Abundance, distribution and occupancy of arctic fox (*Alopex lagopus*) dens in northern Yukon Territory.

Annual Progress Report

C.M.M. Smits and B.G. Slough

September 1987

Yukon Fish and Wildlife Branch
Department of Renewable Resources
Government of Yukon Territory
Box 2703, Whitehorse
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ABSTRACT

Presented are the results of an aerial stratified block sampling census of arctic fox dens on the Yukon Coastal Plain between the Babbage and Crow Rivers to the east, and the Alaska/Yukon Territory boundary to the west. The study area was divided into a high density and a low density area based on the results of earlier surveys. In total, 34.2% of the study area was censused. In the high density area, 23 sampling units, representing 90.4% of the stratum area were censused, whereas in the low density stratum, 21 sampling units representing 19.6% of the stratum area were censused. A sightability correction factor was derived from the proportion of known dens observed during the census which amounted to 77.8%. The estimate of the total number of fox dens in the study area, corrected for sightability bias amounts to 92 ± 19 (95% C.I.). Of 75 dens checked on the ground for use or occupancy by foxes, 19 (25.3%) were classified as active. At three of these (4.0%), arctic foxes were observed while at another one (1.3%) a red fox was observed. No sign of pups was seen at any of the dens. A total of nine dens have produced pups during the period 1984-1987. Further activities planned under the arctic fox project are discussed.

INTRODUCTION

Arctic foxes use dens for rearing of young in spring and summer, and year round for shelter (Eberhardt et al., 1983). Individual dens have been estimated to be active for up to 300 years, often being enlarged, with additional entrances in successive years, until they deteriorate through natural processes (Macpherson, 1969). The clumped distribution of dens and their absence from large areas in northern Yukon Territory (Smits and Jessup, 1985), suggests that suitable denning sites are limited.

Knowledge of the abundance and distribution of den sites is therefore crucial for the management of the species. Such information can assist in making sound land use planning decisions in areas where preserving high capability fox denning habitat is a priority. It also facilitates monitoring of arctic fox productivity which provides important baseline information, against which the impact on the fox population by industrial development and harvest can be measured.

Since 1984 the Yukon Fish and Wildlife Branch has censused northern Yukon Territory for arctic fox dens and monitored some or all of these yearly (Smits and Jessup, 1985; Slough and Ward, 1987). High densities of dens were found locally, however low proportions of natal dens were observed in all years. During these monitoring surveys, dens not previously located were also found. It became clear that in order to obtain a more reliable estimate of den abundance a more intensive census was required. In 1984, the study area had been censused by a systematic transect procedure covering the whole study area (Smits and Jessup, 1985). This census showed the distribution of dens to be clumped. In view of this, a stratified block sampling census (Jolly, 1969a) appeared to be a more appropriate technique and could be designed on the basis of the preliminary den distribution.

This report presents the result of the stratified block sampling census of July, 1987. Incorporated in the census are the results of the total intensive census of Herschel Island of July, 1986 (Slough and Ward, 1987). Also presented are the results of the den monitoring survey which was conducted concurrently with the July 1987 census.

STUDY AREA

The study area includes Herschel Island and the Yukon Coastal Plain (Figure 1).

Herschel Island (101 km^2) 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.

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 in Yukon Territory. 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^2. 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 more 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 is -12.1°C; the mean annual percipitation is 125 mm (Canadian Climate Program, 1982).

Cottongrass tussocks (Eriophorum vaginatum), moss, ericaceous shrubs and willow 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).

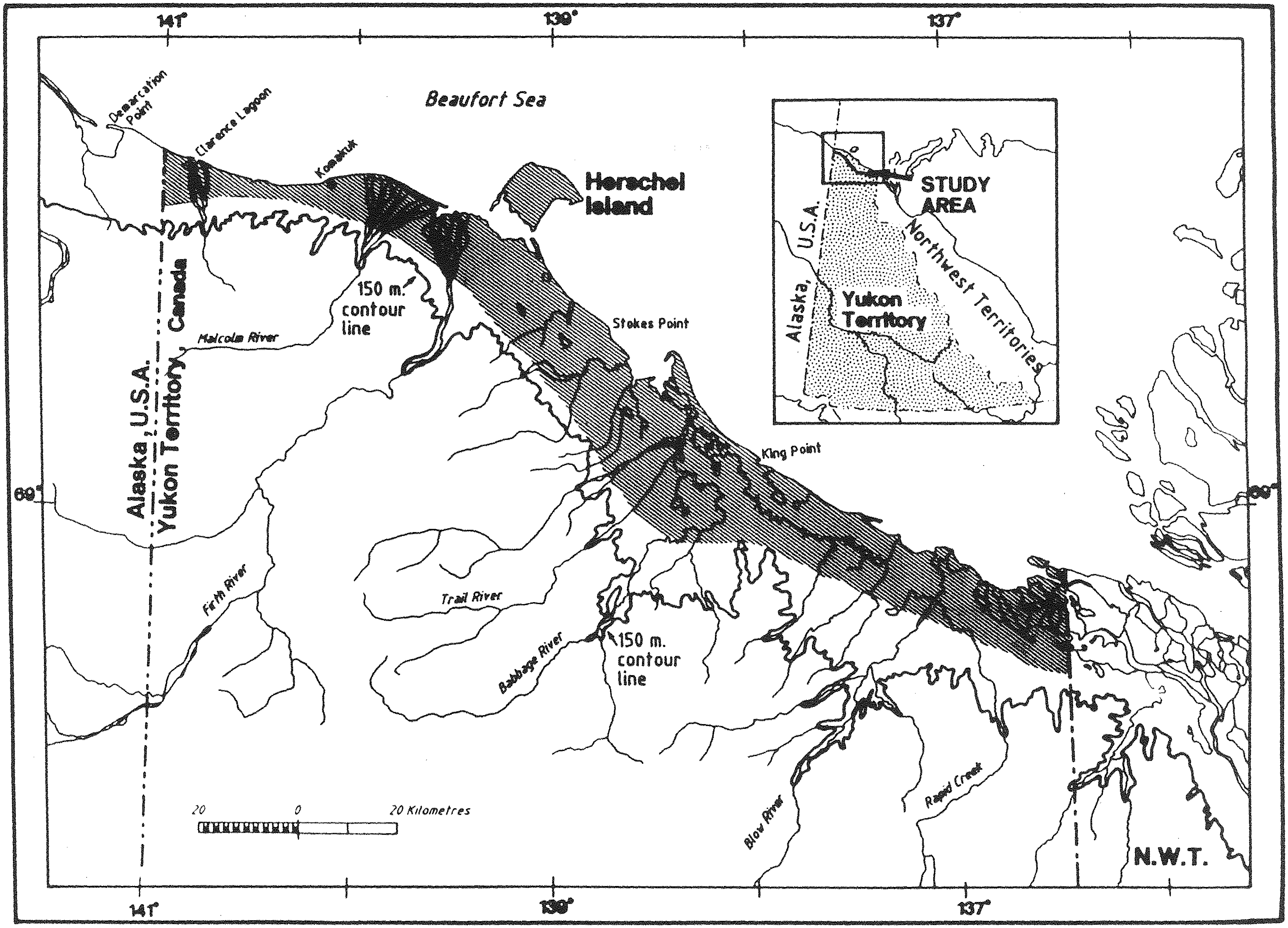

Figure 1. Location of the study area (shaded) northern Yukon Territory.

METHODS

Prior to field activities, a 1:50,000 topographic map of the study area was divided into sample units ranging from approximately 7 - 21 km^2 in size. Boundaries of sample units followed geographical features and were drawn according to suggestions by Gasaway et al. (1986). Initially the study area included the whole Yukon Coastal Plain and Herschel Island. However, the Yukon Coastal Plain east of the Babbage River and Crow River was excluded from the census when it was found that locally dense shrub cover (mainly alder, Alnus sp.) obscured dens. The remainder of the study area was stratified into a high density and a low density area. The high density area included Herschel Island, the Clarence Lagoon area and the coastal portions of the Firth and Malcolm River deltas (Fig. 2, Appendix). The remaining area west of the Babbage River was classified as low density denning habitat. Sampling effort between strata was allocated in proportion to the stratas' relative variances which are a function of their den densities. This procedure ensures that the variance of the estimated population mean is smallest (Cochran, 1953). Allocation of sampling effort was based on preliminary densities of fox dens as determined from a systematic transect census (Smits and Jessup, 1985). An attempt was made to select sample units in each stratum randomly. Some sample units however were chosen for their proximity to the helicopter base as was occasionally dictated by matters of logistics. Sightability of dens during the census was computed as the proportion of the known number (from the systematic transect census) of dens observed during the census.

The census was performed by helicopter (Bell 206 Jet Ranger B) during July 13-19, 1987. 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 burrow openings, presence of bones, avian predators (golden eagles, Aquila chrysaetos, are known to hunt in the vicinity of fox dens; Garrott and Eberhardt, 1982) and foxes. Sample units were censused flying overlapping transects. Transects were flown at 50-100 m AGL at indicated air speeds of 90-100 $km.hr^{-1}$. Two observers, one on each side, were present in the helicopter. Dens located from the air were ground checked to verify their identity by the size of burrow openings and the presence of fox scats, tracks, prey remains and/or the presence of foxes (fox dens can easily be mistaken for ground squirrel, Spermophilus parryii dens from the air). Dens were classified as active if foxes were sighted or if fresh tracks or faeces were present. The presence of juveniles was determined by actual sightings, the presence of small faeces or tracks, or the sound of characteristic barks emitted when disturbed within the dens. Den sites were numbered, photographed from the ground and from the air and their locations plotted on 1:250,000 topographic maps.

The estimate of the total observed den population ($\hat{Y}$) and its variance ($V(\hat{Y})$) was derived using the ratio method developed for unequal-sized units (after Jolly, 1969a):

$$\hat{Y} = \frac{\sum_j y_j}{\sum_j z_j} . Z_i$$

where y_j = number of dens in j^{th} sample unit
z_j = size of j^{th} sample unit (Km^2)
Z_i = total area (Km^2) under survey in i^{th} stratum
$\sum$ denotes summation over all strata

$$V(\hat{Y}) = \frac{\sum_i N_i(N_i - n_i)}{n_i} (Sy^2_i - 2\ R\ SZy_i + R^2 Sz^2_i).$$

where N_i = total number of sampling units in i^{th} stratum,
n_i = number of units selected from i^{th} stratum,

$$Sy^2i = \frac{1}{n_i - 1} \left\{ \sum y^2 i - \frac{(\sum yi)^2}{n_i} \right\},$$

y_i = number of dens per individual unit sampled,

$$Sz^2i = \frac{1}{n_i - 1} \left\{ \sum zi^2 - \frac{(\sum zi)^2}{n_i} \right\},$$

zi = area of each unit sampled,

$$Szyi = \frac{1}{n_i - 1}\left\{ \sum z_i y_i - \frac{(\sum z_i)(\sum y_i)}{n_i} \right\}$$

$$R = \frac{\sum_j Y_j}{\sum_j z_j}$$

$\sum$ denotes summation over all strata

The total observed den population estimate is then corrected for sightability bias:

$\hat{X} = \hat{Y}$. SCF, where X = adjusted population estimate
SCF = sightability correction factor, 1/sightability

The variance of this extended population estimate and its confidence interval (C.I.) is calculated according to procedures outlined in Gasaway et al (1986):

$$V(\hat{X}) = V(\hat{Y}).\ SCF^2$$

$$C.I. = \hat{X} \pm t_{\alpha, Ve} \sqrt{V(\hat{X})}$$

t = Student's t - statistic
Ve = degrees of freedom,
computed as

$$\frac{(V(\hat{X}))^2}{\frac{(V(\hat{X}_h))^2}{n_h - 1} + \frac{(V(\hat{X}_L))^2}{n_L - 1}}$$

Where $\hat{X}_h$ is total den estimate for high density stratum, $\hat{X}_L$ total den estimate for low density stratum, and n_h, n_L the number of SU's flown in high and low density strata, respectively.

RESULTS

Abundance and Distribution

In the high density stratum, 23 sampling units representing 90.4% of the stratum area, were censused, whereas in the low density stratum, 21 sampling units representing 19.6% of the stratum area, were censused. In total 34.2% of the study area was censused. Table 1 gives the calculations from which this sampling allocation was derived. The slight difference between optimum and actual allocation was the result of logistical practicalities.

A total of 56 dens was observed in combined high density sample units versus two in combined low density sample units (Table 2). Four (77.8%) of 18 known dens in 14 sample units were observed during the census (Table 3). In addition to the 18 known dens, ten unknown dens (55.6%) were observed within these 14 sample units. The total number of previously unknown dens found during the 1986/1987 census was 32, representing 36.4 of all known dens (88) (Table 4).

The estimate for the total number of observed dens calculated according to Jolly (1969a) is 71 with a variance of 50.0. Sampling variance of the high and low density strata is 13.5 and 36.5, respectively. Corrected for the 77.8% sightability, the total extended estimate amounts to 92 ± 19 (95% C.I.) (d.f. 33), with a coefficient of variation of 20.5%. Figures 1,2,3 and 4 and Table 4 give the locations of fox den sites known to date.

Den use or occupancy

Seventy-five dens were checked on the ground for use or occupancy by foxes, of which 19 (25.3%) were classified as active (Table 5). At three of these (4.0 %) arctic foxes were observed (a pair in two instances and a single fox in one instance) while at another one (1.3%) a single red fox was observed. No sign of pups was seen at any of the dens. A total of nine dens have produced pups during the period 1984-87. However this figure presents a minimum indication of the number of productive denning sites in the study area as not all dens were revisited by us each year (i.e. in 1986 only dens on Herschel Island were surveyed; more dens were identified as the study progressed).

Table 1. Arrangement of calculations for allocation of sampling units based on the number of fox dens located during a systematic transect census.

Stratum	N_h	W_h	S_h	W_hS_h	W_hS_h as Proportion	Allocation of sampling units	
						Optimum	Actual
High	26	0.20	54	10.80	0.491	22	23
Low	102	0.80	14	11.20	0.509	22	21
Total	128	1.00	68	22.00	1.000	44	44

Definitions:

N_h = Total sampling units per stratum

W_h = Proportion of sampling units in each stratum

S_h = Number of fox dens located during a systematic transect census (Smits and Jessup, 1985)

W_hS_h = Product of W_h and S_h

Table 2. Distribution of observed fox dens in sample units selected from a high density and a low density stratum during an aerial census in northern Yukon Territory, July 1987.

High Stratum			Low Stratum		
Sample Unit ID	No. dens located	Sample Unit area (km^2)	Sample Unit ID	No. dens located	Sample Unit area (km^2)
1	2	10.08	2	0	9.51
2	6	9.90	3	0	9.19
3	1	9.71	5	0	10.49
4	1	13.29	7	0	10.49
5	2	14.01	15	0	9.09
7	0	12.30	16	0	12.41
8	1	10.41	22	0	10.80
9	0	9.79	24	0	10.70
11	0	9.79	25	0	15.20
12	1	10.31	32	0	11.29
14	2	16.34	33	1	10.70
15	1	11.50	34	0	7.30
16	0	14.89	35	0	18.60
17	2	12.90	41	0	14.49
18	2	14.79	52	0	9.09
19	2	11.78	56	0	9.71
20	7	17.09	71	1	11.29
21	3	15.05	73	0	14.49
22	4	18.03	74	0	15.49
23	5	20.90	81	0	13.93
24	6	14.48	84	0	20.31
25	4	10.67			
26	4	13.83			
Sample total:	56	301.83		2	254.57
Area of stratum:		333.75			1288.27
Total sampling units in Stratum:	26			102	

Table 3. Sightability of fox dens during a stratified random block sampling census on Yukon Coastal Plain, July 1987 as determined from the known number of dens observed during the census.

Stratum	Sampling Unit ID	No. of dens observed during census	No. of dens previously located	Additional No. of dens located during census
High	1	2	2	-
	2	2	2	4
	3	0	2	1
	4	1	1	-
	5	2	2	-
	8	1	1	-
	12	1	1	-
	14	2	3	1
	15	1	1	-
	18	1	1	1
	19	1	1	1
Low	15	0	1	-
	35	0	0	1
	41	0	0	1
Totals		14	18	10

Discussion

Censusing fox dens on the Yukon Coastal Plain by stratified random sampling appears to be an efficient technique to estimate den abundance. The method provides a high level of precision (as indicated by the width of the confidence interval) relative to other censuses of this design (i.e. involving moose, Gasaway et al. 1986; black rhinoceros, Goddard 1969; elephant, Watson et al. 1969).

A number of potential biases are inherent in the technique (Gasaway et al 1986, Jolly 1969b). They include: 1) inaccuracies in covering sample units completely, 2) consistent errors in counting, 3) non-random distribution of some sampling units, 4) sightability bias, 5) faulty methods of obtaining the final estimate from the sample counts. We do not expect the first two sources to be responsible for biases, as the 1:50,000 scale topographical maps provided sufficient detail to be confident that the sample units were correctly identified and covered completely, and dens were readily identifiable from adjacent dens and could be mapped accurately. Nor do we expect the non-random distribution of some sample units to cause a significant bias. Only some low density units were chosen non-randomly, and this stratum showed little variation in the number of dens between units, both among random and non-random samples. The sightability bias was determined from a relatively high number of sample units distributed over the two strata and the range of terrain types present. We feel that it should provide a reliable indication of the proportion of dens missed from dens previously located from aerial survey across the entire study area. A negative bias may have arisen from missing recently established dens on which the characteristic, lush vegetation has not developed yet. These dens should be less readily observable from the air, however no quantitative information exists of their observability from the air relative to dens with the characteristic vegetation. Such dens have been reported to constitute 10% (Macpherson, 1969) to 20% (Garrott, 1980) of all dens. However an effort was made to identify dens from all possible sighting clues including burrow entrances which in many instances during the census provided the first indication of a den. Consequently we don't expect this factor to create a significant negative bias. Our methods of computation are proven statistical methods specifically designed for unequal-sized sample units. We therefore assume that our estimate accurately reflects the total number of fox dens on the Yukon Coastal Plain west of the Babbage River and Crow Rivers, and on Herschel Island.

The occupancy rates of dens during this year's monitoring activities were the lowest since 1984 and are reflective of occupancy rates immediately following a population crash.

The low sightability of fox dens east of Babbage River precludes the use of an aerial census of the design used in this study as a means to estimate den abundance. A useful approach might be to delineate low and high visibility habitat from aerial photographs and to survey the high visibility habitat for fox dens. The low visibility habitat, e.g. areas with shrubby vegetation, may well turn out to be unfavourable arctic fox habitat. In other studies, dens with lush shrubby vegetation were mostly occupied by red fox (Ruttan, 1974; Eberhardt, 1977).

Further Activities planned

We are planning to monitor all known dens over the next two summers for den occupancy. From this we expect to obtain information on the spatial and temporal distribution of fox denning. In view of the repeated occupancy of some dens by foxes (Eberhardt et al, 1983; this study) knowledge of the location of these sites may be crucial to managing the species. Additionally, we are proposing to monitor a sample of dens in the low visibility habitat east of the Babbage and Crow Rivers to determine the extent to which this habitat is red fox denning habitat. We also plan to census the high visibility habitat with the stratified block sampling technique.

The rate of increase of foxes after a population crash, and consequently the population size during highs in the population cycle, is a function of the proportion of breeders during population lows. Other factors, no doubt, like ingress of foxes from adjacent areas may also be responsible for the rate of population increase after a crash. Nevertheless, without information on the relative importance of these combined factors, preserving fox dens that are productive in years of low fox abundance should be a high management priority.

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