Den ecology, distribution, and productivity

of foxes at Kokechik Bay, Alaska

ANNUAL REPORT

by

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INTRODUCTION

In May 1985 fieldwork was initiated at Kokechik Bay, Alaska to collect information on the ecology of foxes inhabiting the nesting grounds of geese on the Yukon-Kuskokwim Delta (YKD). The primary focus of the studies is on arctic foxes (Alopex lagopus), which are much more abundant than red foxes (Vulpes vulpes) in areas where nesting geese concentrate. Interest in the ecology of foxes was stimulated by results from recent investigations of declining populations of geese that nest on the YKD (Dzimbal et al. 1984, Petersen 1984, Sedinger 1984, Scanlon 1984). These studies identify fox predation as a major factor limiting productivity of black brant (Branta bernicla nigricans), emperor geese (Anser canagicus), and cackling Canada geese (Branta canadensis minima). Arctic foxes have been studied extensively throughout much of their range above the Arctic Circle, but information on their biology in more southerly latitudes is limited. Studies of fox predation on nesting geese is especially rare.

The long term goals of the fox project are: (1) to determine the food habits and foraging behavior of foxes, (2) to define their home ranges and territories, (3) to determine their seasonal distribution, (4) to determine the predator-prey relationships influencing fox predation on nesting geese, and (5) to assess the feasibility of reducing predation on geese by limited fox control. This information will build on current knowledge for the purpose of managing fox populations in important goose nesting areas on the YKD. Our objectives this first field season were to mark foxes with ear tags and radio transmitters, to observe foxes from towers and blinds, and to locate and describe dens. This report--describing fox dens, movements of radio-collared foxes, productivity of paired foxes, and results of small mammal trapping--is one of three reports on research activities conducted from Kokechik West camp in 1985 (see Annual Reports on brant productivity and fox foraging studies by Kertell and Stickney, respectively).

STUDY AREA

Our field camp was located about 12 km inland from the Bering Sea coast near the most westerly point of the YKD (61° 38' N, 165° 59' W). Studies were conducted in a 10-km long (37 km^2) area bounded on the north by Kokechik Bay and on the south by 20-m high bluffs that roughly paralleled the shore edge on the north (Figure 1). Topography is relatively flat with low (1-3 m high) and high (3-5 m high) pingos centrally located between tidal meadows on the north and fresh-water marsh on the south (Figure 2). About one-third of the area is covered by lakes, ponds, and sloughs (Jackson 1976).

The relatively diverse physiographic and vegetative character of the area provides habitat for many species of nesting birds (Eisenhauer and Kirkpatrick 1977). The low tundra around Kokechik Bay is a primary nesting site for emperor geese and black brant and also supports large numbers of nesting cackling Canada geese (Petersen 1984).

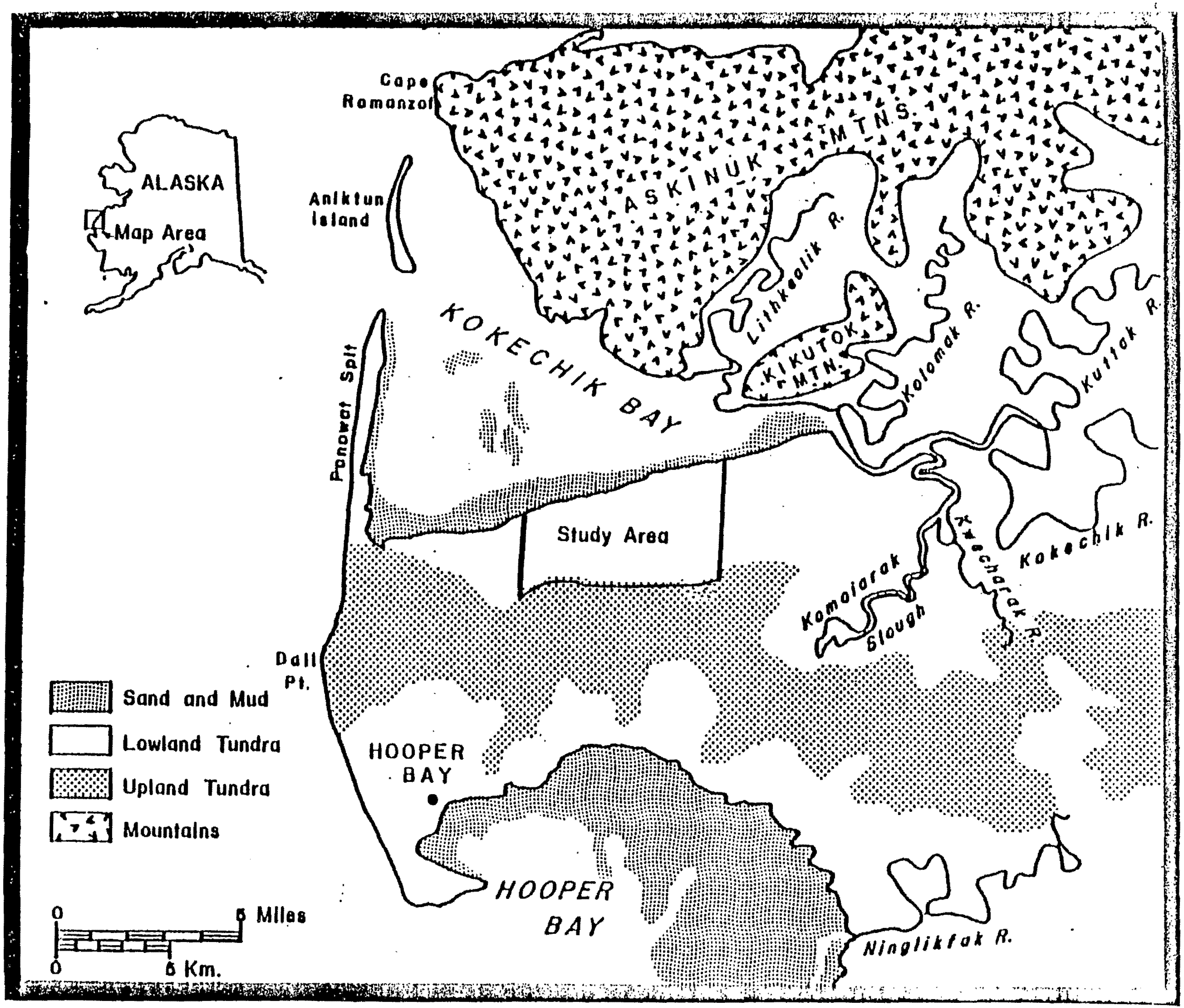

Figure 1. Location of study area at Kokechik Bay on the Yukon-Kuskokwim Delta, Alaska.

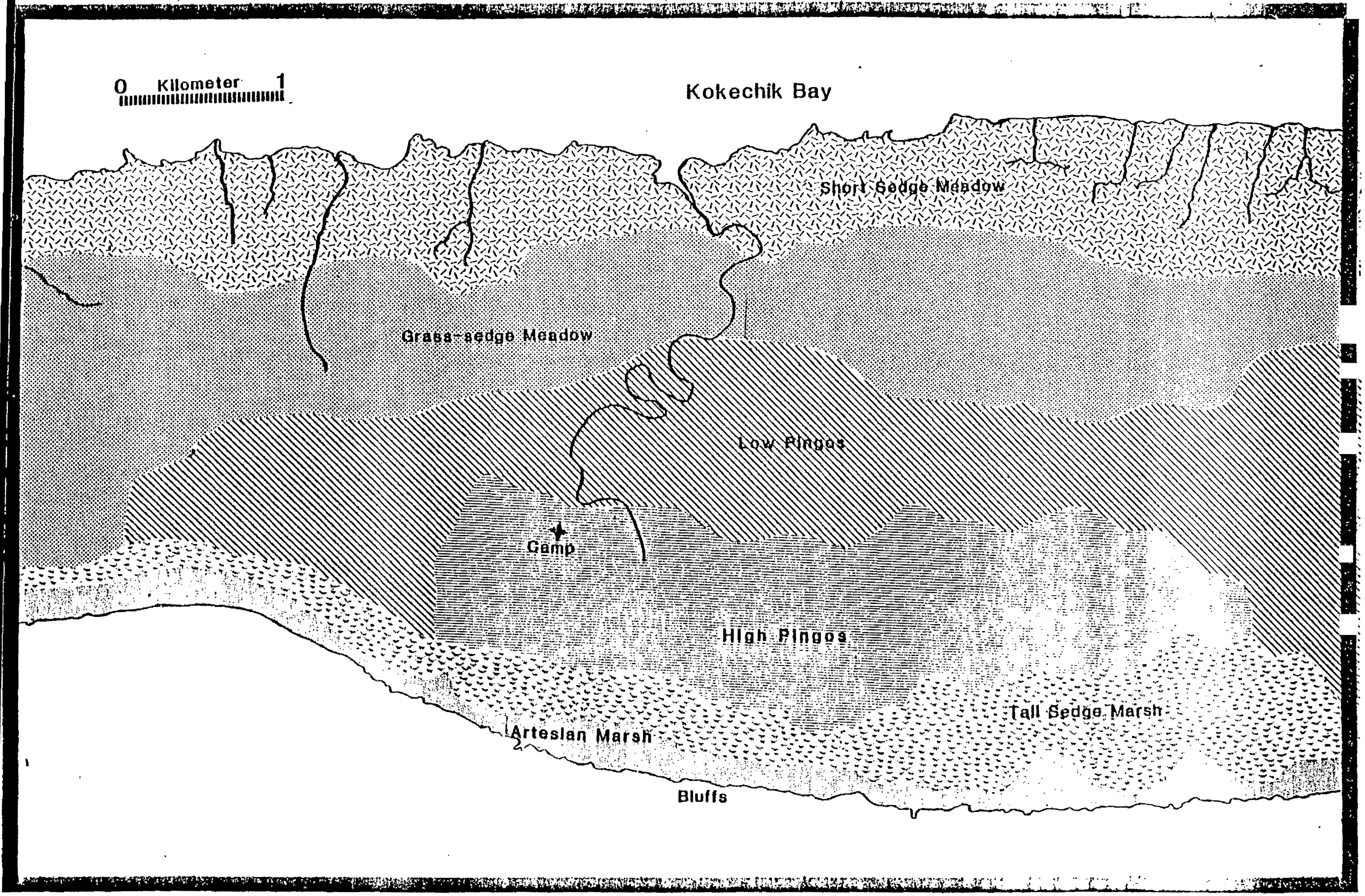

Figure 2. General distribution of major plant communities within the study area at Kokechik Bay, Alaska.

General boundaries of six major plant communities described by Jackson (1976) are shown in Figure 2. Dominant species of these communities are:

Short sedge meadow - Carex rariflora/Potentilla Egedii
Grass-sedge meadow - Carex rariflora/Carex glareosa/Puccinellia phryganodes/Poa eminens
Low pingo - Empetrum nigrum/Rubus chamaemorus/Salix fuscenscens
High pingo - Empetrum nigrum/Ledum palustre
Tall sedge marsh - Carex Lyngbyaei
Artesian marsh - Spagnum moss/Potentilla palustris

Elymus (Elymus arenarius) meadows occupy the levees formed by sloughs. Habitat use by nesting birds is described by Holmes and Black (1973).

METHODS

Den locations

Dens were located by tracking foxes over snow, by systematic ground searches, by searches from aircraft, by observations of fox activity, by radio tracking of marked foxes, and from historical records of den sites. Locations of dens were plotted on aerial photos (1:20,000) and converted to universal transverse mercator (UTM) coordinates for calculation of den spacing. Number of den entrances, distances between den entrances, compass orientation of dens and entrances, and signs of fox activity were recorded when dens were discovered.

In late July vegetation was sampled at ten active dens and ten adjacent locations with similar aspect and topography to assess the feasibility of using indicator species of plants to locate dens. A line-transect, point sample technique was used to estimate percent plant cover. Sample transects, radiating 5 m out from a point judged to be the center of each den, were established in the eight ordinal compass directions (i.e., N, NE, E, SE, S, SW, W, NW). The species of plant occurring at points located 2-dm intervals along the 5-m transects was tallied. Therefore, a total of 200 points were sampled at each den site and each unoccupied control site. More than one plant species was recorded at a sample points having a multi-layered canopy. Frequency of occurence of each plant species at sample points was used to compute percent plant cover (i.e., number of times a plant was tallied/200 sample points = percent cover). Constancy, the frequency with which a plant species was found at sample sites (dens or unoccupied sites), was computed as a percentage of the total number of sites sampled.

Marking foxes

Initial attempts at trapping foxes with box traps in May were unproductive despite the use of techniques that were successful in previous studies (Fine 1980; West et al. 1982; Burgess 1984; Eberhardt, personal communication; Sowls, personal communication). Consequently, leghold traps with padded jaws (No. 1.5 fox traps by Woodstream Corporation*) were used at dirt hole sets and at scent sets beginning 22 May. Leghold traps also were

* Reference to trade names does not imply U. S. government endorsement of commercial products.

used at the entrances of dens known to shelter adult or juvenile foxes. Traps at dens were observed from nearby blinds to minimize the time that foxes were held in traps. Flooding dens with water proved to be an effective method of flushing foxes from small dens; only one fox was captured using this method.

Captured foxes, restrained by taping their muzzle, forefeet, and hindfeet, were placed in canvas bags for holding during processing. This method of restraint was adopted after chemical immobilization of the first two captured foxes with ketamine-xylazine and methoxyflurane, respectively, proved to be unnecessary. Foxes were held in canvas bags for several hours when trapping several family members at a den. Before release all foxes were weighed, measured, examined for reproductive status, examined for tooth condition, tagged in each ear with a colored polyvinyl flag (1-cm by 5-cm) and numbered tag (Rototag, Nasco Corporation), and equipped with a radio collar. Foxes captured before molt to summer pelage were marked with Nyanzol D dye to facilitate recognition at long distances. Adults captured after 21 July were fitted with a 150-g radio collars having mortality-sensing circuitry (Model L2B5, Telonics Corporation). Adult foxes captured before delivery of the more sophicated transmitters were fitted with 35-g radio collars constructed by the Electronics Section, Denver Wildlife Research Center (DWRC), U. S. Fish and Wildlife Service. All kits were fitted with DWRC transmitters because the heavier collar exceeded the limitation on ratio of collar weight to body weight (0.05).

Attempts to radio-track foxes on foot were generally unsuccessful beacuse of limited range of DWRC transmitters, subterranean habits and evasive behavior of foxes, and our limited mobility within the study area. Consequently, movements of marked foxes were determined by ten aerial tracking sessions during 22 June to 11 August. Observations of foxes from towers and blinds, which were made during a related study (Stickney 1985), also were included in movement data. The ten aerial tracking sessions were conducted as early as 1200 h and as late as 2330 h. Most observations from the ground were made from 2100-0100 and from 0700-0900, daylight hours when foxes were most active. Locations of foxes were plotted on aerial photos and converted to UTM coordinates for computing of movement data. Sitings of unmarked foxes also were plotted on aerial photos.

Small mammal trapping

Snap traps (Museum Special traps, Woodstream Corporation) were used in several plant communities in June, July, and August to index small mammal abundance . Because of an anticipated low population of mice, locations of transects were changed each trapping period. Fifty single traps baited with a peanut butter/rolled oat mixture and anchored with a wire flag were set at 10-m intervals along each transect. Traps were placed in runways and near burrows of mice.

Trap lines were run each morning from 1-3 June in upland tundra south of the bluffs, on tops of high pingos, and in a grass-sedge meadow bordering low pingos. These areas, which were not covered by snow or water at the time, were judged to be most likely to be inhabited by mice. During 5-9 July trapping was conducted on high pingos and in grass-sedge meadows.

During 8-10 August trapping was done on high pingos, in grass-sedge meadows, and at the base of high pingos in the grass-heath interface where mice were often observed. Traps that were sprung but contained no animals were excluded from computation of trap success.

Trapped mice were weighed, measured, and examined for reproductive condition. Mice were placed in age categories according to weight (Whitney 1976): juveniles (≤17 g), subadults (18-25 g), and adults (≥26 g) . Males were considered reproductively active if testes were scrotal and epididymal tubules were enlarged. Only pregnant and lactating females were considered reproductively active. Species identification was made by physical characteristics and dental formula.

Analyses

Confidence intervals were computed at the 95-percent level following a procedure for small sample size (Snedecor and Cochran 1980). Plant cover at dens and sites without dens was compared with a paired t-test (Snedecor and Cochran 1980). Differences in number of entrances at occupied and unoccupied dens were determined with a t-test of independent sample means.

Distance to nearest neighboring den was used to determine if dens were randomly located (Clark and Evans 1954). Significance was tested at the 95-percent confidence level.

Gross estimates of whelping dates and breeding dates were made using measurements of hind feet of kits from two litters of captured foxes. These data were interpreted using a modified growth curve for red foxes (Johnson et al. 1975, Sargeant et al. 1981). The regression equation was modified assuming the growth pattern of arctic foxes to be similar to that of red foxes with the exception of the asymptotic value for foot length (Sargeant, personal communication). The age at which the eyes of arctic fox kits open (Novikov 1962) also was used to verify the age of one litter. Date of breeding was computed by back-dating from estimated whelping date assuming a 52-day gestation period (Chesemore 1975).

RESULTS

Dens

Aerial searches for dens, which began on 22 June, were unsuccessful. Tracking over snow, radio tracking, and systematic ground searches were most effective in locating dens. A total of 38 arctic fox dens were found in the 37 km^2 study area (1.03 dens/km^2). No red fox dens were found. All dens were located on elevated mounds; all but one were within the low and high pingo areas (Figure 3). Mean distance between nearest neighboring dens was 314 ± 71 m. This distance is significantly different ($P<0.01$) than the expected distance (493.4) if dens were randomly distributed. Eighteen dens were occupied by foxes at some time from May through August. Of these, six were occupied by one family, six by another family, one by both families at different times, three by a third family, and the remaining two by non-reproducing foxes in May. Most dens were occupied during dispersal of litters beginning in July when kits became more independent. However, one vixen moved her entire litter (9 kits) two times from 9 June to 13 June in apparent response to our disturbance. The non-ambulatory kits were transported 291 m and 1167 m on the two respective moves.

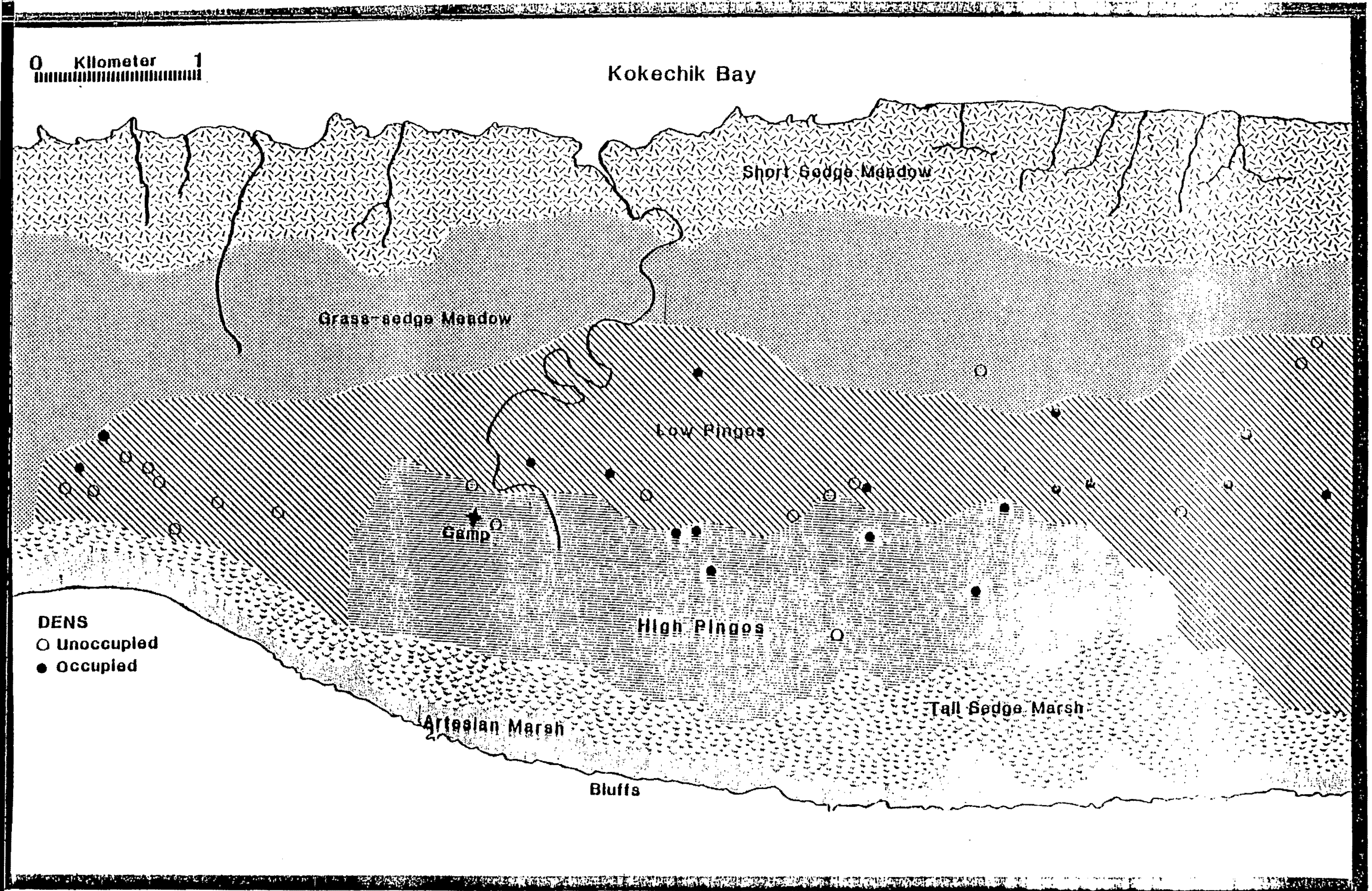

Figure 3. Locations of dens used by foxes (occupied) and unoccupied dens at Kokechik Bay, Alaska.

As illustrated by the size of a single den that was excavated during capture of a fox (Figure 4), it is difficult to adequately describe a den simply from its above ground characteristics. However, based on counts of den entrances, dens at Kokechik Bay generally were relatively simple. Mean number of entrances per den was 4.7 ± 1.35. Occupied dens were more complex than unoccupied dens (6.9 ± 2.1 versus 2.8 ± 0.9 entrances, $P<0.05$). Den entrances (n=134) most often occurred on the tops of pingos (48 percent), followed by side entrances (39 percent), and bottom entrances (13 percent). There was no obvious pattern of den orientation. Thirty-one percent of the dens had eastern exposures, 23 percent had northern exposures, 14 percent western exposures, 11 percent had southern exposures, and 21 percent had no obvious orientation because entrances were on top of pingos or occurred on all sides of pingos.

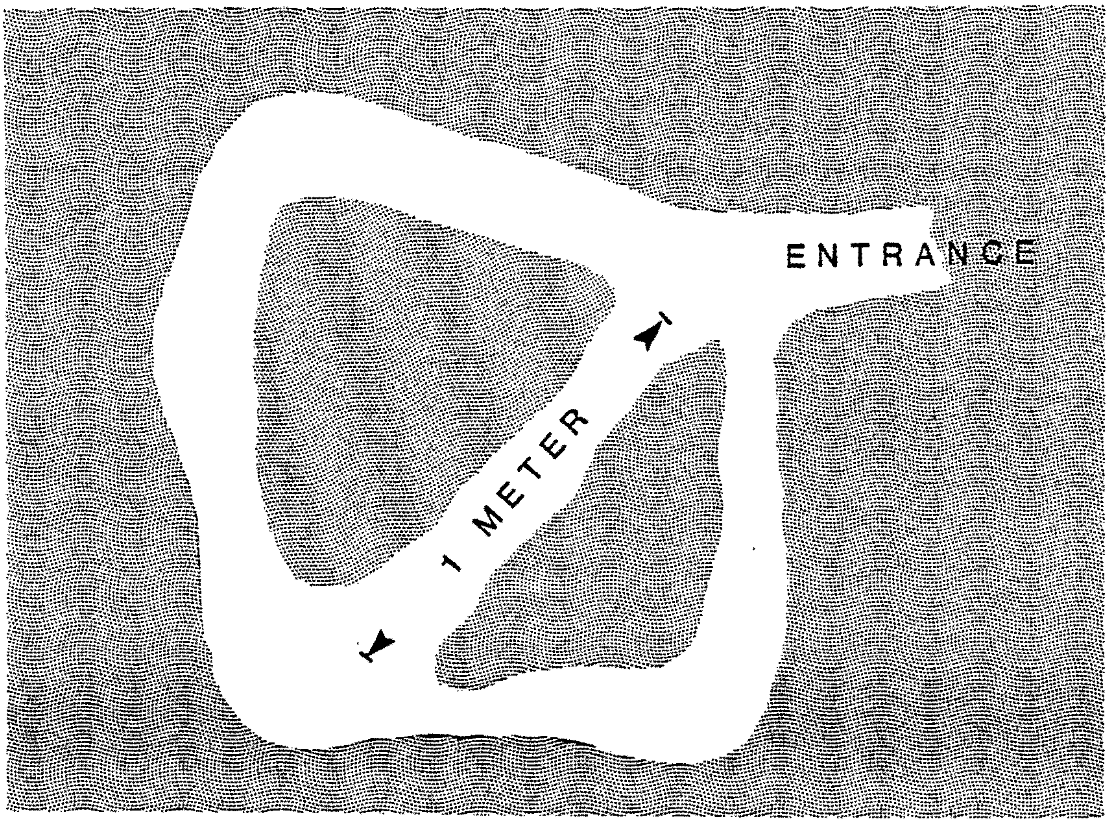

Figure 4. Cross-sectional diagram (in the horizontal plane) of a single-entrance fox den excavated at Kokechik Bay.

Although there was considerable variation in vegetation among den sites and at sites without dens, as a whole, there was little difference in the abundance and diversity of vegetation between dens and control sites (Table 1). Twenty-eight species of plants were found at both den sites and control sites. Three species each were unique to den sites and sites without dens; all were low in abundance. Because of the lack of unique vegetative characteristics, dens were difficult to locate from the air.

Fox movements

A total of 18 foxes were trapped with leghold traps from May 25 to 3 August. One animal was recaptured three times. Injuries as a result of capture were minor with the exception of three adults--two arctic foxes and one red fox--that pulled trap stakes. Also one arctic fox kit sustained a compound fracture of the rear leg after less than an hour in the trap when the trap swivel became fouled with grass. The four animals were killed and prepared for study skins. Fourteen arctic foxes were radio collared (Table 2). Adult foxes carried transmitters 50.5 $\pm$ 18.7 days before tracking was ended. Mean number of locations for adult foxes was 9.0 $\pm$ 2.8 days per animal. Kits carried transmitters for 12.9 $\pm$ 3.7 days before tracking was ended in August.

Red foxes were seen much less than arctic foxes, but four observations of red foxes within the study area and the capture of one female red fox indicate that at least two reds were active within the study area in
Table 1. Percent ground cover found at den sites and control sites.
addition to 10 adult arctic foxes (Figure 5). Mean home range of radio-collared arctic foxes was 4.1 $\pm$ 1.3 km . There was little overlap in the areas used by foxes. Foxes with kits were most often found in pingo habitat where most dens were located. Mated foxes showed strong fidelity to natal dens and were often located in or around dens. Mated females were most often found at dens. Two non-reproducing female arctic foxes that were radio-collared (SF1 and SF2) were not relocated at dens. Instead they were found most often in the nesting areas of geese. Although kits were observed venturing from dens to hunt with parents, radio-collared kits were relocated mostly at dens. A male kit was captured about 200 m from a den on the top of a high pingo on 10 July. On 3 August from 0700 to 0900 another male kit travelled 1325 m between dens.

Fox productivity

Three of six female arctic foxes that were captured had litters. Nine kits were found above ground at the den of a radio-collared fox on 9 June. The kits were not able to walk, but their eyes were open. On 19 June a second litter of ten kits was captured by hand at a den where an adult male was captured. These kits were ambulatory and had gray fur. Eight other kits were observed at the den of the third marked female on 16 July.

Table 1. Percent ground cover found at den sites and control sites. Constancy values are shown in parentheses. Significant differences ($P < 0.05$) are indicated with an asterisk.

Cover Type	DEN		CONTROL		DIFFERENCE
Empetrum nigrum	29.05	(100)	20.55	(100)	8.50*
Litter	21.55	(100)	20.55	(100)	1.00
Rubus chamaemorus	16.60	(60)	11.10	(80)	5.50
Calamogrostis canadensis	15.48	(80)	10.10	(70)	5.38
Salix sp.	8.65	(80)	8.35	(60)	0.30
Vaccinium vitus-idaea	6.15	(60)	4.15	(4)	2.00
Poa arctica	6.00	(20)	0.30	(1)	5.70
Achillea borealis	5.65	(60)	2.20	(40)	3.45
Arctogrostis latifolia	4.15	(70)	5.75	(70)	-1.60
Ligusticum scoticum	3.55	(50)	1.25	(40)	2.30
Trientalis europaea	3.35	(90)	2.25	(70)	1.10
Bare ground	3.25	(90)	1.00	(50)	2.25*
Lichens	3.20	(80)	11.40	(70)	-8.20*
Petasites frigidus	3.00	(50)	1.80	(70)	1.20
Arctostaphylos alpina	1.70	(50)	0.55	(10)	1.15
Cornus canadensis	1.50	(20)	0.30	(10)	1.20
Angelica lucida	1.45	(40)	0.90	(30)	0.55
Sphagnum moss	0.34	(40)	6.55	(60)	-5.60
Elymus arenarius	0.90	(10)	0.55	(10)	0.40
Rubus arcticus	0.80	(30)	0.40	(40)	0.40
Ledum palustre	0.75	(20)	1.15	(30)	-0.40
Artemisia Tilesii	0.65	(40)	0.55	(10)	0.10
Carex rariflora	0.60	(40)	0.00	(--)	0.60
Epilobium palustre	0.60	(30)	1.65	(30)	-1.05
Chrysanthemum arcticum	0.30	(30)	0.05	(10)	0.25
Potentilla Egedii	0.30	(30)	0.00	(--)	0.30
Sedum rosea	0.20	(20)	0.25	(30)	-0.05
Cochlearia officinalis	0.15	(20)	0.15	(10)	0.00
Polemonium acutiflorum	0.15	(10)	0.30	(10)	-0.15
Carex Lyngbyaei	0.05	(10)	0.00	(--)	0.05
Sausserea nuda	0.05	(10)	0.15	(10)	-0.10
Galium trifidum	0.05	(10)	0.15	(10)	-0.10
Artemisia arctica	0.05	(10)	0.05	(10)	0.00
Eriophorum angustifolium	0.00	(--)	0.40	(20)	-0.40
Triglochin palustris	0.00	(--)	0.10	(10)	-0.10
Chrysoplenium tetrandum	0.00	(--)	0.10	(10)	-0.10

Table 2. Fourteen arctic foxes that were radio-collared at Kokechik Bay in 1985. Parenthetical identification codes refer to locations in figure 5.

Capture date	Tag Number	Mate or parent	Age	Sex	Weight (kg)
5/25/85	221 (SF1)	--	Adult	F	3.225
5/26/85	222 (SF2)	--	Adult	F	2.725
6/01/85	223 (PF1)	Unmarked	Adult	F	4.075
6/19/85	226 (PM2)	203	Adult	M	3.540
6/29/85	227 (PF3)	Unmarked	Adult	F	3.765
8/03/85	203 (PF2)	226	Adult	F	3.650
7/24/85	233	223	Kit	M	1.960
7/24/85	231	223	Kit	F	1.980
7/25/85	235	223	Kit	F	1.850
7/28/85	201	223	Kit	M	2.140
7/30/85	111	203	Kit	F	2.000
8/2/85	109	203	Kit	F	1.940
8/3/85	101	203	Kit	F	2.050
8/3/85	113	203	Kit	M	2.010

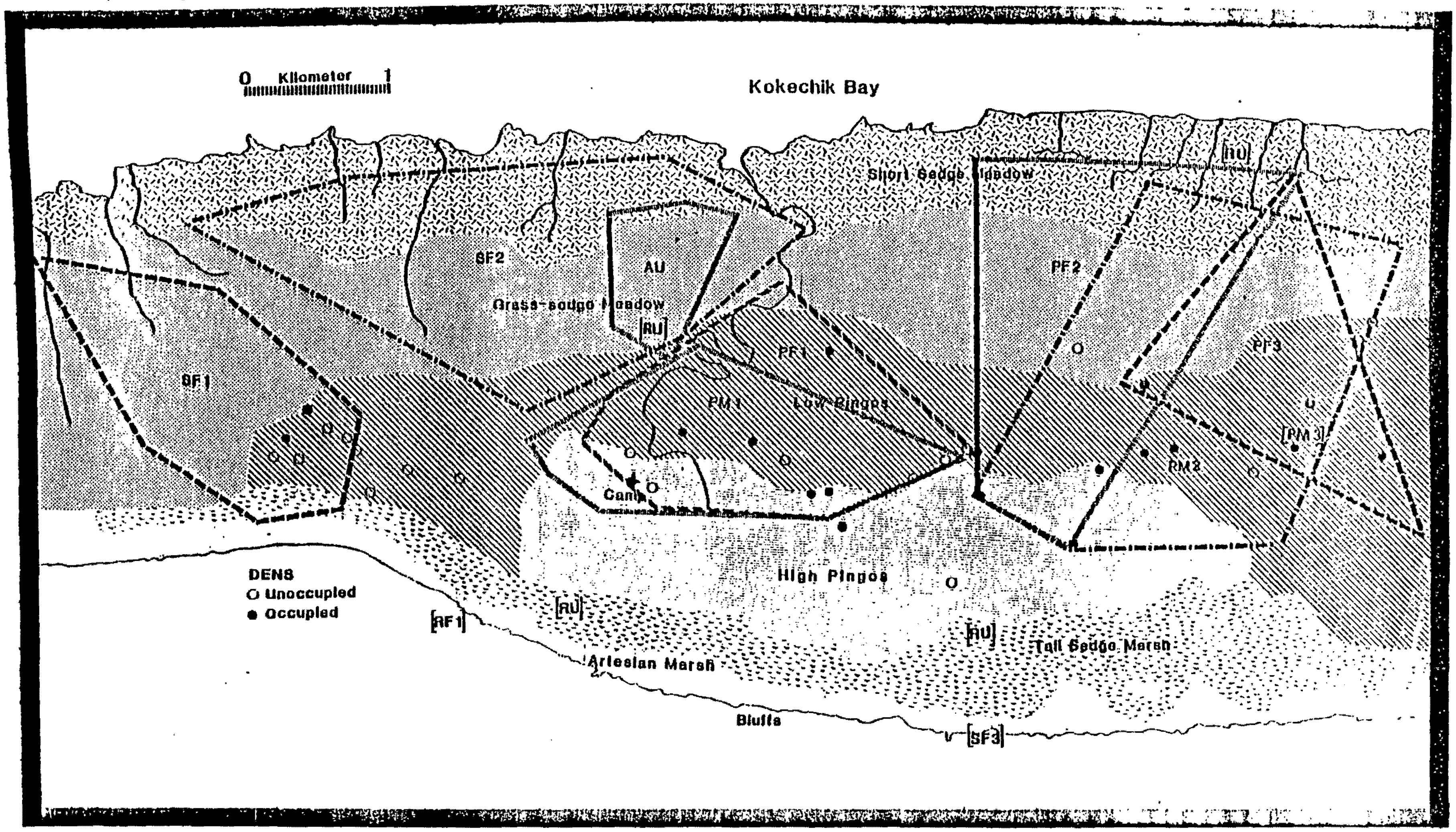

Figure 5. Movements of single female arctic foxes (SF1 and SF2), paired female arctic foxes (PF1-PF3), paired male arctic foxes (PM1 and PM2), and an unidentified arctic fox (AU). Locations of one-time observations of a single female arctic fox (SF3), a paired male arctic fox (PM3), a single female red fox (RF1), and unidentified red foxes (RU) are bracketed.

Mean estimated date of whelping based on hind foot measurements of kits from two litters was 20 May. Back-dating yielded an estimated breeding date of 29 March.

It was not possible to determine kit mortality during the summer because insufficient numbers of kits were marked and bacause kits were widely dispersed and moved often. None of the radio-collared kits died. However, a dead kit estimated to be about 30 days old was found at a den abandoned by a family originally having nine kits.

Small mammals

Despite abundant sign of rodent activity (runways, burrows, nests, and cut grass stems) in the dry tundra communities, capture rates during a total of 1164 trap nights in June, July, and August were generally low (Table 3). Only tundra voles (*Microtus oeconomus*) were captured. Equal numbers of males and females were captured in trap lines. In addition to 34 mice from trap lines, four females were trapped at the grass-heath interface from 13-15 July. All six adult males and nine adult females were reproductively active. Six of eight subadult females were pregnant. Mean number of fetuses for all females was 7.3 ± 0.6. All other mice--seven juvenile males, four subadult males, four juvenile females, and two subadult females--were sexually immature.

Table 3. Small mammal trapping success (captures per 100 trap nights) in four habitat types at Kokechik Bay, Alaska.

	Upland tundra	High pingos	Grass-sedge meadow	Grass-heath
June	0.00	0.00	2.87	--
July	--	0.00	1.57	--
August	--	0.79	1.68	21.13

DISCUSSION

Fox studies conducted from Kokechik West camp in 1985 were mostly probes to establish baseline information about the area and to determine the feasibility of work proposed for the future. Nonetheless, there are noteworthy findings relating to density and characteristics of fox dens, productivity of foxes, dispersal of fox litters, and abundance of microtines.

Density of dens at Kokechik Bay (1 den/1.03 km^2) exceeds all previously reported figures from North America and Russia (1 den/45.5 km^2 ,Garrott 1980; 1 den/36.0 km^2, MacPherson 1969; 1 den/16 km^2, Dementyeff 1958, 1 den/1.6 km^2, Danilov 1968). One explanation of this high density is the small area sampled in our study as compared to many previous studies, which included more unsuitable habitat in the estimates of density. Furthermore, the Kokechik Bay area has habitat features (diverse topography and an abundant, varied food supply) that make it especially attractive to foxes.

Although dens are more abundant they are less complex than in other areas studied. The average number of den entrances reported elsewhere ranges from 7 to 13 (Underwood and Mosher 1982) with maximum numbers from 45 to 100. Greater complexity of dens in other regions is probably the result of use of a limited number of suitable sites year after year, whereas, with greater abundance of dens at Kokechik Bay occupancy of dens may be shifted from year to year. The relatively limited use of den sites (therefore, limited disturbance) may also explain why there was not the obvious difference in vegetation at dens compared to adjacent control sites, which has been reported in other studies (Dementyeff 1958, Danilov 1968, MacPherson 1969, Chesemore 1969, Eberhardt 1977, Garrott et al. 1983). Also, considering the diversity of plant communities in which dens were found, our small sample size (ten dens and ten undisturbed sites) resulted in greater within-treatment variances and, consequently, a less sensitive test for differences between treatments.

Productivity of foxes at Kokechik Bay (9.0 kits/female) was moderate to high compared to previous studies. Although MacPherson (1969) reported a mean placental scar count of 10.6, the average litter size of 22 other authorities was 6.3 (Underwood and Mosher 1982). Litters of up to 25 have been reported (Chesemore 1975).

We suspect some relocations of kits were due to disturbance, but most movements occurred at times of minimal human activities. This behavior, described in northern Alaska and elsewhere (Eberhardt et al. 1983), is thought to be a strategy for improving survival of kits by reducing intersibling competition and minimizing the chance of kit mortality from disease and predators . The occupancy of one den by kits from two different litters was probably influenced by our activities. The female fox, whose kits originally occupied the den, was sensitive to disturbance by humans. She had previously moved her kits following disturbance on two other occasions. Furthermore, just before desertion of the den her mate was inadvertently killed during trapping, which undoubtedly reduced the territory size for the family. Occupation of the den by the second family was probably a response to the reduced territory of the original occupants.

The abundance of rodents has been identified as an important factor affecting arctic fox populations in other regions (Chitty 1950, Chesemore 1969, MacPherson 1969) and may influence predation on geese by foxes (Eisenhauer and Kirkpatrick 1977). Cursory observations indicated that microtines were quite abundant in the study area in spring, but success was low in the majority of areas trapped during summer. Trapping rates from all but one area were within the range of rates reported by Eisenhauer and Kirkpatrick (1977). The concentration of mice in the grass-heath ecotone and the high fecundity rate among all trapped mice cast suspicion on the validity of snap trapping data from other areas. Because of the importance of documenting fluctuations in rodent populations appropriate sampling methods should be determined for next year.

Kokechik Bay was chosen as a study area because of its abundant goose and fox populations. Data on dens, distribution of foxes, and predation on geese this first year indicate that it is probably not representative of most areas on the YKD with fox-goose conflicts. Therefore, to obtain a better understanding of the problem, studies of fox ecology should be expanded to other study areas where nesting geese are being heavily preyed upon by foxes. These studies would focus on determining population structure, den characteristics, and movements of foxes in other habitats.

FUTURE WORK

Continuing activities

Radio tracking of foxes will be continued in fall and winter to determine dispersal of adults and kits from summer breeding areas. Contingent on suitable weather, aerial surveys will be conducted bimonthly from November through March.

In March trapping and radio-collaring of foxes will begin at Kokechik Bay. Trapping will be conducted using snow machines and will continue at regular intervals until breakup. Concurrently, previously located dens will be examined for signs of use. In May intensive radio-tracking, primarily from ground stations, will begin and continue at least through July. Unmarked adults and kits also will be trapped and radio-collared throughout the summer.

Sampling at dens will be increased to include more dens, to collect soil, and to measure depth to permafrost at each den.

Small mammal traping will be conducted monthly from May through August to estimate abundance of rodents. Density of small mammal sign following snow melt will be estimated with randomly located circular plots.

New activities

Assuming productive fox trapping at Kokechik Bay in spring, additional foxes will be captured and marked with radios and visual markers in the vicinity of the goose research camp at Old Chevak. This will allow location of den sites and facilitate observations of fox activity outside the highly productive Kokechik Bay area.

Trapping of foxes to reduce predation on geese will be conducted around the goose research area at the Tutakoke River. Secondary goals will be to assess avian predation in the absence of foxes, collect biological information on foxes, locate dens, and determine the response of foxes to fox free areas containing high concentrations of prey species.

ACKNOWLEDGEMENTS

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