FINAL REPORT

To the U.S. Fish and Wildlife Service

ECOLOGY OF WOLVERINES IN NORTHWEST ALASKA.

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INTRODUCTION

In response to proposed oil and gas exploration and development activities in the National Petroleum Reserve-Alaska (NPR-A), a study of wolverine ecology was initiated in 1978 as part of a larger research program by the U.S. Fish and Wildlife Service on selected wildlife species in NPR-A (National Petroleum Reserve in Alaska, 1979). The study on wolverines was unique in that it dealt with an arctic population that was essentially unharvested. The 2 previous radio-telemetry studies (Hornocker and Hash 1981, Gardner and Ballard 1982) dealt with harvested populations in forested habitat types. The purpose of this paper is to report on the findings from this study related to home range and movements and to compare these findings with those from other wolverine populations.

STUDY AREA

The study area lies between 68° 30′ and 69° N and 160° 30′ and 162° 30′ W in northwestern Alaska along the upper portions of the Utukok and Kokolik River drainages (Figure 1). The area spans 2 major physiographic provinces described by

Wahrhaftig (1965). The Brooks Range Province in the thern portion of the study area ranges in altitude from 1100 m to 1500 m. The Arctic Foothills Province ranges from 360 m to 1100 m in the south and 180 m to 360 m in the north. The Brooks Range Province is characterized by "steep, knife-like ridges, aretes, cirques, and U-shaped valleys" and The Arctic Foothills Province by "tundra-covered rolling hills, plateaus, and low, east-west oriented ridges and sporadic conical ice mounds". (National Petroleum Reserve in Alaska Task Force 1978). The study area is treeless, the vegetation characterized by tussock and alpine tundra and riparian willow along braided streams. Spetzman (1959) presented detailed account of vegetation in the study area. The average maximum temperature (July) recorded for Umiat, the nearest recording station with comparable weather patterns (370 km east of the study area at 69° 22'N, 152° 10'W), was approximately 15° C. The average minimum (February) was approximately -37° C. The average annual precipitation at Umiat is less than 150 mm, with precipitation occurring most frequently in November and December. The annual mean for wind speed at Umiat was 6 knots with a maximum of 60 knots, usually from the west or east. The winds are calm 17% of the time. From December through February, a wind chill of less than -31° C occurs 50% of the time. During February, the coldest month, a wind chill factor of -43° C occurs 50% of the time.

METHODS

Capture Techniques

Five methods of capturing wolverines were used during the study:

1) Drugging from a helicopter using Cap-Chur equipment (Palmer Chemic Equipment Co.)
2) Live-trapping
3) Using a Cap-Chur gun or Jab-stick on wolverines cornered in shallow rock caves or snow tunnels
4) Running young wolverines down on foot and capturing by hand without drugs
5) Digging a litter from a natal den

Drugging

Ketamine hydrochloride (Vetalar, Parke-Davis and Co., Detroit, Michigan) was the most effective drug when used at a dosage of approximately 22 mg/kg. A mixture of phencyclidine hydrochloride (2 mg/kg) (Sernylan, Bio-ceutics Laboratories, Inc., St. Joseph, Missouri) and xylazine (4 mg/kg) (Rompun, Haver-Lockhart Bayvet Div., Cutter Laboratories, Shawnee, Kansas) also produced suitable results, having a response time similar to that of ketamine hydrochloride. Phencyclidine hydrochloride when used alone caused repeated convulsions. The wolverines usually responded to the tranquilizing drug within 5 minutes after it was administered. Recovery began within 30-60 minutes after the animals were tranquilized.

Tagging

The captured wolverines were ear-tagged with plastic rototags (Nasco West, 1524 Princeton Ave., Modesto, Calif.) and tattooed on the inside of the upper lip. Body measurements and weights were recorded (Magoun, in prep.). The first premolar on the upper and lower mandibles were pulled for aging when possible. Photographs of throat coloration patterns were taken. Wounds, scars, and missing toes and teeth were noted. The wolverines were outfitted with radio collars purchased from Telonics, Inc. (1300 W. University Ave., Mesa, Arizona). A number of different types of collars were utilized during the study. Two collar weights were used. The heavier 1 was approximately 260 gm and was used on adult males and some adult females. A smaller package weighed approximately 130 gm and was used primarily on juveniles and some adult females. The collars were equipped with either whip antennas or internal antennas. Some collars had a variable pulse signal. When the wolverine remained motionless for 2 minutes, the pulse rate dropped to about 60 pulses per minute. If the wolverine moved, the pulse rate increased to 80 pulses per minute. This capability allowed me to determine if the wolverine had been inactive prior to the approach of the tracking aircraft.

Radio-tracking

The majority of radio-tracking flights were made in PA-18 Super Cubs equipped with a 3-element Yagi antenna on each wing, mounted perpendicular to the fuselage. The antennas and receivers were also purchased from Telonics. Radio signals were in the 150-151 MgHz range. The wolverines were usually visually located whenever possible to pinpoint their locations and observe activity and habitat type. Radio locations were recorded on 1:250,000 U. S. Geological Survey maps or 1:100,000 aerial photographs. The radio-tracking schedule (Table 1) varied seasonally with the majority of locations being made in the summer (68%). Most winter radio-tracking (63%) was done in March and April which was considered late winter (Table 2). Tracking intensity varied between individual wolverines.

Table 1. Number of locations* for wolverines captured in northwestern Ala

Wolv	Est Age	Yr	Locations per Month** Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oc
Males												
M2	S	78				4	3					
M3	A	78				4	8	17	3			
M5	A	78				5	8	8	3			
M6	A	78				1			1			
M8	K	78						2	8	5	19	
M12	A	79					12	3	1	9	3	
M13	K	79					4	5	2	12	2	2
		80	1	5	7							
M14	K	79					4	5	2	24	2	
M17	A	79				1						
M20	A	80		1	9	1	12	13	8	9	-	
		81			0	1	2					
M21	A	80		2	5			7		1		
M25	K	81				1						
Total(males)			1	8	21	18	53	60	28	62	26	

Females												
F1	U	78				4	9	4				
F4	A	78				6	12	8	3	3	2	
		79			4	1	3	1		2		
		80	1		3	1	1	4	3	1		
F7	A	78						2	8	6	13	
		79			8	7	25	14	3	27	2	2
		80	1	7	9	5	18	31	13	8		
		81				4						
F9	S	78										1
		79			12	5	18	4	1	15	1	
		80		1		1	1					
F10	A	78										1
		79			9	6	21	5	1			
		80	1	4	11	6	14	22	15	9		
F11	A	79					11	4				
F15	K	79					4					
		80		3	9	5	14	20	15	8		
		81				2		3	4			
F16	K	79		2								
F18	U	79										
F19	A	79										
		80	1	4	10	5	2					
F22	S	80			4	4						
F23	S	80				2						
F24	A	81			1	6	0	6	7		1	
		82					3					
F26	K	81				1						
Total (females)			4	21	80	66	152	128	73	79	19	4

*Includes radio-tracking locations, visual sightings, capture locations, and locations of dropped collars.

**December had no locations.

Table 2. Calendar seasons.

Summer	
May - August	Very little or no snow; spring melt occurs in early May; peak of arctic ground squirrel and caribou abundance; peak of wolverine breeding.
Early Winter	
September - October	First significant change from summer weather; snowfall light but snowdrifts beginning to form along drainage lines; freeze-up occurring in early October; arctic ground squirrels entering hibernation caribou migrating south.
Mid Winter	

November - February	Coldest and darkest months; arctic ground squirrels and caribou no longer available.
Late Winter March - April	Still winter conditions but temperature and daylight increasing rapidly; an occasional arctic ground squirrel or caribou appearing in the study area.

Results

Between April 1978 and May 1981, 26 wolverines were captured (Table 1). At the time of capture, 13 wolverines were adults (7 males, 6 females), 7 were kits (4 males, 3 females), and 4 were subadults (1 male, 3 females). The ages of 2 females were undetermined, but both appeared to be young. Ten wolverines were captured more than once. Twenty-three wolverines were radio-collared; 3 were too young to carry collars (M16, M24, F25). Radio-collared wolverines were relocated 972 times. Most of the relocations were made from aircraft. The wolverines were visually sighted during approximately 75% of the relocations.

Female Home Range Size

The summer home ranges of resident females depicted in Figure 2 were determined using the minimum area method (Mohr 1947). Symbols were used in this figure to denote any winter sightings which fell outside the summer home range

boundaries. Female home range size by month is presented in Table 3 for those months with 5 or more locations. Summer home range is a total of all sightings from May through August for those females with 10 or more locations for this period. The annual home range is all locations during 1 year.

Table 3. Home ranges(km3) of female wolverines.

	Mar	Apr	May	Jun	Jul	Aug	Sep	Summer Home Range (May-Aug)	Annu Home (Jan-De
F7									
1978					37*	36*	52	78(16)**	78(
1979	2*	0*	81	85		82		120(69)	120(
1980	1*		186	112	92	19*		211(70)	211
F10									
1979	1*	0*	55	19*				60(27)	66(
1980	16	6*	43	39	23	19		58(60)	71(
F4									
1978		39*	42	45*				106(26)	124(
1979									
1980									
F1									
1978			288*					334(13)	334(
F11									
1979			32					39(15)	39(
F7									
1980	158	68*							287
F24									
1981		14*		38*	298			62(13)	6
F15									
1980	18*	10*	41	36	42	13*		49(57)	49
F9									
1979	32	25*	34	1*		32		80(38)	80(

*Less than 10 locations.
**Total number of locations.

Average summer home range in 1978 was 173 km2 (F1, F4, F7),

in 1979 only 75 km2 (F7, F9, F10, F11) and in 1980 106 km2 (F7, F9, F10, F15). These home range calculations were affected by changes in home range size and by the particular wolverines included in the calculations. For example, the size of a female's home range did not always remain the same from year to year (Figure 2). F7 expanded her home range by 57% from 1979 to 1980; F10's home range remained essentially the same size in these 2 years.

Unusually small or large home ranges affected home range calculations. There is reason to suspect that F1's summer home range may have been particularly large in 1978 due to an extensive movement into the Brooks Range during a 2-day period in early May (Figure 3). If her home range is disregarded, the average summer home range for the 7 remaining female wolverines with more than 10 locations is 86 km2. There is also some reason to suspect that F11's home range may have been particularly small since she was not always successfully located during radio-tracking flights. If her home range is also disregarded, the average summer home range for the remaining 6 females is 92 km2.

Sample size also affected home range calculations. The average summer home range for all individuals for all years was 94 km2. The smallest was 9 km2 (n=7) and the largest 334 km2 (n=13). If those individuals with less than 10 locations for a summer period are disregarded, the average

summer home range is 109 km2, the smallest being 39 km2 (n=15) and the largest 334 (n=13).

Annual home range includes all locations, but the majority are from the summer period. Mid-winter locations were difficult to make due to inclement weather and darkness. Most winter sightings were in the months of March and April (Table 1). No female had more than 3 winter sightings fall outside her summer boundaries except possibly F19 for which there is no summer data (Figure 2). Of those females with both summer and winter sightings, only 1 winter sighting was of any significant distance from the area used in summer. On 9 February, F10 was located approximated 5 km south of her summer area. She was back within her summer range on 23 February and was not found outside its boundaries again though she was located 19 more times before May.

For those individuals in which at least 10 locations were made during winter, the average annual home range was 96 km2 and this figure was essentially the same as the average summer home range for these same individuals (94 km2).

Taking into consideration all the factors mentioned above, the average home range for female wolverines in this study is approximately 100 km2, with a range of 40-350 km2.

Male Home Range Size

Data were sufficient to determine home range size for 4 adult males (Table 4). The smallest summer range was 494 km2, while the largest was 924 km2; the average was 647 km2. The home range of male M20 was 40% larger than the average for the other 3 males (Figure 4).

The average annual home range size for males was 690 km2 (not including that of M21 for which most of the summer sightings are limited to the area where he bred with F7). The annual range of M5 was 143 km2 larger than his summer range and M20's was 30 km2 larger.

Due to loss of collar or radio signal, no male was tracked for more than 1 year though at least 3 males were seen in the study area for more than a year (M5, M17, M20) and the unique track of another male (M21) was found regularly along the Utukok River in spring 1981, a year after his capture.

Table 4. Home ranges(km2) of male wolverines.

	Mar	Apr	May	Jun	Jul	Aug	Summer Home Range (May-Aug)	Annual Home Range (Jan-Dec)
M3								
1978			209*	404			493(28)	493(32)
M5								
1978			334*	396*			624(19)	767(24)
M12								
1979			212			277*	547(25)	547(28)
M20								
1980	132*		281	521	550*	486*	924(42)	954(53)
M21								
1980	160*							160(15)

*Less than 10 locations.

**The number in parentheses represents the number of radio-locations.

Home Range Overlap

Resident female wolverines usually maintained essentially exclusive home ranges from May through September and rarely traveled into neighboring areas even during winter (Figure 2).

Two exceptions to the exclusive use of home ranges by resident females were noted during this study. Represented by open triangles in Figure 2, sightings of F19 from 9 February to 8 May were scattered over 287 km2 and fell within the home range boundaries of at least 3 other collared females. Twenty-one of the 23 locations for this female were from the winter period. Only 2 locations occurred in May before she slipped her collar, so there is essentially no data to establish whether or not her home range would have remained as large during the summer.

Adult female F10 and her yearling daughter F15 were the only 2 resident females known to have overlapping summer home ranges (not including females with kits-of-the-year). F15 was born in March 1979 and her home range that summer probably approximated that of her mother; however; both animals had slipped their collars and could not be tracked

that summer. Other kits remained in their mother's home range during their first summer and fall. Three male offsprings of M7 (M8 in 1978; M13 and M14 in 1979) utilized their mother's home range through their first summer and remained there at least until mid-November. F15 and her female sibling F16 were visually located with their mother on 13 November 1979 indicating that they too were still using their mother's home range in mid-November. Both F10 and F15 were recollared during the winter and tracked during summer 1980. As a yearling, F15 ranged over 62% of her mother's home range with 50% of her locations within the overlap area (Figure 5). Sixty-one percent of F10's home range overlapped her daughter's with 40% of her locations in the overlap area. However, only about half of the overlap area was used intensively by each wolverine, F15 remaining largely to the north and F10 to the south. Only 20% of F15's locations fell within the area intensively-used by her mother and less than 10% of F10's locations fell within the intensively- used area of her daughter.

Unfortunately, not enough data are available to determine whether or not adult male wolverines used exclusive areas during the summer as females did. Only 2 males (M3 and M5) were radio-tracked concurrently (Figure 4) and their home ranges were not contiguous.

Male home ranges overlapped female home ranges. Though it

is likely that males overlapped at least 4 females and possibly as many as 6, documentation of overlap involved only 2 radio-collared females in any 1 year (1979) for any 1 male (M12) (Figure 6).

Home Range Shape

The greatest lengths across the wolverine home ranges were measured and compared to the width at the widest point perpendicular to this length. The average length was approximately 1.6 times the average width for both males and females. The average for maximum width and length for females was 10 km and 15 km, respectively; for males, 25 km and 39 km, respectively.

Topographical features appeared to influence the shape of home ranges to some extent. Rivers, ridges, drainage divides, and well-defined breaks in habitat types often coincided with home range boundaries (Figure 7). The Utukok River formed north-south boundaries between home ranges of female wolverines on either side of the river (Figure 2) even though the river was not a physical barrier. Three locations for F7 were made on the east side of the river in 1978, but these may have been influenced by radio-tagging operations at the time. Boundaries running east and west often coincided with ridges that typically run in this direction in the study area. Topographical features did not

appear to have as much of an affect on male home ranges. While M12's and M20's locations were restricted to opposite sides of the Utukok River in 1979 and 1980, respectively, M3's locations in 1978 occurred on both sides of the river (Figure 4).

Movement Patterns

On the average, male wolverines were found 4 times farther from their location of the previous day than were female wolverines. The average distance between radio locations of female wolverines on consecutive days was 4.1 km. The greatest distance was 15.6 km for female F7 in June 1980. The average distance between daily locations for males was 12.3 km. The greatest distance was 35.6 km for M20 also in June 1980. Distance between daily radio locations was greater in the summer than in winter (Table 5).

Table 5. Average distance between daily radio locations.

	February	March	April	May	June	July	August	September
Females	3.3 (n=4)	2.4 (n=37)	3.9 (n=21)	5.3 (n=41)	5.0 (n=35)	4.3 (n=20)	2.9 (n=4)	5.4 (n=5)
Males	---	9.1 (n=5)	6.1 (n=3)	13.3 (n=11)	15.6 (n=9)	8.8 (n=3)	15.5 (n=3)	---

The average distance between daily locations exhibited yearly variation. For F7, it averaged 5.1 km (n=14) for May and June in 1979 when she had a home range of 120 km2 and 8.0 km (n=17) for the same period in 1980 (an increase of 36%) when she had a home range of 211 km2. The same average distance for F10 also increased (32%) from 2.7 (n=9) in 1979 to 4.0 (n=11) in 1980, even though the size of her home range was essentially the same in both years (58 km2 and 60 km2, respectively).

The actual distance traveled by the wolverines daily was certainly much greater than that indicated by the distance between radio locations on consecutive days. During 8 1-hr continuous observatons of active wolverines, the actual distance covered was 33% greater than the straightline distance between locations at the beginning and at the end of the hour (Figure 8). The average rate of travel for adult male wolverines was 8.6 km/hr and for females, 4.6 km/hr. The greatest rate of travel observed for a male was 10.6 km/hr and for a female, 8.0 km/hr.

One of the major influences on late winter movements for female wolverines was the presence of a natal den. In 1979 F7 and F10 were nursing kits during March and April; F9 was a young female that did not produce kits in 1979. The movements of F9 in March and April were considerably different from those of the lactating females. Radio tracking loca-

tions in Figure 9a-c reflect this difference in the form of multiple locations at a central point (the natal den) for the lactating females and no concentration of radio locations for F9, the non-lactating female.

Similarly, movements in May and June for females with kits are influenced by the fact that females must return to kits which are left at rendezvous sites while the female hunts. Radio locations under these circumstances tend to be clustered at certain points (Figure 10). For the 12 days on which F10 was tracked in May 1979, she was located at a rendezvous site at least once each day.

F7's movements showed a dramatic change in May 1980. During 1978 and 1979 and late winter of 1980, F7 could predictably be found within the boundaries of the 1979 home range depicted in Figure 2. Of 146 locations, only 3 fell outside the 1979 boundaries, these during capture operations in 1978. On 9 May 1980, she was located 6 km north of the 1979 northern boundary (Figure 11a), the first of 16 days in which she was located in this new area during summer 1980. From 9 May until 7 June, she was found north the 1979 boundaries 33% of the time. Her average distance between locations was 11 km; the average interval between locations was 1.7 days.

From 8 June until 13 July, F7 was found north of the 1979

northern boundary 40% of the time (Figure 11b). On 15 June, [redacted] was at a caribou carcass in the northeastern corner of her 1980 home range and continued to visit the carcass area until at least 13 July. The average distance between locations in Figure 11b is 8 km; the average interval between locations was 1.8 days.

Locations from mid-July until the end of August were largely restricted to the southern end of her home range (Figure 11c). Only 14% of her locations were outside the 1979 boundaries. The average distance between locations was 7 km; the average interval between locations was 2.5 days.

The average interval between locations could affect the average distance between locations. Therefore, the average distance between locations for Figures 11a-c were also calculated for just those locations with a 2-day interval. The results were comparable to the average distances for all intervals.

The movements of male M20 (Figures 12a-c) changed from late winter 1980 through the following summer. M20's locations were all in the southern end of his home range in March 1980. One location each for February and April were also in this area (Figure 12a). The average distance between these locations was km; the average interval was days.

From Figure 12b, it is obvious that M20's movements expanded

greatly in May, but most of his locations from 5 May until June were restricted to the southwestern portion of his range. He was found only twice in the northeastern portion of his range during this period. From 26 June until 19 August, this male's movements (Figure 12c) were concentrated in the eastern half of his range and involved extensive movements between the northern and southern boundaries.

While paired with a female, M20's locations were confined to a small area. The average distance between his locations on consecutive days from May-August was 14 km. His locations on 11 and 12 June, when he was paired with F9, were only 1 km apart (Figure 12a). M20 was possibly paired with another female on 31 July and 1 August 1980. On both days, he was located (though not visually sighted) in dense willows; the locations were less than 1 km apart (Figure 12b). Breeding pairs of wolverines commonly rested in willows (Magoun, in prep.). This fact and his limited movements suggest he was paired at the time. Distances between locations of female wolverines when they were paired with males further support this assumption. While the average distance between consecutive day locations for F7 during summer 1980 was 8 km, the distance between the locations on the days she was paired with a male wolverine (5 and 6 June) was only 1 km (Figure 11b). Another female, F9, moved an average of 1 km per day during the 3 days she was paired with a male in 1979 (Magoun, in prep.).

Dispersal

Dispersal was difficult to document because the distances traveled by dispersing wolverines were relatively great compared to the transmitting capabilities of their radio packages. The last radio location for kit M8 born to F7 in 1978 was on 16 November 1978 in his mother's home range. Tracking was not resumed until the following March. The kit could no longer be found in the study area. In May his carcass was obtained from a trapper who reported capturing the animal in March 1979 in an area south of the Brooks Range 100 km from F7's home range. The date of capture could not be verified. That the kit may actually have dispersed in early March just before his reported capture is quite possible since another male (M13), born to F7 in 1979, dispersed between 9 March and 11 March 1980.

M13 was born in March 1979. Radio locations of M13 were all in or near his mother's home range (Figure 13) until 27 February 1980 when M13 was located away from his mother's home range for the first time. He was sleeping in an area approximately 10 km southeast of F7's range. On 7 March 1980, M13 was back in F7's home range in a snow tunnel with his mother and a radio-collared adult male (M21). On the next day the kit was again located outside his mother's home range near the 27 February location. He was in this area on 9 March as well, but on 11 March, the kit was found 60 km to

the south along the same drainage where M8 was trapped the year before.

While these are the only documented cases of dispersal, supporting evidence is available to indicate that dispersal may occur at least as early as January and as late as May for first year dispersers. Before this study was initiated, a female wolverine was ear-tagged and released in the study area incidental to other research. The animal was tagged in October and a trapper reported taking an ear-tagged wolverine in January approximately 300 km south of the study area. Since it is very unlikely that any other wolverine had been ear-tagged in that area of Alaska, I assumed the tagged wolverine originated in the study area. Though the ear tags could not be recovered, they were reportedly the same color as those on the wolverine tagged in the study area. There is no way to know if the wolverine had been born in the study area; she may have been a disperser or a transient. Her teeth showed no wear and her mammae averaged less than a millimeter. A premolar taken at the time of her capture had only 1 cementum line. A canine taken from M8 at the time of his death as a yearling had only 1 cementum line suggesting that the female was approximately a year old.

One member of each of 2 litters born in the study area may have moved out of the study area in mid-winter before they were a year old. Female kit F16 (sibling of F15) and male

kit M14 (siblings of M13), both born in March 1979, were all in the study area in November 1979. However, when field work was resumed in February 1980, circumstantial evidence suggested that the 2 kits were no longer in the study area. The siblings of F16 was captured on 14 February and her mother on 24 February, but F16 was not recaptured. Since F16 was not radio-collared, I could not search for her.

While neither M13 nor M14 were recaptured after November 1979, M14 was relocated 9 times in his mother's home range between 25 January and 7 March 1980 just prior to his dispersal. On 3 of these occasions, he was with his mother. But M14 was never seen with his mother again and was not relocated after November 1979. At that time his radio signal was erratic so the radio may have been failing. On 17 May 1980, a signal corresponding to M14's was received 40 km east of his mother's home range, but the source of the signal could not be traced and the signal was never heard again.

A young male wolverine (M2) may have been either dispersing or passing through the study area in spring 1978. His radio signal was heard 10 times in a relatively small area (40 km^2) between his capture on 15 April and the disappearance of his signal after 6 May. I searched for him nearly 150 km in all directions on several occasions, but I never heard the sig-

nal again. At first I attributed the disappearance of his signal to radio failure, but after further experience with tracking wolverines in mountainous areas and knowing the distance that some dispersing wolverines covered, it is just as likely that the male moved out of the study area and I was not fortunate enough to pick up the signal again. Whether or not this male was born in the study area is not known. His average testis size was smaller (20 mm) than that of the other 3 males captured in April 1978 (27 mm).

A similar incident occurred involving F22, a young female (mammae size and condition of her teeth indicated she could have been a yearling). On 18 March 1980, she was captured and radio-collared. She was recaptured on both the following 2 days in another trap 4 km from her original capture site. On 24 March she was 10 km to the east and on 9 and 10 April she was located in an area 8 km farther to the northeast. On 24 April she was again seen in that area fighting with an uncollared wolverine judged from its size to be another female. She was seen the next day 3 km northeast of where the fight took place and then never located in the study area again. In October that year, a radio signal corresponding to hers was heard by a biologist flying over the headwaters of the Kugururuk River just south of the Brooks Range. Due to inclement weather, he could not pinpoint the location or verify the signal. If the signal was

that of F22, she had moved approximately 15 km south of her original capture site. Again, I do not know if she was born in the study area.

DISCUSSION

Home Range Size

Accurate estimates of average home range size are limited by sample size problems. For example, M20's summer home range is 33% larger than that of M5; however, locations for M20 were gathered into August while those for M5 ended after 13 July. If only M20's summer locations up to mid-July are considered, his home range would have measured 726 km2, only 15% larger than that of M5. Data collection for M3 also ended in mid-July but extended into August for M12.

Another problem affected home range calculations for M12. This male could not be located consistently when attempts were made to radio-track him. Either inclement weather in the mountains or limitations on flight time prevented a thorough search for him on some days. This suggests that some of the outlying locations of his home range were

missed, perhaps resulting in a calculated home range considerably smaller than his actual home range. Similarly, M5 was not always located because of a weak radio signal and flight time limitations. These problems also occurred for the female wolverines, but a larger sample size improves the credibility of average home range figures for females.

Because of the problems mentioned above, comparison to other wolverine home range figures in the literature should be qualified. Hornocker and Hash (1981) found an average yearly range for male and female wolverines of 422 km2 and 388 km2, respectively. One female had a range of 963 km2 which they stated was somewhat atypical. Depending on their sample size, this 1 female may have significantly influenced their calculation of female home range size. It is not clear how many home ranges were used in the calculation of average yearly range in their study. Their yearly home range for males was smaller than both the summer and annual home range figures from my study area, and their female yearly range was larger. Two lactating females in their study area exhibited spring and summer ranges of 100 km2 each. This agrees closely with the average home ranges of F7 and F10 in 1979 when they were both lactating (90 km2) and with that of a lactating female (042) in Gardner and Ballard's (1982) study (86 km2).

My calculations for female home ranges in March and April particularly small for some females (Table 3). Because the activity of lactating females center around natal dens, there was only a small chance of finding them away from the dens during March and April. The actual area used by lactating females in March and April is probably comparable to their summer range. Bjarvall (19) snow-tracked female wolverines from natal dens in March and April in northern Sweden. The home ranges of 3 denning females averaged 170 km2. From snow-tracking M7 in April during the time she was denning in 1979 and 1981, it was obvious that she was traveling away from the den daily and her movements were in all directions from the den. Tracking conditions were poor due to blowing snow so she could not be followed for long stances, but on at least 1 occasions in 1981, she had traveled as far as her eastern boundary on the Utukok River and back to her den, a distance of km. Even though F7 and F10 did not raise kits in summer 1980, their radio locations in March and April 1980 were concentrated in a small area resulting in very small home range calculations. I believe these 2 females were attempting to den at that time but were unsuccessful (Magoun, in prep.). F15, yearling daughter of F10, also had a relatively small home range during that time because her movements were still being influenced by those of her mother (Magoun, in prep.).

Gardner and Ballard's study involved primarily male wolverines. The largest home range was 627 km2 for an adult male from April 1980 to April 1981 and the smallest was 89 km2 for a juvenile male in March 1981. Two males of unknown age had home ranges of 272 km2 (May-Dec) and 378 km2 (May - Dec). If the juvenile's range is disregarded, the average male home range is 426 km2, very similar to Hornocker and Hash's figure but smaller than male home range in this study even though their data were collected over a greater period of time. Juvenile male home ranges are not considered in my calculations of male home range size since juvenile home ranges approximate their mothers' during their first year. The juvenile home ranges of M8, M13, and M14 averaged 54 km2 (not including M13's locations just prior to his dispersal). Hornocker and Hash (1981) do not stipulate whether or not juvenile home ranges are included in their calculations.

Home Range Shape

Because rivers and mountains are not physical barriers to wolverine movements (Hornocker and Hash 1981), the coincidence of such topographic features with boundaries between contiguous female home ranges must be related to some other factor. While scent-marking is probably the method by which females maintain exclusive use of their home ranges (Magoun, in prep.), changes in terrain features may be important as visual references to established boundaries. Visual

reference would enhance the likelihood that resident females deposit scent-marks consistently within the same area and would make it easier for them and neighboring wolverines to recognize when they are approaching an established boundary. Boundaries are flexible, however, probably being influenced mainly by the social status of neighboring wolverines (Magoun, in prep.) when food resources are stable.

Home Range Overlap

The exclusive use of summer home ranges for females wolverines in my study area was clearly evident in the pattern projected in Figure 2. It would have been interesting to follow F19 through the summer of 1980 if she had not dropped her collar. Her frequent excursions into the home ranges of other females during the winter of 1980 probably resulted from impending starvation and attraction to baited live-traps. Nearly all sightings of this female on the west side of the Utukok River were at baited live-traps. Once she killed and ate a red fox that was caught in 1 of the traps and was observed trying to kill another fox caught in a trap in the same area. She was 1 of the only wolverines to consume the bait in a trap once she was caught. She was live-trapped more times than any other wolverine. At her last capture on 10 April, she seemed lethargic. She had very worn teeth and was apparently an old animal. Hornocker and Hash (1981) noted that both wolverines which starved to

death during their study visited bait stations frequently, lying heavily on the baits just before their deaths. Since F19 was still alive in early May, she probably survived since food becomes abundant in the study area by late May. Because winter food shortages are probably not uncommon in wolverine populations, overlap in home ranges probably occurs more commonly in winter and where food supplies are adequate, overlap by resident females does not normally occur.

Hornocker and Hash(1981) stated that home ranges overlapped in their study area between individuals of the same and opposite sex and claimed that territorial defense was essentially non-existent (citing Koehler et al. 1980). They pointed out, however, that they were not always able to establish the residency status of individuals in their population. Though limited, the data from the present study demonstrate the importance of establishing the familial relationship of individuals of the same sex with overlapping home ranges. As stated above, females with overlapping home ranges might be mother/immature daughter combinations. Young males which have not yet dispersed may be overlapped by resident adult males. M13's home range overlapped that of adult male M21 until his dispersal at 1-year of age. M8's home range was overlapped by that of M3 in 1978. Gardner (pers. comm.) verified that the 1 case of overlap by male wolverines which he observed in his study area involved

a juvenile and an adult male.

Hornocker and Hash also suggested that high mortality due to trapping may be severe enough to contribute to behavioral instability causing a breakdown in the territorial system. They pointed out that unexploited mountain lion populations showed a highly refined system of territoriality (citing Hornocker et al., 1969 and Seidensticker et al., 1973), while exploited populations were not territorial at all (citing Hornocker, 1976).

Movement Patterns

It appears that movements of male wolverines during the summer are influenced mainly by breeding activity. While the distance between daily radio locations for males was 4 times that of females, rate of travel was only twice that of females. This suggest that male wolverines are more active, spend a greater proportion of their active time traveling, or travel more direct routes than females. Since males probably monitor the breeding condition of 4 to 6 females in their home range from at least May through August, they probably spend a greater proportion of their time traveling and their movements would tend to be less circuitous and cover greater distances than those of females. Hornocker and Hash (1981) stated that male wolverines in their study area made longer, more direct movements than females.

Females had a "progressive travel pattern directed toward a ...e uniform coverage", while the male "traveled to the extremities of their range in relatively shorter periods than did females." This appeared to be the case in our study as well.

Home range size appears to influence average distance between daily radio locations. When there was a 50% difference in F7 and F10's home range size in 1979, there was a 32% difference in the average distance between their daily radio locations. When the difference in home range size increased to 73% in 1980, the difference in distance between their daily radio locations increased proportionally to 47%. This suggests that as home range size increases for female wolverines, they either increase the distance traveled daily or make more direct movements or both.

Raising kits appears to be an important factor influencing female movement patterns during summer. The increase in distance between daily radio locations from 1979 to 1980 for F7 and F10 was probably related to the presence of kits in 1979. It could be argued that the increase for F7 was solely the result of the increase in her home range size. However, F10 showed a similar increase in daily movement distance but essentially no change in home range size.

The reason for the increase in the size of F7's home range

in 1980 is not clearcut. It is questionable whether F7 expanded her home range in 1980 solely to seek a male for breeding purposes. Her use of the 1980 addition continued into August even though she bred on 11 June within her 1979 home range with a male (M21) that was known to have overlapped this area during the preceding winter and was observed near her on at least 2 occasions in April 1980. However, the greatest average distance between radio locations for F7 (11 km) in summer 1980 occurred in the period just prior to breeding (Figure 11a) and may have been related to the approach of the breeding season.

It is not likely that F7's expansion occurred as a result of food shortages in her 1979 home range. The expansion occurred in May when food resources become abundant in the study area. In addition, the expansion occurred to the north encompassing mainly low tussock tundra which has fewer food resources than the higher terrain to the south and west (Magoun, in prep.). The presence of the caribou carcass in the northeastern corner of F7's 1980 home range certainly influenced F7's continued use of the 1980 addition through mid-July, but it was not the factor which initiated the expansion of her home range. Food was apparently in short supply during the winter of 1979-1980; however, F10, the resident adult female to the south, did not expand her home range even though she was sharing her home range with a yearling daughter.

When F7 was first observed in the new area, she was traveling rapidly and scent-marking vigorously. She appeared very interested in other scent that she encountered. It appeared that another wolverine had been in the area. It could be argued that F7 was responding to the scent of a male in breeding condition. However, another explanation should also be considered. A young female, F23, had been captured in the area in April 1980. One cementum line from a premolar suggested she was a yearling. She was initially sighted near the northern boundary of what was to become F7's 1980 home range addition. F23 ran into the 1980 addition when chased with a snowmachine and was captured and collared there. The next day her collar was found lying on the ground km north of the addition (Figure 2). F23 may have been an immature female residing in the area north of F7's range. The area may have been vacant due to the death of the resident female over the winter, and because of F23's immaturity, F7 may have been able to successfully challenge her use of the area.

It is possible that F7 usually occupied the entire 1980 home range in years when she did not raise kits, restricting herself to the southeast portion of her home range when she had kits. However, there is no evidence to indicate that this is the case other than her use of the larger area in 1980 when she had no kits. F10 did not show a comparable expansion in 1980 though she also had no kits. However, the

presence of a yearling offspring in 1980 may have been a factor in this difference between the 2 females.

Dispersal

Dispersal of juvenile wolverines occurred during their first winter, but not all juveniles dispersed. Female F15 was still in her natal area in July 1981 when she was 16 months old. She probably remained there at least until early winter and may have established residency near her mother's home range. Storm et al. (1976) found for red foxes that 80% of subadult males but only 37% of subadult females dispersed during their first winter. By the end of their second winter, 96% of the males and 58% of the females had dispersed at least 8 km from their natal areas.

The distances traveled by dispersing wolverines may have been as great as 300 km in this study. The direction of movement in those cases that could be documented was generally south. Winter food is more abundant south of the study area where boreal forest occurs, suggesting that winter dispersal may be partly influenced by food availability.

Agonistic interactions among wolverines, though infrequently observed, occurred only during late winter in this study (Magoun, in prep.) and in Bjarvall's (pers. comm.) and Gardner and Ballard's (pers. comm.). Agonistic interac-

tions, perhaps related to the approach of the breeding season, may influence the timing of dispersal for some juvenile wolverines.

Summary and Conclusions

A radio telemetry study of wolverine home range and movements in northwestern Alaska was conducted from 1978 to 1981. Twenty-six wolverines were captured, 23 of which were radio-collared. The average home range size for females was approximately 100 km2 and for males approximately 700 km2. Home ranges of resident female wolverines did not overlap (at least during summer) except for 1 female with a yearling daughter. There was not enough data to determine if adult male home ranges overlapped, but male home ranges did overlap those of females and their immature offspring. The average length of male and female home range was 1.6 times the average width. Topographic features appeared to influence the shape of female home ranges. On the average, male radio locations were 4 times farther apart on successive days than were those of females. The greatest distance between daily locations was 15.6 km for females and 35.6 km for males; the average distance was 4.1 km and 12.3 km, respectively. Male wolverines averaged 8.6 km/hr and females 4.6 km/hr when traveling. Average distance between daily radio locations varied annually at least for females.

The presence of kits and the size of the home range were 2 factors which influenced yearly variation. Radio locations were centered around natal dens, rendezvous sites, and large sources of food. Breeding condition appeared to influence the movements of male wolverines and, to a lesser extent, female wolverines. Dispersal of juveniles occurred between November and May of their first year, though 1 juvenile, a female, remained in or near her natal area indefinitely. The maximum dispersal distance (supported by circumstantial evidence) in this study was approximately 300 km.

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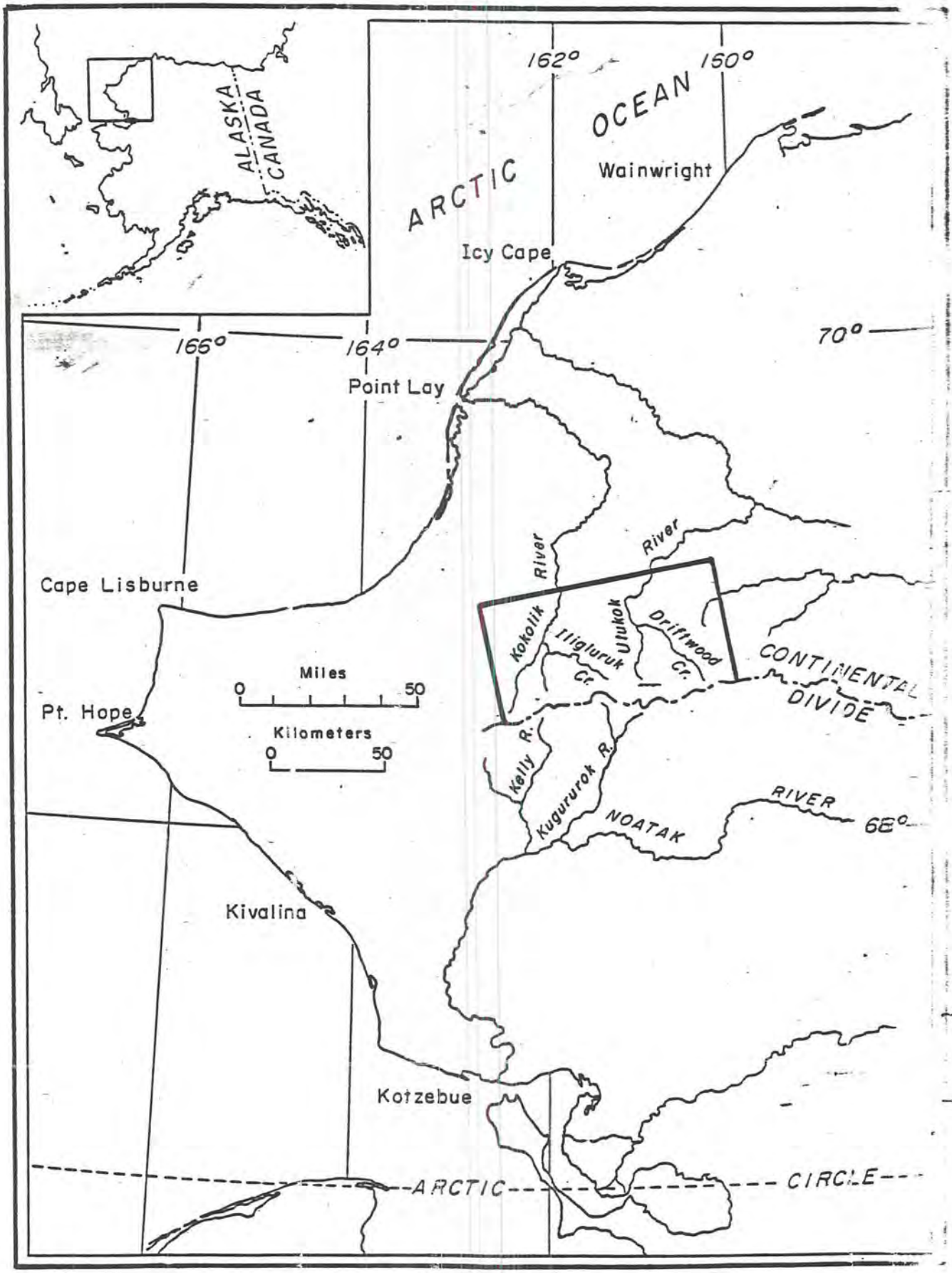
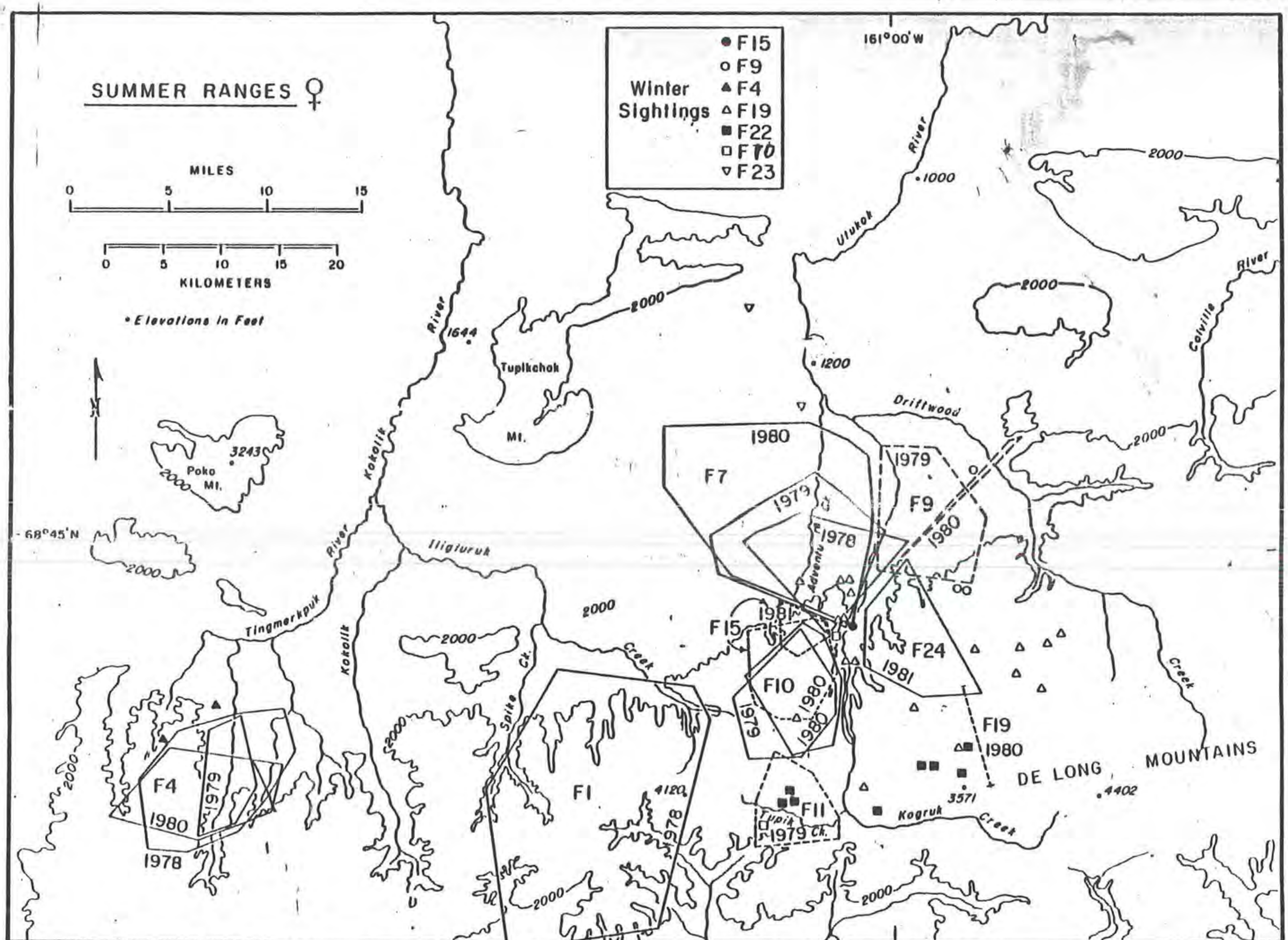


Figure 1. Location of the study area.


SUMMER RANGES ♀
MILES
0 5 10 15
0 5 10 15 20
KILOMETERS
• Elevations in Feet
Winter Sightings
F15
F9
F4
F19
F22
F10
F23
161°00'W
68°45'N
Ulukok River
Kokolik River
Tupikchak Mt.
Poko Mt.
Iligluruk
Tingmerkpuk River
Spike Ck.
Creek
Driftwood
Colville River
Adventure
Tupik Ck.
Kogruk Creek
DE LONG MOUNTAINS
1644
1000
1200
3243
4120
3571
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1978
1979
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1981

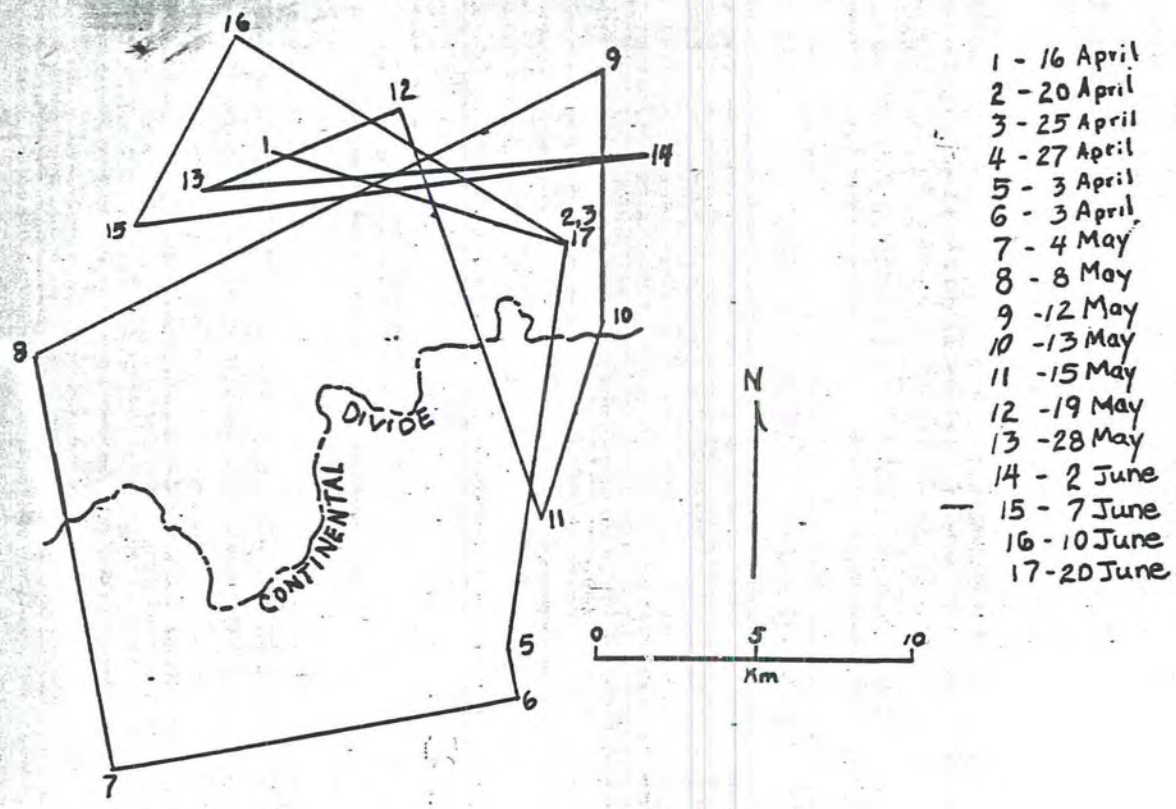


Figure 3. Movements of female F1 showing extensive movement to the south during a 2-day period in May.

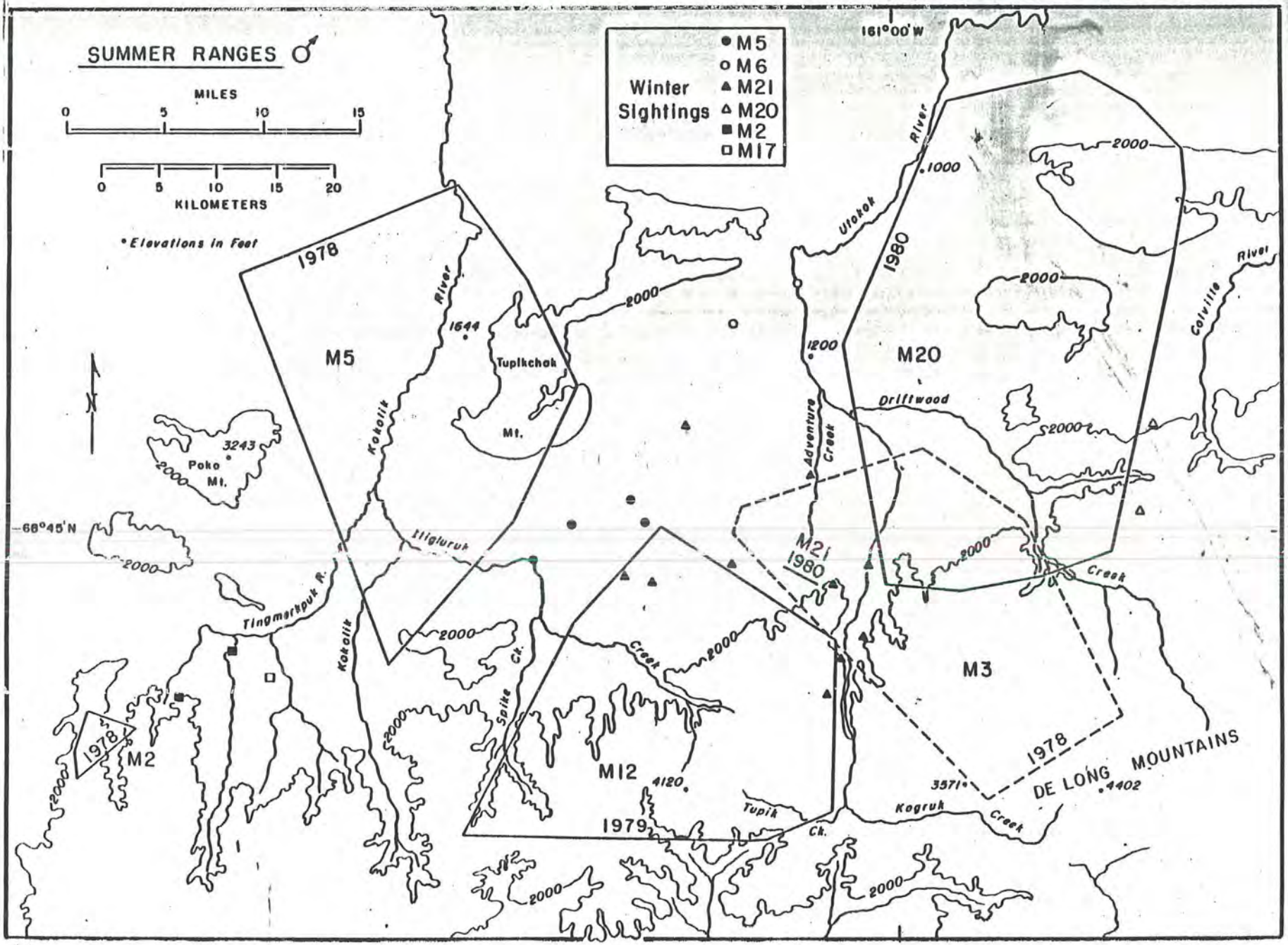


Figure 4. Summer home ranges of male wolverines. Water sightings which were outside

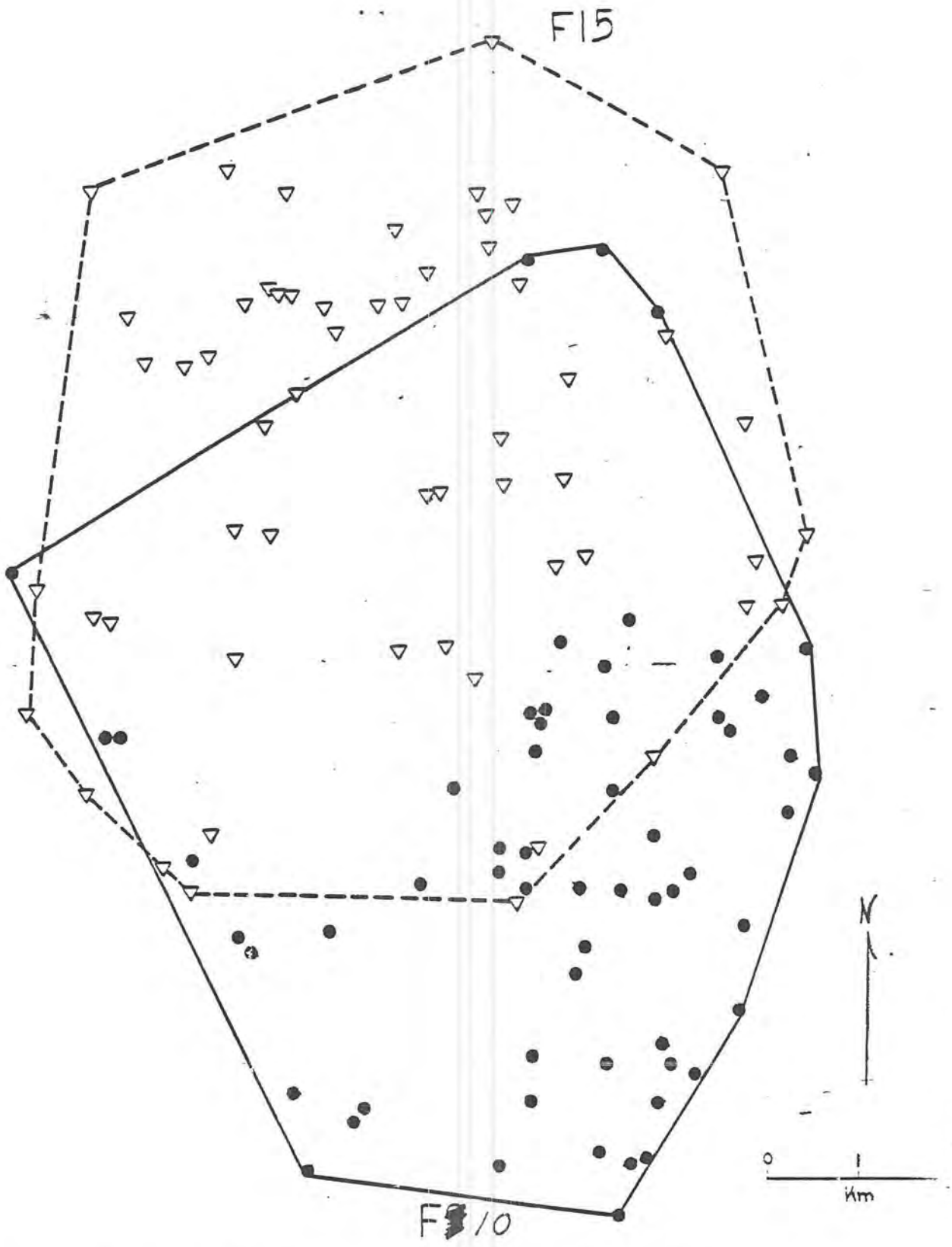


Figure 5. Overlap of home ranges of F10 and her yearling daughter F15.

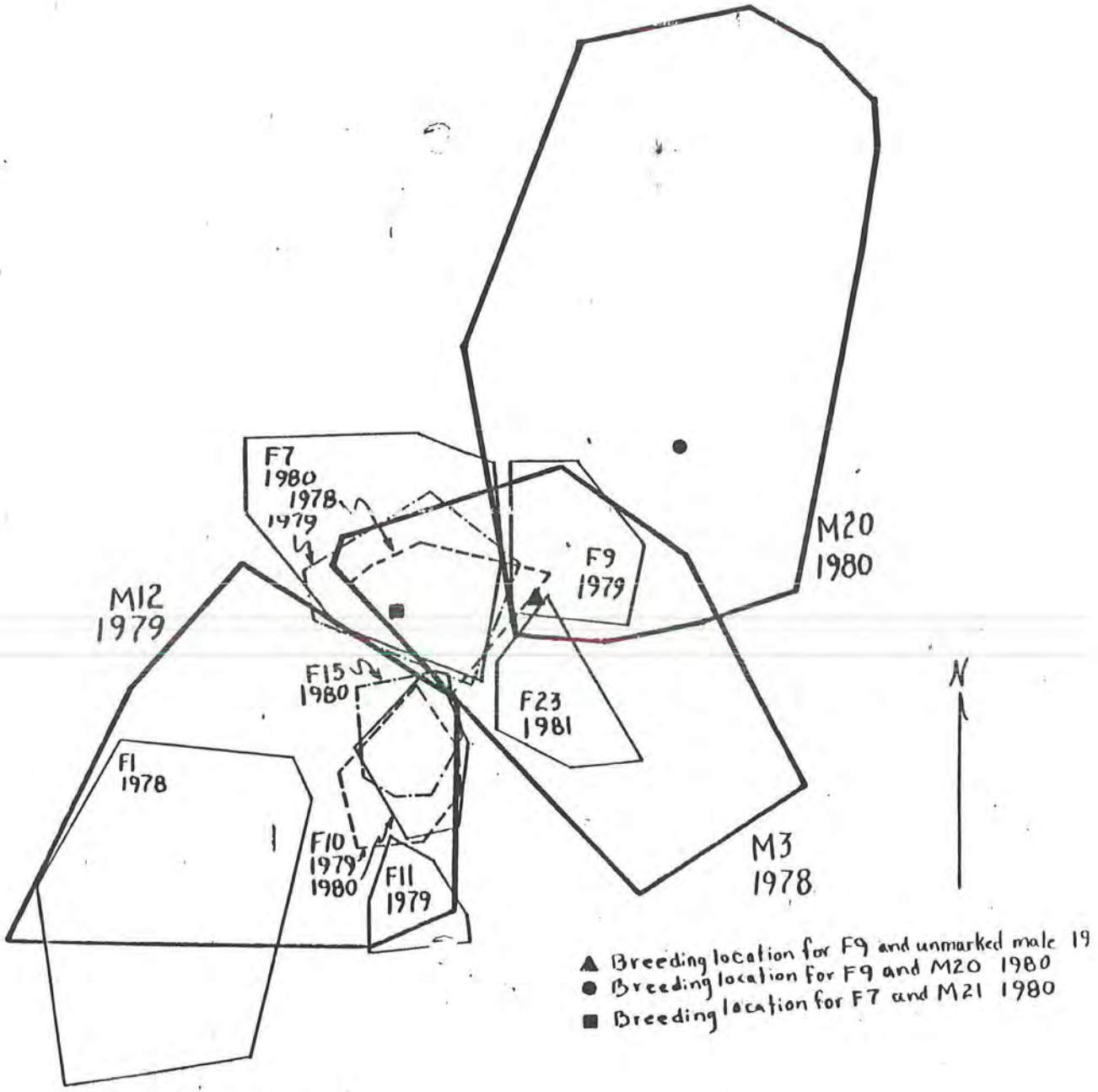
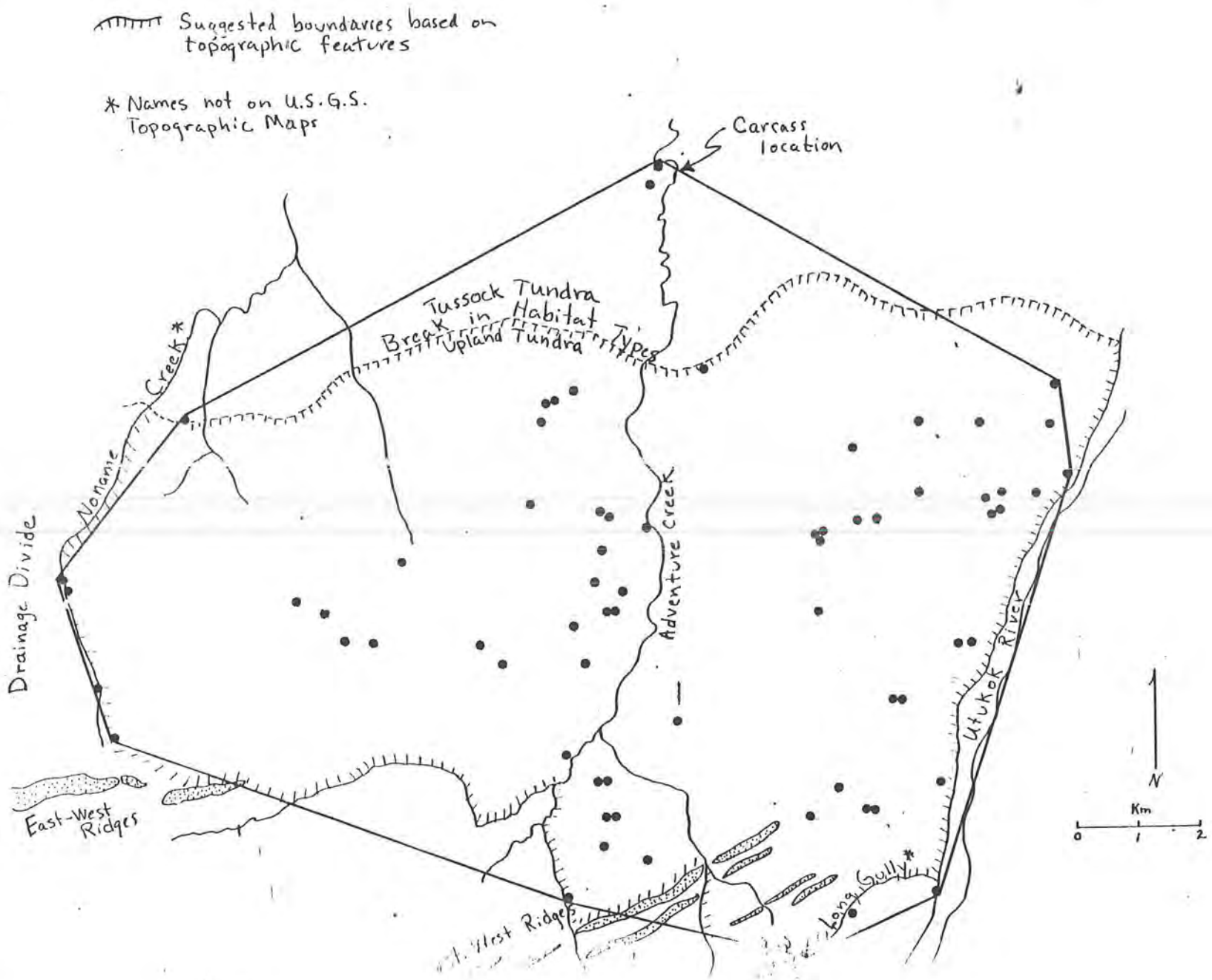


Figure 6. Overlap of male and female home ranges.

Figure 7. Home range boundaries and radio locations of F7 in 1979 showing topographic features which "coincided" with her home range boundaries.



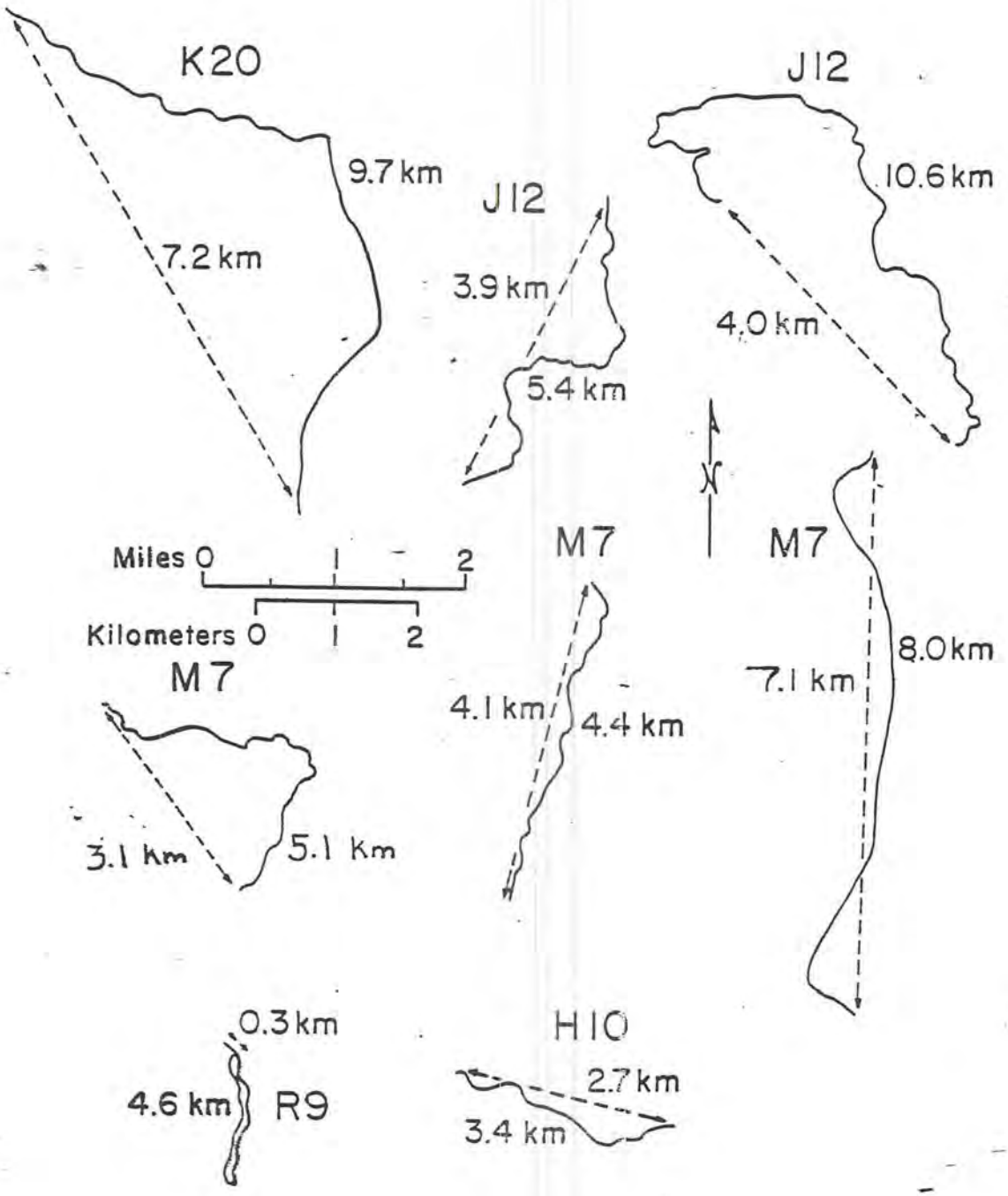
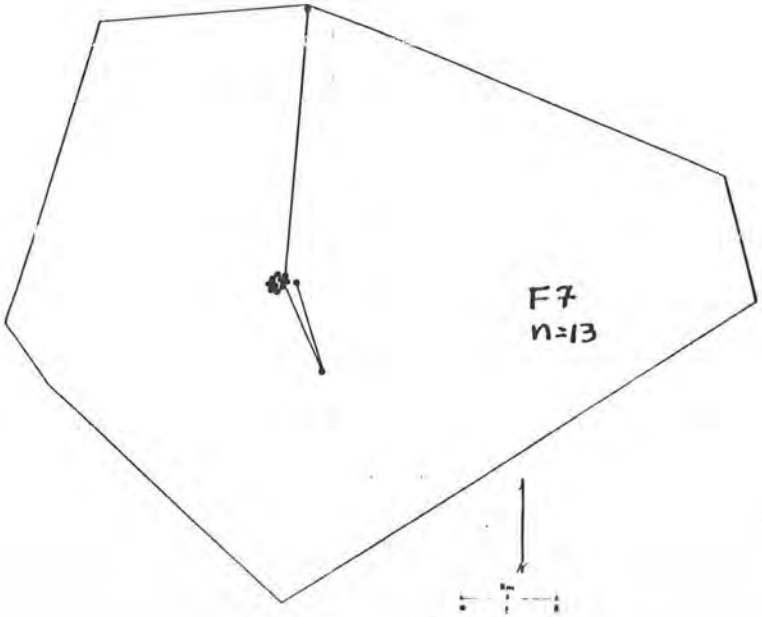
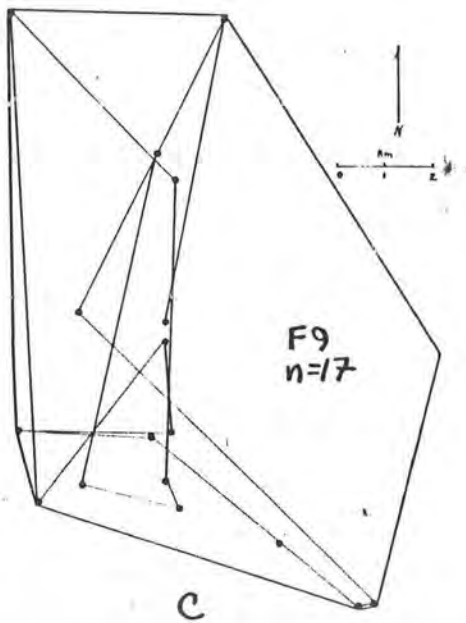


Figure 8.

Exact routes traveled by wolverines under constant watch from an aircraft for a period of one hour. The distance of the travel route and the straightline distance between the beginning and ending points are given.



a



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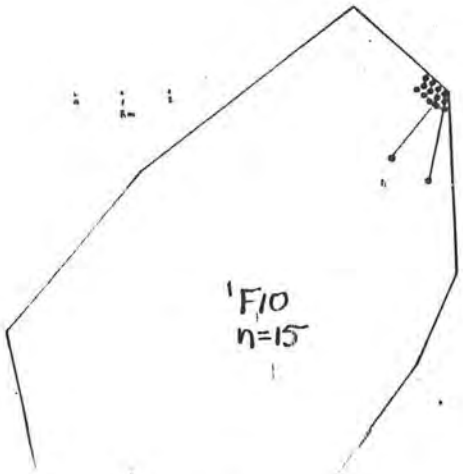


Figures 9a-c. Locations of 3 female wolverines in March and April 1979 showing the difference in movement patterns between 2 lactating females (F7 and F10) and 1 non-lactating female (F9).

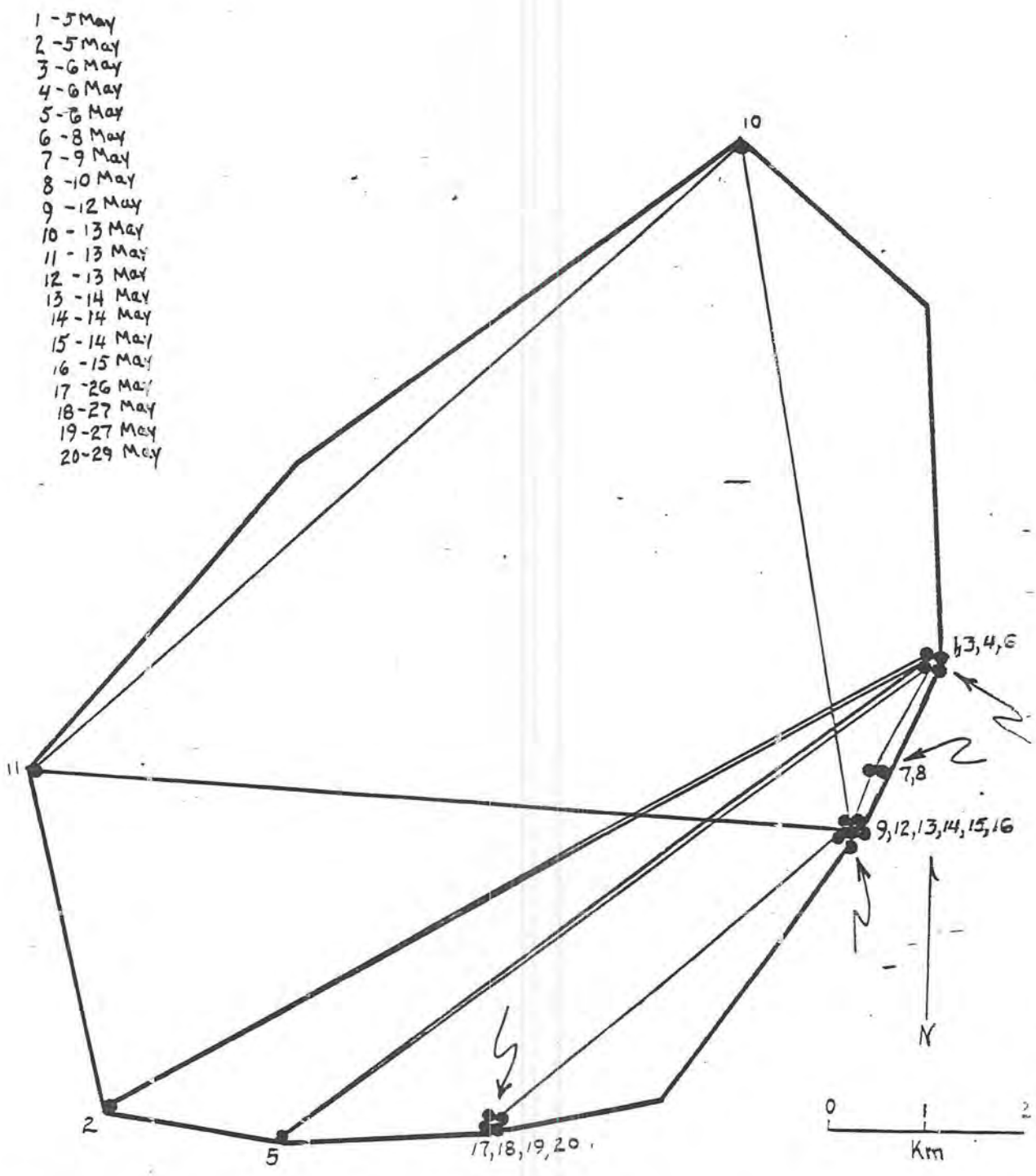


Figure 10. Locations of F10 influenced by movements in relation to rendezvous sites. Rendezvous sites are marked with arrows.

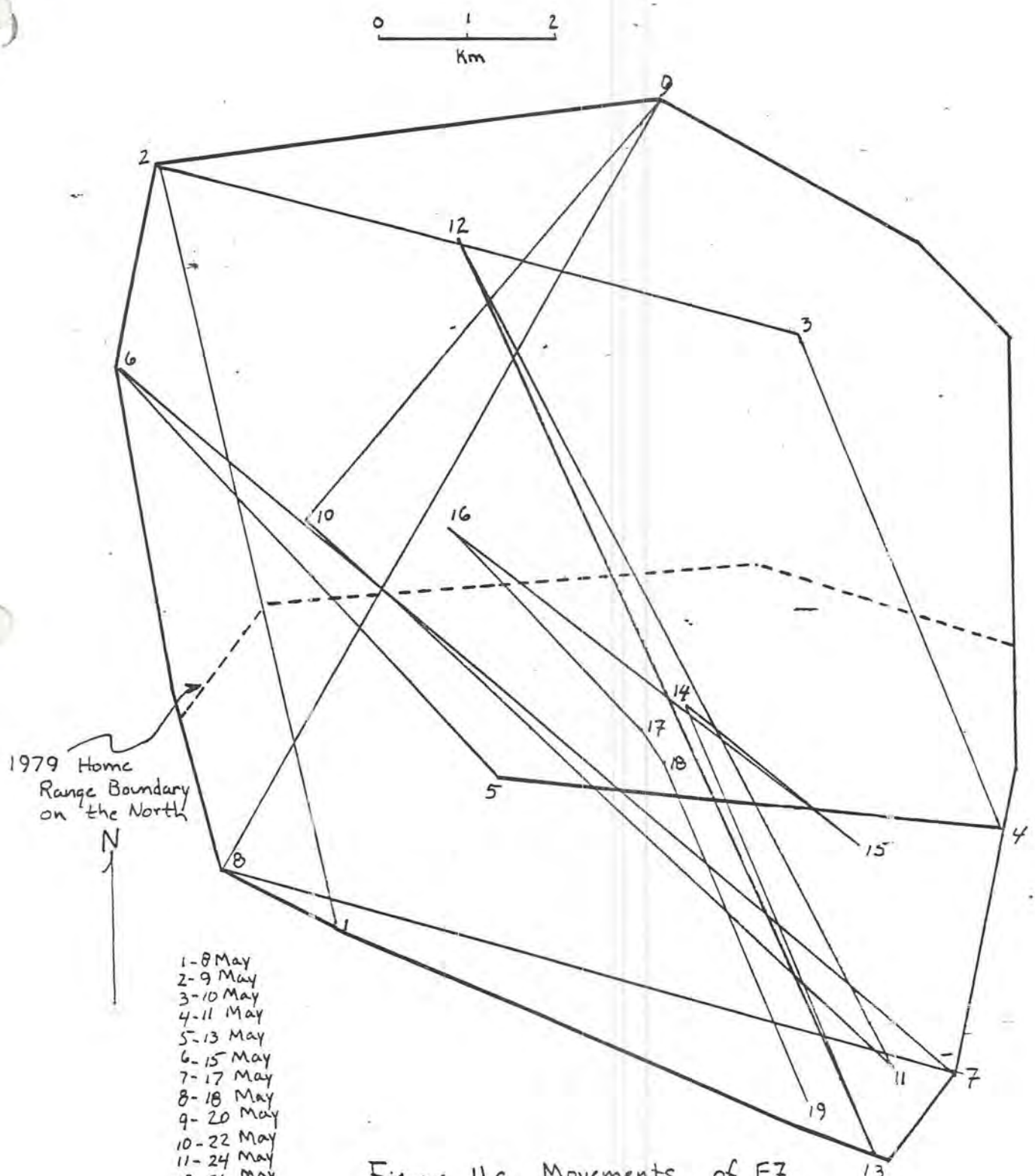
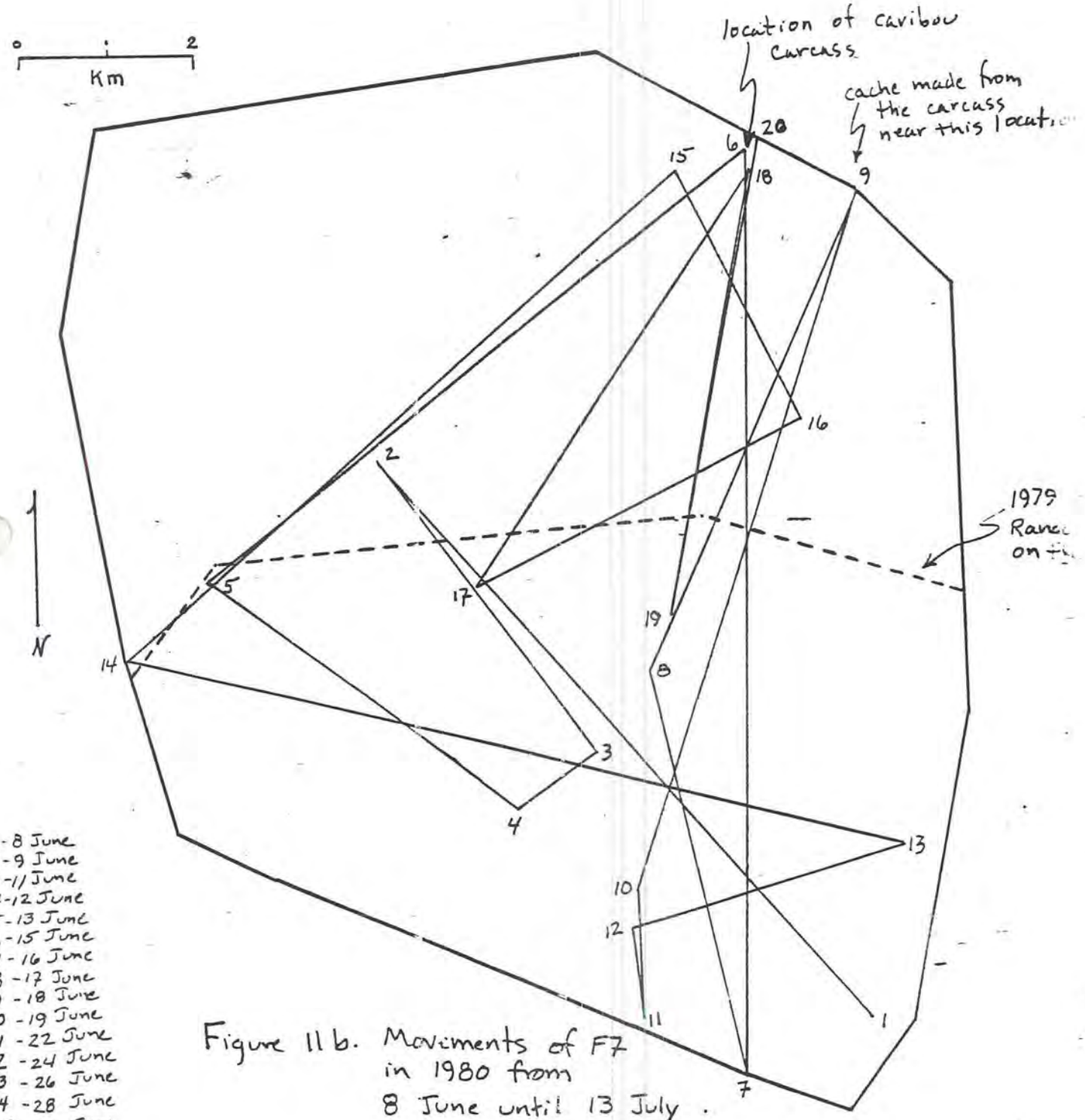


Figure 11a. Movements of F7 in 1980 from 8 May until 7 June.



1 - 8 June
2 - 9 June
3 - 11 June
4 - 12 June
5 - 13 June
6 - 15 June
7 - 16 June
8 - 17 June
9 - 18 June
10 - 19 June
11 - 22 June
12 - 24 June
13 - 26 June
14 - 28 June
15 - 30 June
16 - 4 July
17 - 6 July
18 - 8 July
19 - 11 July
20 - 13 July

Figure 11b. Movements of F7 in 1980 from 8 June until 13 July.

1 - 15 July
2 - 18 July
3 - 20 July
4 - 22 July
5 - 26 July
6 - 28 July
7 - 30 July
8 - 1 August
9 - 3 August
10 - 5 August
11 - 7 August
12 - 9 August
13 - 14 August
14 - 17 August
15 - 19 August

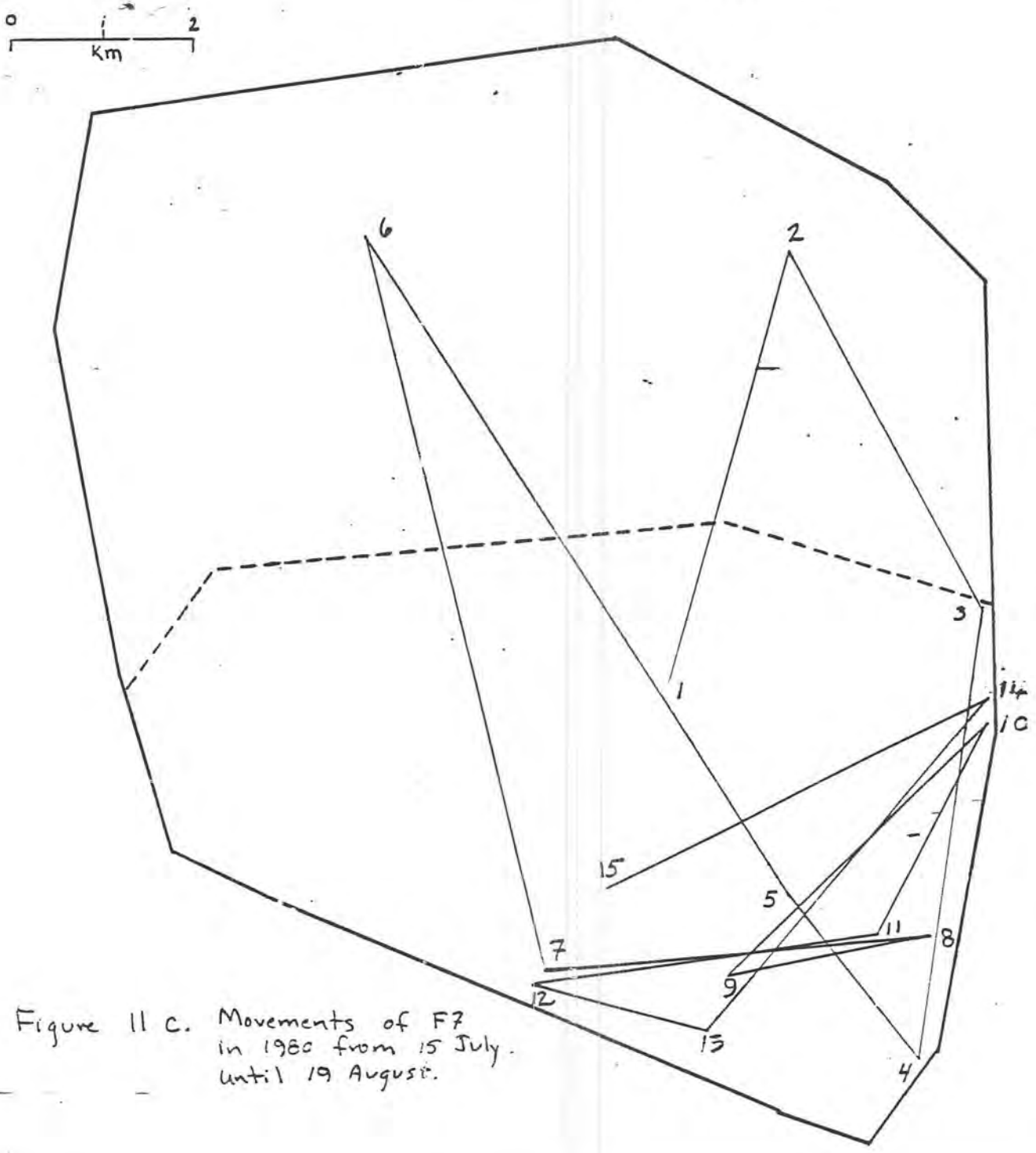
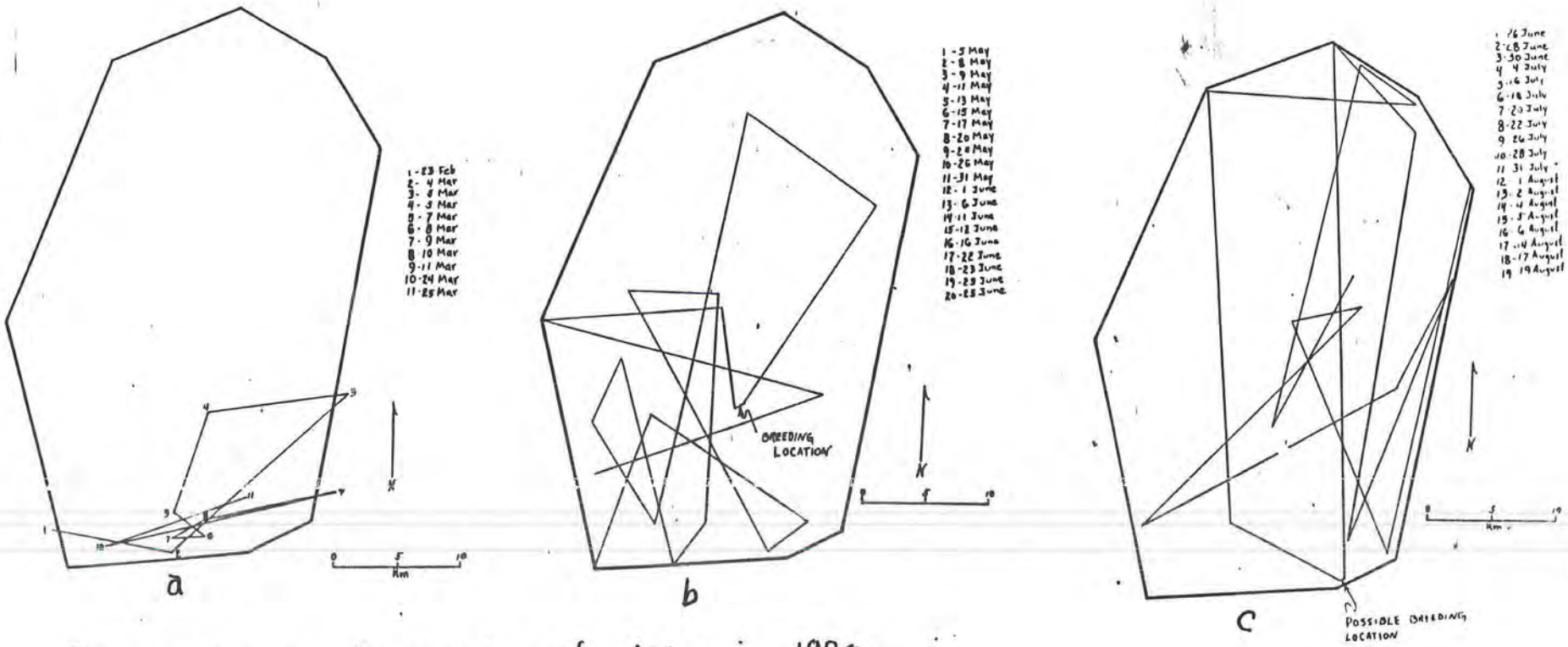


Figure 11 c. Movements of F7 in 1980 from 15 July. until 19 August.



Figures 12 a-c. Movements of M20 in 1980.

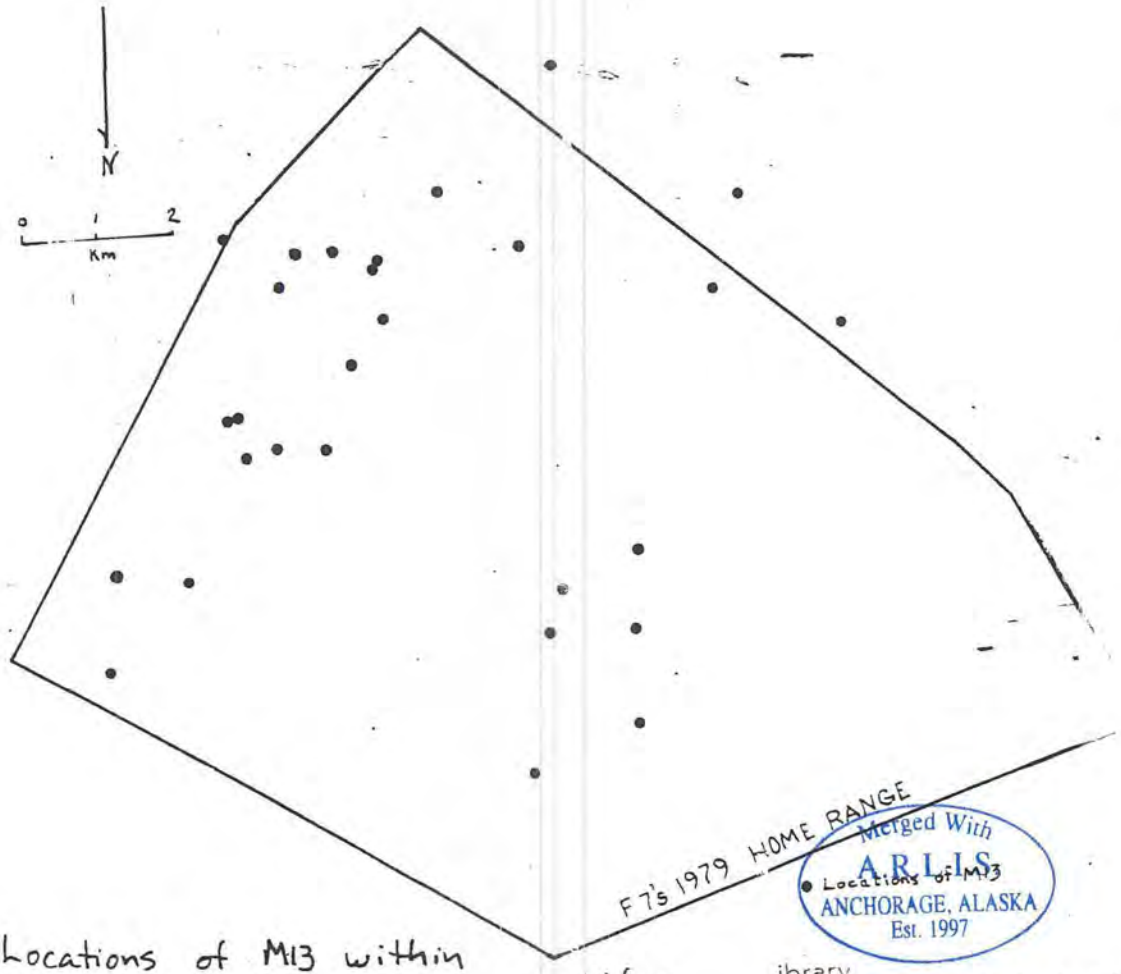


Figure 13. Locations of M13 within his mother's home range and before his dispersal in March 1980.