

54d

U 12

PHYSICAL CHARACTERISTICS, TERRAIN ASSOCIATIONS AND  
SOIL PROPERTIES OF ARCTIC FOX (Alopex lagopus)  
DENS IN NORTHERN YUKON TERRITORY, CANADA

Final Report

C.M.M. Smits, Wildlife Biologist II<sup>1</sup>  
C.A.S. Smith, Pedologist<sup>2</sup>  
B.G. Slough, Wildlife Biologist II<sup>1</sup>

February 1987

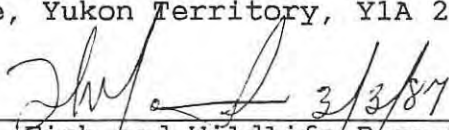
<sup>1</sup>Yukon Fish & Wildlife Branch  
Department of Renewable Resources  
Government of Yukon Territory  
Box 2703, Whitehorse  
Yukon Territory, Y1A 2C6

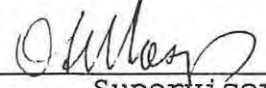
<sup>2</sup>Land Resource Research  
Institute  
Agriculture Canada  
Box 2703, Whitehorse  
Yukon Territory, Y1A 2C6

Physical characteristics, terrain associations  
and soil properties of arctic fox  
(Alopex lagopus) dens in northern  
Yukon Territory, Canada\*

C.M.M. Smits, C.A.S. Smith, and B.G. Slough

Yukon Departemnt of Renewable Resources, Box 2703  
Whitehorse, Yukon Territory, Y1A 2C6

 3/3/87  
\_\_\_\_\_  
Director, Fish and Wildlife Branch

  
\_\_\_\_\_  
Supervisor

The wildlife projects reported here are continuing and conclusions are tentative. Persons are free to use this material for education or informational purposes. Persons intending to use the information in scientific publications should receive prior permission from the Fish and Wildlife Branch, Government of Yukon, identifying in quotation the tentative nature of conclusions.

February 1987

\* submitted for publication to Arctic and Alpine Research Journal



CONTENTS

List of Tables	ii
List of Figures	iii
Acknowledgements	iv
Abstract	v
Introduction	1
Study Area	2
Methods	4
Results	8
Den mound characteristics	8
Terrain associations of arctic fox dens	11
Soil properties of dens and surrounding landscapes	15
Discussion	17
Conclusions	22
Literature cited	24
Appendix	27

List of Tables

Table 1.	Physical characteristics of arctic fox den sites, northern Yukon Territory.....	10
Table 2.	Summary of Herschel Island and Yukon Coastal Plain Map Units.....	12
Table 3.	Summary of fox den distribution on Herschel Island and Yukon Coastal Plain according to various map units.....	14
Table 4.	Summary of landscape and soil characteristics of selected fox den sites.....	16

List of Figures

Figure 1. Location of the study area.....3

Figure 2. Proportions of major aspects for combined  
Herschel Island (n=17) and Yukon Coastal  
Plain (n=25) arctic fox dens.....9

Figure 3. (Appendix) Land capability classification for fox  
denning on Herschel Island.

Figure 4. (Appendix) Land capability classification for fox  
denning on the Yukon Coastal Plain.



## ACKNOWLEDGEMENTS

The study was coordinated by the Lands, Parks and Resources Branch, Department of Renewable Resources, Whitehorse and funded by the Northern Oil and Gas Action Program (NOGAP). We thank P. Lortie, and D. Ladret, field coordinators. Our gratitude is also expressed to H. Jessup, A. Baer and M. Waterreus for assistance in the aerial surveys and to C. Kennedy, A. Hargrave, K. McKenna, D. Murray, D. Talarico and R. Ward for assistance in the field. T. Rodger prepared the figures while E. Gustafson, B. Pethick and L. Cox typed the manuscript. M. Hoefs, H. Jessup, H. Monaghan, D. Mossop, R. Stephenson, R. Ward and one anonymous reviewer critically read the manuscript.



**ABSTRACT**

Physical and soil characteristics of arctic fox (Alopex lagopus) dens on Herschel Island and the Yukon Coastal Plain, Yukon Territory, Canada are described. Additionally, their distribution (n=42) is related to terrain map units within the study area. Dens are generally associated with warm and well drained landscape positions. Burrow entrances are significantly oriented toward the south ( $P < 0.0025$ ). Soils of dens are coarse textured and well drained. Mean depth to permafrost under the den (172 cm) is greater ( $p < 0.02$ ) than at adjacent sites (44 cm). Certain unique soil profile characteristics, particularly the replacement of common cryoturbation features with those of zooturbation and the formation of humus rich surface horizons, appear to be the result of denning activities by foxes. Observed differences in soil temperature and depth to permafrost between den site soils and adjacent soils have likely been caused, at least in part, by denning activities. Den distribution is evaluated using an 1:25,000 ecological (soil and vegetation) map of Herschel Island and a 1:125,000 map of surficial deposits and landforms of Yukon Coastal Plain. Distribution of dens over the various map units is significantly different from random ( $p < 0.001$ ). The map unit foxes prefer for denning on Herschel Island is characterized by moderately eroded, sloping, gullied terrain where foxes select sandy erosional mounds for denning. The map unit preferred for denning on the Yukon Coastal Plain is a fluvial unit where foxes select streamside cutbanks and occasional dunes for den location. The non-random association of fox dens with certain landforms facilitates the use of existing terrain maps in making land use planning decisions.



## INTRODUCTION

Arctic foxes (Alopex lagopus) use dens for rearing of young and shelter (Eberhardt et al. 1983). Den sites may be chosen for exposure to sun, small accumulation of winter snow, protection from summer winds, and height above water and permafrost tables (Macpherson, 1969). Dens can be utilized for up to 300 years, often being enlarged, with additional entrances in successive years, until they deteriorate through natural processes (Macpherson, 1969). Dens may be utilized year round for shelter or as natal dens in spring and summer (Eberhardt et al., 1983). Arctic foxes often select historically preferred dens (Eberhardt et al., 1983), however the basis for this preference has not been determined. There is some evidence of fidelity of some adults and juveniles to the use of same dens in successive years. It has also been noted that litters are sometimes split into multiple dens, possibly to reduce the risk of predation or disease transmission (Eberhardt et al., 1983). Although it is not yet known whether arctic fox populations are limited by the availability of suitable den sites (Macpherson, 1970), it seems obvious that the availability of suitable denning sites plays an important role in the reproductive performance of the species. Because dens are necessary for reproduction and are focal points of activity in summer, foxes are most susceptible to human disturbance during the denning season.

In the Yukon Territory, arctic fox breeding habitat is confined to the relatively narrow belt of low lying tundra comprising the Yukon Coastal Plain, bordering the Beaufort Sea and Herschel

Island. Some overlap with red fox (Vulpes vulpes) breeding range occurs (Nolan et al., 1973; Ruttan, 1974; Smits and Jessup, 1985). Knowledge of the requirements for den sites is critical for sound management of foxes in this northern ecosystem, especially in light of accelerating development of natural resources. Additionally, classification of landscapes according to their suitability to sustain denning arctic foxes is crucial for multiple land use planning.

The purpose of the present study was to describe the physical and soil characteristics of fox dens in the northern Yukon Territory and to relate their distribution to map units described on existing ecological and geomorphic maps available for the study area.

#### STUDY AREA

The study area includes Herschel Island and the Yukon Coastal Plain.

Herschel Island (101 km<sup>2</sup>; Figure 1) is composed of marine sediments that have been deformed and ice-thrusted into their present form (McKay, 1959; Bouchard, 1974). While these deformed marine sediments are predominantly fine grained, there are limited exposures of sand and gravel. Differential erosion has led to the development of coarse textured ridges existing within a landscape of otherwise fine grained materials. Most of the surface is rolling upland at elevations ranging from about 60 to 180 m above sea level.

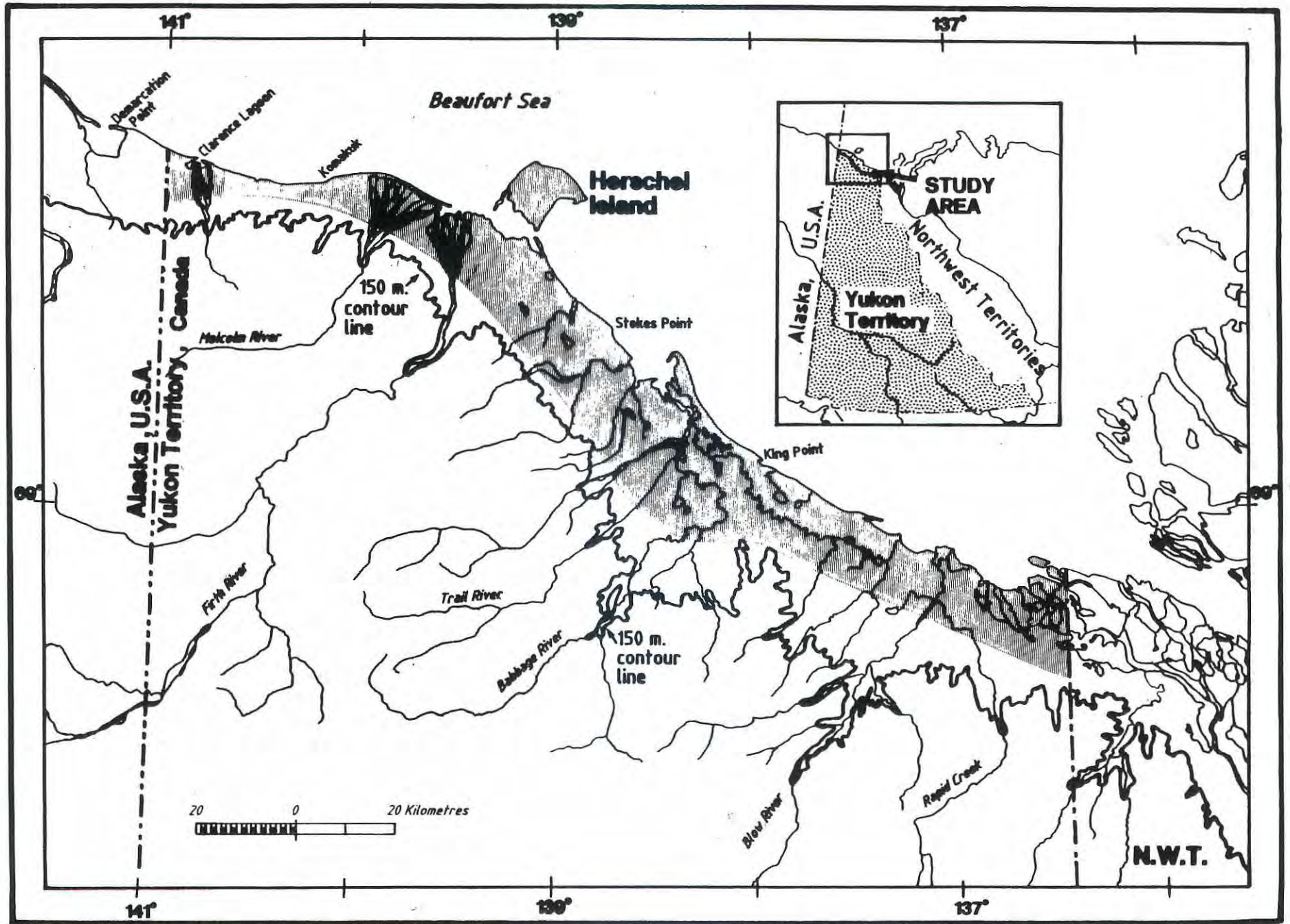


Fig. 1. Location of the study area (shaded), northern Yukon Territory, Canada.

The Yukon Coastal Plain (Bostock, 1970) is an eastward extension of the Arctic Coastal Plain (Wahrhaftig, 1965) from north coastal Alaska, averaging 20 km in width. It slopes from a high point of 150 m above sea level northwards to the Beaufort Sea coast and encompasses an area of approximately 3700 km<sup>2</sup>. The surficial materials of the Yukon Coastal Plain have mixed origins, being derived from glacial and non-glacial processes. Morainic, lacustrine and fluvial deposits are most common. Active fluvial landforms (large deltas) predominate on the plain west of Herschel Island. East of Herschel Island, the plain consists of rolling morainic deposits interspersed with nearly flat areas of lacustrine material. Lakes and ponds of thermokarst origin dot the plain and local relief rarely exceeds 30 m (Rampton, 1982). Mean annual temperature at Komakuk (Figure 1) is -12.1°C; the mean annual precipitation is 125 mm. Eastern and western winds predominate and their velocity surpasses those of winds of all other directions (Canadian Climate Program; 1982 a, 1982 b).

Cottongrass tussocks (Eriophorum vaginatum), moss and ericaceous shrubs (Salix spp.) comprise the dominant vegetation cover on imperfectly drained upland sites in the study area. On sites with better drainage avens (Dryas integrifolia), vetch (Astragalus spp.) and arctic willow (Salix arctica) predominate, commonly interspersed with mud boils (Wiken et al., 1981).

#### METHODS

Fox dens were located by searching the study area from a helicopter early July 3-10, 1984, June 29 - July 14, 1985 and

July 24-25, 1986 (Herschel Island only). During this period, the color of the lush den vegetation contrasted with that of the surrounding area and improved observability considerably. Other identification clues included the presence of bleached bones, arctic foxes and avian predators (golden eagles are known to hunt in the vicinity of arctic fox dens (Garrott and Eberhardt, 1982)). Transects were flown in an east-west direction on Herschel Island and a north-south direction on the Yukon Coastal Plain. They were spaced 400 m apart and flown 60-90 m a.g.l. at air speeds of 100-130 km hr<sup>-1</sup>. Dens located from the air might be mistaken for wolf (Canis lupus), or ground squirrel (Spermophilus parryii) dens. To verify their identity, dens were checked on the ground for presence of arctic fox scats, tracks, hair, prey remains and/or presence of arctic foxes.

Den sites were numbered and their locations plotted on a 1:25,000 map (Herschel Island, n=34) or a 1:125,000 map (Yukon Coastal Plain, n=36). Measurements were taken from randomly selected dens on Herschel Island (n=17) and Yukon Coastal Plain (n=25), of the surface area of the den site and the maximum and minimum height of the mound. Surface profiles, position of den site on the landscape, and aspect (of side of den with most burrow entrances) were recorded following Day (1983). Distribution of den aspects were analyzed using circular statistics (Zar, 1984). The number of burrow entrances was counted and their dimensions measured. Soil temperatures on the den sites mound and at a site approximately 10 m from the den typical of the surrounding terrain were measured at a depth of approximately 8 cm.

Distances to nearest fresh surface water were estimated in the field. Differences between den characteristics of Herschel Island and Yukon Coastal Plain or between characteristics of dens and those of adjacent sites were examined using the two-sample t-test (Zar, 1984).

The association of dens with the various map units was evaluated using an ecological map of Herschel island (scale 1:25,000, Smith et al. in press) and, on the Yukon Coastal Plain, a geomorphic map (scale 1:125,000, Rampton 1982). Map units of Herschel Island incorporated soil survey information and vegetation community descriptions. Soil mapping followed procedures outlined for an inventory level two (i.e. detailed) survey (Expert Committee on Soil Survey, 1979, Day 1983). The vegetation cover was classified into communities based on physiognomy, species presence and species cover. On the Yukon Coastal Plain, map units were compiled after the generic category of the landform units described by Rampton (1982). The total area covered by each map unit was calculated using a digital planimeter and expressed as percent of total area of Herschel Island and Yukon Coastal Plain, respectively.

An index of map unit selectivity was calculated based on the ratio of proportional occurrence of fox dens to proportional availability of map units in which dens occurred. This index allowed each map unit to be rated for its potential to supply denning habitat for arctic fox. The assumptions implicit in the use of such a land capability classification follow Slough and

Sadleir (1977). The frequency distribution of dens over the various map units was examined using Chi square goodness-of-fit tests.

A random sample of 14 dens (10 on Herschel Island, four on Yukon Coastal Plain), representing the range of terrain conditions, was examined for various soil characteristics. At each of these sites a soil pit was dug, usually slightly off to one side and away from any burrow openings. Pits were excavated through the den mound to permafrost. For comparative purposes a second soil pit representative of the surrounding landscape was dug at a site immediately adjacent to a sub-sample of dens (Seven on Herschel Island, three on the Yukon Coastal Plain). Differences between depth to permafrost at dens and adjacent sites were examined using the paired-sample t-test (Zar, 1984).

In order to characterize and classify the soils, the soil profile was described and a limited set of laboratory analyses were conducted on soil samples. Soils were sampled by horizons following the method of McKeague (1978) and classified according to Canadian Soil Survey Committee (1978) and Soil Survey Staff (1975). All soil samples were air dried, sieved and the >2mm fraction used for laboratory analyses for organic carbon content, pH (CaCl<sub>2</sub>), total nitrogen and particle size following methods outlined by Sheldrick (1984).

## RESULTS

An estimated 50% of all dens were located during systematic surveys. A complete den count was obtained on Herschel Island, where the complete ground area was searched using low air speeds and variable heights above ground level.

### Den mound characteristics

The physical characteristics of 42 arctic fox den sites (17 dens on Herschel Island and 25 dens on the Yukon Coastal Plain) are presented in Table 1. Mean mound heights are less on the Yukon coastal Plain, although den surface areas and numbers of burrow entrances are similar. Soil temperatures of dens are higher than those of adjacent sites.

Twenty four of 25 dens sampled on the Yukon Coastal Plain are located on level terrain and their general aspect is consequently non-directional. All 17 dens sampled on Herschel Island are located on slopes, however their general aspects are not oriented in a specific direction. Aspects of the side of the den with most burrow openings for all dens surveyed are not uniformly distributed in all directions (Raleigh's test,  $z=4.06$ ,  $p<0.002$ ) and were strongly oriented in a southerly direction (mean aspect =  $171^{\circ}$ ; V-test,  $U=2.81$ ,  $p<0.0025$ ) (Figure 2.).

While the magnitude of slopes differs between the two physiographic regions within the study area, in both cases dens were located on what was described as upper slope or crest positions (27 or 65.9% on the Yukon Coastal Plain; 16 or 66.7% on Herschel Island).

Table 1. Physical characteristics of arctic fox den sites, northern Yukon Territory.

	Mound Height (m)		Surface Area (m <sup>2</sup> )	Number of Burrow Entrances	Burrow Entrance Dimensions (cm)		Distance to Fresh Surface Water (m)	Soil Temperature at 8 cm depth (°C)	
	Max.	Min.			Width	Height		on Den	off Den
Herschel Island:									
Mean	4.5*	1.2	123.1	19.6	19.8**	18.1***	180.3	8.6	7.8
S.D.	2.2	1.3	122.3	13.7	5.1	4.5	203.0	3.1	2.7
Range	1-8	0-4	6-480	3-47	11-37	10-28	15-700	3-16	3-13
n	17	16	17	17	130	130	17	16	15
								9.0****	7.7****
Yukon Coastal Plain:									
Mean	2.1*	0.4	130.1	18.7	16.9**	15.3***	118.4	9.4	7.6
S.D.	1.3	0.6	115.9	9.3	5.5	4.2	187.0	2.5	2.3
Range	0.5-6.0	0-2.5	9-466	4-38	7-40	8-33	1-700	5-15	3-13
n	24	24	25	25	230	230	25	25	25

\*  $p < 0.001$  ( $t=6.5$ ,  $df=39$ )  
 \*\*  $p < 0.001$  ( $t=4.1$ ,  $df=358$ )  
 \*\*\*  $p < 0.0001$  ( $t=41.0$ ,  $df=358$ )  
 \*\*\*\*  $p < 0.05$  ( $t=2.3$ ,  $df=78$ )

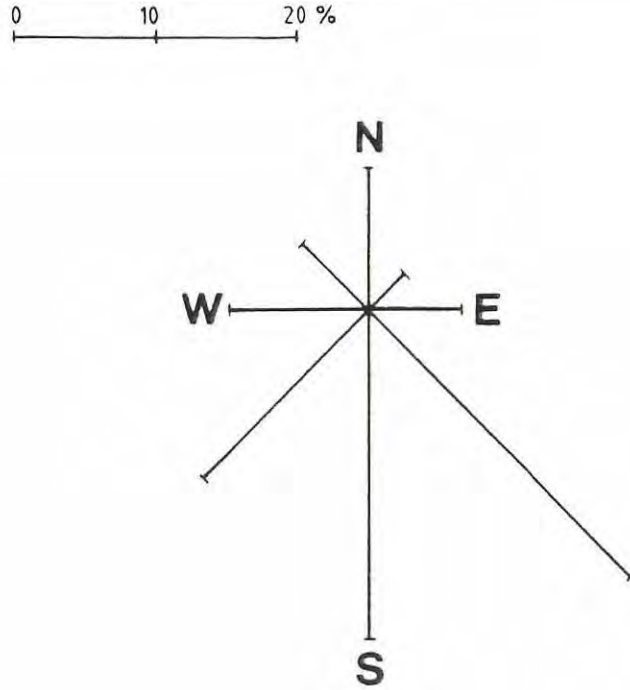


Figure 2. Proportions of major aspects for combined Herschel Island (n=17) and Yukon Coastal Plain (n=25) arctic fox dens.

Terrain Associations of arctic fox dens

The two physiographic regions (Herschel Island and the Yukon Coastal Plain) comprising the study area differ greatly in geomorphic composition. Similarly, the map units used to assess den site selection differed in their definition and scale. Table 2 summarizes the characteristics of the map units for both regions. Table 3 summarizes the areal distribution of map units and the corresponding fox den occurrences. A selectivity index value is listed for each unit and is used as a relative measure of a landscape's capability to provide denning habitat. A selectivity value 1.6 is interpreted to indicate high capability, a value of 0.4 - 1.6 medium capability and a value 0.4 low capability of a map unit to sustain fox denning. Distribution of dens on Herschel Island over the various map units is significantly different from random ( $\chi^2 = 46.2$ ,  $df = 7$ ,  $p < 0.001$ ). The Jaeger unit has a high capability to sustain denning foxes (selectivity index = 2.5), the Herschel, Avadlek and Orca units have low capabilities (selectivity index = 0). The Komakuk, Thrasher, Guillemot and Plover units show a range of selectivity index values and are grouped as having medium capability to sustain denning foxes.

The areal distribution of seven individual geomorphic units of Yukon Coastal Plain is also presented in Table 3. Distribution of dens over the various geomorphic units is significantly different from random ( $\chi^2 = 73.8$ ,  $df=6$ ,  $p < 0.001$ ). The Fluvial unit is strongly selected (selectivity index value = 1.9), the lacustrine, colluvial, estuarine and marine units are not

Table 2. Summary of Herschel Island and Yukon Coastal Plain Map Units

Map Unit	Characteristics
Herschel Island, 1:25,000 ecological (soil and vegetation) map	
Guillemot	Depressional areas on uplands, abundant thermokarst ponds and ice wedge polygonal features, occasional pulsa mounds, poorly-drained; <u>Carex</u> and <u>Eriophorum</u> tussocks on polygon centers, ice wedge depressions comprised of <u>Carex aquatilis</u> , <u>Salix</u> spp. and moss.
Orca	Active fans and channel fills, smooth gently sloping surfaces composed of silts and clays, seepage common; drier portions of fans colonized by <u>Salix arctica</u> , <u>Pedicularis</u> spp. <u>Petasites</u> spp. and moss. Seepage areas support <u>Carex aquatilis</u> , <u>Salix</u> spp. and moss.
Avedlek	Marine landforms - spits, beaches and bars; exposed areas sparsely vegetated, sheltered lagoons colonized by <u>Carex</u> spp. <u>Stellaria humufosa</u> , and <u>Minuartia</u> spp.
Herschel	Level uplands, very shallow active layer, imperfectly drained, fine textured soil; tussocks of <u>Eriophorum vaginatum</u> predominate with <u>Salix</u> spp., <u>Cassiope tetragona</u> , and <u>Vaccinium vitis-idaea</u> .
Komakuk	Gently sloping uplands, moderately well-drained, fine textured soil; occasional erosional mounds and non-sorted patterned grounds; <u>Dryas integrifolia</u> , <u>Astragalus</u> spp. and <u>Salix arctica</u> predominate.
Plover	Gently sloping, strongly patterned uplands, well to moderately well-drained, common, fine textured unvegetated soil; discontinuous vegetation cover of <u>Dryas integrifolia</u> , <u>Astragalus</u> spp. and <u>Salix arctica</u> .
Jaeger	Moderately eroded, sloping, gullied terrain; common erosional mounds; active slumping, variable soil texture; vegetation varies with slope and age of surface, mature, well-drained soils are characterized by <u>Dryas integrifolia</u> , <u>Astragalus</u> spp. and <u>Salix arctica</u> .
Thrasher	Severely eroded, steeply sloping terrain, irregular surface, many erosional mounds and gullies; variable vegetation cover depending on slope, surface roughness and surface age.

Cont'd

Table 2. Summary of Herschel Island and Yukon Coastal Plan Map Units - Cont'd

---

Map Unit	Characteristics
Yukon Coastal Plain, 1:125,000 geomorphic (surficial geology) map	
Fluvial	Channel, floodplain, terrace, alluvial fan and deltaic deposits, sand and gravels, many cutbanks and occasional dune mounds.
Morainic	Undulating till of variable coarse fragment content and texture depending on underlying materials. Affected by periglacial processes of solifluction, thermokarst and mass wastage.
Lacustrine	Level and depressional areas of thermokarst origin, occurring most commonly within moraine areas, silty clay, silt and silty sands.
Glaciofluvial	Outwash plains and fans, valley trains, kames, terraces and eskers, poorly sorted pebbly to cobbly gravels, hummocky, well-drained.
Colluvial	Material affected by mass wastage, variable texture and coarse fragment content.
Estuarine	Material deposited by fresh water or by brackish and saline water during storm tides, fine texture common organic debris.
Marine	Beaches and spits, baymouth bars, sand and gravel, level smooth surfaces.

Table 3. Summary of fox den distribution on Herschel Island and Yukon Coastal Plain according to various map units.

Unit <sup>1</sup>	Area (km <sup>2</sup> )	% of study area	Fox dens		Selectivity <sup>2</sup> Index	Den Capability
			Number	% of total		
Herschel Island, total area 101.1 km <sup>2</sup> , 34 dens						
Komakuk	45.3	44.3	7	20.6	0.5	Medium
Jaeger	20.1	19.7	17	50.0	2.5	High
Herschel	14.5	14.5	0	0.0	0.0	Nil
Thrasher	12.9	12.8	7	20.6	1.6	Medium
Guillemot	3.6	3.7	2	5.8	1.6	Medium
Plover	2.4	2.4	1	2.9	1.2	Medium
Avadlek	1.4	1.4	0	0.0	0.0	Nil
Orca	0.9	0.9	0	0.0	0.0	Nil
Yukon Coastal Plain, total area 3,711 km <sup>2</sup> , 35 dens						
Fluvial	1207.3	32.5	22	62.8	1.9	High
Morainic	1084.7	29.2	7	20.0	0.7	Medium
Lacustrine	858.1	23.1	2	5.7	0.3	Low
Glaciofluvial	397.5	10.7	4	11.4	1.1	Medium
Colluvial	81.7	2.2	0	0.0	0.0	Nil
Estuarine	59.4	1.6	0	0.0	0.0	Nil
Marine	22.3	0.6	0	0.0	0.0	Nil

<sup>1</sup>Units defined in Table 2.

<sup>2</sup>Selectivity index calculated as % of arctic fox dens divided by % of study area comprised by each unit.

(selectivity index  $< 0.4$ ). The morainic and glaciofluvial map units are used by arctic foxes for den construction approximately in proportion to their occurrence.

#### Soil properties of dens and surrounding landscapes

Dens on Herschel Island are associated with erosional features and hummocks, (Thrasher and Jaeger map units) while on the Yukon Coastal Plain, stream cutbanks, terrace escarpments, dunes (Fluvial map unit), and morainic ridges (Morainic map unit) provide the required relief for den location. Dens are located on soils with sandy loam to sand textures and moderately well to rapid drainage (Table 4). The only exception is den 14 which is located on a soil with imperfect drainage.

Soils of den sites on Herschel Island are usually quite different from those of the surrounding landscape. Within the occupied units on Herschel Island, foxes select coarse textured soils over the fine textured soils that make up the majority of each unit. On the Yukon Coastal Plain, where large fluvial and glaciofluvial landforms are utilized, little textural difference between den and surrounding landscape is evident. Rather, local relief and the presence of ridges or hummocks dictate den location. Mean depth to permafrost under combined Herschel Island and Yukon Coastal Plain dens is 72 cm, significantly different ( $t=3.2$ ,  $df=9$ ,  $p < 0.02$ ) from adjacent sites (44 cm) (Table 4).

Table 4. Summary of landscape and soil characteristics of selected fox den sites

Den ID No.	Unit	Site Description	Soil Texture <sup>1</sup>		Soil Drainage <sup>1</sup>		Depth to Permafrost (cm)		Classification of Soil Development on Den Mound <sup>2</sup>	
			Den Site	Adjacent Site	Den Site	Adjacent Site	Den Site	Adjacent Site	Canada	U.S.
<b>Herschel Island</b>										
37	Thrasher	erosional remnant mound at gully head	SL-LS	SiL <sup>3</sup>	Well	Imperfectly	105	25	Regosolic Static Cryosol	Pergelic Cryorthent
44	Thrasher	erosional remnant mound near coast	fS-SiL	SiL	Well	Imperfectly	110	60	Orthic Regosol	Pergelic Cryorthent
50	Jaeger	gravelly ridge exposed by moderate erosion	gLs	SL	Moderately-Well	Moderately-well	45	39	Regosolic Static Cryosol	Pergelic Cryoboroll
47	Jaeger	sandy ridge exposed by moderate erosion	SL	CL	Well	Imperfectly	63	25	Regosolic Static Cryosol	Pergelic Cryoboroll
48	Jaeger	erosional remnant mound near gully head	SL	-	Well	-	-	-	Regosolic Static Cryosol	Pergelic Cryorthent
38	Jaeger	erosional remnant mound near steep coastal bluff	SL	-	Well	-	-	-	Regosolic Static Cryosol	Pergelic Cryorthent
41	Komeluk	plateau mound near coastal bluff	SL	SiCL	Moderately-well	Imperfectly	63	57	Orthic Static Cryosol	Pergelic Cryaquept
39	Komeluk	hammock mound on rolling terrain	S-LS	SiL	Well	Moderately-well	53	31	Regosolic Static Cryosol	Pergelic Cryosamment
36	Komeluk	mound of exposed mixed sediments	L/peat	-	Moderately-well	-	-	-	Orthic Turbic Cryosol	Pergelic Eptic-Ruptic Cryoccept
53	Plover	mound near patterned ground, upper	LS	SiCL	Well	Imperfectly	50	30	Regosolic Static Cryosol	Pergelic Cryoboroll
<b>Yukon Coastal Plain</b>										
2	Eolian/Fluvial	mounds associated with sand dune complex	S	S	Rapidly	Rapidly	82	73	Regosolic Static Cryosol	Pergelic Cryosamment
18	Fluvial	Firth River delta	LS	LS	Rapidly	Rapidly	105	95	Orthic Regosol	Pergelic Cryosamment
24	Fluvial	Firth River delta	SL/S	-	Rapidly	-	-	-	Orthic Static Cryosol	Pergelic Cryoccept
8	Fluvial	silty fluvial fan	SiL	S	Imperfectly	Imperfectly	40	6	Orthic Turbic Cryosol	Pergelic Ruptic Cryaquept
						Mean	72	44		
						SD	27	27		

<sup>1</sup>Soil texture and drainage are according to Canadian Soil Survey Committee (1978);

<sup>2</sup>Canadian soil classification is according to Canadian Soil Survey Committee (1978)  
U.S. soil classification is according to Soil Survey Staff (1975)

<sup>3</sup>Soil texture classes: SL-sandy loam, LS-loamy sand, fS-fine sand, SiL-silt loam, S-sand, L-loam, gLS-gravelly loamy sand, SiCL - silty clay loam

10

Soil with permafrost within 1 m of the surface belong to the Cryosolic order in the Canadian soil classification system (Canadian Soil Survey Committee, 1978). The most common fox den soils are classified as Orthic Static Cryorols. Only two soils examined do not fall into this order; these are classified as Regosols. Within the U.S. system of soil taxonomy all soils have Pergelic temperature regimes and belong to Cryic great groups of various suborders of the Entisol, Inceptisol and Mollisol orders depending on the degree and sequence of horizon development. Most common fox den soils are classified as Pergelic Cryorthents (Soil Survey Staff, 1975).

#### DISCUSSION

The difference in mound sizes of fox dens between Herschel Island and the Yukon Coastal Plains reflects a difference in terrain between the two areas. Mounds are a characteristic feature of the erosional terrain of Herschel Island and are far less common on the level landscape of the Yukon Coastal plain.

Fox dens of the northern Yukon Territory are larger with more complex burrow systems than those reported for the Bolshezemelskaya tundra, USSR (Danilov, 1961) and the Teshekpuk Lake area of northern Alaska (Chesemore, 1969). However, den sites of the Colville River delta in northern Alaska (geomorphically similar to the Firth River delta in this study) (Garrott et al., 1983) are approximately twice as large with twice as many burrow entrances. This variation in reported den

sizes and complexity of burrow systems may be a function of the suitability of the terrain and soil for burrow construction, the fecundity of the arctic fox population in the area, the age of the den, or use of the dens by other mammals.

Burrow entrance dimensions agree well with those reported by Sdobnikov (1960), Chesemore (1969) and Eberhardt (1977). The smaller average dimension values of the Yukon Coastal Plain may be the result of arctic ground squirrels using fox dens on the Yukon Coastal Plain. Arctic ground squirrels are known to occupy deserted fox dens and create additional, smaller burrows (Macpherson, 1969; Garrett et al., 1983; pers obs.). Although obvious arctic ground squirrel burrows were excluded from the calculations, some overlap between large ground squirrel burrows and arctic fox burrows may have occurred during recording. Arctic ground squirrels are relatively abundant on the Yukon Coastal Plain and were not observed on Herschel Island. Fresh surface water is near all fox dens, although it is not known if the proximity of water is a significant factor in den site selection.

The higher soil temperatures of arctic fox dens relative to off-den sites is a common phenomenon of den sites (Danilov, 1961; Chesemore, 1969), and may be related simply to the coarser texture of den soils. It is not clear whether den sites are inherently warmer than nearby sites before foxes start constructing the dens, or if the favourable soil thermal regime and the lowering of the permafrost table on den sites result from

the presence of burrows which act as ventilation ducts. In most cases, observed conditions probably result from a combination of inherent and altered factors.

The position of Herschel Island dens usually involves gentle slopes (5-15%), the microclimate of which would probably differ little with aspect. The southerly orientation of the burrow entrances supports the contention that arctic foxes select for favourable microclimate conditions to construct dens (Danilov, 1961; Chesemore, 1969).

We observed the usual preference for warm and well drained landscape positions for denning (Table 4). The use of the streamside cutbanks and dunes characteristic of the Fluvial unit for denning, as recorded on the Yukon Coastal Plain, is a common phenomenon (Dementyeff, 1955; Danilov, 1961; Macpherson, 1969). On Herschel Island, where the classic fluvial, glaciofluvial and eolian landforms are absent, the foxes select sandy erosional mounds unique to the Jaeger and Thrasher units. Within the Plover unit, one den was observed on a mound associated with patterned ground (non-sorted circles), and numerous small dens (apparently non-natal) were observed on pulsa mounds set within polygonal wetland areas of the Guillemot units.

In both physiographic areas soil and terrain maps were beneficial to understanding the arctic fox den distribution. Both types of maps worked well in distinguishing various classes of denning

activity by arctic foxes, even though their scales and mapping concepts were different. Our data indicate that landforms control the distribution of den sites. However, the large differences in density of den sites (Table 3) between Herschel Island and Yukon Coastal Plain suggest that factors other than landscape such as prey abundance and diversity, determine the actual number of dens a given area can support at a given time.

Foxes transport nutrients, both directly (carcasses) and indirectly (scats and urine) to the den site thereby increasing the soil fertility at the den site as reflected in a lush vegetation cover relative to surrounding tundra. Foxes tend to mix materials through burrowing, bringing fresh material to the surface and burying organic materials. Many soil profiles contain bones at all depths. Soil profile characteristics, particularly the replacement of cryoturbation (frost churning) features with those of zooturbation (biological mixing) and the formation of humus rich surface horizons are the result of denning activities. On Herschel Island these soils are more often classified as Static rather than Turbic Crysols (CSSC 1978). Surface horizon enrichment leads toward the development, in extreme cases, of Pergelic Cryoborolls (Soil Survey Staff, 1975), a soil taxa relatively rare elsewhere on the island. On the Yukon coastal Plain soil taxa associated with fox den sites, are not unlike those of the surrounding landscape. Within both physiographic areas, soil taxa per se are not definitive in terms of identifying fox den habitat.

Differences in soil temperature and depth to permafrost between den site soils and adjacent soils are likely a result, at least in part, of fox denning activity. Certain soil properties (well drained, coarse textured) that make fox den soils distinct from those surrounding the den are little altered by fox activity. These inherent soil properties no doubt contribute to the initial selection of the site for denning.

## CONCLUSIONS

The arctic fox is adaptive and opportunistic in den site selection. Notable differences between soils on dens and soils off dens were observed in this study. Some of these differences are inherent and others are undoubtedly the result of denning activity. When the classic coarse-textured landforms (dunes, fluvial deposits) are not present, the foxes will use any other micro-climatically suitable landscape feature. Foxes select den sites where relatively warm, dry conditions prevail whether these be found on the erosional mounds and ridges of Herschel Island, the fluvial landforms of the Yukon Coastal Plain or even rock crevices such as reported by Østbye et al. (1978), for bedrock dominated landscapes in Norway. As such, it is not possible to state in absolute terms, a set of universal terrain conditions required for den establishment. Rather, it emphasizes the need to develop associations of den locations with landforms, and where available cartographic units presented on terrain maps, in order to assess regional denning habitat.

Our observations indicate that it is neither appropriate to extrapolate associations beyond the boundaries of one physiographic region nor attempt to base habitat capability on soil taxa alone, regardless of the taxonomic system followed. Associations developed for Herschel Island would not apply to the mainland but those developed for the Yukon Coastal Plain would likely be applicable to the contiguous Arctic Coastal Plain of Alaska. The non-random association of den locations with certain

landforms allows the use of terrain maps of various scale and composition to rank the potential importance of landscapes for fox denning. This ability to rank landscapes facilitates the use of existing terrain maps to assist in making environmentally-sound land use planning decisions in areas where preserving high capability fox denning habitat is a priority.

LITERATURE CITED

- Canadian Climate Program. 1982 a. Canadian climate normals-temperature and precipitation, The North, 1951-1980. Environment Canada, Downsview, Ont. 55 pp.
- Canadian Climate Program. 1982 b. Canadian climate normals, Vol. 5, wind, 1951-1980. Environment Canada, Downsview, Ont. 283 pp.
- Canada Soil Survey Committee. 1978. The Canadian System of Soil Classification. Canadian Department of Agriculture Publication 1646. Supply and Services Canada, Ottawa. 164 pp.
- Chesemore, D.L. 1969. Den ecology of the arctic fox in northern Alaska. Canadian Journal of Zoology, 47:121-129.
- Danilov, D.N. 1961. Den sites of the arctic fox (Alopex lagopus) in the east part of the Bol'shezemel'skaya tundra. Problems of the North, 2:223-229 (Translation National Research Council, Ottawa).
- Day, J.H. (ed). 1983. Manual for describing soils in the field. Land Resource Research Institute, Cont. No. 82-52, Research Branch, Agriculture Canada, Ottawa. 97 pp.
- Dementyeff, N.I. 1955. Biology of the arctic fox in the Bolshezemelskaya tundra. Translation Russian Game Reports Vol. 3, pp. 166-181. (Translation National Research Council, Ottawa).
- Eberhardt, W.L. 1977. The biology of arctic and red foxes on the North Slope. M.Sc. thesis, University of Alaska, Fairbanks.
- Eberhardt, L.E., R.A. Garrott and W.C. Hanson. 1983. Den use by arctic foxes in northern Alaska. Journal of Mammalogy, 64: 97-102.
- Expert Committee on Soil Survey. 1979. A proposed soil mapping system for Canada. Land Resources Research Institute Agriculture Canada, Ottawa. 60 pp.
- Garrot, R.A. and L.E. Eberhardt. 1982. Mortality of arctic fox pups in northern Alaska. Journal of Mammalogy, 63: 173-174.
- Garrott, R.A., Eberhardt, L.E. and W.C. Hanson. 1983. Arctic fox den identification and characteristics in northern Alaska. Canadian Journal of Zoology, 61:423-426.
- Macpherson, A.H. 1969. The dynamics of Canadian arctic fox populations. Canadian Wildlife Service Report Series, No. 8. Ottawa. 52 pp.
- Macpherson, A.H. 1970. Situation report on Canadian arctic fox research. IUCN Publ. New Series, 16:33-41. Morges.

- McKay, J.R. 1959. Glacier ice-thrust features of the Yukon coast Canada. Department of Mines and Technical Surveys, Geographic Branch, Geogr. Bull., 13:5-21.
- McKeague, J.A. (ed) 1978. Manual on soil sampling and methods of analysis. Canadian Society of Soil Science. Ottawa. 212 pp.
- Nolan, J.W., B.C. Goski and G.W. Wilde. 1973. Atlas of wildlife habitat inventory maps. - Arctic Fox. Canadian Wildlife Service, Ottawa.
- Østbye, E., H.J. Skar, D. Svalastog and K. Westby. 1978. Arctic fox (Alopex lagopus) and red fox (Vulpes vulpes) on Hardangervidda; den ecology, distribution and population status. Meddelelser fra Norsk Viltforskning, 3:1-66.
- Rampton, V.N. 1982. Quaternary geology of the Yukon Coastal Plain. Geological Survey of Canada Bulletin, 317. Ottawa. 49 pp. and maps.
- Ruttan, R.A. 1974. Arctic fox on north slope of Yukon Territory, 1972. In: Ruttan, R.A. and D.R. Wooley (eds.) Studies of furbearers associated with proposed pipeline routes in the Yukon and Northwest Territories. Arctic Gas Biological Report Series, Vol. 9, pp 1-52.
- Smith, C.A.S., C. Kennedy and A.E. Hargrave. (in press). Ecological survey of Herschel Island, Yukon Territory. Yukon Soil Survey Report No. 2, Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa.
- Sdobnikov, V.M. 1960. The arctic fox in Taymyr. Problems of the North, 1:229-238 (Translation National Research Council, Ottawa).
- Sheldrick, B.H. (ed) 1984. Analytical methods manual 1984. Land Resource Research Institute. LRRI Contribution No. 84-30. Agriculture Canada, Research Branch, Ottawa.
- Slough, B.G. and R.M.F.S. Sadleir. 1977. A land capability classification system for beaver (Castor canadensis Kuhl). Canadian Journal of Zoology, 55:1324-1335.
- Smits, C.M.M. and R.H. Jessup. 1985. Den distribution, harvest and management of arctic fox in northern Yukon Territory. Unpubl. Report, Fish and Wildlife Branch, Yukon Department of Renewable Resources. Whitehorse. 44pp.
- Soil Survey Staff 1975. Soil Taxonomy. Agricultural Handbook 436, USDA. U.S. Government Printing Office, Washington, D.G. 754 pp.
- Wahrhaftig, C. 1965. Physiographic divisions of Alaska. U.S. Geological Survey Professional Paper, 482. 52 p.

Wiken, E.B., D.M. Welch, G.R. Ironside and D.G. Taylor. 1981.  
The northern Yukon: an ecological land survey. Ecological  
Land Classification Series, No. 6. Environment Canada, Ottawa.

Zar, J.H. 1984, Biostatistical analysis. Prentice-Hall, Inc.,  
Englewood Cliffs, N.J. 718 pp.

APPENDIX

