

Habitat Use, Movements and Grouping Behaviour of Woodland Caribou, *Rangifer tarandus caribou*, in Southeastern Manitoba

WILLIAM R. DARBY¹ and WILLIAM O. PRUITT, JR.

Department of Zoology, University of Manitoba, Winnipeg, Manitoba R3T 2N2

¹Present address: Ontario Ministry of Natural Resources, 922 Scott Street East, Fort Frances, Ontario P9A 1J4

Darby, William R., and William O. Pruitt, Jr. 1984. Habitat use, movements and grouping behaviour of Woodland Caribou, *Rangifer tarandus caribou*, in southeastern Manitoba. *Canadian Field-Naturalist* 98(2): 184-190.

The Aikens Lake Woodland Caribou (*Rangifer tarandus caribou*) herd of 30 to 40 individuals was studied from March 1975 to April 1977. Caribou were monitored by aerial surveys and ground searches during months with snow cover and by ground searches only during snow-free months. Two Caribou were radio-collared. Caribou and Caribou tracks were seen relatively more often in mature coniferous upland habitat than in other available habitats, except during October, December and January when semi-open and open bogs were used more. The increased use of bogs coincided with a seasonal change in diet and onset of the rut. Favoured use of bogs continued until mid-February when snow cover thickness and hardness restricted foraging. Caribou then switched back to sites with more favourable snow-cover conditions in mature coniferous uplands, especially rocky ridges with Jack Pine (*Pinus banksiana*). Caribou did not migrate. Seasonal herd ranges consisted largely of overlapping individual ranges and varied from 100 to 180 km² in early spring, 175 to 190 km² in late spring and summer, 115 km² in autumn and 95 to 140 km² in winter. Mean group size was 5.8 in early spring, 1.2 in late spring and summer, 6.2 in autumn and 5.5 in winter.

Key Words: Caribou, habitat use, movements, behaviour.

Woodland Caribou (*Rangifer tarandus caribou*) have been studied in mountainous (Moisan 1958; Edwards and Ritcey 1959; Bergerud 1973; Freddy 1979; Oosenburg and Theberge 1980) and open habitats (Bergerud 1974; Dauphiné et al. 1975), but information on Caribou in the boreal forest is limited (Stardom 1975; Shoesmith and Storey 1977; Fuller and Keith 1981). From March 1975 to April 1977 we studied Woodland Caribou in southeastern Manitoba to determine seasonal patterns of habitat use, movements and grouping behaviour, and to test Stardom's (1975) threshold values for Woodland Caribou tolerance of snow cover in open bogs.

Study Area

The study area was 1600 km² surrounding the University of Manitoba Taiga Biological Station (51°02'N; 95°20'W) near Wallace Lake (Figure 1). The study area is characterized by ridges of Precambrian Shield oriented northwest-southeasterly at 300 to 350 m above sea level, and drainage is westward to Lake Winnipeg.

Uplands were dominated by mature stands of Jack Pine (*Pinus banksiana*), White Spruce (*Picea glauca*) and Black Spruce (*Picea mariana*), with dense ground lichens (*Cladonia* spp.) on rocky ridges with Jack Pine. Sub-dominant species included Balsam Fir (*Abies balsamea*), Paper Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*Populus balsamifera*). Lowlands varied from dense Black Spruce bogs to open Sedge (*Carex* spp.) tussock bogs with scattered Tamarack (*Larix laricina*)

and Black Spruce supporting arboreal lichens (*Alectoria* sp., *Evernia* sp., *Parmelia* sp., *Ramalina* sp., *Usnea* sp.). Other vegetation communities were immature Jack Pine (less than 15 m high) and mixed-wood and hardwood stands. For a more detailed description of vegetation communities and their distribution see Darby (1979).

During 1976, fires destroyed 40 km² of mature forest southeast of Aikens Lake, but most lowland sites were not burned. Trapping and tourism occurred throughout the study area, but road access and logging occurred only in the southwest.

The study area has a boreal continental climate and lies within a dry subhumid moisture region. Mean monthly temperature is 19°C for July and -21°C for January (Woo et al. 1977). Annual precipitation averages 423 mm of which 40% falls as snow (152 cm) between 1 October and 30 April. Climatic conditions and snow accumulation were near average during 1975-1976. Rainfall during the spring and summer of 1976 was less than average, as was snowfall (135 cm) during the following winter.

Caribou in the study area are referred to as the Aikens Lake herd. We inventoried them in late March 1976 and 1977 by aerial surveys and then checked the estimates by ground searches. The Aikens Lake herd appeared to number 30-40 individuals at those times. The closest known herds of Caribou were 50-100 km away; they were not observed to interact with Aikens Lake Caribou.

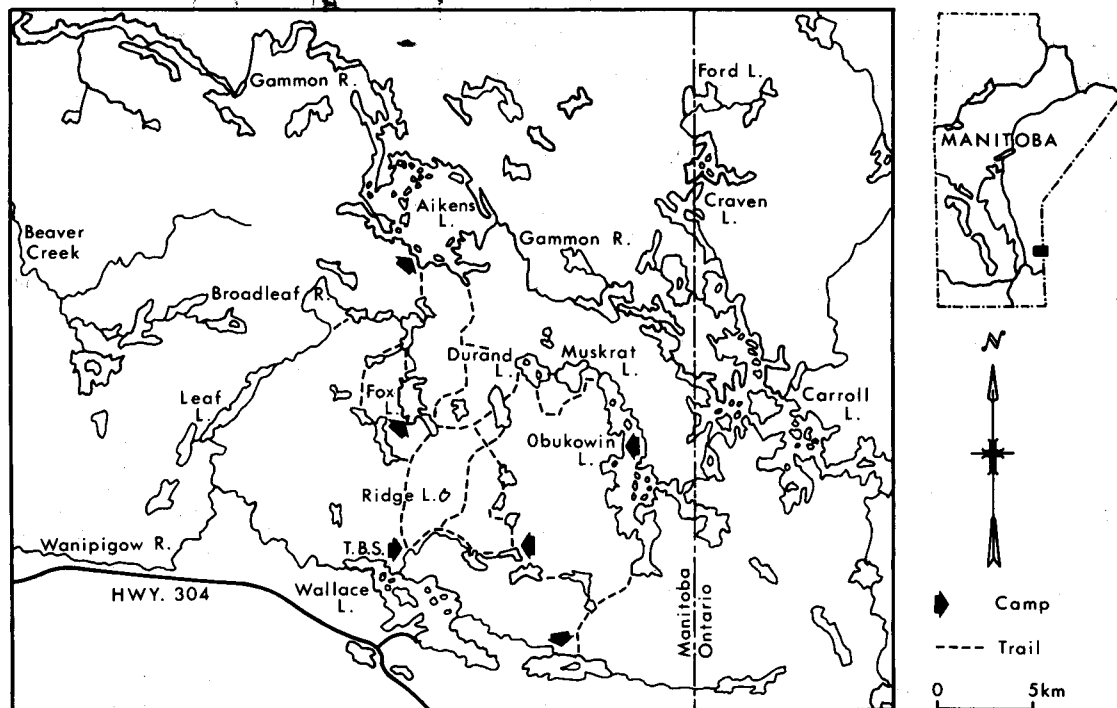


FIGURE 1. The Aikens Lake study area.

Methods

Data on seasonal changes in habitat use, movements and group size of Caribou were obtained during 13 flights (36 h) in a Piper PA-12 aircraft, and 1017 person-days of ground investigation involving more than 10000 km of travel by foot, canoe and snowmobile. Aerial surveys were flown once a month during March and April 1975, December through April 1976 and December through March 1977, with an additional survey flown in March of both 1976 and 1977. During each survey the aircraft flew at 145 km/h, 125 m above ground level, along 11 east-west transects 30 km long, 2.5 km apart. Two observers, one on either side of the aircraft, recorded all observations of Caribou, Caribou tracks and feeding craters, and the habitat type(s) for each observation. Fresh tracks were followed and back-tracked whenever possible. The return trip from each survey was used to check areas peripheral to the transects. Ground investigations involved tracking Caribou during all seasons. We recorded all observations of Caribou, Caribou tracks and pellet groups and the corresponding habitat type(s). Travel was facilitated by a system of trails established throughout the study area and by caching boats and canoes on water systems.

Field investigations were not conducted during spring break-up (20 April to 10 May).

Two adult Caribou were radio-collared during the study. Radio-collars containing AVM model SB-2 transmitters were attached to swimming Caribou and relocations were obtained on foot, from tree towers and by aircraft, using an AVM model LA-12 portable receiver and 4-element Yagi antenna(e).

Habitat use by Caribou was determined from records of habitat type for each observation of Caribou and Caribou tracks. Radio-tracking data were not used for habitat determination because the error polygons of intersecting bearings contained two or more habitat types. We excluded observations in which Caribou appeared to be aware of the observer's presence. We also excluded habitat records for radio-collared Caribou when sightings occurred more than twice in the same day, in order to maintain independence of observations. One track observation constituted the trail of one or more Caribou; where tracks were followed for some distance, each 0.5 km segment was recorded as one track observation. Thus, two or more habitat types often corresponded to one track observation, and sometimes to one visual sighting. For the purpose of recording habitat data, lowlands

were categorized as semi-open and open bog, heavily treed bog, and lakes including the land within 50 m of the shore. Upland categories were mature coniferous forest, mixedwood and deciduous forest, immature Jack Pine, and burns less than one-year old. Availability of these types was determined from forest cover maps of the Manitoba government as a percentage of a 720 km² area encompassing the Caribou seasonal ranges. Caribou use of islands during late spring and summer was investigated by searching most islands in lakes and rivers in the study area for Caribou or Caribou tracks and pellet groups.

Seasonal ranges of the herd were determined by mapping all observations of Caribou, Caribou tracks and pellet groups, and radio-tracking locations. Seasonal range sizes were estimated by plotting and joining perimeter observations to form minimum convex polygons (Mohr 1947). Calendar dates of seasonal change were used except for early spring (21 March to 30 April) and late spring and summer (1 May to 21 September). Mean group size for each season was determined from visual observations and from tracking records where Caribou fanned out while crossing open areas of snow, or sand and mud.

Stardom's (1975) threshold values for Woodland Caribou tolerance of snow cover thickness (65 cm), maximum hardness (400 g cm⁻²) and maximum density (0.18 to 0.24 g cm⁻³) in open bogs were evaluated by testing the hypothesis that Caribou show no observable change in their use of semi-open and open bogs when threshold values are exceeded. Maximum hardness is the maximum average hardness recorded for any layer in a snow profile, and maximum density is

the maximum average density for any layer (Stardom, personal communication). Data on snow cover thickness, hardness and density were collected following the methodology of Klein et al. (1950) at five locations in three habitat types in the Caribou winter range: one in semi-open bog and one in open bog; two on Jack Pine-rock ridge; and one on lake ice.

Results

Habitat Use

Observations of Caribou using a specific habitat type during a specific month totalled 719, based on an average 1.4 habitat types recorded for each of 48 visual sightings of one or more Caribou, and 482 tracking records. During both years of study the Aikens Lake herd occupied an area of mature coniferous uplands dissected by semi-open and open bogs. Caribou used mature coniferous uplands more than any other habitat type except during October, December and January when semi-open and open bogs were used more frequently (Table 1). Most of the mature upland forest was a mosaic of stands of Jack Pine, Jack Pine-Black Spruce-White Spruce, Black Spruce-Feather Moss (*Dicranum* sp., *Pleurozium schreberi*) and White Spruce-Balsam Fir-Paper Birch. Caribou selected areas of Jack Pine and Jack Pine-spruce. Within favoured sites, lush stands of ground lichens and ericoids (*Arctostaphylos uva-ursi*, *Chimaphila umbellata*, *Pyrola* spp., *Vaccinium myrtilloides*) were established under relatively open canopies of Jack Pine.

During early spring Caribou fed on terricolous and saxicolous lichens (*Cladonia* spp. and *Parmelia* spp.,

TABLE 1. Monthly use of habitat types by Aikens Lake Caribou from March 1975 to April 1977.

Habitat type	Percentage of Observations												Percentage available	
	Jan. (78) ^a	Feb. (155)	Mar. (129)	Apr. (37)	May (13)	Jun. (52)	Jul. (81)	Aug. (51)	Sep. (14)	Oct. (53)	Nov. (21)	Dec. (30)		Mean
LOWLANDS														
Semi-open and open bog	35	31	9	17	—	4	5	6	22	40	24	37	19	3
Heavily-treed bog	11	11	5	9	8	4	2	27	7	11	24	17	11	13
Lake	22	18	16	31	23	25	36	20	21	11	14	20	22	13
Total	68	60	30	57	31	33	43	53	50	62	62	74	52	29
UPLANDS														
Mature coniferous	31	36	69	43	46	59	42	47	43	32	38	23	42	28
Mixedwood and deciduous	—	—	—	—	8	6	10	—	7	6	—	—	3	10
Immature Jack Pine	—	—	—	—	15	2	5	—	—	—	—	—	2	29
Burns < 1 year old	1	4	1	—	—	—	—	—	—	—	—	3	1	4
Total	32	40	70	43	69	67	57	47	50	38	38	26	48	71

^aNumber of records of Caribou using a specific habitat type.

respectively) exposed by sublimation of snow in old feeding craters and clearings on Jack Pine-rock ridges, south-facing slopes and lakeshores. They also fed on the tips of willow (*Salix* sp.) and alder (*Alnus* sp.) twigs. In April sightings of Caribou and Caribou tracks were relatively numerous on mature coniferous uplands and lake ice (Table 1). During late spring and summer Caribou were observed feeding on ground forbs, deciduous foliage and arboreal and ground lichens, and they used a greater diversity of habitat types (Table 1).

Caribou calved in early May. Surveillance of islands and lakeshores revealed at least six Caribou using lakes frequently during late spring and summer of 1975: one cow-calf pair, two single cows (calves not observed if present), and two bulls. During the same period in 1976, at least three cow-calf pairs and two bulls were known to use islands and lakeshores frequently. Excursions into mainland portions of the late spring-summer range showed that many Caribou were still using mainland habitats.

In early autumn Caribou aggregated near semi-open and open bogs; this coincided with the dormancy of ground forbs and leafy browse, and with onset of the rut. Caribou fed on ground lichens, arboreal lichens, sedges and bog ericoids (*Andromeda glauco-*

phylla, *Chamaedaphne calyculata*, *Kalmia polifolia*, *Ledum groenlandicum*) at that time. The intensive use of bogs continued until snow restricted travel in mid-February; Caribou then used feeding craters on Jack Pine-rock ridges where they fed on *Cladonia* sp. and *Vaccinium myrtilloides*. Throughout winter Caribou used frozen lakes for travel, escape habitat and craters for drinking overflow water. Loafing on lakes was only common in late winter.

During most of each winter snow cover was thickest in semi-open and open bogs, less on Jack Pine-rock ridges and least on lake ice (Figure 2). Until mid-February maximum hardness values of snow cover on lakes were usually greater than in other habitats. Mean density values did not appear to bear any relationship to snow cover thickness, time, habitat or Caribou behaviour, and are not reported here. Until February, thickness and maximum hardness values of snow in semi-open and open bogs were less than Stardom's (1975) respective tolerance thresholds of 65 cm and 400 g cm⁻² ($\text{Log}_{10} = 2.602$). After 1 February 1976 and 24 February 1977 either or both of these thresholds was often exceeded (Figure 2). Caribou showed a change in their use of semi-open and open bogs by switching most of their feeding activity to Jack Pine-rock ridges in mature coniferous stands for the rest of

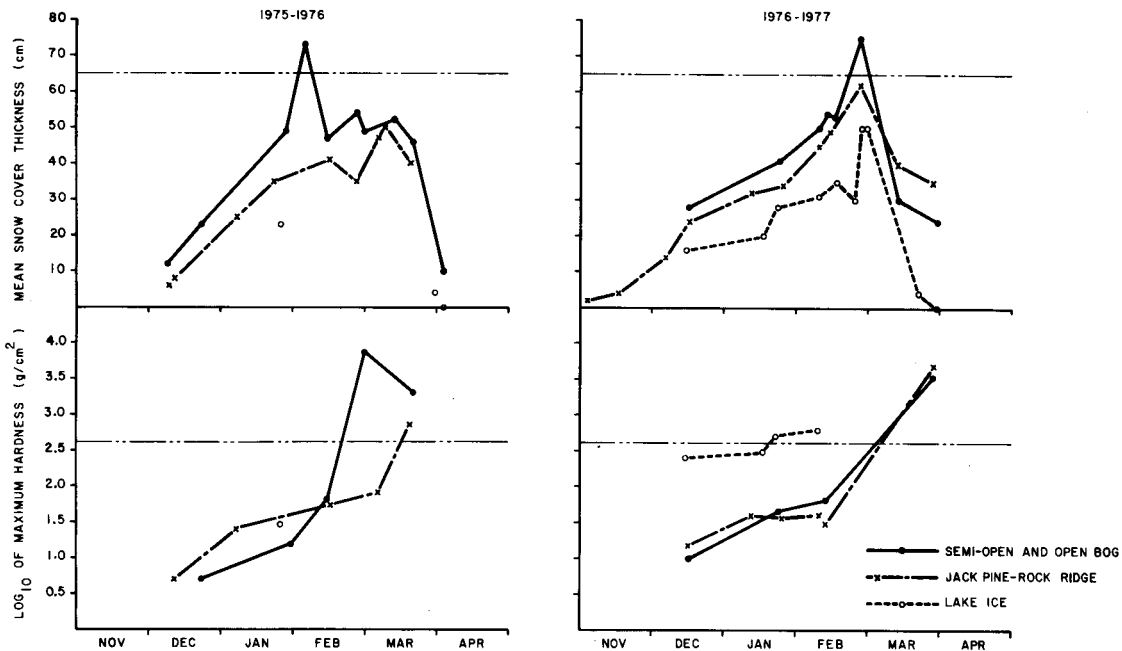


FIGURE 2. Summary of snowcover data for three habitats in the wintering range of Aikens Lake Caribou, 1975-1977. The horizontal double-dashed lines represent tolerance thresholds in semi-open and open bogs determined for Aikens Lake Caribou by Stardom (1975).

the winter (Table 1). They continued to cross semi-open and open bogs, especially in February, but they generally did so at narrow locations and in single file.

Seasonal Movements of Radio-collared Caribou

A total of 132 radio-tracking locations (n) were obtained for the two adult Caribou. An additional 15 radio-tracking locations resulted in the Caribou being sighted, so they were classed as visual sightings. Seasonal ranges of the two individuals were largely overlapping.

An 8-year-old female was radio-tracked from 19 May 1976 to 15 March 1977. During late spring and summer she occupied an area of 28 km² (n = 30) spanning Obukowin Lake (Figure 1). In late September she moved 7 km west to an area of open bogs occupied by Caribou. She expanded her range to 56 km² (n = 31) during autumn. During winter she occupied at least 34 km² (n = 7). On 15 March 1977 she was killed by wolves. During late spring, summer and autumn 61 radio receptions were obtained for the female during 73 attempts (84%), but in winter receptions fell to 7 of 24 attempts (29%) due to transmitter malfunction.

An adult male was radio-collared on 17 July 1976 after being frequently observed along the shore of Aikens Lake, and he was radio-tracked until 15 November 1976 when radio contact ceased. During summer the bull usually occupied 10 km² (n = 57) exhibiting very sedentary and habitual behaviour. He alternately used two areas of lakeshore on Aikens Lake, 5 km apart, for several days at a time. In each area he repeatedly used specific beds in or near favoured feeding sites. On three occasions, four to six weeks apart, he travelled south of Aikens Lake for one to three days. Radio-contact was lost at those times. His autumn range comprised at least 53 km² (n = 22); it included areas he was known to frequent in summer plus an area of open bogs south of Aikens Lake. During summer 57 radio receptions were obtained for the male during 62 attempts (92%), but in autumn only 22 receptions were obtained during 37 attempts (59%).

Seasonal Movements of the Herd

We used 738 pieces of evidence of Caribou presence recorded from March 1975 to April 1977 to estimate seasonal herd ranges: 49 visual sightings of one or more Caribou, 132 radio-tracking locations, 510 track observations, and 47 observations of pellet groups. Caribou did not migrate. Seasonal herd ranges were largely overlapping and consisted mainly of overlapping individual ranges (Table 2). For detailed maps of the ranges see Darby (1979).

During late spring and summer some Caribou were known to disperse beyond limits of the estimated herd range (one in 1975 and five in 1976), at least temporar-

TABLE 2. Seasonal changes in herd range size for Aikens Lake Caribou

Season	Herd Range Size (km ²)		
	1975-1976	1976-1977	1977-1978
Early spring 21 March-30 April	— (16) ^{a,b}	180 (65)	100 (42)
Late spring-summer 1 May-21 September	190 (61)	175 (203)	
Autumn 21 September- 21 December	— (11) ^b	115 (126)	
Winter 21 December- 21 March	95 (89)	140 (125)	

^aNumber of observations including visual sightings, radio-tracking locations, and observations of tracks and pellet groups.

^bNumber of observations is insufficient to delineate a range.

ily, but they could not be followed. Extensive ground searches of portions of the study area peripheral to the estimated herd range did not reveal evidence of Caribou presence.

Grouping Behaviour

We used a total of 170 observations (n) to estimate mean group size for the different seasons: 44 visual sightings and 126 track observations. Caribou were gregarious during autumn, winter and early spring and essentially solitary during late spring and summer. Mean group sizes (calves included) were: early spring 5.8 (n = 16, range 1 to 19, SD = 5.6); late spring-summer 1.2 (n = 55, range 1 to 3, SD = 0.4); autumn 6.2 (n = 17, range 1 to 24, SD = 5.9); and winter 5.5 (n = 82, range 1 to 17, SD = 3.6). Only the late spring-summer value differed significantly from other seasonal means (Tukey's $P < 0.05$). When calendar dates of seasonal change are used for all seasons, only the summer value differs significantly from other seasonal means (Tukey's $P < 0.05$): spring 3.8 (n = 30, range 1 to 19, SD = 4.6); summer 1.1 (n = 41, range 1 to 2, SD = 0.3); autumn 6.2 and winter 5.5 as above.

Caribou groups dispersed in late April, hence our separation of early spring observations from those of late spring and summer. From May to September, Caribou were usually observed as singles or pairs. Caribou aggregated in late September and the largest groups were observed in early December (i.e. late autumn).

Discussion

We recognize three sources of bias in our habitat data, but we believe our method of following Caribou tracks acted to counter this effect. Firstly, our aerial

observations were probably subject to visibility bias that increased the proportion of observations in open habitats; 199 of 434 (46%) observations of habitat use from December to April were recorded during aerial surveys. Secondly, although frequent excursions were made into mainland areas during late spring and summer, our primarily water-borne mode of travel during that season may have increased the proportion of observations recorded for lake habitat. Thirdly, it is not known if our surveillance of islands and lakeshores was a disturbance factor reducing Caribou use of lake habitat during late spring and summer.

Nevertheless, seasonal patterns of habitat use by Aikens Lake Caribou are similar to those reported for other boreal forest herds (Simkin 1965; Fuller and Keith 1981). Habitat use and movements appeared to be governed at least in part by food preferences and availability, and snow cover conditions. Summertime use of islands and lakeshores was less than that reported for Woodland Caribou in central Manitoba (Shoemith and Storey 1977), but similar to observations at Wells Gray Park, British Columbia (Edwards and Ritcey 1959). Aikens Lake Caribou were recorded more often than expected on frozen lakes during early spring, in semi-open and open bogs during autumn through early spring, and on mature coniferous uplands during later winter through summer (Table 1). Total use of lowland habitats was greater than expected but comparable to use of upland habitats. Fuller and Keith (1981) reported selection of lowland habitats by Caribou in northeastern Alberta during all months except August. The observed responses of Aikens Lake Caribou to changing snowcover in semi-open and open bogs agreed with Stardom's (1975) threshold values for snowcover thickness and maximum hardness, but not for maximum density.

During the study Aikens Lake Caribou occupied essentially the same range year round. Seasonal ranges were largely overlapping and varied in size among years. The winter ranges were located within the 235 km² wintering area reported by Stardom (1975) for 35 to 37 Aikens Lake Caribou during 1971 and 1972. This sedentary behaviour differs from movements of other Woodland Caribou. Moisan (1958), Edwards and Ritcey (1959), Bergerud (1973, 1974), Dauphiné et al. (1975), Freddy (1979) and Oosenberg and Theberge (1980) all reported seasonal range shifts. Fuller and Keith (1981) reported considerable variation among individual ranges; some Caribou concentrated their seasonal activity in areas separated by 17 to 48 km, while others had no identifiable seasonal ranges. Shoemith and Storey (1977) reported seasonal range shifts, although Shoemith (1978) indicated that movements varied among individuals.

Seasonal mean group sizes of Aikens Lake Caribou varied significantly during late spring and summer only, but were comparable to findings of Shoemith (1978) for Caribou in central Manitoba, and of Simkin (1965) and Fuller and Keith (1981) for Caribou in Ontario and northeastern Alberta respectively. Segregation of adult bulls in winter did not occur at Aikens Lake as in northeastern Alberta.

No specific calving area was observed at Aikens Lake, nor were post-calving aggregations formed as often occurs in Newfoundland, (Bergerud 1974), the Yukon (Oosenberg and Theberge 1980) and Quebec (Dauphiné et al. 1975).

Acknowledgments

Many people provided assistance at various times, and their efforts are greatly appreciated. The most significant contributions were made by D. A. Darby and D. Remillard. Other participants were L. Brownlie, W. Conley, Mr. and Mrs. W. A. Darby, D. Giannotti, P. Hanson, R. Leonard, D. MacDonald, C. Penny, E. Pruitt, C. Pruitt, P. Reum, R. Riewe, G. Sutherland, E. Upton and K. Vipont. Thanks are also due to pilots A. Gafree, L. Gafree and P. Holden of Silverpine Airways. The project was funded by the following agencies: the Canadian National Sportsmen's Show; the Canadian Wildlife Service; the Manitoba Big Game Trophy Association; the Manitoba Department of Renewable Resources and Transportation Services; the Manitoba Department of Tourism, Recreation and Cultural Affairs; the Manitoba Naturalists' Society; and Parks Canada. D. Euler, R. Riewe, D. Simkin and D. Voigt reviewed the manuscript, and two anonymous reviewers provided helpful comments.

Literature Cited

- Bergerud, A. T. 1973. Movement and rutting behaviour of Caribou (*Rangifer tarandus*) at Mount Albert, Quebec. *Canadian Field-Naturalist* 87: 357-369.
- Bergerud, A. T. 1974. The role of the environment in the aggregation, movement and disturbance behaviour of Caribou. Pp. 552-584 in *International symposium on the behaviour of ungulates and its relation to management*. Edited by V. Geist and F. Walther. International Union for the Conservation of Nature Publication, New Series, Number 24, Volume 1.
- Darby, W. R. 1979. Seasonal movements, habitat utilization and population ecology of Woodland Caribou (*Rangifer tarandus caribou* Gmelin) in the Wallace-Aikens lake region of Southeastern Manitoba. M.Sc. thesis, University of Manitoba, Winnipeg. 187 pp.
- Dauphiné, T. C., Jr., F. W. Anderka, C. A. Drolet, and D. T. McIlveen. 1975. Distribution and movements of marked Caribou in Ungava, June 1973 to 1974. *Canadian Wildlife Service Progress Note* Number 46. 19 pp.

- Edwards, R. Y., and R. W. Ritcey.** 1959. Migrations of Caribou in a mountainous area in Wells Gray Park, British Columbia. *Canadian Field-Naturalist* 73: 21-25.
- Freddy, D. J.** 1979. Distribution and movements of Selkirk Caribou, 1972-74. *Canadian Field-Naturalist* 93(1): 71-74.
- Fuller, T. K., and L. B. Keith.** 1981. Woodland Caribou population dynamics in northeastern Alberta. *Journal of Wildlife Management* 45(1): 197-211.
- Klein, G. J., D. C. Pearce, and L. W. Gold.** 1950. Method of measuring the significant characteristics of a snow-cover. National Research Council of Canada Technical Memorandum Number 18. 22 pp.
- Mohr, C. O.** 1947. Table of equivalent populations of North American small mammals. *American Midland Naturalist* 37: 223-249.
- Moisan, G.** 1958. Le Caribou de la Gaspésie. Extrait du *Naturaliste Canadien*, La Société Zoologique de Québec 83(10): 225-234; 83 (11-12): 262-274; 84(1): 5-27.
- Oosenbrug, S. M., and J. B. Theberge.** 1980. Altitudinal movements and summer habitat preferences of Woodland Caribou in the Kluane Ranges, Yukon Territory. *Arctic* 33(1): 59-72.
- Shoesmith, M. W.** 1978. Social organization of Wapiti and Woodland Caribou. Ph.D. thesis, University of Manitoba, Winnipeg. 155 pp.
- Shoesmith, M. W., and D. R. Storey.** 1977. Movements and associated behavior of Woodland Caribou in central Manitoba. *Proceedings of the International Congress of Game Biologists* 13: 51-64.
- Simkin, D. W.** 1965. A preliminary report of the Woodland Caribou study in Ontario. Ontario Department of Lands and Forests, Section Report (Wildlife) Number 59. 76 pp.
- Stardom, R. R. P.** 1975. Woodland Caribou and snow conditions in southeast Manitoba. Pp. 436-461 in *Proceedings of the first International Reindeer and Caribou symposium*. Edited by J. R. Luick, P. C. Lent, D. R. Klein, and R. G. White. Biological Papers of the University of Alaska Special Report Number 1.
- Woo, V., G. F. Mills, H. Veldius, and D. B. Forrester.** 1977. A guide to biophysical and land classification Hecla-Carroll Lake 62P-52M Manitoba. Northern Resource Information Program, Canada-Manitoba Soil Technical Report Number 77-3. 32 pp.

Received 16 June 1982

Accepted 14 March 1984