Radio-tracking of Moose in the Boreal Forest of Northwestern Ontario[1]

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Movements of eight Moose (*Alces alces*) equipped with radio-transmitter collars were followed by airplane flights at approximately weekly intervals between July 1972 and June 1973, in boreal forest of northwestern Ontario. Two adults and one yearling made migrations of 2–13 km linear distance between a mid- and late winter range, and a second range used at other times of the year. These animals occupied ranges of 2–12 km^2 in winter, and 6–90 km^2 in other seasons. Another adult used an area of 14 km^2 during the year, with adjacent winter and non-winter range. Two adults used areas of 10–14 km^2, but winter tracking was incomplete. Two yearlings showed large movements, and one dispersed over a distance of 25 km. Most of the Moose alternated between periods of wide-ranging movements and periods of localized movements. Most animals moved to conifer-dominated winter range in December or January, near the time when snow-cover thickness increased rapidly to about 50 cm.

Key Words: Moose, *Alces alces,* movements, migration, dispersion, home range, habitat, radio tracking, snow, boreal forest.

Information on Moose movements in the boreal forest is extremely limited (Van Ballenberghe and Peek 1971), although good studies have been done in other types of habitat (e.g., LeResche 1972; Phillips et al. 1973). From results of earlier studies in Ontario it became apparent that the use of ear tags was providing only limited information on Moose movements (Goddard 1970; Saunders and Williamson 1972). Accordingly a radio-tracking study was conducted to provide more complete information on movements and habitat use than that provided by conventional aerial survey or ground observations.

Study Areas

The two study areas consist of boreal forest on flat lowland to rolling upland sites ranging between 360 and 460 m asl (Figure 1). The areas are dominated by coniferous forest on swamp, moist or upland sites, with some mature White Birch (*Betula papyrifera*) and Trembling Aspen (*Populus tremuloides*) present, and an upper canopy ranging from open to relatively closed. Other vegetation communities present, roughly in order of percentage occurrence, are pure stands of Black Spruce (*Picea mariana*) on upland and lowland sites, wet treed bog and thicket with dwarf or immature Black Spruce, ridge tops and scattered rock outcrops with a sparse growth of trees, untreed wetlands, and mature mixed forest. The Lac Seul area also contains a large tract of land burned in 1961. The burn is dominated by abundant regeneration of deciduous species, dense stands of immature Jack Pine (*Pinus banksiana*), open mixed forest, and mature unburned Black Spruce on wet sites. No significant logging has occurred. Both study areas contain numerous small lakes and wetland areas. The Lac Seul area is bordered to the south by Lac Seul, a reservoir of about 1300 km^2 surface area.

Weather records were compiled from the stations nearest to the study areas (Figure 1). Mean daily temperature, based on averages between 1941 and 1970 (Atmospheric Environment Service, no date), ranged from monthly highs of 16–17°C in July and August to lows of –19 to –20°C in January. Annual precipitation averaged 60–75 cm. In most winters, snow began to accumulate in early November and reached a maximum depth of 70–85 cm in late March. During the year of study, all stations recorded a cold December (–19 to –20°C), a warmer January (–14 to –15°C), and an unusually rapid accumulation of snow of 20–25 cm in mid-December to 50–55 cm by the first week of January, with little further accumulation during the remainder of the winter (Ontario Ministry of Natural Resources, unpublished records).

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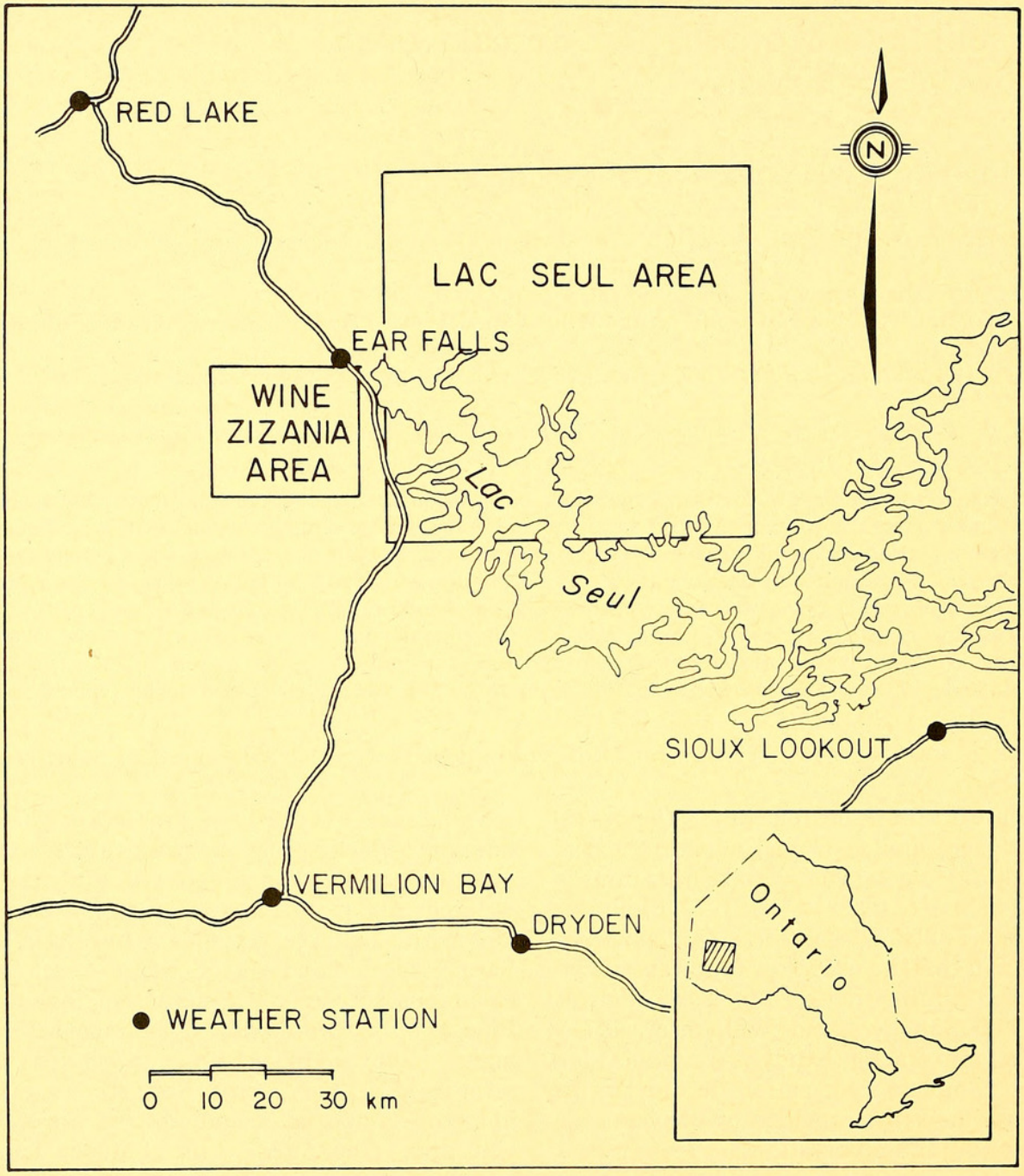

FIGURE 1. Location of the Wine-Zizania (50° 30′N, 93° 23′W) and Lac Seul (50° 40′N, 92° 40′W) study areas, and of the five weather stations.

Methods

Radio collars consisted of a two-stage transmitter and four D-size Mallory ZM 12 mercury batteries encased in a fiberglass canister with a leather covering (Addison 1973). Two brass strip antennae encased in leather formed a collar of adjustable length with a snap fastener. Each transmitter had a different emission frequency and pulse rate.

Collars were attached to five adult females, three adult males, three yearling females, and two yearling males, during 28 h of helicopter flying between 24 June and 15 July 1972, using a method similar to that of Simkin (1963). Yearlings were identified by the size and appearance of the body and antlers, as described by Goddard (1970) and subsequently confirmed by Saunders and Williamson (1972). The collar was attached to one antler on Moose number 7 (M7), a large adult bull, because it was too small for the animal's neck.

Animals were located from the air during 41 flights in a Turbo-Beaver aircraft between 14 July 1972 and 13 June 1973, usually between 10:00 and 14:00. A modified Cochran receiver (Cochran and Lord 1963) was used, with a whip antenna during the first four

flights, and a 10-element 2-m Yagi antenna in the remaining flights. Most flights were made at intervals of 6–8 d, with 3 and 16 d representing extreme cases. At the time of flight 1 (14 July) several of the Moose had not yet received collars. Flights 2 and 31 (20 July and 21 March) were done only for the Lac Seul area, and flights 12, 29, and 33 (11 October, 5 March, and 8 April) only for the Wine-Zizania area.

The flights were typically 4.5 h duration for the two study areas combined. Intensive searching usually began where one of the animals had been located on the previous flight. If the animal was not detected immediately, a series of widening circles was made at an altitude of 200–250 m over a radius of 2 km from the starting point. Subsequent searching, when necessary, consisted of flying along waterways and ridges at a maximum altitude of 650 m. This was typically done over a radius of 3–5 km from the starting point, but digressions of up to 16 km were made on occasion.

Throughout the flight the radio receiver was set to scan the transmission frequencies of all 13 collars, and both the pilot and observer monitored the receiver during most of the flight. When a signal was detected, the area was flown in a series of circles. The animal's position was determined on the basis of signal strength with the gain control of the receiver set at a low level. The location of a Moose was marked on a 1:250 000 topographical map. On several occasions the animals were observed, and on three occasions a transmitter which had fallen or was attached to a dead animal was recovered on foot after being located from the aircraft.

Tracking was also completed by triangulation of bearings received at two fixed radio towers in the Wine-Zizania area. Successful tracking was largely confined to three Moose during parts of the first 3 mo of study with some tracking at all times of day. The results will be reported separately, but are mentioned here because they give some information about movements between weekly aircraft searches.

Results

Five of the 13 Moose were not located after October or November. One Moose lost its collar, one died, and three cases of transmitter failure were suspected. Data for these animals were omitted from analysis. Data derived from the remaining animals are given in Table 1. The movements of these Moose followed three different patterns.

1) Three Moose migrated between a small range used exclusively in the winter, and a larger area used at other times of the year. For example M8, an adult male, used a winter range of 12 km^2 (calculated approximately by joining outer locations to form a convex polygon) between 10 January and 18 April, and a 90-km^2 non-winter range 6 km to the north (Figure 2). Details for the other migratory Moose are given in Table 2. For M4 and M8, the distance between successive locations was smaller on the winter range than at other times of the year ($P < 0.02$ by Student's t test after logarithmic transformation of the data).

2) One Moose (M13, an adult female) did not use a winter area which was clearly separated from the rest of the annual range (Figure 3). Between 13 December and 5 March, M13's locations were concentrated in the more southern part of its range, but the mean ± SE distance between locations was not substantially smaller during this period (1.3 ± 0.4 km) than at other times (1.6 ± 0.3). The animal's annual range consisted of 14 km^2.

3) Two Moose, both of them yearlings, had periods of localized activity alternating with long "wandering" movements covering areas to which the animal did not

TABLE 1—Moose number, age and sex class, tracking period, number of successful and unsuccessful attempts to locate the animal, and mean (± SE) distance between successive locations, for eight Moose on two study areas

Moose number	Age and sex		Tracking period	Number of locations	Unsuccessful attempts	Distance (km)
Lac Seul area						
M2	Yearling	♀	9 Aug.–13 June	26	8	4.8 ± 1.3
M4	Yearling	♂	20 July–6 June	27	9	3.2 ± 0.7
M8	Adult	♂	20 July–13 June	34	3	4.3 ± 0.6
Wine-Zizania area						
M6	Adult	♀	26 July–13 June	28	10	1.6 ± 0.2
M7	Adult	♂	26 July–21 Feb.	25	0	1.0 ± 0.2
M12	Adult	♀	26 July–13 June	36	2	1.3 ± 0.1
M13	Adult	♀	3 Aug.–12 April	30	0	1.5 ± 0.2
M16	Yearling	♀	14 July–18 April	23	10	1.9 ± 0.5

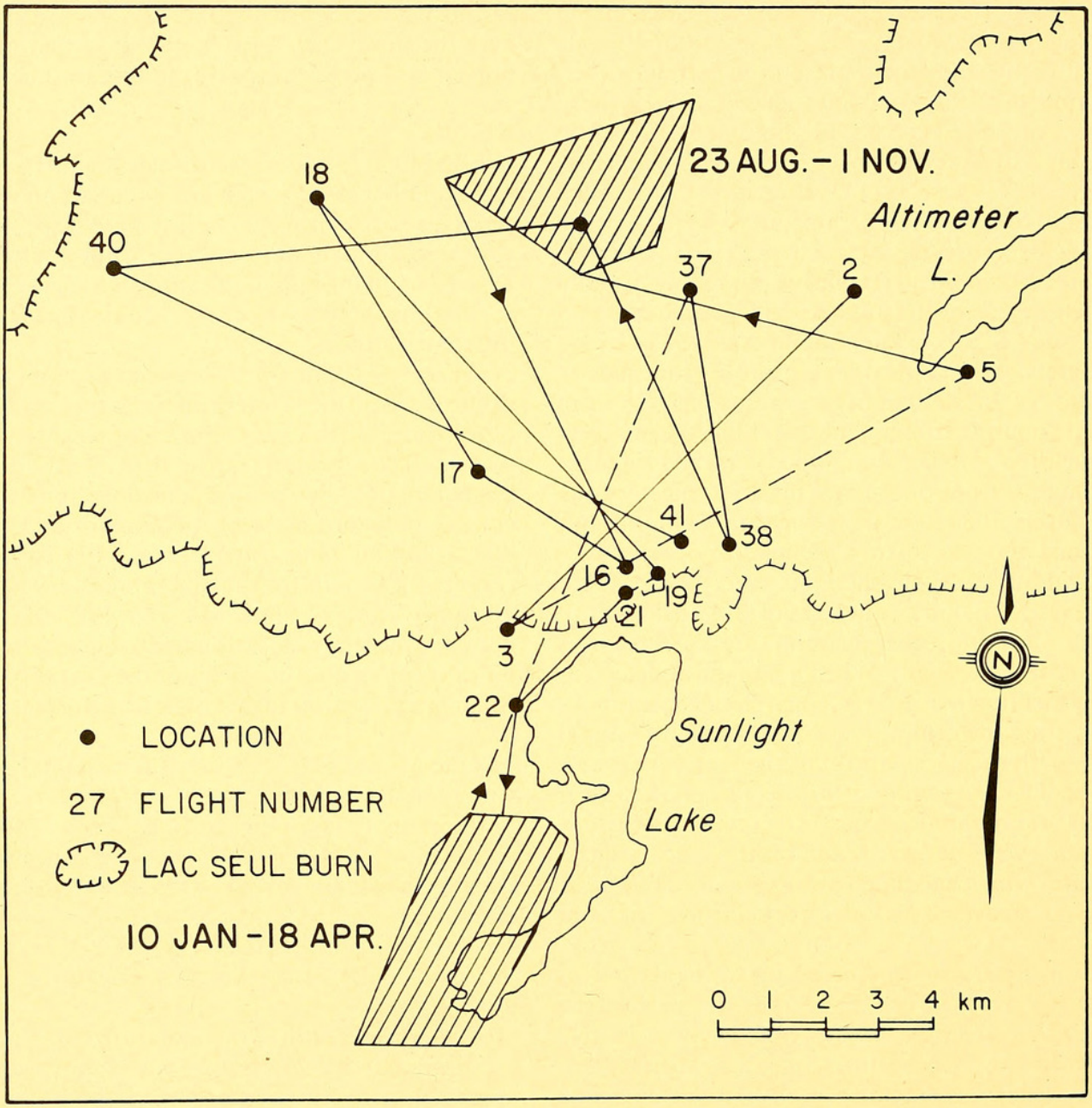

FIGURE 2. Locations of M8, an adult bull in the Lac Seul area. Localized ranges were used between 23 August and 1 November (flights 6 to 15), and between 10 January and 18 April (flights 23 to 35). Broken lines indicate that the animal could not be found during one or more flights between successive locations.

TABLE 2—Dates of use of winter range, size of range, and distance (mean ± SE) between successive locations for winter and non-winter ranges, and distance between the two ranges, for the three Moose which used a winter range separate from areas used at other times

		Winter range		Non-winter range		Distance between ranges (km)
Moose	Dates	Size of range (km²)	Distance between locations (km)	Size of range (km²)	Distance between locations (km)	
M4	10 Jan.–27 Mar.	3	1.3 ± 0.3	32	4.0 ± 0.8	13
M8	10 Jan.–18 Apr.	12	2.2 ± 0.5	90	5.2 ± 0.7	6
M12	23 Jan.–18 Apr.	2	0.9 ± 0.1	6	1.4 ± 0.2	2

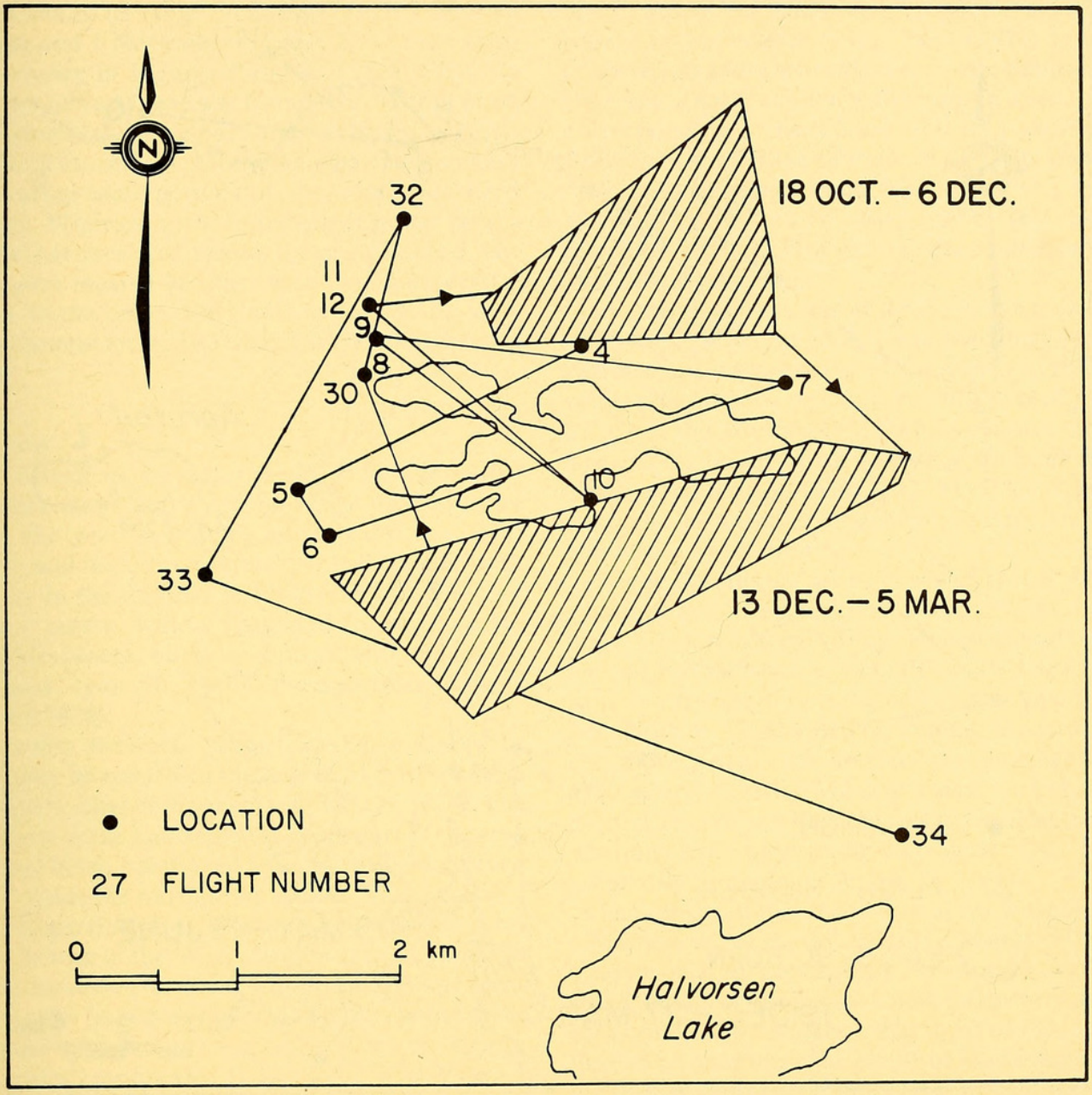

FIGURE 3. Locations of M13, an adult female in the Wine-Zizania study area. Movements were somewhat localized between 18 October and 6 December (flights 13 to 19), and between 13 December and 5 March (flights 20 to 29).

subsequently return. For example, M2 was found several times near the north end of the Lac Seul burn in September, moved 30 km to the southwest by 24 November, and moved 17 km east to a winter range of 4 km^2 occupied between 19 December and 27 March (Figure 4). M16 remained in a 4-km^2 area between 14 July and 13 December, and then ranged widely. It was found on only four subsequent flights between January and April, in widely separated locations up to 10 km from its small original range.

For the remaining two Moose, winter tracking data were inadequate. M6 was not found between 21 February and 8 April, perhaps because it had moved to a winter range which was never found by the observers. Tracking of M7 ended in February after the transmitter was lost when the antlers were shed. Based on successful locations, we found ranges to consist of 14 and 10 km^2 for the M6 and M7, respectively.

Habitat was classified with the aid of 1:15 840 aerial photographs. All three Moose in the Lac Seul area (M2, M4, and M8) spent some time in the Lac Seul burn, but they all moved to winter ranges in areas of Black Spruce swamp outside the burn. The one distinct winter range in the Wine-Zizania area, used by M12, was a gently rolling area with an open upper canopy of Trembling Aspen and a dense understory of immature coniferous trees.

In addition to the use of winter ranges, some Moose had periods of limited movement in small areas at other times of the year. For example, M8 was found at

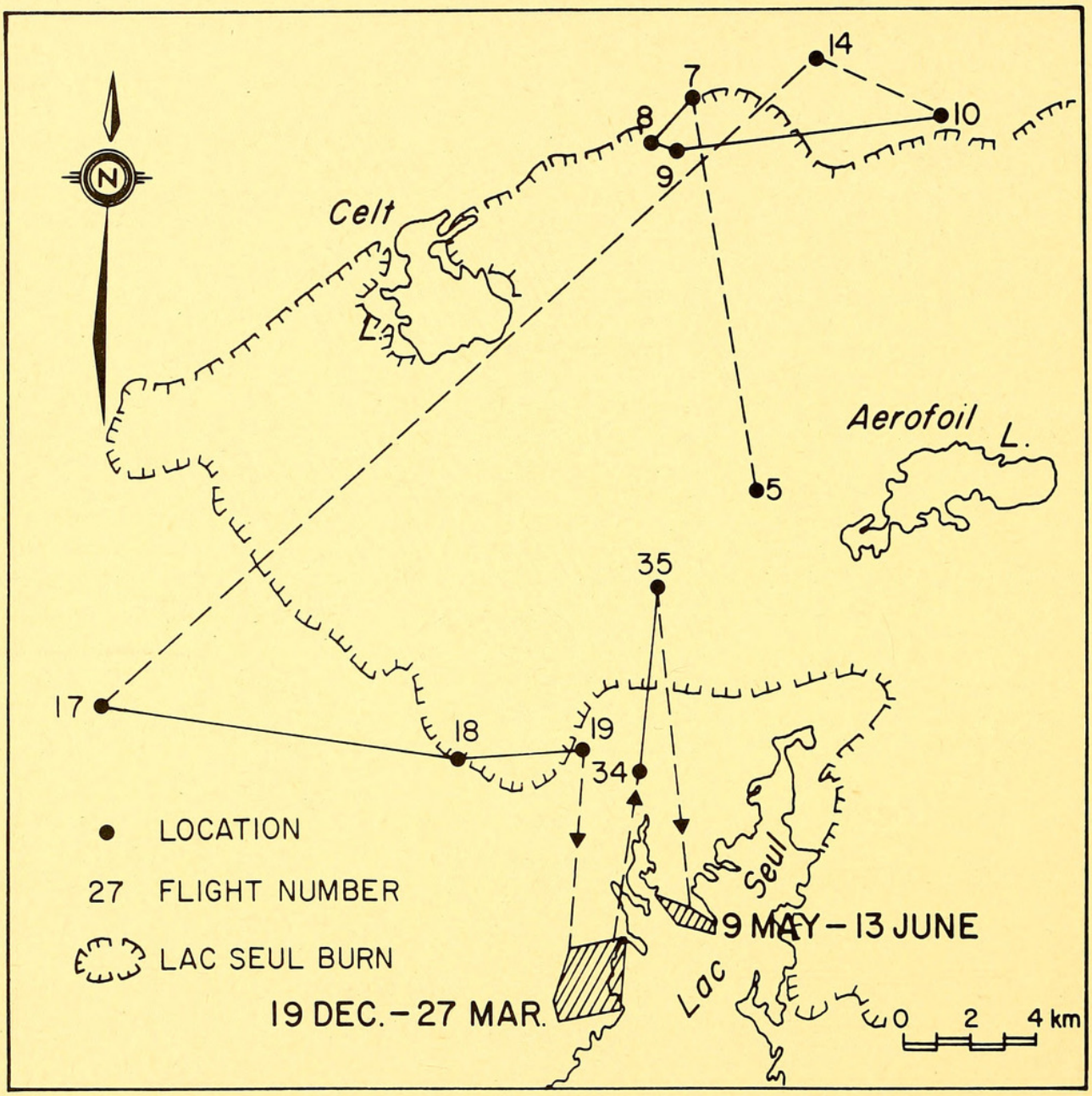

FIGURE 4. Locations of M2, a yearling female, in the Lac Seul study area. The Moose was found several times at widely separated locations, then wintered in an area of 4 km² near Lac Seul between 19 December and 27 March (flights 21 to 32). After additional movements, it remained in a second small area between 9 May and 13 June (flights 37 to 41).

TABLE 3—Dates of use, size of range, and brief habitat description for the seven localized ranges used at times other than mid- to late winter

Moose number	Dates	Size of range (km²)	Habitat
M6	23 Aug.–25 Oct.	1.5	Rolling area of mature and semi-mature coniferous trees
M8	23 Aug.–1 Nov.	8.2	10-yr-old burn with deciduous and Jack Pine regeneration
M4	20 Sept.–15 Nov.	3.7	Mainly conifer swamp
M13	18 Oct.–6 Dec.	1.7	Rolling area with mainly coniferous trees
M6	15 Nov.–13 Dec.	1.3	Rolling area with mixed coniferous and deciduous trees
M12	24 Nov.–10 Jan.	1.1	Black Spruce swamp
M2	9 May–13 June	0.8	Low-lying area with mixed coniferous and deciduous trees

the north end of its range on all eight flights between 23 August and 1 November (Figure 2). Other examples are shown in Figures 3 and 4. Table 3 lists the occasions when a Moose was found five or more times in succession in the same portion of its range, suggesting localized movement. Moose were particularly easy to find during these periods of apparently localized movement. While using the four distinct winter ranges and the other localized ranges listed in Table 3, the animals were located 98 times with two unsuccessful attempts. In the rest of the tracking period, the same six animals were located 83 times with 30 unsuccessful attempts.

Discussion

Three Moose in this study migrated between a distinct winter range and a second range used at other times of the year, but other animals did not. This variation, and the short migratory distances involved, are similar to the findings of Phillips et al. (1973) for an area of marsh, willow flats, and forest in northwestern Minnesota, but they contrast with the longer migrations seen in some mountainous areas (LeResche 1974).

Differences between Moose in the tendency to migrate may be related to the degree of interspersion of different habitat components (LeResche 1974). The three Moose in the Lac Seul area spent part of the year in the large burn, but moved to areas of Black Spruce swamp outside the burn in the winter. These animals also had larger distances between successive locations than the Moose in the Wine-Zizania area. A shortage of coniferous cover or other important habitat components in the burn may have caused the Moose there to be more mobile and migratory. The one clearly non-migratory moose (M13) was in the Wine-Zizania area. It wintered in an area with coniferous cover, adjacent to the range used at other times.

The use of coniferous areas in mid- to late winter is similar to the findings of Telfer (1968), Peek (1971), Van Ballenberghe and Peek (1971), Eastman (1974), and Peek et al. (1976). The movement to winter range, which occurred in December and January, was earlier and more synchronous than the pattern observed on other ranges. In mountainous areas the migration to lowlands is often a gradual process which continues throughout the winter (Edwards and Ritcey 1956; Stevens 1970), although LeResche (1974, p. 400) cites an exception from Alaska. In non-mountainous areas patterns of movement are less clear, but aerial Moose surveys in Ontario generally show a gradual disappearance of Moose from open areas between late December and March.

In the year of study, the sudden accumulation of snow to a thickness of 50 cm by early January may have caused the early and relatively synchronous retreat to late-winter cover. Peek (1971) found evidence of a gradual movement to winter habitats in one year, but a more sudden movement in a second year, corresponding to heavy snowfall in a short period. Phillips et al. (1973) and Peek et al. (1976) observed a movement to winter range when there was less than 50 cm of snow, but in other studies the change of habitat coincided with greater accumulation (Telfer 1968; Prescott 1968).

In addition to the use of localized range in mid- to late winter, different Moose had sedentary periods in various types of habitat at various times of the year. A similar finding was reported by Phillips et al. (1973, p. 272). For one adult cow (M6) and one adult bull (M8), a period including the rut was spent in a localized area. Three adult females (M6, M12, M13) spent the early winter in localized areas which included substantial coniferous vegetation.

The wide-ranging movements of two of the three yearlings are consistent with other studies reporting large movements by young Moose (Goddard 1970; Roussel et al. 1975; Lynch 1976). Perhaps yearling Moose disperse into new areas more readily than adults. Peek (1974) noted that young Moose in particular moved into newly-created favorable habitat after a forest fire. Yearling M2 dispersed from a very lightly hunted area to the borders of Lac Seul where heavy hunting had presumably depleted the previous population.

The results of this study do not show the full range of movements of the animals. The Moose were almost always located successfully when they were using small, localized ranges, but were frequently missed at other times. This suggests that most of the failures to find an animal were the result of inadequate searching, not temporary technical difficulties with equipment. In addition the limited amount of ground tracking, with fixes at 30- and 60-min intervals, suggested that Moose ranged more widely than weekly aerial tracking indicated. Future work of this type should include a more wide-ranging search pattern and more frequent flights.

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