# Den distribution, harvest and management of arctic fox in northern Yukon Territory.

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## ABSTRACT

The distribution and occupancy of arctic fox (Alopex lagopus) dens is discussed from data collected on aerial surveys of the Yukon Territory's arctic coastal plain and Herschel Island during the summers of 1984 and 1985. In addition, information on harvest of arctic fox from the area is reported. A total of 55 fox dens were identified in the study area, 36 on the mainland and 19 on Herschel Island. Den density for Herschel Island (0.1478 $dens.km^{-2}$) and mainland dens (0.0099 $dens.km^{-2}$) is very high and low, respectively, in comparison with densities reported elsewhere. Three of four natal dens located on Herschel Island were occupied by arctic fox and one by red fox (Vulpes vulpes), both in 1984 and 1985. No natal dens were found on the mainland in 1984; in 1985 two natal dens on the mainland yielded a red fox family and an arctic fox family. Red fox densities as evidenced from den occupancy rates have declined since a survey in 1972. Proportions of natal dens were low in both years and are suggestive of low population levels of arctic fox in the study area. The number of pups seen at dens varied from zero to five, but this information is insufficient to accurately reflect on total pup production. Dens were randomly dispersed on Herschel Island, the mainland, and all areas combined. Spacing of natal dens on Herschel Island departed significantly ($p<0.01$) from random in both years and suggests territoriality among breeding foxes. Foxes were sighted 27 times involving 28 arctic foxes (23 on Herschel Island; five on the mainland) and 14 red foxes (five on Herschel Island; nine on the mainland).

Five trappers have been trapping the northern Yukon Territory in the recent past. Harvest data are scant and imprecise. The catch during the last three trapping seasons varied from < 45 in 1983/84 to 98 in 1984/85. More trapping activity occurred during the period 1970 - 1980, with yearly catches probably surpassing 100 arctic foxes (and in one year 200 arctic foxes). The value of the fox catch may have amounted to over $7,000 in the late seventies, but decreased during the early eighties. In the 1984/85 season it amounted to approximately $1,000. Red fox was of little significance in the catch. It is considered unlikely that the 98 arctic foxes in the catch of 1984/85 could have been produced on the study area and we suggest that part of this catch reflects an influx of arctic foxes from adjacent areas. Based on the low density of fox dens in the area, the harvest potential for foxes is believed to be low. Further monitoring of breeding arctic fox performance and harvest are proposed.

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## 1.0 LITERATURE OVERVIEW:

The arctic fox (Alopex lagopus) is a circumpolar species with breeding range extending over the whole of the arctic tundra zone of North America and Eurasia; and including areas of alpine tundra in the mountains of Scandinavia. The species occurs in two distinct colour morphs, known as "blue" and "white". Each colour phase also changes seasonally. The "blue" fox moults from chocolate brown in summer to a winter coat of a slightly lighter shade of brown tinged with a blue sheen. The "white" variety is almost pure white in winter. Their summer coat is grey to brownish-grey dorsally and light grey to white below. Throughout most of their North American range the "blue" phase constitutes less than 1% of the total population, however, the proportion of blue foxes increases to the west in Alaska (Anderson 1934) and to the east in Canada, reaching 4.4% on eastern Baffin Island (Fetherston 1947).

There is considerable evidence that arctic foxes are highly mobile during fall, winter, and early spring, when many move onto the sea ice (Chesemore 1968), make long distance movements (Wrigley & Hatch 1976, Eberhardt & Hanson 1978), or even make mass movements in some regions (Bannikov 1970). Ear-tagging studies have revealed journeys of 1000 km or more (Wrigley & Hatch 1976). Large-scale emigrations may result from drastic reductions in food supply, such as population declines amongst lemmings. It is unknown whether these animals move back to their summer ranges.

Year round home range data are reported only from Finland, where the home range of an arctic fox pair in the northern part of that country varied between 3 and 60 $km^2$ within one year, with changes in food availablity (Kaikusalo 1971).

Summer home ranges of three arctic fox groups in Iceland ranged from 8.6 to 18.5 $km^2$ over a period of two years (Hersteinsson & Macdonald 1982). Eberhardt, Hanson, Bengtson, Garrott & Hanson (1982) record spring and summer home ranges for adult arctic fox in north central Alaska of 20.8 to 12.5 $km^2$. Burgess (1984) reports summer home ranges of 18.5 $km^2$ and 23.9 $km^2$ for northeastern Alaska. Speller (1972) provides the only estimate of arctic fox home range size based on direct observation. He found that two pairs of adult arctic foxes with young in the Northwest Territories had an average dry-land (water areas excluded) observed summer hunting range of 1.7 $km^2$ and a suspected range of 2.9 $km^2$. Hersteinsson & Macdonald (1982) report defence of home ranges by arctic fox family units against intruders. Other evidence of territoriality among denning foxes is reported by Fine (1980) who notes that the mean distance between family dens was about twice the mean distance between any two dens.

The arctic fox is an opportunistic predator. Over most of its range in arctic North America and the U.S.S.R. rodents comprise the major prey (Tchirkova 1951; Shibanoff 1951; MacPherson 1969; Stephenson 1970; Garrott 1980). Indeed, cycles in numbers of arctic rodents, particularly lemmings (Lemmus and Dicrostonyx) are mirrored in arctic fox populations (Tchirkova 1953). However, even in the tundra there are areas where geese (Anser and Branta spp.) (Savage & Cooper 1965) and reindeer or caribou (Rangifer tarandus) (as carrion) (MacPherson 1969; Pulliainen & Ala-Kotila 1982) are important, while locally the rock ptarmigan (Lagopus mutus) is a major prey (Braestrup 1941, Hersteinsson & Macdonald 1982). In Amundsen Gulf and the Beaufort Sea (Canadian Arctic) it has been found to be an active predator of newborn ringed seal pups (Phoca hispida), in their birth lairs (Smith 1976). Lavrov (1932) reports that on the Pribolov and Commander Islands (USSR) sea-birds, fish, marine invertebrates and seaweeds were eaten. On St. Lawrence Island, Alaska, and in western and southern Greenland and Spitsbergen cliff-nesting birds, mainly alcids, are important food (Stephenson 1970; Hersteinsson & Macdonald 1982). On Kildin Island (USSR) (Lavrov 1932) and Iceland (Hersteinsson & Macdonald 1982), arctic foxes are accused of killing sheep.

Although generally regarded as monogamous, Boitzov (1937) reports that under the semi-natural conditions of island fur farms, some males will mate with more than one female. Whelping occurs underground in breeding dens which are used for many years. The whelps are born in late spring and the family is supported until the mid-summer weaning period almost exclusively by the dog fox. The den is abandoned by the whelps in late summer, although foxes may inhabit some dens all winter (MacPherson 1969). Arctic foxes are capable of breeding by the latter part of their first winter (Lavrov, 1932). The reproductive ability of arctic foxes may change sharply from year to year. In one year 70-80% of the females may be pregnant and all natal dens occupied, but in other years the vast majority of females may be barren and only 10-15% of natal dens occupied (Bannikov 1970).

Most authors dealing with reproduction of arctic fox assume that adults present at a natal den consist of one pair (MacPherson 1969; Fine 1980; Garrott 1980). Recent findings in Iceland (Hersteinsson & Macdonald 1982) and Alaska (Eberhardt, Garrot & Hanson 1983) resulting from monitoring of tagged and radio-collared foxes indicate that foxes (at least in the denning season) may live in social groups of two adults (male and female) plus cubs of the year or one or two additional adults.

The number of young in one litter during an abundance of food averages eight to 12 but occasionally goes as high as 20 and 22. During years of food scarcity the average number of kits in a litter is three to five (Bannikov 1970). The mechanisms involved in this density-dependent regulatory process are not well understood but may involve reduced sexual activity (Cheatum & Severinghaus 1950) resorption of embryos (Bannikov 1970) and whelp mortality (MacPherson 1969).

Fox populations tend to fluctuate concurrently with the microtine cycles where these rodents form the major portion of their diet (Braestrup 1941; Elton 1942; Chitty 1950; Shibanoff 1951; MacPherson 1969). Periodic highs and lows in the fox population are reported to occur every three to four years, with population maxima differing from population minima by factors varying from three to ten (Braestrup 1941; Elton 1942; Bannikov 1970). Disease as well as lack of sufficient food reduces the density of foxes, especially in winter. The epizootics of rabies are the most prevalent disease among arctic foxes (Williams 1949; Rausch 1958; Syuzyumova 1967; Secord, Bradley, Eaton & Mitchell 1980). The disease persists in the population at levels of 0.7 to 6.0% in years of lemming abundance and reaches levels of 10 to 75% during winters of food shortage and the peak of the cycle (Bannikov 1970). The epizootic peaks are linked with high population densities in which young of the year are prevalent and most seriously affected, whereas in years when greater adult to young ratios occur the prevalence of the disease subsides (Syuzyumova 1968).

The valuable pelt of the arctic fox attracted many European explorers and traders into the Arctic. In Canada alone, 7,363 (1969-1970) to 81,783 (1954-1955) arctic fox pelts are sold annually, a catch valued to the trapper at

$102,395 (1969-1970) to $3,015.348 (1922-1923) (Statistics Canada, Catalogue 23-207 annual).

The importance of arctic fox to the fur trade has led to intensive research on their numerical fluctuations (Braestrup 1941; Shibanoff 1951; Tchirkova 1953, 1955; Bannikov 1970). In the USSR attempts to develop methods of forecasting arctic fox harvests were made (Tchirkova 1953, 1955). It was found that all factors influencing fox population dynamics, such as food supply, population density, weather conditions, outbreaks of epizootics, constituted a network of inter-related phenomena which may serve as a basis for forecasting future fluctuations in numbers.

The dramatic oscillations in population densities combined with the more consistent harvest pressure of arctic fox pose a serious management problem. The role of trapping in the population dynamics of the species is thought to be enormous (Smirnov 1967). In the USSR where statistics on population density and harvest are known from certain areas. If was found that during years of low numbers, when productivity of arctic fox decreased by a factor of four or more in comparison with years of high numbers, the harvest decreased only by a factor of two. This can be explained by an increase in trapping effort during these years (Bannikov 1970). Clearly, a need exists to develop a management strategy that allows the harvest to follow the population dynamics of the species more closely for both conservation and harvest optimization reasons (see Caughley 1977).

## 2.0 INTRODUCTION:

The present study was carried out under the Northern Oil and Gas Action Program (NOGAP), project G-15 (Economic Harvest Potential and Management of Arctic Fox in Yukon and a segment of project G-10 (Herschel Island Territorial Park Planning Project), a program involving federal departments and the territorial government intended to advance the state of governmental preparedness for hydrocarbon development in the north. The study objectives were to identify present arctic fox populations, habitats and harvest utilization, and to determine harvest potential and management strategies in conjunction with proposed developments in Yukon's Beaufort Sea Region.

The Yukon Territory's Arctic Coastal Plain, north of the British and Richardson Mountains is essentially unknown in terms of furbearer populations and habitat potential. Six species: arctic fox (Alopex lagopus), ermine (Mustela erminea), muskrat (Ondatra zibethicus), red fox (Vulpes vulpes), wolf (Canis lupus), and wolverine (Gulo gulo), are known to occur on the coast, with arctic fox being the most abundant and most heavily utilized by arctic trappers.

Until recently, the arctic ecosystem has remained relatively pristine; however, rapid exploration for petroleum resources has magnified man's influence in arctic areas. Because activites associated with petroleum exploration are concentrated in the northern Yukon Territory along the coast, where primary denning areas for the arctic fox are located, there is high potential for significant impacts on arctic fox populations. In addition, improved access to the coast, and the direct employment of native trappers on the north slope in petroleum exploration and development activities and at D.E.W.-line sites, has the potential to increase the harvest pressure on the arctic fox.

Monitoring fox populations may become necessary as development progresses, however, no standardized techniques are available. One approach to this problem which appears promising is the mapping of traditional fox dens over a large area and surveying these dens during the summer for occupancy and litter production (Shibanoff 1951; Smirnov 1967; Chesemore 1969; Ruttan 1974; Fine 1980; Garrott 1980; Eberhardt et al 1983). Previous aerial surveys for arctic fox dens and potential habitat in the northern Yukon were carried out as part of a preliminary inventory of wildlife habitat and/or wildlife populations within and adjacent to proposed gas and oil pipeline corridors (Nolan, Goski & Wilde 1973; Ruttan 1974). The largest concentration of dens was found to occur on Herschel Island and the portion of the mainland coastal plains between the Malcolm and Spring rivers. Denning sites include moss-covered frost mounds in flat, wet areas; river banks and sand-silt dunes at the mouths of rivers; on the slopes and tops of silt-mantled ridges; and in hills of sand and fine gravel (Ruttan 1974). Out of 50 fox dens located in 1972, 24 (48%) were occupied by arctic fox and seven (14%) by red fox. Only two arctic fox dens (4%) were known to have produced pups (Ruttan 1974).

Fox trapping had been a major source of revenue for northern people during the early fur trading days and continued with varying intensity until the 1930's. When the native people on Yukon's coastal plain were relocated from Herschel Island and Shingle Point to the site of present day Aklavik, N.W.T. during the 1940's, fox trapping on the coast declined as the trappers either switched to the fur resource on the MacKenzie delta or became industrial wage earners through opportunities afforded by hydro-carbon development.

The combined sale of arctic fox, seal and polar bear skins was less than 1% of the total earned income in Aklavik from 1973 to 1975 (Brackel, 1977). The number of active trappers on the study area has averaged less than six over the past 15 years (Cliff Cook, pers. comm. 1985). Of these active trappers, one was a full time employee at the Distant Early Warning (D.E.W.) Line station at Komakuk Beach and another was a year round resident on Herschel Island until 1980.

In recent years, arctic fox trapping on Yukon's coast line has become primarily a socio-economic activity for three to five families with an average annual harvest of less than 20 animals. However, when viewed as a single component of a way of life, arctic fox play a significant role in the traditional lifestyle of northern native peoples. Anticipated impact of resource development in the region presents a need to inventory this resource carefully, and at the same time, develop strategies to optimize its harvest.*

*At present the largest user group of arctic fox in the Yukon Territory are northern trappers. The influx of non-consumptive users into arctic fox range concurrent with resource exploration and territorial park development may soon result in their predominance. The relative scarcity of other large mammals amplifies the importance of arctic fox as a non-consumptive resource.

3.0 STUDY AREA:

The study area consists of that portion of the Arctic Coastal Plain (Bostock 1948) extending along the Beaufort Sea between the international boundary (Alaska), the Mackenzie River Delta, and Herschel Island. The southern boundary follows the 150 m contour line approximately (Fig. 1). It lies wholly

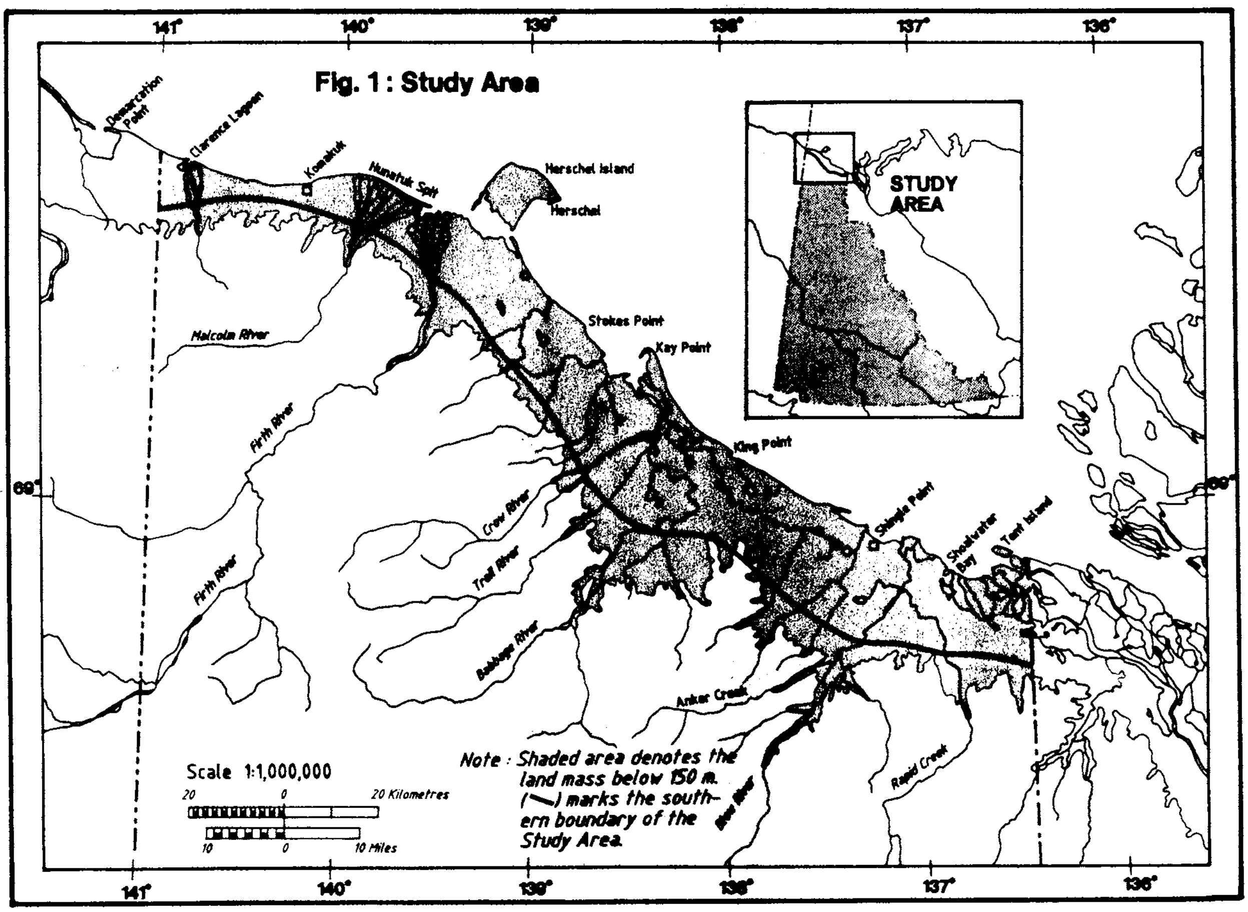


Fig. 1 : Study Area

within the Northern Coastal Plain Ecoregion (Wiken, Welch, Ironside & Taylor 1981). The following description is derived from Wiken et al (1981). Topographically, the arctic coastal plain is a gently sloping surface. It averages 20 km in width and slopes from a high point of 500 ft above sea level northwards to the Beaufort Sea coast. Along this smooth plain, the surficial materials have mixed origins, being derived from glacial and non-glacial processes. While bedrock exposures are very limited in occurrence, moraines, lacustrine and fluvial deposits are common. Their distribution is distinctive and two divisions of the plain can be recognized. Recent fluvial deposits, still in the process of formation, predominate on the plain west of Herschel Island. From a more detailed perspective, this plain is gentler and more regular than its counterpart to the east. The fluvial deposits which form this area consist of extensive braided deltas and prominent inactive and active river channels. East of Herschel Island, the plain consists of rolling moraine deposits interspersed with nearly flat areas of lacustrine material. Visible components of surface soils include gravels, shale, sands and silt as well as mixtures of these coarse and fine-grained materials. Herschel Island encompasses an area of approximatley 115 $km^2$ and is situated less than 3 km offshore. Most of the surface is rolling upland tundra, at elevations varying from about 60 to 180 m above sea level. The island is composed of quaternary marine sediments. Visible surface soils consist largely of silt or silt-clay-gravel mixtures. Mud slides are common on the slopes of steep ravines at several points.

Organic terrain is uncommon in this ecoregion and deposits are generally shallow. The ecoregion lies within the zone of continuous permafrost (Brown, 1973) which occurs near the surface.

Climatic data presented in Oswald & Senyk (1977) indicate mean annual precipitation of between 250 and 380 mm on the arctic coastal plain and about 125 mm along the arctic coast. Mean annual temperatures are probably between -10°C and -11°C.

Vegetation of this ecoregion is typified as arctic tundra and thus trees are absent. The vegetative cover is continuous. In the uplands, it consists primarily of tussocks of cottongrass interspersed with trailing shrubs and heath. Members of the sedge family are common. In the low-lying depressions, sedges and mosses are dominant. The predominance of trailing forms is likely the result of summer frosts, the retardation of plant growth due to the persistence of cold air temperatures, and the character of the soils (Wiken et al 1981).

## 4.0 METHODS:

The data collection phase of the study involved two aerial den surveys on the Arctic Coastal Plain and Herschel Island during the summers of 1984 and 1985 to determine den distribution and occupancy along with identification of fox harvest utilization through interviews with N.W.T. Fish and Wildlife officers and examination of harvest records. A number of physical and biotic characteristics of dens were also recorded. A detailed description of landscape, soil and vegetation based on those data will appear under separate cover (Smits, Smith & Kennedy, in prep) as will the results of the analysis of fox scats collected at dens (Smits, Slough & Cumbaa, in prep).

Identification of arctic fox dens has been performed by both ground surveys (Danilov 1961; Chesemore 1968; Smirnov 1968; Østbye, Skar, Svalastog & Westby 1978; Fine 1980; Garrott 1980; Pulliainen & Ala-Kotila 1982) and aerial surveys (Chesemore 1968; MacPherson 1969; Nolan, Goski & Wilde 1973; Ruttan 1974; Fine 1980; Garrott 1980; Eberhardt et al. 1983).

The most efficient technique for the survey of extensive areas appears to be aerial surveying, however the method is subject to some limitations. Verifications of aerially surveyed areas by ground methods has shown that fox den densities are under-estimated by aerial survey (MacPherson 1969; Garrott 1980). To date, no controlled experiments to ascertain the biases involved in aerial survey techniques for arctic fox dens have been published. For example, it can be expected that recent dens, where the lush vegetation typical of arctic fox dens has not yet been established, would be underrepresented in the aerial survey. The magnitude of this bias might be quite large as the occurrence of recent dens has been reported to vary from 10% (MacPherson 1969) to 20% (Garrott 1980), figures which have themselves been derived from aerial censuses. Underestimation of occupancy rates as well as misidentification of red fox and arctic ground squirrel (Spermophilus parryii kennicottii) dens as arctic fox dens has also been reported (Ruttan 1974; Garrott 1980).

When aerial surveys are carried out by helicopter, some of the biases can be reduced or eliminated. The relatively slow airspeed at which helicopters can fly will likely increase the number of dens being sighted, all other factors being equal. Dens can be ground checked for proper identification and presence of kits.

In the present study a systematic helicopter (Bell 206 Jet Ranger B) survey was carried out over the study area during July 3-10, 1984. During this period the colour of the lush den vegetation contrasted well with that of the surrounding area and improved sightability considerably. The landscape was searched for this contrast in vegetation at dens and other identification clues including presence of bones, avian predators (golden eagles are known to hunt in the vicinity of fox dens; Garrott & Eberhardt 1982) and foxes. Transects were flown in a north-south direction on the Arctic Coastal Plain. The Malcolm and Firth River deltas were covered more intensely, employing east-west transects as well. Herschel Island was surveyed flying east-west transects with particular attention being paid to the coastline and creek valleys. Transects were spaced 400 m and were flown 60-90 m AGL at air speeds of 100-130 $km.hr.^{-1}$. Two observers were present in the helicopter. Dens located from the air were ground checked to verify their identity by the presence of fox scats, tracks, prey remains and/or the presense of foxes.

During June 29-July 14 1985, dens identified the year before were resurveyed by helicopter. Arctic fox scats, particularly fresh ones, were collected. Den sites were numbered and their locations plotted on 1:250,000 topographical maps (Arctic Coastal Plain), 1:50,000 maps (Herschel Island), and 1:12,000 aerial photographs (Herschel Island).

The distribution of fox dens was tested for conformity to a random distribution using the distance to nearest neighbour method (Clark & Evans 1954). The mean of the distances between each den and its nearest neighbour is computed, as is the mean to be expected if dispersion were random. The ratio (R) of the observed mean distance to the expected mean distance serves as the measure of departure from randomness. In a random distribution, R equals 1. Under conditions of maximum aggregation, R equals 0, while under conditions of maximum spacing R equals 2.1491. The significance of the difference between the means of observed and random dispersion patterns is obtained from the standard variate of the normal curve (c). The c values 1.96 and 2.58 represent respectively the 5% and the 1% levels of significance (Clark & Evans 1954).

Harvest data from records kept by the Government of the Northwest Territories (GNWT) on the northern Yukon Territory is limited and there is no distinction made between those furs taken within our study area and those trapped over the entire Aklavik region. Therefore, the data were collected through interviews with trappers known to be operating in the northern Yukon Territory. With the aid of GNWT Fish and Wildlife staff, five trappers and their families were identified as the only active trappers on the study area in recent years.

Interviews were conducted in Aklavik, N.W.T. with the regional Fish and

Wildlife Officer and one trapper in October 1984, and with the remaining four trappers in September 1985. Interviewed were Mr. Cliff Cook, Fish and Wildlife Officer in Aklavik, Mr. Colin Harry, Mr. George Allen, Mr. Andy Kayotuk, and Mrs. Elizabeth McKenzie, all trappers from Aklavik and Mr. Laughingwell Shingatuk, a D.E.W. Line station employee and trapper from Tuktoyaktuk, N.W.T.

## 5.0 RESULTS:

### 5.1 Distribution and Occupancy of Dens

Forty-seven dens were identified during the survey of July 3-10, 1984; 14 on Herschel Island, and 33 on the mainland part of the study area. During the aerial re-survey of June 29-July 14, 1985, three additional dens, all on Herschel Island, were found. Two more dens were found on Herschel Island by co-workers, coincidental with their field duties on the ground. On the mainland, three dens were identified that had not been located in 1984 (Fig. 2, 3, Appendix 1*; Table 1). In total, 55 dens were identified in the study area, 36 on the mainland and 19 on Herschel Island.

Table 1 Geographical Locations and Utilization of all Fox Dens in the Study Area

| Den ID No | Utilization* | Latitude | Longitude | Den ID No | Utilization | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| 1 | — | 69°37'N | 140°59'W | 29 | Q('85) | 69°26' | 139°05' |
| 2 | Nr('85)Q('84) | 69°37' | 140°55' | 30 | W('84,'85) | 69°21' | 138°55' |
| 3 | — | 69°37' | 140°55' | 31 | S('84)W('84,'85) | 69°18' | 138°55' |
| 4 | W('84)Q('84) | 69°36' | 140°57' | 32 | S('85)W('85) | 69°16' | 138°58' |
| 5 | Q('85) | 69°35' | 140°55' | 33 | Q('85) | 69°13' | 138°43' |
| 6 | W('84) | 69°37' | 140°52' | 34 | W('84) | 69°10' | 138°40' |
| 7 | S('85)W('84) | 69°37' | 140°44' | 35 | — | 68°56' | 136°13' |
| 8 | S('85)W('84,'85) | 69°44' | 140°36' | 36 | — | 69°35' | 139°12' |
| 9 | Q('84,'85)S('85)W('85) | 69°36' | 140°37' | 37 | Na('84,'85) | 69°36' | 139°10' |
| 10 | W('84,'85) | 69°35' | 140°32' | 38 | Na('85) | 69°37' | 139°04' |
| 11 | — | 69°35' | 140°08' | 39 | — | 69°36' | 139°05' |
| 12 | W('84) | 69°36' | 140°05' | 40 | Nr('84,'85) | 69°37' | 138°57' |
| 13 | W('84) | 69°37' | 139°59' | 41 | Nr('84,'85) | 69°37' | 138°57' |
| 14 | W('85)A('84) | 69°36' | 139°54' | 42 | Nr('84,'85) | 69°37' | 138°57' |
| 15 | W('84) | 69°36' | 139°48' | 43 | — | 69°35' | 138°53' |
| 16 | S('84)W('84) | 69°34' | 139°41' | 44 | — | 69°34' | 138°53' |
| 17 | — | 69°33' | 139°40' | 45 | — | 69°34' | 139°02' |
| 18 | Na('85) | 69°33' | 139°38' | 46 | — | 69°34' | 139°03' |
| 19 | Q('84) | 69°32' | 139°38' | 47 | W('85) | 69°35' | 139°08' |
| 20 | Q('84,'85) | 69°32' | 139°38' | 48 | Na('84) | 69°33' | 139°11' |
| 21 | — | 69°30' | 139°42' | 49 | A('84) | 69°33' | 139°08' |
| 22 | Q('85) | 69°30' | 139°26' | 50 | Na('85) | 69°34' | 139°04' |
| 23 | S('85)W('84) | 69°31' | 139°23' | 51 | — | 69°33' | 139°06' |
| 24 | W('84,'85) | 69°27' | 139°21' | 52 | — | 69°33' | 139°06' |
| 25 | W('85) | 69°27' | 139°15' | 53 | Na('84)W('85) | 69°33' | 139°07' |
| 26 | W('84) | 69°25' | 139°17' | 54 | Na('85) | 69°32' | 139°07' |
| 27 | — | 69°24' | 139°19' | 55 | W('84) | 69°37' | 140°47' |
| 28 | — | 69°23' | 139°13' | | | | |

* N - Natal den (year): a - arctic fox; r - red fox
A - Occupied by adult arctic fox only (year)
S - Utilized by fox since previous (year) winter
W - Utilized by arctic fox as evidenced from presence of white hair in burrows in (year).
Q - Ground Squirrel use (year).
— - not occupied or itlized by fox during 1984-1985 surveys, nor by ground squirrels.

*Aerial photographs with den locations of Herschel Island are deposited with the Lands, Parks and Resources Branch, Yukon Department of Renewable Resources, Whitehorse.

With the exception of a den at Shingle Point, all dens were located west of the Babbage River. Areas with the highest density are Herschel Island, the Malcolm River delta and the area around Clarence Lagoon (Fig. 2, 3, Appendix 1).

Natal dens identified during the two surveys were all located on Herschel Island or on the mainland west of the Firth River. In 1984 four (8.5%) dens were natal dens (all on Herschel Island), three (6.4%) of which were occupied by arctic fox and one (2.1%) by red fox. In 1985 six (10.9%) dens were identified as natal dens, four (7.3%) of which were occupied by arctic fox and two (3.6%) by red fox. As in 1984, four natal dens occurred on Herschel Island (three occupied by arctic fox; one occupied by red fox), two of which had been vacant in 1984. In 1985 two natal dens were also found on the mainland (one occupied by red fox, the other by arctic fox).

Time limitations did not allow for intensive observation periods at dens to determine pup production. Number of pups seen at natal dens varied from zero to five (Table 2), but it is felt that the number of pups seen is a minimum figure.

In addition to occupied natal dens, a number of dens showed sign of recent (since the previous winter) fox use, as evidenced from fresh digging, scats, and/or tracks or sightings of fox. In 1984 five dens were in that category, versus four dens in 1985 (Table 1).

A visual assessment of known red fox and arctic fox dens revealed no apparent differences in their shape and size. Dens vacant during the 1984 and 1985 survey periods could therefore not be assigned to either species. Past use by arctic fox could be ascertained through the presence of white (moulted) hair for 16 dens in 1984 and 10 dens in 1985 (Table 1).

Table 2 Dens occupied by arctic and red fox families during the 1984 and 1985 surveys.

| Den ID No | Location | Occupant Fox Species | Number of Pups | Year |
|---|---|---|---|---|
| 37 | W. Herschel Island | Arctic Fox | 1 | 1984 |
| 41 | N. Herschel Island | Red Fox | 2 († ) | 1984 |
| 48 | S. Herschel Island | Arctic Fox | 2 | 1984 |
| 53 | S. Herschel Island | Arctic Fox | 1 | 1984 |
| 2 | N.W. Mainland | Red Fox | 5 | 1985 |
| 18 | Malcolm River Delta | Arctic Fox | ?* | 1985 |
| 37 | W. Herschel Island | Arctic Fox | 4 | 1985 |
| 40, 41, 42 | N. Herschel Island | Red Fox | 3 | 1985 |
| 50 | Central Herschel Island | Arctic Fox | ?* | 1985 |
| 54 | S. Herschel Island | Arctic Fox | 1 | 1985 |

* Number unknown, but pup(s) present as verified by size of fresh scats or aural clues.

† - dead

? - unknown

Some fox dens (five in 1984, six in 1985, Table 1) were also used by arctic ground squirrels. Dens were in no instance used simultaneously by arctic ground squirrels. Ground squirrels usually had some (smaller) burrows dispersed throughout the fox burrows.

## 5.2 Den Dispersion

### 5.2.1. All Dens

When taking the whole study area and all dens into account, dens appear to be dispersed randomly ($R = 0.88$, $c = 1.63$, $P > 0.05$; Table 3, see also Fig. 4a). Data analyzed separately for Herschel Island and the mainland part of the study area also indicate random dispersion of dens for these units (R = 1.20, c = 1.64, P > 0.05, resp. R = 0.94, c = 0.23, P > 0.05; Table 3).

Table 3 Arctic fox den distribution and dispersion. 1984-1985.

| Region | Area ($km^2$) | No* of Dens | Dens/$km^2$ | $\bar{r}_A$ | $\bar{r}_E$ | R | C | P |
|---|---|---|---|---|---|---|---|---|
| Whole Study Area | 3647 | 52 | 0.0143 | 3.70 | 4.19 | 0.88 | 1.63 | > 0.05 |
| Herschel Island | 115 | 17 | 0.1478 | 1.57 | 1.30 | 1.21 | 1.64 | > 0.05 |
| Mainland part of Study Area | 3532 | 35 | 0.0099 | 4.74 | 5.02 | 0.94 | 0.23 | > 0.05 |

* The number shown is the maximum number found during the '84 and'85 surveys. Dens no. 40, 41 and 42 are lumped together for these calculations.

$\bar{r}_A$ The mean of the series of distances to nearest neighbor dens.

$\bar{r}_E$ The mean distance to nearest neighbor dens expected in an infinitely large random distribution of the same density.

R Equals $\frac{\bar{r}_A}{\bar{r}_E}$

C The standardized variate of the normal curve.

P The level of significance (P) is that for the difference between the distribution and a random one of the same overall density. Computation from Clark & Evans (1954).

### 5.2.2 Natal Dens

The only natal dens found in 1984 occurred on Herschel Island. They were more widely spaced than they would have been under random conditions (R = 1.79, c = 3.03, P < 0.01; Table 4, see also Fig. 4b). Natal dens found in 1985 all seemed to be more widely spaced than they would have been if randomly dispersed, but the difference is only significant for the Herschel Island dens (R = 1.87, c = 3.35, P < 0.01; Table 4).

Table 4 Arctic fox natal den distribution and dispersion. 1984-1985.

| Region | Period | Area (km$^2$) | No of Dens | Dens/km$^2$ | $\bar{r}_A$ | $\bar{r}_E$ | R | C | P |
|---|---|---|---|---|---|---|---|---|---|
| Whole study area | '85 | 3647 | 6 | 0.0016 | 14.92 | 4.12 | 1.19 | 0.91 | $>0.05$ |
| Herschel Island | '84 | 115 | 4 | 0.0348 | 4.80 | 2.68 | 1.79 | 3.03 | $<0.01$ |
| Herschel Island | '85 | 115 | 4 | 0.0348 | 5.03 | 2.68 | 1.87 | 3.35 | $<0.01$ |
| Mainland part of study area | '85 | 3532 | 2 | 0.0006 | 34.70 | 20.41 | 1.70 | 1.89 | $>0.05$ |

* The number shown is the maximum number found during the '84 and '85 surveys. Dens no. 40, 41 and 42 are lumped together for these calculations.

$\bar{r}_A$ The mean of the series of distances to nearest neighbor dens.

$\bar{r}_E$ The mean distance to nearest neighbor dens expected in an infinitely large random distribution of the same density.

R Equals $\frac{\bar{r}_A}{\bar{r}_E}$

C The standardized variate of the normal curve.

P The level of significance (P) is that for the difference between the distribution and a random one of the same overall density. Computation from Clark & Evans (1954).

## 5.3 Fox Sightings

Fox sightings were in most instances associated with dens. Seven sightings (involving five arctic fox and four red fox), associated with as many different locations, took place in 1984. Twenty sightings (involving 23 arctic fox and ten red fox) occurred in 1985, associated with 13 different locations (Table 5). The preponderance of sightings on Herschel Island in 1985 reflects the amount of time spent there by the authors and co-workers in that year. Considering that, a) several of these involved recurrent sightings at the same dens some, or all, of which probably involved the same fox(es), b) that some or all of the sightings away from dens may have involved foxes sighted elsewhere, and c) that sampling intensity differed between areas, these figures cannot be construed to indicate population densities.

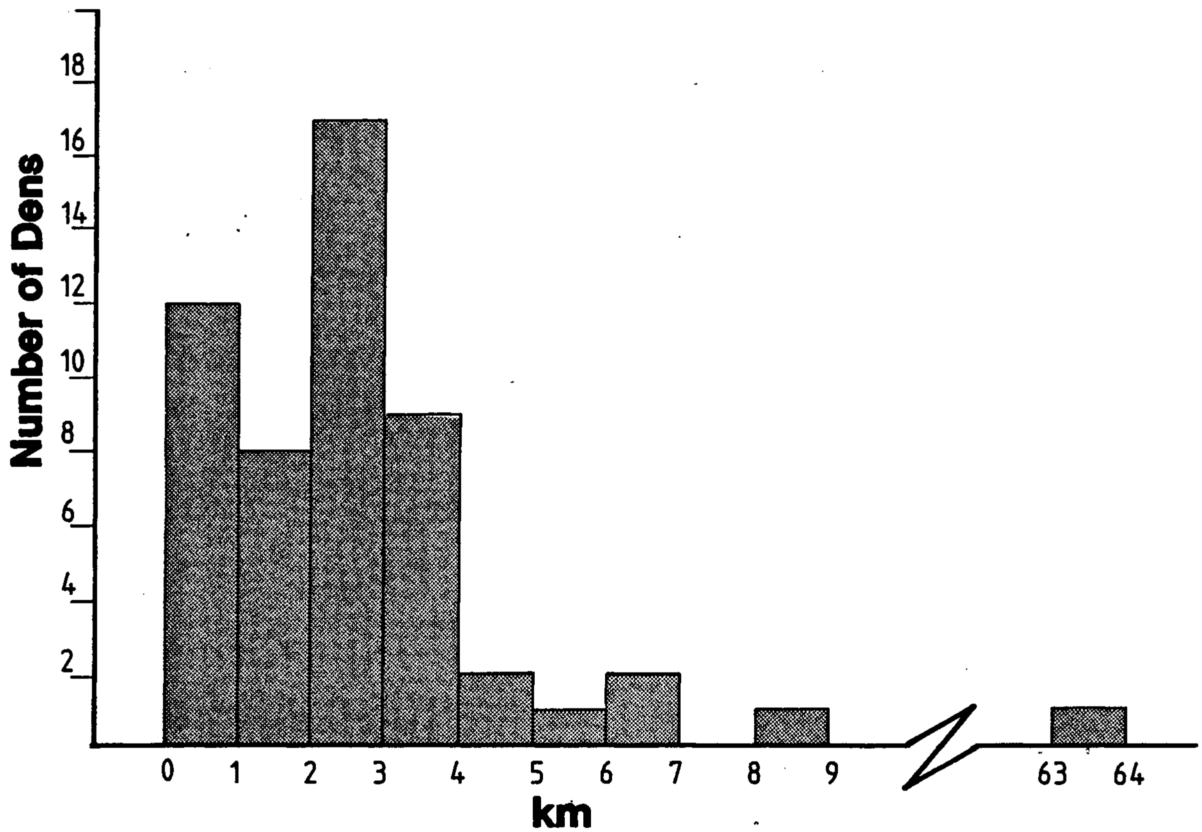


Fig. 4a : Distribution of distances between all fox dens and their nearest neighbours in the study area.

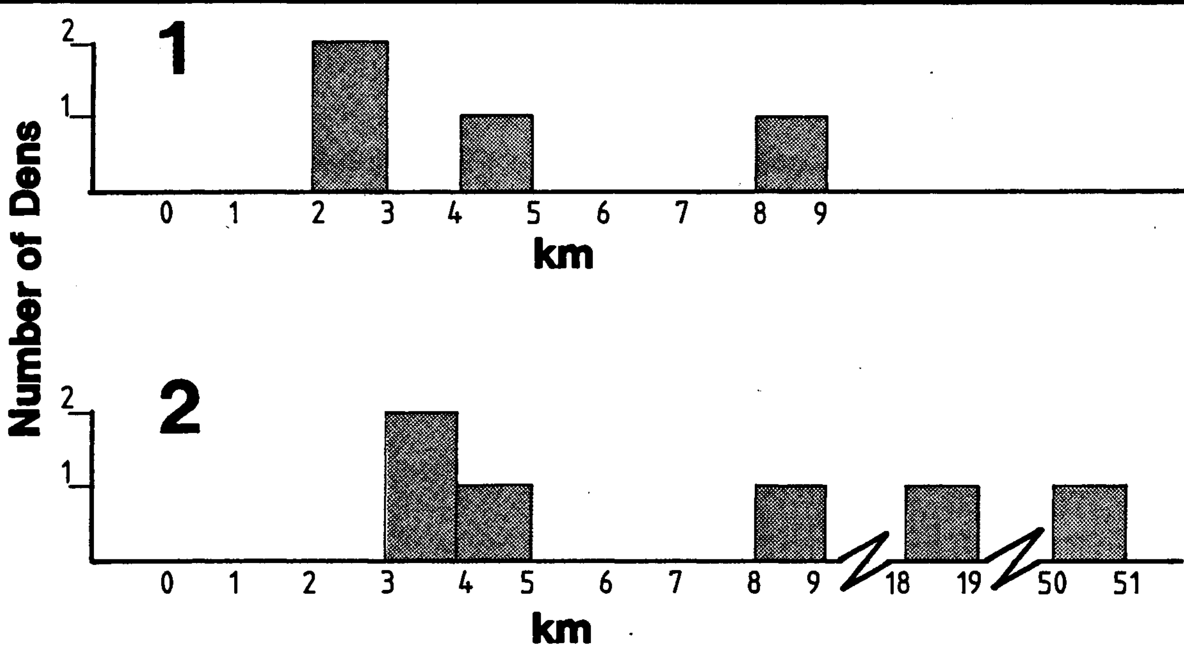


Fig. 4b : Distribution of distances between natal fox dens and their nearest neighbours in the study area ;
1 ( 1984 ),
2 ( 1985 ).

Table 5. Fox sightings, 1984-1985.

| Date | Location* | Arctic Fox (number) age class Herschel Island | Arctic Fox (number) age class Mainland | Red Fox (number) age class Herschel Island | Red Fox (number) age class Mainland |
|---|---|---|---|---|---|
| Spring '84 | Komakuk Beach (M) | | | | (1) adult |
| Spring '84 | Den No. 35 (M) | | | | (1) adult |
| Early July '84 | Den No. 49 (H) | (1) adult | | | |
| July 10 '84 | Den No. 14 (M) | | (1) adult | | |
| Early July '84 | Den No. 48 (H) | (2) pup | | | |
| Early July '84 | Den No. 37 (H) | (1) pup | | | |
| Early July '84 | Den No. 39 (H) | | | (2) pup | |
| June 24 '85 | Beach, Clarence Lagoon (M) | | (1) adult | | |
| June 29 '85 | NE Herschel Island | | | (1) adult | |
| June 29 '85 | Den No. 40 (H) | | | (1) adult | |
| June 29 '85 | Den No. 37 (H) | (1) adult | | | |
| June 30 '85 | Den No. 50 (H) | (2) adult | | | |
| July 02 '85 | Den No. 2 (M) | | | | (1) adult/(5) pup |
| July 03 '85 | Den No. 18 (M) | | (1) adult | | |
| July 06 '85 | Den No. 50 (H) | (1) adult | | | |
| July 08 '85 | Den No's. 41, 42 (H) | | | (1) adult | |
| July 08 '85 | Den No. 37 (H) | (1) adult | | | |
| July 13 '85 | Den No. 2 (M) | | | | (1) adult |
| July 13 '85 | Den No. 50 (H) | (1) adult | | | |
| July 14 '85 | Den No. 50 (H) | (2) adult | | | |
| July 14 '85 | Den No. 37 (H) | (1) adult | | | |
| July 14 '85 | Den No. 18 (M) | | (2) adult | | |
| July 20 '85 | 2 km So. of Den No. 48 (H) | (1) adult | | | |
| July 24-27, '85 | N.W. Herschel Island | (1) adult | | | |
| July 25 '85 | N.W. Herschel Island | (1) adult | | | |
| July 26 '85 | Den No. 37 (H) | (1) adult/(4) pup | | | |
| Aug. 13 '85 | 1 km So. of Den No. 53 (H) | (1) adult/(1) pup | | | |
| TOTAL: | | (15) adult/(8) pup; | (5) adult | (3) adult/(2)pup; | (4) adult/(5) pup |

* M: mainland part of the study area
H: Herschel Island

Foxes sighted at dens would typically disappear into the den when approached, although occasionally a fox (adult) would leave the den.

## 5.4 Mortality

Two dead red fox pups were found in 1984 while surveying for dens. Additionally, co-workers, coincidental to their field duties on the ground, located four dead adult arctic foxes, 1985 (Table 6). In two instances, the time period when mortality occurred appeared to be that spring. Causes of mortality could not be ascertained.

Table 6 Known mortalities of arctic and red fox, 1984 and 1985

| Location of Carcass | Date Found | Estimated Period that Mortality Occurred | Arctic/Red Fox | Number | Sex | Age Class | Mortality Cause |
|---|---|---|---|---|---|---|---|
| Den #41 | 1st half July 1984 | Spring 1984 | Red Fox | (2) | ? | Pup | ? |
| NE side of Herschel Island | June 1985 | ? | ? | (1) | ? | ? | ? |
| SE Shore of Herschel Island | June 1985 | ? | Arctic Fox | (1) | ? | Adult | ?* |
| NW side of Herschel Island | July 16, 1985 | Spring 1985 | Arctic Fox | (1) | ? | Adult | ?** |
| W side of Herschel Island | August 1, 1985 | ? | Arctic Fox | (1) | ? | Adult | ? |

*This carcass was sent to Dr. D.V.M. Wobeser, pathologist, University of Saskatchewan, for examination for rabies. Unfortunately no nervous tissue remained within the cranium to reach a diagnosis.

**Also submitted to Dr. Wobeser for rabies tests. Rabies virus was not found in the brains of this animal.

## 5.5 Harvest

The following information on arctic fox harvest was obtained through interviews with the five trappers operating in the area. Some information from fur dealer records is also used.

Three of the trappers interviewed have been employed by oil exploration companies from time to time and their trapping activities were usually associated with occasional 2 - 3 week periods off from their employment. Traplines follow the whole Yukon coastline and often overlap. Traditional camps are at Shingle Point, Stokes Point, Ptarmigan Bay and Herschel Island. Little travel takes place on the ice due to unsafe conditions and navigational difficulties associated with frequently encountered fog banks. Most trappers were unable to remember their catch beyond the last few trapping seasons.

Trapping activities occur mainly between December and April with most foxes caught in late winter and early spring. There seems to have been little trapping pressure in the recent past (Table 7). The catch during the last

Table 7 Arctic fox harvest utilization in northern Yukon Territory as obtained from interviews with trappers operating within the area.

| Trapper (& Co.) | Number of foxes caught per trapping season* | | | | | |
|---|---|---|---|---|---|---|
| | trapping seasons 1970 - 1980 | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 |
| L. Shingatuk | ? | ? | ? | <10 | - | - |
| E. McKenzie | ≈100/yr.average (<5 red fox) ≈200 one year in late seventies | - | - | - | - | - |
| C. Harry | ? | - total of 60 during four seasons - | | | | - |
| G. Allen | ? | ? | ? | <30 | <30 | - |
| A. Kayotuk | ? | ?(3) | ?(9) | - | - | 98 (+ 5 red fox) |

* - : no trapping activity.

? : unable to remember catch.

() : from fur dealer record. This figure is a minimum figure as not all pelts are usually sold to fur dealers.

three trapping seasons varied from <45 in 1983/84 (assuming an average yearly catch of 15 by C. Harry during the four seasons from 1980 - 1984) to 98 in 1984/85. More trapping activity seems to have ocurred during the period 1970 - 1980. During that period the yearly catch probably surpassed 100 foxes, but by how much is not clear. E. McKenzie & families' catch alone on Herschel Island and adjacent mainland during one year in the late seventies reached approximately 200 foxes.

Red fox are of little significance in the total harvest and are thought by two trappers to disappear from the coast (i.e. move south) during November. The trappers believe that arctic fox spend most of their time during winter on the sea ice. Movements towards the coastal plains are noted when the ice pack had moved against the shore (some areas, i.e. around Herschel Island and Phillips Bay, have ice advancing and retreating all winter). Arctic fox are common around drilling ships during the winter and appear to be attracted by the available garbage.

Arctic fox were the only terrestrial furbearer of any significance reported in the study area. The only other furbearers of any economic significance are wolf and wolverine, although it is rare that more than one or two are caught per trapper, yearly.

## 6.0 DISCUSSION:

### 6.1 Results

The number of dens identified during the course of this study must be considered a minimum figure as new den locations were identified throughout the re-surveys. The magnitude of this survey error is thought to be small for Herschel Island which was surveyed intensively. Several co-workers spent considerable time traversing the island on the ground during the summer and large areas of the island were re-surveyed aerially in 1985 while attempting to relocate 1984 dens. The error involved in the mainland survey is probably greater.

Some fox dens, particularly in the mainland section south of Herschel Island, reported by Ruttan (1974) could not be relocated. Some others that were relocated turned out to be arctic ground squirrel dens. The size of the burrow entrances in these often well established dens were typical of arctic ground squirrel dens and it seems unlikely that they were fox dens in 1972. It is therefore possible that Ruttan mis-identified these dens. From his report it is not clear what criteria were used to distinguish between unoccupied arctic fox and arctic ground squirrel dens from the air.

The density of fox dens (0.0143 $dens.km^{-2}$) is very low in comparison with other studies when taking the whole study area into account (Table 8). This discrepancy is mainly caused by the low density of the mainland part of the study area (0.0099 $dens.km^{-2}$), the Herschel Island fox den density (0.1478 $dens.km^{-2}$) being much higher than most densities reported elsewhere.

Table 8 Comparison of arctic fox den densities reported in arctic fox studies

| Location | Den Density ($dens/km^2$) | Authority |
|---|---|---|
| Islands, S.W. Alaska | 1.25 | Ashbrook & Walker 1925 |
| Whole tundra zone, U.S.S.R. | 0.0313 | Boitzov 1937 |
| Bol'shezemel'skaya upland region, U.S.S.R. | 0.1695 | Dementyiev 1955 |
| Taimyr, U.S.S.R. | 2.0 | Sdobnikov 1958 |
| Bol'shezemel'skaya tundra, U.S.S.R. | 0.1 - 0.6 | Skrobov 1961 |
| Yamal, U.S.S.R. | 0.15 - 0.5 | Skrobov & Shirovskaya 1968 |
| Aberdeen Lake area, N.W.T. | 0.0278 | MacPherson 1969 |
| St. Lawrence Island, Alaska | 0.0046 | Stephenson 1970 |
| Hardangervidda, Norway | 0.0049 | Østbye et al 1978 |
| Prudhoe Bay, Alaska | 0.0667 | Fine 1980 |
| Prudhoe Bay, Alaska | 0.0833 | Eberhardt et al 1983 |
| Colville Delta, Alaska | 0.0294 | Eberhardt et al 1983 |
| Whole study area, Y.T. | 0.0143 | This study |
| Herschel Island, Y.T. | 0.1478 | This study |
| Mainland part of the study area, Y.T. | 0.0099 | This study |

The northern Yukon Territory study area reported here, as well as those of Nolan et al (1973) and Ruttan (1974) were chosen with the extent of potential human impact in mind and it is not certain that they contain the total breeding range of the arctic fox in the Yukon Territory. Lavrov (1932) and Skrobov (1961) report that the southern limit of the arctic fox breeding range in the USSR coincides approximately with the tree line. However, it is generally felt that arctic fox densities decrease from north to south over their breeding range (Bannikov 1970). Although no systematic surveys for fox dens have been performed on the tundra uplands south of the present study area, observations coincidential with other aerial surveys showed a notable absence of dens in the alpine tundra (D. Mossop, pers. comm. 1985).

Observed proportions of natal dens (6.6% - 7.3%) may be overestimated due to the possible use of a number of dens by a single family group (Eberhardt et al 1983) but the likelihood of this possibility is difficult to assess. The low natal den rates observed both years, particularly on the mainland, suggest that the arctic fox population is at a cyclic low. In other studies the proportions of natal dens have varied from 0% to 100% depending on the stage of the cycle (Table 9).

Table 9 Proportions of natal dens reported for arctic fox den surveys

| Location | % Natal Dens | Authority |
|---|---|---|
| U.S.S.R. | 31.4 - 74 | Shibanoff 1951 |
| Bol'shezemel'skaya tundra, U.S.S.R. | 12 - 100 | Tchirkova 1955 |
| Taimyr, U.S.S.R. | 5.6 - 100 | Sdobnikov 1960 |
| Bol'shezemel'skaya tundra, U.S.S.R. | 3 | Skrobov 1961 |
| Teshekpuk Lake area, Alaska | 4 | Chesemore 1969 |
| Aberdeen Lake area, N.W.T. | 11.8 - 49.7 | MacPherson 1969 |
| Whole tundra zone, U.S.S.R. | 10 - 80 | Bannikov 1970 |
| Keewatin district, N.W.T. | 0 - 43 | Speller 1972 |
| Northern Yukon Territory | 4 | Ruttan 1974 |
| Prudhoe Bay, Alaska | 25 | Underwood 1975 |
| Prudhoe Bay, Alaska | 42.4 | Fine 1980 |
| Prudhoe Bay, Alaska | 18 - 74 | Eberhardt et al 1983 |
| Colville Delta, Alaska | 6 - 55 | Eberhardt et al 1983 |
| Whole study area, Y.T. | 6.4 (1984) - 7.3 (1985)* | This study |
| Herschel Island, Y.T. | 21.4 (1984) - 15.6 (1985)* | This study |
| Mainland part of study area, Y.T. | 0 (1984) - 2.9 (1985)* | This study |

*Red fox data were excluded from these calculations.

Only MacPherson (1969) and Eberhardt et al (1983) report on proportions of natal dens over the course of at least one population cycle. The proportions of natal dens of the present study are similar to those reported by these authors for a low stage in the population cycle. The occurrence of such low proportions in two successive years differs markedly from their studies were a low proportion of natal dens was followed by a high proportion in every instance. Clarification regarding the possible cause(s) of this phenomenon will require further study.

Arctic foxes use dens for both shelter and rearing of young (Eberhardt et al 1983). Non-natal dens that showed signs of being used during the spring previous to our summer field investigation might be in the former category. Another explanation might be that the foxes involved were unsuccesful in breeding or that uterine resorption or whelp mortality occurred (see MacPherson 1969).

Red fox densities as derived from occupancy rates of dens appear to have decreased since Ruttan's survey of 1972 (Ruttan 1974)(seven dens occupied by red fox in 1972, versus a maximum of two during the course of this study). During his study, Ruttan (1974) found evidence of displacement of arctic fox by red fox on Herschel Island. Various other studies suggest a worldwide trend for red fox to extend their range northward (Marsh 1938, Skrobov 1961, MacPherson 1964, Tchirkova 1968). Tchirkova (1968) speculates that the principle cause of the change in the boundaries of distribution of both species is the direct effect of the change in climate. Whether or not red fox will eventually replace arctic fox in this region is conjectural. Behavioural studies of captive red and arctic fox indicates that red foxes are dominant over arctic foxes during encounters (Rudzinski, Graves, Sargeant & Storm 1982). However, arctic foxes may be superior overall competitors in arctic tundra areas and on sea ice, even though red foxes may be physically superior in direct competition. Trappers have reported red foxes to be absent from the study area in winter.

As in MacPherson's (1969) study, natal fox dens were more widely spaced than they probably would have been if randomly dispersed. Such behaviour is generally taken to indicate territoriality (see review by Davies 1978).

Further evidence of territoriality among denning arctic foxes comes from Hersteinsson & Macdonald (1982) who actually observed defence of home ranges of breeding foxes. Information on the benefits of spacing out in denning arctic foxes is lacking. Predation has been identified as a factor favouring spacing-out in some other animals (Tinbergen, Impekoven & Franck 1967; Horn 1968; Croze 1970; Krebs 1971). Many studies have indirectly suggested that one benefit from spacing out is food acquisition; spacing out occurs when food resources are predictable and dispersed (see review by Davies 1978). It is not known whether limitation of the breeding population density of arctic fox is a consequence of territorial behaviour.

Poor success in establishing mortality causes from completely or partially decomposed carcasses has hampered animal ecological research enormously and foxes represent no exception in this respect. Dead arctic fox pups have been found by various workers (MacPherson 1969; Speller 1972; Eberhardt 1977; Garrott & Eberhardt 1982). Eberhardt (1977) and Garrott & Eberhardt (1982) attributed pup mortality found by them to predation. Sixty-five percent (13 pups) of the pup mortality (20 pups) noted among family dens visited by Garrott & Eberhardt (1982) was attributable to predation and the cause of death for theremaining pups was unknown. Evidence at the carcasses suggested that those pups were consumed by avain predators (golden eagle, snowy owl). Avian predation on the arctic fox is probably prevalent only on fox pups at den sites (Chesemore 1975). Pup mortality has been ascribed to intraspecific strife also (Chesemore 1975).

Disease (e.g. rabies, Braestrup 1941; Rausch 1958; Syuzyumova 1968) and predation (arctic fox, red fox, wolf, wolverine, polar bear (Urus maritimus), human trapper; Chesemore 1975) have been identified as mortality agents for older age classes.

Harvest data are scant and imprecise and conclusions are tenuous. There seems to be a downward trend in trapping activities in the northern Yukon Territory. The reasons for this are not clear but may involve increased dependance on a wage economy by trappers and a decrease in prices for arctic fox pelts.* The low proportions of red fox in the catch is surprising in view of their relatively high proportions. The trappers were of the opinion that red fox were largely absent from the coastal area after November. The preponderance of arctic fox in the yearly catches might, at least in part, also be attributable to arctic fox being more trap prone (Marsh 1938; Tchirkova 1968). The value of the fox catch may have amounted to over $7,000 in the late seventies, but decreased during the early eighties. In the 1984/85 season it amounted to approximately $1,000.

*Prices for arctic fox pelts have been decreasing steadily on the average during the eighties from $38.38 in 1979-80 to $19.29 in 1983-84 (Statistics Canada, Catalogue 23-207 annual).

In view of the low density of fox dens of the study area relative to other areas (Table 8), the average harvest potential of foxes produced in the area is probably low. We can only speculate on the magnitude of the maximum sustained yield of foxes produced in the area. The maximum number of foxes caught in one year may have been well over 200 during the late seventies. The number of breeding pairs necessary to produce such a catch of, say, 250 arctic foxes can be calculated. The average percentage of whelps in the catch data from MacPherson (1969) amounts to 47.3. In order to produce 118 whelps (47.3% of 250) during trapping season, a minimum of approximately 19 breeding pairs should have been present the previous spring (based on an average loss rate of 12% of trapped foxes (Usher 1970), an average summer mortality rate of 35% (MacPherson 1969)(we were unable to find data on fall mortality rates in the literature), and a mean litter size at implantation of 10.6 (MacPherson 1969)) assuming similar average conditions. Given the number of dens identified during the surveys and proportions of natal dens during cyclic highs in other populations (MacPherson 1969; Eberhardt et al 1983), the area could have produced 19 breeding pairs in a high density year. However, the catch of 98 arctic foxes in 1984/85 would have required eight breeding pairs, based on the same calculations and assumptions. As only three* dens identified in 1984 were natal arctic fox dens it would not seem likely that foxes caught in 1984/85 were produced within the study area. These findings are suggestive of an influx of foxes from adjacent areas. Such movements of arctic foxes into and through the study area have been identified to originate from northern Alaska (Eberhardt & Hanson 1978) and Banks Island, Northwest Territories (Wrigley &

* extrapolation of this figure from the known number of dens in 1984 to the number identified in 1985 did not cause it to change.

Hatch 1976) through ear-tagging studies. Obviously, further quantitative information is required of the dynamics of arctic fox movements into and out of the study area before a numerical assessment of the harvest potential of the area can be attempted.

Whether catches of this magnitude can be sustained, or even augmented, during various stages of the cycle is not known.

### 6.2 Management implications

Effective management of wildlife populations exhibiting marked fluctuations in rates of increase requires management plans that vary harvest rate directly with changes in rate of increase. Failure to curtail or suspend harvesting during periods of a negative rate of increase can inhibit the populations' ability to increase when conditions again become favourable (Caughley 1977). Ideally, a "tracking strategy" management plan should be initiated where harvest rates vary directly with recruitment into the harvestable population. To date no management strategy other than a limited open season is in place for arctic fox and essentially unrestricted numbers of foxes (probably Yukon Territory's rarest furbearer breeder, B.G. Slough, pers. comm. 1985) can be harvested from the population each year. This liberal management strategy is based on the assumption that trapping effort automatically "tracks" the abundance of fox (D. Mossop, pers. comm. 1985). However, high pelt values during low levels of population abundance may provoke sufficient trapping pressure to be detrimental to population resilience (Smirnov 1968).

In order to develop an effective management strategy, more information on the population ecology of arctic fox is needed. The low proportions of natal dens during the last two years warrant further monitoring of dens during the breeding season. An investigation into the possible causes of low reproductive performance should be considered in the event of persisting low productivity. In addition, the harvest pressure on the species should be closely monitored through continued liaison with trappers in the area. In view of the limited extent of arctic fox habitat in the northern Yukon Territory (relative to adjacent areas) and given the dynamic nature of arctic fox as well as the fact that trappers harvesting the northern Yukon Territory reside in the Northwest Territories, cooperation with management agencies of adjacent jurisdictions will be necessary.

## REFERENCES


Anderson, R.M. 1934. The distribution, abundance, and economic importance of the game and furbearing mamals of western North America. Proc. Pacif. Sci. Congr. 5: 4055-4075.

Ashbrook, F.G. and E.P. Walker. 1925. Blue fox farming in Alaska. U.S. Dept. Agric. Bull. No. 1350. 33 pp.

Bannikov, A.G. 1970. Arctic fox in the U.S.S.R.: biological premises of productivity. In: Fuller, A.W. and P.G. Kevan (eds.) Productivity and conservation in northern circumpolar lands. IUCN Publ. New Ser. No. 16: 33-41.

Boitzov, L.V. 1937. The arctic fox: biology, food habitats, breeding. Trudy Arkt. Nauchno-Issled Inst. 65: 7-144. (U.S.S.R.).

Bostock, H.S. 1948. Physiography of the Canadian Cordillera with special reference to the area north of the fifty-fith parallel. Geol. Surv. Can Mem. 247. Ottawa. 106 p.

Brackel, W.D. 1977. The socio-economic importance of wildlife resource utilization in the southern Beaufort Sea. Beaufort Sea Technical Report #32. Dept. Fisheries and the Environment. Victoria.

Braestrup, F.W. 1941. A study on the arctic fox in Greenland. Meddel Groenland 131: 1-101.

Brown, R.J.E. 1973. Permafrost in Canada. University of Toronto Press. Toronto.

Burgess, R.M. 1984. Investigations of patterns of vegetation distribution and abundance of small mammals and nesting birds, and behavioral ecology of arctic foxes at Demarcation Bay, Alaska. M.Sc. thesis, University of Alaska. Fairbanks.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley & Sons. New York.

Cheatum, E.L., and C.W. Severinghaus 1950. Variations in fertility of white-tailed deer related to range conditions. Trans. 15th N.Am. Wild. Conf. pp. 170-189.

Chesemore, D.L. 1968. Distribution and movements of white foxes in northern and western Alaska. Can. J. Zool. 46: 849 - 854.

Chesemore, D.L. 1969. Den ecology of the arctic fox in northern Alaska. Can. J. Zool. 47: 121 - 129.

Chesemore, D.L. 1975. Ecology of the arctic fox (Alopex lagopus) in North America - a review. In: Fox, M.W. (ed.) 1975. The wild canids. Van Nostrand Reinhold, New York.

Chitty, H. 1950. Canadian arctic wildlife enquiry, 1943-49: with a summary of results since 1933. J. Anim. Ecol. 19(2): 180 - 193.

Clark, P.J. and F.C. Evans 1954. Distance to nearest neighbour as a measure of spatial relationships in populations. Ecology 35(4): 445-453.

Croze, H.J. 1970. Searching image in carrion crows. Z. Tierpsychol. Beiheft 5, pp. 86.

Danilov, D.N. 1961. Den sites of the arctic fox (Alopex lagopus) in the east part of Bol'shezemel'skaya Tundra. Problems of the North 2: 223-229 (Nat'l Res. Council, Ottawa).

Davies, N.B. 1978. Ecological questions about territorial behaviour. In: Krebs, J.R., Davies, N.B. (eds.). Behavioural ecology. An evolutionary approach. Blackwell; Oxford.

Dementyiev, N.I. 1955. Biology of the arctic fox in the Bol'shezemel'skaya Tundra. Transl. Russ. Game Reports 3: 166-181 (Nat'l Res. 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. J. Mamm. 64(1): 97-102.

Eberhardt, L.E. and W.C. Hanson 1978. Long-distance movements of arctic foxes tagged in in northern Alaska. Can. Field-Nat. 92(4): 386-389.

Eberhardt, L.E., W.C. Hanson, J.L. Bengtson, R.A. Garrott, and E.E. Hanson 1982. Arctic fox home range characteristics in an oil-development area. J. Wildl. Manage. 46(1): 183-190.

Elton, C. 1942. Voles, Mice and lemmings: problems in population dynamics. Oxford 496 pp.

Fetherston, K. 1947. Geographic variation in the incidence of occurrence of the blue phase of the Arctic fox in Canada. Can. Field-Nat. 61:15-18.

Fine, H. 1980. Ecology of arctic foxes at Prudhoe Bay, Alaska. M.Sc. Thesis, University of Alaska; Fairbanks.

Garrott, R.A. 1980. Den characteristics, productivity, food habits, and behavior of arctic foxes in northern Alaska. M.Sc. Thesis, Pennsylvania State University.

Garrott, R.A., and L.E. Eberhardt 1982. Mortality of arctic fox pups in northern Alaska. J. Mamm 63(1); 173-174.

Hersteinsson, P. and D.W. MacDonald 1982. Some comparisons between red and arctic foxes, Vulpes vulpes and Alopex lagopus, as revealed by radio tracking. Symp. Zool. Soc. Lond. 49: 259-289.

Horn, H.S. 1968. The adaptive significance of colonial nesting in the Brewer's Blackbird Euhpagus cyanocephalus. Ecology 49: 682-294.

Kaikusalo, A. 1971. Nalin pesimisesa Luoteis - Enontekiossa. Suomen Rusta No. 23: 7-16

Krebs, J.R. 1971. Territory and breeding density in the great tit, Parus major L. Ecology 52: 2-22.

Lavrov, N.P. 1932. The arctic fox. Scientific Popular Library of Fur Animals of the USSR. Zhitkov, G.M. (ed.) Moscow: Board of Foreign Trade (Bureau of Animal Populations, Oxford, Transl. No. 18).

MacPherson, A.H. 1964. A northward range extension of the red fox in the eastern Canadian Arctic. J. Mammal 45(1); 138-140.

MacPherson, A.H. 1969. The dynamics of Canadian arctic fox populations. Can. Wildl. Serv. Report. Ser. No. 8.

Marsh, D.B. 1938. The influx of the red fox and its colour phases into the barren lands. Can. Field-Nat. 52(3): 60-61.

McEwen, E.H. 1951. A literature review of arctic foxes. M.A. Thesis, University of Toronto; Toronto.

Nolan, J.W., B.C. Goski and G.C. Wilde 1973. Atlas of wildlife habitat inventory maps for environmental-social program, Northern Pipeliens. Can. Wildl. Serv.; 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. Medd. Norsk Viltforskning 3(4):1-66.

Oswald, E.T., and J.P. Senyk 1977. Ecoregions of Yukon Territory. Can. For. Serv., Environment Canada. Victoria.

Pulliainen, E., and N. Ala-Kotila 1982. Population status of the arctic fox, Alopex lagopus, in Utsjoki, northern Finland, in 1980-1981. Aquilo Ser. Zool. 21:53-56.

Rausch, R. 1958. Some observations on rabies in Alaska with special reference to wild Canidae. J. Wildl. Manage. 22(3): 246-260.

Rudzinski, D.R., H.B. Graves, A.B. Sargeant, and G.L. Storm 1982. Behavioural interactions of penned red and arctic foxes. J. Wildl. Manage. 46(4): 877-884.

Ruttan, R.A. 1974. Arctic fox on north slope of the Yukon Territory, 1972. In: Ruttan, R.A. Wooley, D.R. (eds.) Studies of furbearers associated with proposed pipeline routes in the Yukon and Northwest Territories. Biol. Report Ser. Vol. 9. Can. Arctic Gas Study Ltd.

Savage, H.G., and J.C. Cooper 1982. Bones from an arctic fox den on Knight's Hill in northern Manitoba. Can. Field-Nat. 96(3): 342-344.

Sdobnikov, V.M. 1960. The arctic fox in Taimyr. Problems of the North 1:229-238.(Tansl. Nat'l Res. Counc.; Ottawa).

Secord, D.C., J.A. Bradley, R.D. Eaton, and D. Mitchell 1980. Prevalence of rabies varius in foxes trapped in the Canadian Arctic. Can. Vel. J. 21: 297-300.

Shibanoff, S.V. 1951. Dynamics of arctic fox numbers in relation to breeding, food and migration conditions. Transl. Russ. Game Reports 2:5-28 (Nat'l Res. Counc.; Ottawa).

Skrobov, V. 1961. The arctic fox. U.S.S.R. Ministry of Agriculture. Jan. pp. 17-20.

Skrobov, V.D., and E.A. Shirovskaya 1968. The role of the arctic fox in improving the vegetation cover of the Tundra. Problems of the north 11:1-8 (Transl. Nat'l Res. Counc.; Ottawa).

Smirnov, V.S. 1968. Analysis of arctic fox population dynamics and methods of increasing the arctic fox harvest. Problems of the north 11:71-101 (Tansl. Nat'l Res. Counc.; Ottawa).

Smith, T.G. 1976. Predation of ringed seal pups (Phoca hispida) by the arctic fox (Alopex lagopus). Can. J. Zool. 54: 1610-1616.

Speller, S.W. 1972. Food ecology and hunting behaviour of denning arctic foxes at Aberdeen Lake, Northwest Territories. Ph.D. thesis, University of Saskatchewan; Saskatoon.

Stephenson, R.O. 1970. A study of the summer food habits of the arctic fox on St. Lawrence Island, Alaska. M.Sc. thesis, University of Alaska. Fairbanks.

Syuzyumova, L.M. 1968. Epizootiology of rabies among arcitc foxes on the Yamal Peninsula. Problems of the North 11:113-121 (Transl. Nat'l Res. Counc.; Ottawa).

Tchirkova, A.F. 1951. A preliminary method of forecasting changes in numbers of arctic foxes. Transl. Russ. Game Reports 3: 50-69 (Nat'l Res. Counc.; Ottawa).

Tchirkova, A.F. 1953. Dynamics of fox numbers in Voronezh Providence and forecasting of fox harvests. Transl. Russ. Game Reports 2: 50-59 (Nat'l Res. Counc; Ottawa).

Tchirkova, A.F. 1955. Experiment in mass visual census and forecasting harvest of arctic foxes. Transl. Russ. Game Reports 2: 101-165 (Nat'l Res. Counc.; Ottawa).

Tchirkova, A.F. 1968. The relationship between arctic fox and red fox in the far north. Problems of the North 11: 129-131 (Transl. Nat'l Res. Counc; Ottawa).

Tinbergen, N. Impekoven and M.D. Franck 1967. An experiement on spacing out as defence agains predators. Behaviour 28: 307-321.

Underwood, L.S. 1975. Notes on the arctic fox (Alopex lagopus) in the Prudhoe Bay area of Alaska. In: Brown, J. (ed.). Ecological investigations of the Tundra biome in the Prudhoe Bay region, Alaska Biol. Pap. Univ. Alaska, Special Rep. no. 2: 144-149.

Usher, P.J. 1970. The Bankslanders: economy and ecology of a frontier trapping community. Dept. Indian Affairs & Northern Development; Ottawa.

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

Williams, R.B. 1949. Epizootic of rabies in interior Alaska, 1945-47. Can. J. Comp. Med. 13: 136-143.

Wrigley, R.E. and D.R.M. Hatch 1976. Arctic fox migrations in Manitoba. Arctic 29: 147-158.