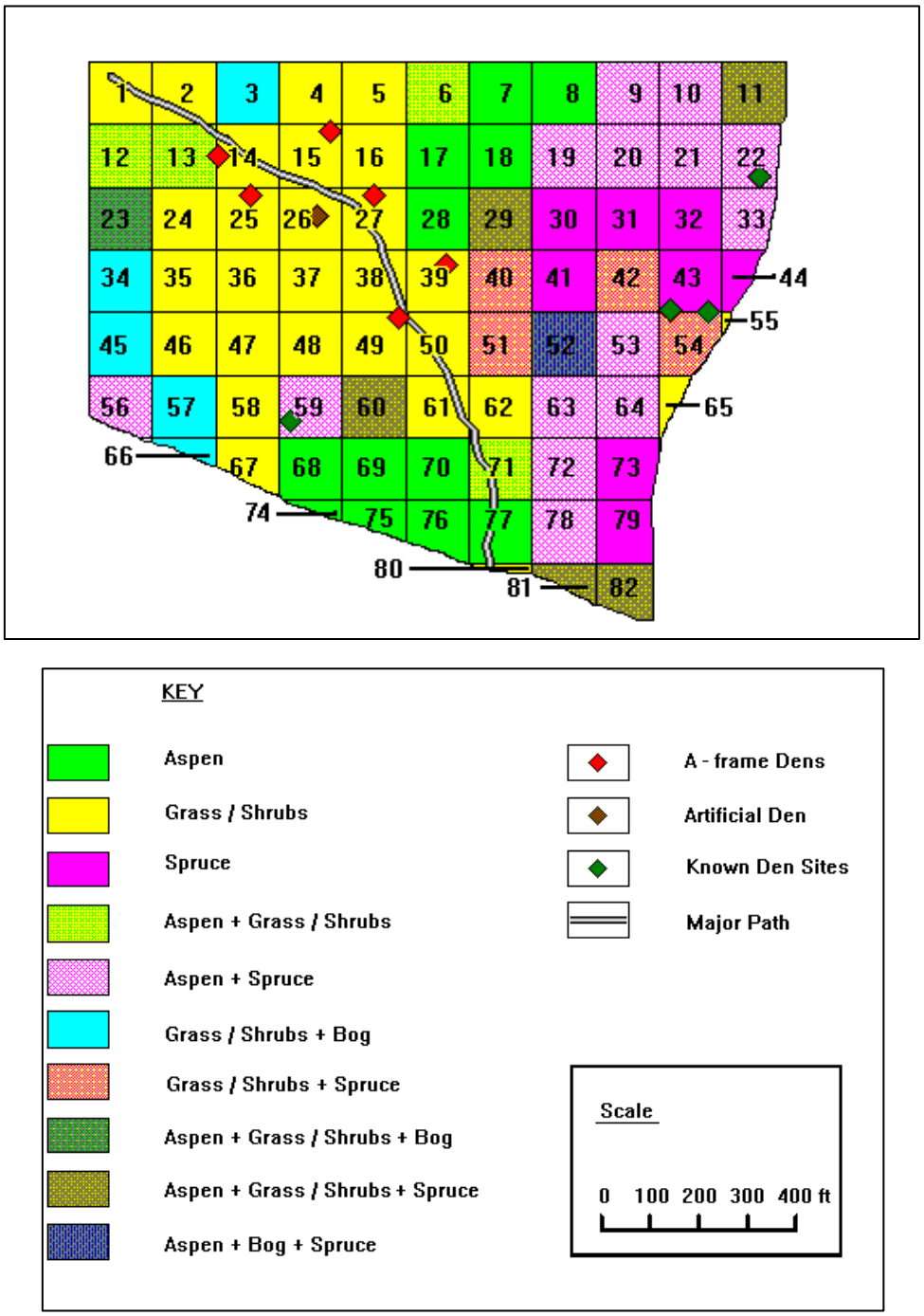
Splitting each multi-habitat-type grid section equally between its constituent habitat-types, percent-cover by the four major habitat-types can be calculated. This is shown in Chart 8.

Chart 8: Habitat types in 20 acre pen.



The dominant habitat-type in the pen is grass/ shrub, forming approximately 44% of the vegetative cover, considerably more than either the aspen, spruce or bog habitats; the total wooded area is marginally larger than the total area of grass/ shrub cover, being approximately 52%.

Map 1: Major Habitat Distribution within the Large Pen (1.6.94)



Total area of Pen = 18.7 Acres

Map 1 also shows the positions of the den-sites (both artificial and those dug by the foxes) in the large pen during the study period. It can be seen that seven artificial dens have been provided for the foxes, all within the areas characterised by grass/ shrub habitat. The four dens which the foxes have dug since being introduced to the pen however, are all located within spruce or mixed spruce and aspen areas, all having been dug at the base of spruce trees. It is generally agreed that swift fox in the wild prefer areas of low ground cover and high visibility, and Zoellick *et al.*(1989) have theorised that in the closely related San Joaquin kit fox, this preference for open ground corresponds to the increased safety that this provides for a fast-moving animal, compared to an area of denser vegetation through which it may be stalked by its major predators. It may be seen as inappropriate that the foxes are denning in the heavily wooded areas but this could be as a result of a variety of factors which would not influence their denning behaviour in the release areas (for example, varying soil condition, prey abundance, and spatial separation of the foxes). It has also been observed that no data is available on the relative amounts of usage of the different dens, or of the amounts of time that the foxes spend in the different habitat-types.

b) Assessment of plant species in the large pen:

It was initially hoped that relative abundance of plant species could be calculated using estimates of species cover within a number of quadrats in each habitat-type. It was found however, that to estimate this over a short-period, would require identification of all species within a high number of quadrats (due to the high degree of zonation of plant species - see photographs in appendix A) and in a very short space of time (making identification difficult, as some of the species would almost certainly not be in flower). To estimate species' relative abundance in the future, a high number of fixed quadrats should be used, and estimates of species cover within those quadrats should be made at regular intervals (of perhaps ten days) throughout the flowering period.

Major species within each habitat-type were noted in order to compare the habitat of the large pen with that of the foxes natural habitat, specifically of the areas in which the foxes are released. In *Wild plants of the Canadian prairies* (Budd and Best, 1964), the region of prairie into which the foxes are released, including southeastern Alberta and southwestern Saskatchewan, is listed as the 'Southwestern Zone' of the Canadian prairie. This zone is described as a moisture-deficient area, with few trees, and a generally xerophytic flora; the major species are listed as blue grama grass (*Bouteloua gracilis*), spear grass (*Stipa comata*), June grass (*Koelaria cristata*), Sandberg's blue grass (*Poa secunda*), sedges (family: Cyperaceae), prairie selaginella (*Selaginella densa*), sage bush (*Artemisia cana*), and cactus (family: Cactaceae). The Parks Canada brochure *Grasslands National*

Park also lists the wheatgrasses (*Agropyron spp.*) as an important species on the short-grass prairie, where 325 species of grasses, forbs and sedges form the major cover.

Given that few trees grow in the foxes' natural habitat, much of the pen (with up to 1500 trees per acre; see tables 1 and 2) is obviously extremely dissimilar to the foxes' release areas. Even the grass/ shrubs habitat which most closely resembles the short-grass prairie, has few species in common (the presence of *Agropyron sp.* and *Koelaria macrantha* [=*K. cristata*] being the only major similarities) and it was observed that for much of the summer months at least, vegetation in this area was generally between 18 to 30 inches high, compared to about 12 inches at the most in the drier, prairie areas. These differences would only be critical however, if the foxes showed a preference for the more densely vegetated areas after release, and such areas are extremely uncommon in the short grass prairie.

(ii) Prey-base Survey

a) Snap-trapping results:

Table 3 shows the record of snap-trapping during the course of the study. Trapping was conducted solely in order to acquire food sources for the preliminary scat study, and reference specimens for scat analysis. The array of factors influencing trapping (including area of trapping, bait used, number of traps used, time of year, and weather conditions), prevent conclusions from being drawn regarding the relative abundance of small mammals in the area. In order to estimate abundances of small mammals, it is suggested that a much more extensive mark-recapture type would be required, involving trapping in an array of different habitat-types.

It is worth noting however, that of the animals trapped using snap-traps, 25 (73.5%) were *Microtus pennsylvanicus*, 4 (11.8%) were *M. longicaudus* and 5 (14.7%) were *Sorex arcticus*. These figures might indicate that *M. pennsylvanicus* is the more abundant of the three small mammals, but this apparent preponderance may be due to only two trap-nights (23.6.94 and 25.6.94), on which a brush pile apparently housing a colony of *M. pennsylvanicus* was trapped extensively. It is interesting that no specimen of *Peromyscus maniculatus* was trapped on the Reserve. Deer mice have been seen in this area before, although it is thought, not for several years. Given that deer mice have been trapped in Grasslands National Park, with the same type of traps, and using peanut butter as bait, this might imply that the deer mouse is no longer extant within the confines of the Reserve. It is also interesting to note the presence and absence of deer mice remains in scats and pellets from the Cochrane area, and this will be discussed further in section 2(iii).

b) Mammalian collection:

Table 4 lists the small mammals acquired in the Cochrane area. It is evident that these are not the only small mammals in the area (the northern pocket gopher [*Thomomys talpoides*] and Richardson's ground squirrel [*Spermophilus richardsonii*] are two obvious omissions), but it was believed that these would be the only mammals likely to form the prey-base of foxes living in the large pen. A hair sample was taken from one specimen of *S. richardsonii* however, and this was used for analysis of scats and pellets from other local predators, as well as analysis of scat in the preliminary scat study. The specimen of *Lepus townsendii* was also kept for analysis of scat from other local predators, and analysis of scat from Grasslands National Park in Saskatchewan.

c) Other prey-types:

It is possible that swift fox will eat any type of insect but only those thought likely to be identifiable from scat were collected. It was discovered that where insect remains were found in scat, identification beyond order-level was rarely possible, and hence the specimens were not identified beyond this point. Other insects of similar sizes certainly exist in the area, but collection of insects is a time-consuming task, and it was thought that those collected were sufficient for the purposes of this study.

No reptiles were trapped or seen in the large pen, and the only amphibian collected from the area was the wood frog (*Rana sylvatica*). As with the insects, other amphibians (for example, the chorus frog [*Pseudacris triseriata*]) are known to exist in the area, but it was thought that these would not be found in the large pen, particularly as the bogs in this area are to a large extent dry during the summer months.

2. **Dietary Analysis**

(i) Scat Pilot Study

This study was conducted in order to gain basic information on the amount of food eaten and scat produced, as well as the types of remnant which could be expected to be found in scat after meals of known constitution.

Table 6 shows the summary of Dakota's feeding during the study. It can be seen that an average of 314 ∀ (SD)53.3g (11.1 ∀ 1.9 Oz) of food was given to Dakota each day, but that only 253.8 ∀ (SD)74.8g (9.0 ∀ 2.6 Oz) of this was eaten. The amount eaten is approximately the range of 7 to 11 Oz per day, recommended by the Reserve's directors. The main bulk of food not eaten included:

380g of horsemeat (almost all the horsemeat given on 19.7.94 and 21.7.94); 217.5g of Iams (over half the total quantity of this puppy food given in the study); 186g of Richardson's ground squirrel (the heads and forelegs of two of these animals, left after consumption of the rest of their bodies on 14.7.94 and 25.7.94); and 94.6g of day-old chicks (less than 4% of the total amount of chicks given to Dakota during the study).
It is difficult to draw inferences on the preferences of swift fox for different food-types from this study, given that the food-types were not presented in a methodical fashion, or in controlled conditions. It must be noted that Dakota was in the confined pen used for the study, because he was at the time undergoing treatment for an injured leg; he would obviously have been less active than other swift fox in the colony because of this, and may have had different dietary requirements as a result of his injury. Stress may also be a factor influencing feeding and digestion, and the location of the pen as well as the nature of the study, definitely led to greater interaction with humans than is usual in the breeding colony. It is nevertheless noticeable, that of the three foods most regularly given to Dakota during the study - day-old chicks, horsemeat and Iams, this fox ate a considerably higher proportion of the day-old chicks (96.36% as opposed to only 62.32% of horsemeat, and 48.70% of Iams). This can only indicate individual preferences.

The preliminary study also provided useful information on the general composition of swift fox scat, and how this relates to the food eaten. One of the most basic observations was that, of the nine different food-types given to Dakota during the study, identifiable remains of all but two of them were isolated from scat by the methods used. Only horse meat and Iams yielded no recognisable, undigested remains after sifting and washing of scat contents. It was observed however, that many scats which contained little evidence of consumption of the other food-types (for example, D2), were made up to a large extent, of a red-brown, clay-like substance, which disintegrated in water and was not retained by sifting; given that this was also observed in the large pen scat study (see section (ii), below), where scats containing no evidence of other food-types consumed were sometimes composed of this substance alone, this substance was assumed to be a general product of digestion. Where minimal evidence of other food-types was found however, the red-brown, clay-like substance was assumed to be primarily the product of consumption of horse meat.

Other implications of this study on scat-composition can be discussed by food-type, as follows.

Day-old chicks: The scat D6 contained much evidence of consumption of chicks, probably as a result of the 200g of chicks given to Dakota on the previous night (17.7.94); this would indicate that evidence of chicks appears quite rapidly after consumption (no chicks were given to Dakota on 18.7.94). The types of remains produced after a chick-meal, were: feathers, of which a slide was made, and which were found to have a distinctive structure; skin from around the lower leg and foot

(identifiable by its scaly structure); whole claws, still embedded in the flesh of the toes; claw-coverings; and (throughout the whole study) only one type of bone, believed to be the still-forming bony material from the wing.

Microtines: The study showed that remains of these voles isolated by scat analysis included both hair and bone. On one occasion, hair was found in substantial quantity the day after ingestion (as shown by scat D1), but scat D9, collected the day after a meadow vole was given to Dakota, shows no evidence of vole consumption. Hair was found in varying amounts on the second, third and fourth days after consumption (as shown by scats D1, D2, D11 and D12, respectively). It should be noted however, that vole hair found in D12 was found in substantial quantity, and may have come from a vole which had entered the pen and been caught by Dakota, as it was believed unlikely that hair from such a small vole as was eaten on 20.7.94, would still be the source of a substantial quantity of hair, as was found on 24.7.94. The only hard materials from these animals which were found in scats, included a single humerus bone from *M. longicaudus* (D1), a molar tooth from *M. pennsylvanicus* (D3) and a mandibular ramus (D5), also from *M. pennsylvanicus*; these were found one, one and three day(s) after ingestion of the source animal, respectively.

Richardson's ground squirrel: Hair from this animal was found in scat one day after it was given to Dakota (see scat reports D3 and D14) and two days after being given (see report D15). No whole bones were found, but fragments of bones were found both two days after the animal was given as food (see D4) and, it is thought, six days afterwards (see D8). A single claw from *Spermophilus richardsonii* was also found seven days after the ground squirrel was given to Dakota (see report D9); this indicates a considerable period of retention in the gut for some hard materials.

Juvenile passerines: These included only a 40g juvenile American robin (*Turdus migratorius*) and a 20g juvenile dark-eyed junco (*Junco hyemalis*) given to Dakota on 13.7.94. Both birds had fallen from nests and been brought in for rehabilitation but had been in too critical a condition to save. Being juveniles and in poor condition, these birds were probably of low nutritional value, and Dakota had eaten only 20g of the robin, and 5g of the junco. Only feathers from these birds were found in scat, and these in only small quantity after one day (see scat report D2), and slightly greater quantity after two days (see D3).

Orthopterans: These were fed to Dakota on only one day, but in very high number. Their remains were found in scat one day after being included in the diet (remains included many very small shards of chitin - see report D10), two days afterwards (including only one leg and one fairly large, thoracic section of exoskeleton, see scat D11), and three days afterwards (including two legs and some more fragments of chitin, see D12).

The study did permit several other observations to be made. Of these, perhaps the most notable, is that made from scat collected on 24.7.94. Scat collected was often made up of a number of 'pellets', and it was observed from scat D12, that the contents of these pellets seemed to be segregated, so that each pellet contained material of a different sort. Thus D12 was made up of three pellets, one containing mainly microtine hair, one containing chick remains, and one containing grasshopper remains. It may be that these pellets were produced at different times during the 24 hour period between collection, but a similar phenomenon of food-type segregation was also noted in the large pen scat study, between pellets still attached to each other.

As regards the composition of scat, it should be noted that periods of time between food consumption and appearance of remains in scat can only be used as vague indicators. This is because whilst some food may have been consumed immediately after being given to Dakota, other food items may have been consumed only a short time before food remains were collected; thus of food-types recorded as being given and eaten on one day, close on 24 hours may have elapsed between consumption of the different items.

Finally, the study also included measurement of daily scat mass. The daily average was found to be 11.0 ∀ (SD)6.1g. As can be deduced from the standard deviation, these figures varied greatly (from less than 2.5g, to 21.5g). It has also been observed in the results section, that scales used to weigh scats D1 to D7, lacked precision, and figures could only be obtained to the nearest 5g. Waterlogged scats were noticeably much heavier than drier scats of similar sizes, and it was thought that both weather and diet could affect scat masses. It is suggested that future studies involve measuring masses of dried scats.

(ii) Large Pen Scat Study

a) Study of scat contents:

Table 7 shows the record of food distributed in the large pen and it can be seen that similar amounts of horse meat and day-old chicks were given throughout the course of the study. The total amount of food given equated to a daily average of 2138 ∀ (SD)392g (75.4 ∀ 13.8 Oz). Given that six adult foxes were present during the study, this would be a daily average of 356 ∀ 65g (12.6 ∀ 2.3 Oz) per adult, considerably over the range recommended by the Reserve's directors. However, three cubs were also present in the pen during the study, and by the end of the study it is believed that these

cubs would have been consuming approximately the same quantity of food as the adult foxes. The actual daily average per fox probably falls between the average over six foxes (given above), and the average over nine, which was 238 ∀ 44g (8.4 ∀ 1.5 Oz), and hence in the range 194 to 421g (6.9 to 14.9 Oz); this is closer to the range of 7 to 11 Oz recommended by the Reserve's directors, although possibly still a little high.

Between one and five scats were collected each day for 42 days, with the daily average being 2.3 ∀ (SD)1.2 scats. Of the 94 scats weighed, the average mass was found to be 2.6g, indicating that an average of almost 6g of scat was collected each day. This is lower than the average amount of scat collected from a single fox during the scat pilot study, but reasons for the unreliability of these comparisons have been discussed above (see section (i)).

Scat analysis for this part of the investigation has been summarised in Table 8 and charts 1 and 2. It can be seen that vole remains formed the primary content in 49% of the scats collected, compared to 43% formed primarily from the red-brown, clay-like substance believed to be indicative of a horse meat meal, and only 7% containing primarily day-old chick remains. The only scat found to consist mainly of the remains of a different food-type, was T6b, which was also the only scat found to contain bird remains.

Primary content of scat may be subject to doubt, as not only may the primary content of a given scat be only marginally greater in volume than its secondary content but also, different food-types may lead to different amounts of remains per unit volume eaten. A method of determining the relationship between food-types eaten, and amount of remains in scat has been discussed under Recommendations (see below). It should however be noted that when fed day-old chicks, raptors at the Cochrane Wildlife Reserve produce pellets containing a substantial amount of chick skin and feather; given the strength of raptor digestion, this may imply that chick remains after digestion are substantial. Thus the 7% figure for scats in which chick was the primary constituent might be treated with more confidence, and not considered artificially low due to the chicks being highly digestible. This low figure has been explained by the fact that food is distributed widely in the large pen (not given within 60 feet of the foxes, as with the smaller pens), and it is thought that aerial scavengers may account for a large amount of the consumption of distributed food, particularly of the brightly coloured, day-old chicks.

Relative amounts of food remains in scat have been effectively ignored in chart 2. In this chart, all occurrences of a food-type in scats have been summed, and the occurrence has been expressed as a percentage of the total occurrences of all food-types in scat. Vole material can still be seen to have occurred in more scats than material from any other food-type, whilst chick remains can be seen to

have occurred in a similar number of scats to meat remains. Remains of insects, which formed the primary constituent of none of the scats were actually found in a significant number of scats. Remains of other food-types occurred in only 5 scats, representing 3% of all occurrences. These findings, along with other important inferences derived from the scat reports in appendix F, can be briefly discussed according to food-type, as follows.

Small mammals:

Only two species of small mammal were identified from remains in scat from the large pen; these were the voles *Microtus pennsylvanicus* and *M. longicaudus*, corresponding to the only two types of vole trapped in the area. Where the species was identified, *M. pennsylvanicus* was found to be the commoner, corresponding to the results of trapping in the locale. Identification was generally by analysis of hair under the microscope, and was often prevented by the degree of digestive breakdown of the hair. It was felt that identification to generic-level was sufficient for the purposes of this study.

Microtines were found in two-thirds (50 out of 74) of the scats analysed, accounting for 33% of the occurrences of all food-types. They were the primary constituent of 49% of the scats analysed. This indicates that these rodents form a significant part of the diet of the foxes in the large pen, possibly as important as the food given as the daily requirement. This could be due to one of three reasons: first, the foxes may lose a large proportion of the food provided for them to aerial scavengers, and hence be forced to hunt; second, the foxes may hunt out of preference, taking live prey rather than horse meat or dead chicks; third, the foxes may have vastly increased appetites, due to the greater area of the pen and the greater potential for activity; they may therefore hunt in order to supplement an inadequate diet. Whatever the reason, it should be noted that left-over food is never seen in the large pen, and it must therefore be completely consumed by the foxes and by scavengers, or possibly partly cached by the foxes.

That no other small mammal remains were found in scat is significant. No deer mice (*Peromyscus maniculatus*) were trapped in the area either, and this could imply that they are no longer extant on the Reserve. Although one snow shoe hare (*Lepus americanus*) has been observed in the large pen on a number of occasions, this is believed to be an isolated individual, and the probability of finding its remains in scat is low. No other Lagomorpha are thought to be present in the large pen. The only other small mammals acquired in the area were the red squirrel (*Tamiasciurus hudsonicus*) and three species of shrew (*Sorex spp.*). The red squirrel is an unlikely prey-item for the swift fox, given that for most of the wooded areas of the pen, the canopy is sufficiently dense to allow squirrels to remain in the trees. Foxes in the large pen were observed jump up at the bases of trees in response to

squirrels' chattering, but it is unlikely that they would actually catch a squirrel in this way. Shrews are equipped with malodorous scent glands (Banfield, 1974) and are generally believed to be quite unpalatable; they have few mammalian predators other than weasels and other shrews. A number of shrews were found outside the den in grid square 49, and appeared to have been killed by a fox, but not eaten. Remains of three unidentified mammals were also found in scats, and these have been discussed below, under "Other".

Insects:

Although these formed the primary constituent of none of the scats, their remains were found in 18 of the 74 scats examined. This indicates that insects form an important part of the diet for these foxes, although perhaps not as important as would be expected in the wild (see further discussion below).

Regular diet (horse meat and day-old chicks):

The low figure for the number of scats in which the dominant content was chick remains has already been discussed. It might further be pointed out that foxes in the smaller pens at the Cochrane Wildlife Reserve have been observed to take day-old chicks in preference to horsemeat, at this time of year. This would indicate a preference for the chicks which is reinforced by the results of the preliminary study in this investigation. If it were the case that foxes preferred chicks to horse meat, they might be expected to eat chicks as well as other food-types, but eat hose meat only when no other food was available. This would result in horse meat often being the dominant food in those scats in which it was found at all, and would consequently give a higher figure for scats composed primarily of horse meat than that for scats composed primarily of chicks, even though remains of the two food-types occurred in a similar number of scats (as can be seen from charts 1 and 2).

Overall these two food-types dominated 37 of the 74 scats analysed at the Cochrane Wildlife Reserve, and were responsible for 52% of the occurrences of all food-types in scat.

Other:

Other than the food-types already discussed, only one scat was dominated by a different food-type, this being T6b, dominated by bird remains. Unfortunately this bird could not be identified, but it would appear that consumption of wild-living birds is rare amongst the foxes in the large pen.

One scat (T35b) contained the shell of a mollusc, thought to be from a planorbid gastropod. This was very small (only 4mm in diameter) and could have been ingested incidentally whilst drinking. It was the only item of its kind found in all 74 of the scats analysed at the Reserve.

Remains of unknown mammals were found in three scats. That found in T12a, consisted of only a very few hairs, which were not recovered after analysis; these were probably from a small rodent such as a vole. Remains in T1a consisted of a single claw, and this was thought to have come from a squirrel-sized rodent, but did not match the claws from the red squirrel available for comparison. It was customary at the time, to release live-trapped Richardson's ground squirrels into the smaller fox pens; some of these escaped, and one at least was seen in the large pen. It may be that the claw found in T12a came from one of these ground squirrels, but no specimen was available for comparison. Hairs found in T18b were thought to have come from one of the house mice fed to the large pen foxes four days earlier. Unfortunately digestive breakdown of the hairs prevented this from being confirmed.

Finally, it should be noted that plant remains were found in nearly all of the scats studied. These were almost always in such small amounts (for example, a few spruce needles or a few blades of grass) however, that it was thought that their ingestion had probably been incidental.

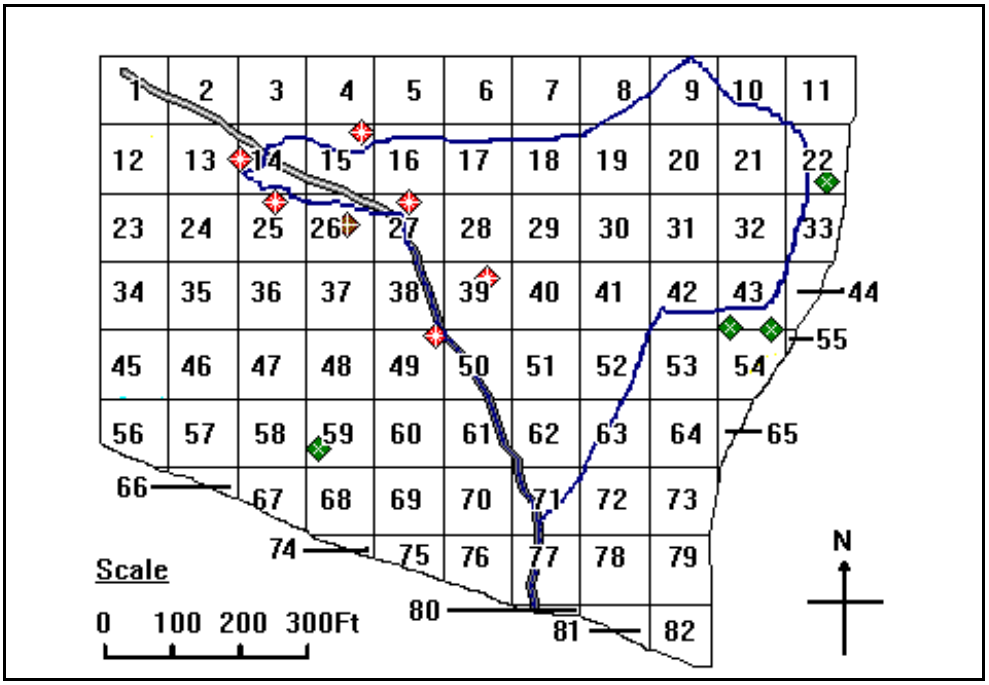
Zumbaugh and Choate (1985) examined the stomach contents of 142 swift fox from the Colorado-Kansas border area, in the winters of 1981-83. They found that 65.2% of the contents consisted of mammalian flesh, and that of the mammalian flesh, 47.1% was of leporid origin, whilst 34.7% was derived from mouse and rat-sized mammals. The only insect material they found was of orthopteran origin; although this accounted for only 7.7% of the total contents of the 142 stomachs, it was found in 50 stomachs, more than any other food-type. Birds remains were found to make up 18.4% of the stomach contents.

In a dietary study of the San Joaquin Kit fox in California, Vanderbilt White *et al.* (In Press) found that rodents (most commonly pocket mice [*Chaetodipus sp.* and *Perognathus sp.*], deer mice [*Peromyscus maniculatus*] and kangaroo rats [*Dipodomys ordii*]) were the most commonly occurring prey in scat, at 48.2% of occurrences, whilst leporids accounted for only 4.3% of occurrences in scat. At the most (in the wet season of 1990), leporids accounted for only 7.2% of the occurrences in scat. Insects accounted for 35.2% of occurrences, whilst birds made up 8.6%.

It would appear from these studies, that mammals are the most important components of the diets of North American arid-land foxes. Mammalian food items make up at least 60% (33% microtine and

27% horse meat) of the occurrences of all food items in scat from the large pen (Chart 2), or closer to 69% if provisioned food items are discounted. Zumbaugh and Choate (1985) found leporids to be the most important type of mammalian prey and it is unfortunate that the foxes in the large pen lack this component of the prey base. In both of the dietary studies quoted, wild birds made up a significant part of the diet; that evidence of only one wild bird was found in the scat from the large pen may be due to the scarcity of wild fowl in this area, such as the ring-necked pheasant (*Phasianus colchicus*) found in the study area of Zumbaugh and Choate (1985). Occurrence of insects in scat from the large pen, is also lower than in the two dietary studies discussed. Differences in population densities of prey insects between the latitude of the Cochrane Wildlife Reserve and warmer prairie areas are readily observable, and may be responsible for this discrepancy. It is also possible that hunting insects requires a higher effort to energetic yield than does taking other food items, and hence at the Reserve where food is in good supply, foxes will take the more rewarding types of food.

b) Observations on scat collection:



Map 2: Daily scat-collection route for the Large Pen

(Blue line indicates route walked)

Chart 3 shows the locations from which scats were collected during the study. These are of greater relevance when compared to the route walked for scat collection, as shown in Map 2. It is

noticeable that the route walked, incorporated all the dens in the large pen except that in grid square 59. This den was believed to be no longer in use by the time the study commenced.

From chart 3, it can be seen that more scat was collected in grid square 80 than in any other square. This is probably due to the fact that this is the square into which the gate opens, and hence the point of access for all human activities; it is probable that this is one of the most obvious points for a fox to mark, being a point at which food is often left, and both human and fox activity must be high. Similarly, much scat was also collected from grid square 71, a square, in which many of the subsidiary paths intersect with the main path. Other squares from which large amounts of scat were collected, include 25, in which the A-frame used as the main natal den was located, and 27, which contained another regularly used A-frame den.

Chart 4 shows the division of points of deposition at which the 92 scats for which location was recorded were collected. Almost half the scats had been collected from stones laid out for the deposition of scat, whilst 28% had been deposited on paths used by the foxes, and 23% were found in the areas of trampled ground around the A-frame dens. Given that the stones were all laid out on the paths, this shows that scat was found far more commonly on the routes used by the foxes, than around their dens. It is also apparent that the stones laid out were used by the foxes, although given that all the stones were checked each day, they were certainly not used by many of the foxes on a daily basis. It is thought that the stones were a useful aid to promoting the deposition of scat in locations where they would be easily spotted, but that they may lead to bias in scat studies, if only a small number of the studied animals tend to use them.

(iii) Other Predator Scat Study

The purpose of this study was to see how the diet of the swift foxes in the large pen compared to the diets of other predators living in the nearby area, which presumably had a similar prey-base; also to compare the diets of the swift fox in the large pen, with those of foxes living in the area into which many of the foxes from the Cochrane Wildlife Reserve are released.

Only a small number of scats and pellets from other local predators were collected, including seven coyote scats, five red fox scats and ten pellets from raptors of unknown species. The contents of these have been summarised in tables 9, 10 and 11 respectively.
All seven of the coyote scats collected contained remains of deer. This is probably because the coyotes from the neighbouring property utilise the Reserve's charnel-pit (at which are dumped the remains of road-killed deer on regular occasions) as an important point for foraging. It should be

noted however, that scat 1CS does contain what appear to be the hooves from a fawn. As no fawns have been dumped at the charnel-pit, it must be assumed that unless one of the deer dumped there was pregnant, the hooves are from a fawn acquired from other sources. Only one of the scats contained the remains of a Richardson's ground squirrel, but these are rare in the immediate area of the Reserve, and this individual, as with that suspected to be indicated in one of the scats from the large pen, may have been one which escaped from the smaller pens at the Reserve. The most important observation which can be made from the coyote scats, is that five of the seven contained the remains of microtines. This indicates that the coyotes are utilising the same part of the prey-base as the foxes in the large pen. No other mammalian remains were found in the coyote scats, supporting the evidence for the absence of the deer mouse from this area, and indicating that lagomorphs and rodents other than the microtines may not be a common source of prey for these predators either. Insect remains were also noticeably absent, and this may indicate either that the coyotes have sufficient food not to require the consumption of insects, or that prey-type insects are sufficiently uncommon in the area to make their ingestion rare. It must be remembered that these observations are based on only seven scats, and can be treated as indicators only.

The red fox scats were acquired from a site somewhat further from the Reserve than the coyote scats. It is not surprising that these scats contain evidence of consumption of some other prey-types therefore, including deer mice (in two of the five), a leporid (in one scat), and also hair from an unknown mammal (in scat RF5). It is important to note that all the red fox scats studied did contain microtine remains, once again indicating a high degree of overlap between the prey base of this predator and that of the swift foxes in the large pen.

The ten raptor pellets were acquired from the same property as the coyote scats but were believed to be much older, judging by their condition. Prey species identification from these pellets was much easier than in the mammalian scats, in which the main evidence of mammalian prey is hair. This is because the raptor pellets contain considerably more whole bone than do the mammalian scats, and these bones may be easily compared to the skeletons prepared for reference. Half of the raptor pellets contained evidence of deer mice having been eaten, and this supports the view that deer mice have been present in this area previously. Seven of the scats also contained evidence of microtine remains (four of *M. longicaudus* and three of *M. pennsylvanicus*), indicating (as with coyotes and red fox) some degree of overlap between the prey-bases of these aerial predators, and the swift fox in the large pen.

In order to analyse scat from the foxes in Grasslands National Park in Saskatchewan, it was first necessary to acquire reference specimens from the park. Table 12 summarises the trapping of small animals in the Park, showing that two small mammals not trapped at the Reserve in Cochrane were captured. These were the deer mouse and the sagebrush vole (*Lagurus curtatus*). As has been

stated, hair from two lagomorphs from the area was also used for reference.

Table 13 and charts 5 and 6 summarise the results of the analyses of 21 scats from Grasslands National Park. It can be seen that unknown mammals (thought to be rodents for which no reference material was available, or whose hair had been subject to sufficient digestive attack as to render them unidentifiable) formed the main content of 9 of these scats, whilst 6 were composed primarily of small rodents, and 5 were mainly made up of insect remains. Chick remains were also found to dominate the contents of one scat, but this scat was collected the day after release of the foxes, and thus still contained a remnant of its last provisioned meal.

The percent occurrences shown in chart 6 indicate that mammalian remains were the most commonly occurring food-type in scat (with 57% of occurrences), although insect remains (with 39% of occurrences) were found in more scats than any single type of identified mammal. Small rodents made up at least 34% of occurrences, although it is thought that all of the mammalian remains were those of small rodents. These figures are comparable with the findings of Zumbaugh and Choate (1985), except that their figures represent percent volume of food-types in the stomach, rather than occurrence in scat. The major difference between the diets of the foxes studied in Grasslands National Park, and those studied by Zumbaugh and Choate (1985), seems to be the absence of bird remains from the scats of foxes released in Grasslands National Park. The only explanation for this must be the difference in bird prey species between Grasslands National Park and the Kansas-Colorado border, or the fact that the majority of scats studied from Grasslands National Park, were from recently released animals which lacked the ability to catch birds. It is notable however, that one of the scats (S7b) collected from the road near Lockhart's ranch in the East block, contained parasitic round worms; this would imply that the fox was not a recently released fox, but rather was a wild fox. Scats S7a to S7d from the same location might also be reasoned to be scats from wild foxes. These scats contained no bird remains either, but were all made up primarily of mammalian remains. Only two scats from released foxes brought-up in the large pen were examined. These were S2a and S2b, and the major content of both was mammalian.

SUMMARY

The vegetation survey of the large pen showed it to be 18.7 acres in area, only a fraction of the area that a swift fox is believed to utilise in the wild, but almost 500 times the area of the other pens in use at the Cochrane Wildlife Reserve. The major habitat-type within the pen was found to consist mainly of grasses and shrubs, but a larger proportion of the pen is densely wooded. The habitat was found to be highly dissimilar to that in the foxes natural habitat, but this was thought unlikely to be critical.

Only three small mammals were trapped in the area, namely the arctic shrew, the meadow vole and the long-tailed vole. Scat analysis of foxes from the large pen showed that of these, only the two voles were regularly preyed upon by the foxes in the large pen. The deer mouse was not trapped in the area, and is thought to be no longer extant at the reserve, although analysis of old raptor pellets and previous sightings (Michie, pers. comm.) have indicated that it once was.

A pilot study showed that one fox consumed an average of 253.8 ∀ 74.8g (9.0 ∀ 2.6 Oz) of food, per day over a 15 day period. The same fox ate a greater proportion of the day-old chicks provided during this period, than either horse meat or Iams puppy food.

Six adults and three cubs in the large pen were provided with an average daily amount of food of between 194g and 421g (6.9 Oz and 14.9 Oz) each, over a six week period. The food consisted of similar amounts of horse meat and day-old chicks. 97 scats were collected during this time, and 74 of these have been analysed at the Cochrane Wildlife Reserve. 50 of these scats contained evidence of consumption of microtines and 18 contained evidence of consumption of insects. Microtine material was the primary component of 49% of scats, compared with horsemeat (43% of scats) and chicks (7% of scats). Evidence of chicks and horsemeat having been consumed occurred in similar numbers of scats. That they were the dominant food-type in less scats than horse meat may imply that horse meat is more often eaten in the absence of other food-types.

A small number of scats from coyotes and red foxes from the area, as well as pellets from raptors were examined. All were found to have some degree of dietary-overlap with the swift fox in the large pen, primarily because all preyed on microtines to some extent. The raptor pellets contained evidence solely of microtines or microtine-sized rodents.

21 scats from foxes in Grasslands National Park in Saskatchewan were analysed. Mammalian food-types thought to be all small rodents, were found to make up 57% of food-type occurrences in scat. 39% of occurrences were insect remains, indicating a higher reliance on insect prey than was seen in the large pen. No wild-living bird or lagomorph remains were found in any of the scats, even in four scats strongly believed to come from wild (as opposed to recently released) foxes; this was in contrast to the findings of Zumbaugh and Choate (1985), whose study of 142 swift foxes, found that lagomorphs made-up 30.7% of stomach contents, whilst birds accounted for a further 18.4%. Differences in type and abundance of prey between Grasslands National Park and the study area of Zumbaugh and Choate (1985), was thought to be an important factor in contributing to this contrast.

Overall, it was observed that live-prey makes up a significant proportion of the food eaten by the foxes in the large pen. Whatever the reasons for this, it can only be beneficial to them after release, given that they are learning to recognise live prey, and that the types of small rodents and insects available for them to hunt in the large pen, are similar to those forming a significant part of their diet in the wild.

RECOMMENDATIONS

This study aimed to establish some basic information concerning the habitat of the large pen, and the food habits of the captive swift fox. Further study in any of the areas covered would require more detailed and rigorous experimentation. A number of observations have been made in the discussion regarding weaknesses in experimental design and possibilities for further study. These and other recommendations arising from the study will now be summarised briefly.

1. It was apparent that all the dens which the foxes had dug prior to the end of the study period were located within spruce or mixed spruce and aspen areas, all having been dug at the base of spruce trees. It was felt that a tendency towards more densely vegetated areas may be detrimental to the survivorship of foxes after release. It would be valuable to investigate the relative amounts of time which each fox in the large pen spends in each habitat-type.

2. For assessment of plant species relative abundance in the large pen, it was found that a high number of quadrats (or similar sampling techniques) would be required, due to the high degree of species zonation. It was felt that fixed quadrats should be used, as many species can only be recognised during a short flowering period, which is far from synchronous throughout the species present.

3. The trapping for this experiment was conducted in order to supply specimens for reference. It was felt that a more detailed investigation of the prey-base within the large pen would be beneficial, involving population estimates for the main prey-species (derived from mark-recapture experiments). Estimates of seasonal variation in prey-abundance would permit examination of the relationship between prey-occurrence in scat and prey-abundance.

4. Indications of the amount of live-prey that the foxes are eating would be of greater significance if the amount of prey remains in scat could be related to the amount eaten. A method for determining this relationship has been suggested and is summarised, as follows:

Foxes could be taken individually and placed in a confined box-pen similar to that used in the scat pilot study. Floyd *et al.*(1978), state that it was necessary to fast wolves (*Canis lupus*) for only 36-48 hours in order to clear their digestive systems. Given the much smaller size of the swift fox and assuming that it has a much higher metabolic rate therefore, it should only be necessary to fast these animals for about 16-20 hours to clear their digestive systems. Following this, the box-pen could be cleared of scat, and the individual could be fed a meal consisting solely of a given food-type. Scats could be collected until scat production ceased.

Scat would be dried and weighed, before being soaked in water and examined. Contents identified as being the remains of the given food-type would also be dried and weighed, and the percent of dried weight resulting from the meal could be calculated. This could be repeated on a number of different occasions with a number of different foxes, so that the average percent of scat dry-weight which was made up of identifiable food remains could be calculated for each food-type, across a number of individuals and in a variety of conditions.

5. The average number of scats collected each day was 2.3 ∀ (SD)1.2. This was felt to be quite low and it is recommended that for similar studies, an extended scat collection route should be used, including more of the smaller paths used by the foxes.

6. Collection of scat from other predators in the area was opportunistic and yielded low numbers of scats and pellets. Study of greater numbers of such scats and pellets may provide more useful comparisons regarding prey-base utilization.

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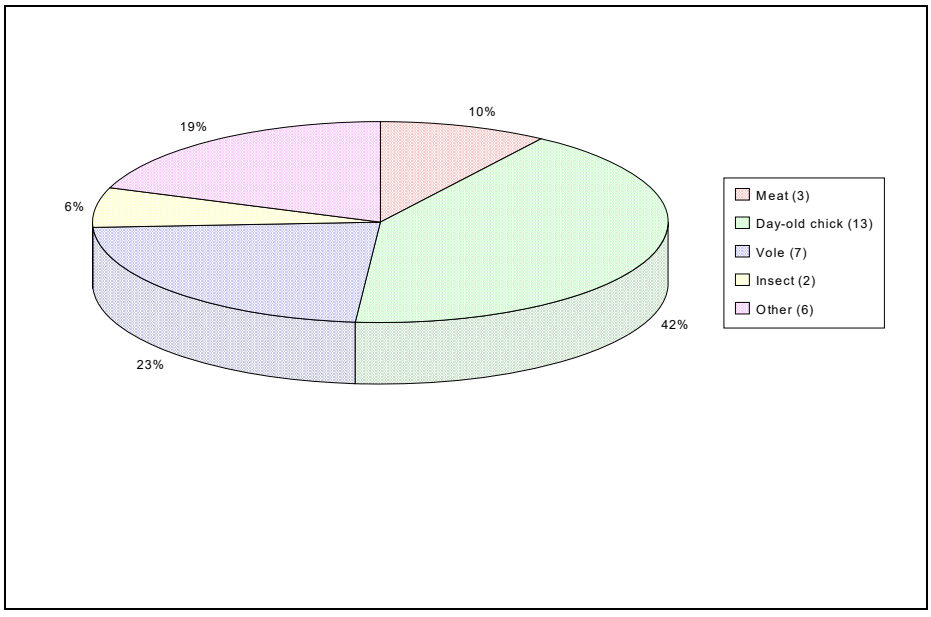
ADDITIONAL ANALYSIS

As stated in Results (section 2(ii), page 13), 97 scats were collected from the large pen over 42 days of study. 75 of these scats were analysed at the Cochrane Wildlife Reserve, according to the methods described in the Methods section (2(i), page 4). A further 22 scats (those collected during the final week of study) were sent to the University of Toronto for further analysis; these were analysed only on the basis of the hard material (bones, teeth, etc) that they contained; soft material was noted only where its origin could be identified easily by eye (as was the case for day-old chick feathers). Specimens of all trapped rodents were provided for the University of Toronto by the Cochrane Wildlife Reserve, for use as reference material

RESULTS

The full reports for each scat are given in Appendix I, following. These results are summarised in table 14 on the following page, and in chart 9, below:

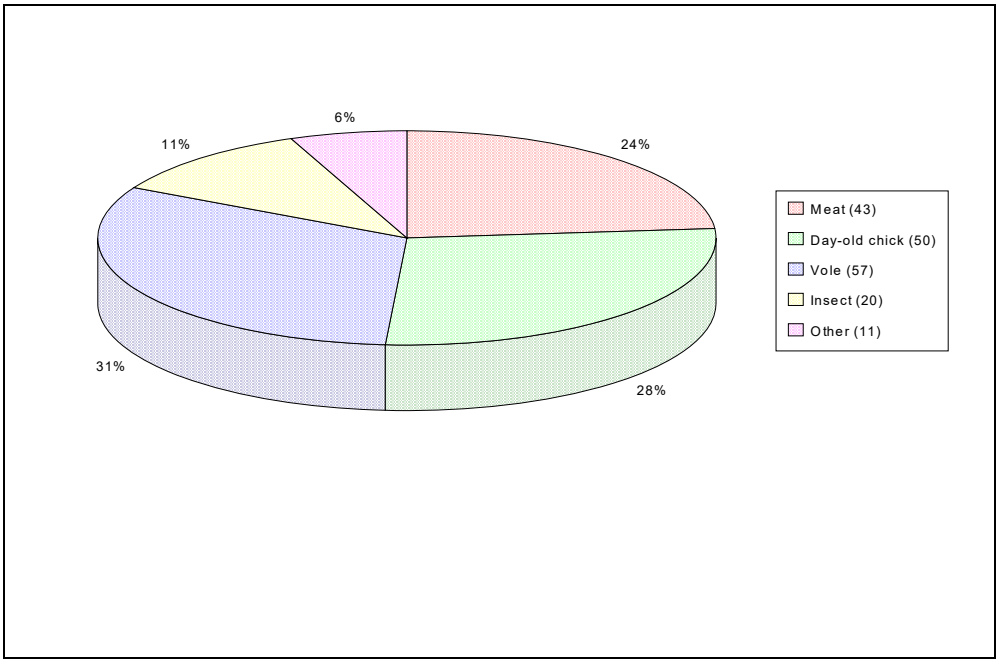
Chart 9: Occurrence of all food types in 22 Scats analysed at the University of Toronto



Brackets indicate number of scats in which food-type was found

Combining these results with those of the 75 scats analysed at the Cochrane Wildlife Reserve (as summarised in table 8 and chart 2), the following food-type occurrence summary is obtained:

Chart 10: Occurrence of all food-types in all 97 scats collected during the study



Brackets indicate number of scats in which food-type was found

DISCUSSION

The results of 22 scats analysed by the University of Toronto are summarised in chart 9. These can be compared to chart 2, which summarises the occurrence of food-types in the 75 scats analysed at the Cochrane Wildlife Reserve.

It can be seen that 160 food-type occurrences were recorded for the 75 scats analysed at Cochrane Wildlife Reserve, an average of 2.00 ± 0.82(SD) food-types per scat. For the 22 scats analysed at the University of Toronto, 31 food-types were recorded, an average of 1.41± 0.59(SD) food-types per scat. It is likely that the higher average occurrence for scats analysed at Cochrane Wildlife Reserve is due to the method used, which involved analysis of both hard and soft-material, as opposed to only hard-material analysis performed at the University of Toronto.
Charts 2 and 9 show marked differences in food-type occurrences; these shall be discussed according to food-type, as follows:

Meat: Horsemeat remains were found to occur in 40 of the 75 scats analysed at the Cochrane Wildlife Reserve, accounting for 27% of all food-type occurrences. Meat was only recorded in 3 of the 22 scats analysed at the University of Toronto, accounting for 10% of all food-type occurrences. This discrepancy can be explained by the fact that only hard-material analysis took place at the University of Toronto; meat remains in scat are only recognisable as soft-material. In the University of Toronto analysis, meat-remains could only be recorded as being present in a scat, where no other food-type was recorded. This difference results in the slightly lower figure of 24% shown for occurrence of meat remains in chart 10 (cf. 27% in chart 2).

Day-old chick: Day-old chick remains were found to occur in 37 of the 75 scats analysed at the Cochrane Wildlife Reserve, accounting for 25% of all food-type occurrences. Chick was recorded in 13 of the 22 scats analysed at the University of Toronto, accounting for 42% of all food-type occurrences. It is likely that this discrepancy can be explained because chick material was the only soft-material recorded for the scats analysed at the University of Toronto; the study at the Cochrane Wildlife Reserve found that other food-types (meat and vole) are often only identifiable from soft-material in scat, and hence these food-types are under-represented in chart 9, so that chick-remains account for a larger percentage of the total number of occurrences.

Vole: Vole remains were found to occur in 50 of the 75 scats analysed at the Cochrane Wildlife Reserve, accounting for 33% of all food-type occurrences. Vole was recorded in 7 of the 22 scats analysed at the University of Toronto, accounting for 23% of all food-type occurrences. As stated above, it was found during analysis at Cochrane Wildlife Reserve, that vole remains in scat were often only identified from soft-material (hair). As hair was not analysed at the University of Toronto, some vole occurrences in scat may have been undetected. Nevertheless, vole material was still found to represent nearly a quarter of all food-type occurrences in scats analysed at the University of Toronto.

Insect: Insect remains (both of orthopteran origin) were identified in only 2 of the scats analysed at the University of Toronto, representing only 6% of all food-type occurrences, as opposed to 12% for the analysis conducted at the Cochrane Wildlife Reserve. It is probable that this is because the scats analysed at the University of Toronto, were the scats collected during the final week of study. Examination of the identification of insect remains in scat shows that insects were commonly found in scat until day 20 of the study, until which time they represented 19% of occurrences. In scats collected during the remaining 22 days of study, insect remains were found in only 3 scats, representing 3% of occurrences. The low figure for insect occurrences is not wholly suprising therefore, given that insects are fairly uncommon in these latitudes during the first week of October.

Other: The following components of scats analysed at the University of Toronto have been recorded under the heading 'Other': Fragment of rodent hip;

Elements of the feet of a very small rodent - possibly a mouse;
Unidentifiable bone fragments;
Unidentifiable claw coverings, claw and long bone fragments;
Unidentifiable mammalian fragments; and
Unidentifiable fragments from a small rodent.

These six occurrences account for 19% of all food-type occurrences recorded at the University of Toronto. Only five occurrences are listed as 'Other', from the analyses conducted at Cochrane Wildlife Reserve; these represent only 3% of all occurrences in scat from the first five weeks of study.

It is apparent that all the occurrences of food-types from the University of Toronto analyses which do not fit into the four previous categories (meat, chick, vole and insect), involve unidentifiable bone fragments. This is indicative of the amount of mastication to which the food of the swift fox is subject, and suggests that soft-material analysis is an essential part of swift fox scat analysis, given that hard-material will often be too fragmented to identify.

The components listed under 'Other' above, also indicate the existence of some sort of mouse in the large pen. It has been suggested that this is either the deer mouse (*Peromyscus sp.*), or the house

mouse (*Mus musculus*); of these, the deer mouse is the more likely, having been seen in the area previously, as well as being identified in the pellets of local raptors. That this species has only been indicated in a single scat, would suggest that if it is present, it is rare or transient; this may account for the fact that it was not trapped on the Cochrane Wildlife Reserve.

SUMMARY

The results of analysis of 22 scats collected from the large pen during the final seven days of study are presented. The scats were analysed at the University of Toronto, using hard-material analysis only. The results show that fewer food-types were recorded per scat for the 22 scats analysed at the University of Toronto (1.41± 0.59(SD)) than for the 75 scats analysed at the Cochrane Wildlife Reserve (2.00 ± 0.82(SD)); this was thought to be because some food-types are often only recognisable by soft-material analysis.

The type of analysis used was also thought to be responsible for discrepancies between the percentage occurrences of meat remains, chick remains and vole remains between the analyses conducted at Cochrane Wildlife Reserve and at the University of Toronto. Insect remains accounted for only 2 of the 31 food-type occurrences in scats analysed by the University of Toronto, but this low figure was attributed to the seasonal decline in insect abundance towards the end of the study period.

Food remains which could not be identified as those categories discussed above, were more common in the scats analysed at the University of Toronto than those analysed at Cochrane Wildlife Reserve (19% cf. 3%); this was thought to be because of the method of analysis, which only involved the examination of (often fragmented) hard materials, ignoring the soft materials (hair etc) often associated with them. It was thought that in view of the fragmentation of hard materials during the swift fox digestive process, soft material analysis must be an essential part of any study of swift fox scat. Some material recorded under the category 'Other' was thought to indicate the presence of some species of mouse, possibly the deer mouse (*Peromyscus sp.*).

Of the 22 scats analysed at the University of Toronto, food-type occurrences were found to be as follows:

Meat.....10%
Chicks.....42%
Vole.....23%
Insect.....6%
Other.....19%

A total of 48% of occurrences were of food-types not provided for the foxes.

Of all 97 scats collected during the study, food-type occurrences were found to be as follows:

Meat.....24%
Chicks.....28%
Vole.....31%
Insect.....11%
Other.....6%

Once again, a total of 48% of occurrences were of food-types not provided for the foxes.

ACKNOWLEDGEMENTS

Thanks to Debbie J. Berg of the University of Toronto for analysing the scats.

APPENDIX A

Plant Species found in Large Pen

Family	Species	Common Name
BETULACEAE	*Betula glandulosa*	Bog birch
CAMPANULACEAE	*Campanula rotundifolia*	Common harebell
COMPOSITAE	*Achillea millefolium*	Common yarrow
	Agoseris glauca	Large-flowered false dandelion
	Antennaria spp.	Everlasting (×2)
	Aster laevis	Smooth aster
	Aster sp.	Aster
	Cirsium vulgare	Bull thistle
	Erigeron grandiflorus	Large-flowered fleabane
	Erigeron peregrinus	Tall purple fleabane
	Hieracium aurantiacum	Orange hawkweed
	Hieracium canadense	Canada hawkweed
	Solidago multiradiata	Rocky mountain goldenrod
	Taraxacum officinale	Common dandelion
CAROPHYLLACEAE	*Cerastium arvense*	Field chickweed
GRAMINAE	*Agropyron sp.*	Wheat grass
	Agrostis sp.	
	Bromus inermis	Smooth brome
	Bromus pumpellianus	Northern brome grass
	Danthonia intermedia	Timber oat grass
	Deschampsia sp.	Hair grass
	Elymus innovatus	Hairy wild rye
	Elymus junceus	Russian wild rye
	Elymus sp.	Wild rye
	Festuca rubra	Creeping red fescue
	Koelaria macrantha	June grass
	Phleum pratense	Timothy
	Poa canbyi	Canby blue grass
	Puccinellia nuttalliana	Nuttall's alkali grass
HIPPURIDACEAE	*Hippuris vulgaris*	Mare's tail
IRIDACEAE	*Sisyrinchium angustifolium*	Blue-eyed grass

Plant Species found in Large Pen (Continued)

LEGUMINOSAE	*Lathyrus ochroleucus*	Wild sweet pea
	Trifolium sp.	Clover
	Vicia americana	Wild vetch
	Vicia cracca	Tufted vetch
	Vicia sativa	Common vetch
	Vicia spp.	Vetch (×3)
LILIACEAE	*Lilium montanum*	Western wood lily
	Zygadenus elegans	White camas
PINACEAE	*Picea glauca*	White Spruce
	Picea mariana	Black Spruce
	Pinus banksiana	Jack Pine
PRIMULACEAE	*Dodecatheon pauciflorum*	Shooting star
RANUNCULACEAE	*Delphinium glaucum*	Tall larkspur
	Ranunculus acris	Tall buttercup
	Ranunculus cymbalaria	Creeping buttercup
	Ranunculus sp.	
ROSACEAE	*Fragaria glauca*	Wild strawberry
	Geum triflorum	Old man's whiskers
	Potentilla fruticosa	Shrubby cinquefoil
	Potentilla sp.	Cinquefoil
RUBIACEAE	*Galium boreale*	Northern bedstraw
SALICACEAE	*Populus tremuloides*	Aspen poplar
	Salix bebbiana	Beaked willow
	Salix spp.	Willow shrubs (×2)
SCROPHULARIACEAE	*Castilleja sp.*	Paintbrush
UMBELLIFERAE	*Zizia aptera*	Meadow parsnip

APPENDIX B

Analysis of Ground Cover by Trees

Trees sampled within randomly - located, 400 sq. ft. sections, within grid squares as indicated.

Tree Types:	1) Aspen	*Populus tremuloides*
	2) Black Spruce	*Picea mariana*
	3) White Spruce	*Picea glauca*
	4) Jack Pine	*Pinus banksiana*

Habitat Type: Aspen

Grid No.	Tree type	Circumference at Base/ ins.	Area at Base/ sq. ft.
7	1	21	0.49
7	1	21	0.49
7	1	19	0.40
7	1	27	0.81
7	1	23	0.58
7	1	24	0.64
7	1	28	0.87
7	1	19	0.40
7	1	23	0.58
7	1	24	0.64
7	1	18	0.36
7	1	21	0.49
7	1	20	0.44
7	1	16	0.28
7	1	8	0.07
28	1	21	0.49
28	1	25	0.69
28	1	24	0.64
28	1	24	0.64
28	1	16	0.28
28	1	19	0.40
28	1	23	0.58
28	1	12	0.16
28	1	13	0.19
28	2	23	0.58
77	1	12	0.16
77	1	18	0.36
77	1	15	0.25
77	1	22	0.53
77	1	24	0.64

77	1	22	0.53
77	1	34	1.28

Aspen Habitat (continued)

Grid No.	Tree type	Circumference at Base/ ins.	Area at Base/ sq. ft.
77	1	13	0.19
77	1	14	0.22
77	1	12	0.16
77	1	28	0.87
77	1	30	0.99
77	1	29	0.93
Totals	1	-	18.70
	2	-	0.58

Total number of trees:
Aspen = 37 = 1233 per acre
Black spruce = 1 = 33 per acre

Percent cover of Aspen habitat:
Aspen = 1.56%
Black Spruce = 0.05%

Habitat Type: Spruce

Grid No.	Tree type	Circumference at Base/ ins.	Area at Base/ sq. ft.
30	2	15	0.25
30	1	38	1.60
30	1	21	0.49
30	2	10	0.11
30	2	21	0.49
30	2	27	0.81
30	2	11	0.13
30	2	11	0.13
30	2	4	0.02
30	2	13	0.19
30	2	13	0.19
30	2	9	0.09
30	2	6	0.04
30	3	24	0.64
30	3	8	0.07
30	3	25	0.69
30	3	17	0.32
30	3	5	0.03
30	3	9	0.09

30	3	18	0.36
44	1	22	0.53
44	2	24	0.64
44	2	23	0.58
44	2	3	0.01

Spruce Habitat (continued)

Grid No.	Tree type	Circumference at Base/ ins.	Area at Base/ sq. ft.
44	2	31	1.06
44	3	18	0.36
44	3	36	1.43
79	1	36	1.43
79	2	2	0.00
79	2	1	0.00
79	2	1	0.00
79	2	1	0.00
79	2	1	0.00
79	2	3	0.01
79	2	2	0.00
79	2	10	0.11
79	3	1	0.00
79	3	2	0.00
79	3	2	0.00
79	3	3	0.01
79	3	20	0.44
79	3	3	0.01
79	3	25	0.69
79	3	10	0.11
79	4	78	6.72
Totals	1	-	4.05
	2	-	4.87
	3	-	5.26
	4	-	6.72

Total number of trees:

Aspen	= 4 = 133 per acre
Black spruce	= 23 = 767 per acre
White spruce	= 17 = 567 per acre
Jack pine	= 1 = 33 per acre

Percent cover of spruce habitat:

Aspen	= 0.34%
Black spruce	= 0.41%
White spruce	= 0.44%
Jack pine	= 0.56%