
**Rudy Boonstra**1 and A. R. E. Sinclair2

1Division of Life Sciences, St. Michael's College, University of Toronto, 1265 Military Trail, West Hill, Ontario M1C 1A4
2Institute of Animal Resource Ecology, Department of Zoology, University of British Columbia, Vancouver, British Columbia V6T 1Z4


A systematic aerial survey technique combined with calculated transects in selected habitats and movements of large mammals in remote areas of Canada is described. Twelve surveys were conducted in the Spatsizi Park, British Columbia, to monitor major movements and distributions, and habitat preferences of Caribou and Moose. There was a major movement of Caribou toward the northwest in winter, so that most of them were wintering along the lower portion of the Stikine River Valley, whereas in spring movements were toward the southeast portion of the park. Caribou showed no habitat preference in late winter, a preference for brush, and spruce-pine forest in summer, and a preference for alpine areas in fall. Moose tended to be restricted to the major river valleys in winter and were more widely distributed in spring and fall. Moose showed a general preference for spruce or bush in all periods, with some associated preference for spruce, spruce-pine, or pine forests. In both fall and late winter, Moose showed an avoidance of alpine areas.

Key Words: Aerial survey, British Columbia, Caribou, Rangifer tarandus caribou, distribution, habitat selection, Moose, Alces alces andersoni, movement, Spatsizi.

The Spatsizi Plateau Wilderness Area in northern British Columbia contains one of the last major concentrations of Woodland Caribou, *Rangifer tarandus caribou* (Baird 1843) in the province. It is estimated that between 3000-5000 Caribou inhabit this and adjacent areas (O'Connell-Jones et al. 1977). In British Columbia, this species has received relatively little attention. Edwards and Riley (1959, 1960) studied the Caribou in Wells Grey Provincial Park and Fredrick (1979) has recently completed a study of the nearly intact Selkirk Caribou herd on the British Columbia-Idaho border. However, in other regions, considerably more is known about Woodland Caribou ecology (Cirignan 1957, Bergerud 1971, 1973, 1974, Stantom 1975, Shoesmith and Storey 1977). They appear to be behaviorally diverse, being primarily in the closed boreal forest (Shoesmith and Storey 1977), but showing periods of graziness in mountain regions (Bergerud 1973). Moose (Alces alces andersoni) also occur in the Spatsizi, as they do throughout the boreal forest of Canada (Baird 1974). They are potentially suitable, though sometimes they gather in groups of 3-4 in winter.

The purpose of this paper is to describe the distribution, habitat use, and major movement patterns of Caribou and Moose in the fall, late winter, and spring. A systematic aerial survey with calibrated transects has been used successfully for remote areas in Africa and Australia (Sinclair 1974, 1971, Pennycuick, 1975, Norton-Griffiths 1975, Maddock 1979) and we considered it could be applied usefully to wilderness areas of Canada. This method is appropriate for Caribou in particular since knowledge of their distribution and movements is essential for their conservation.

**Study Area and Methods**

The Spatsizi Plateau Wilderness Park (Figure 1) was created in December 1975 by the British Columbia Provincial Government. It lies approximately 100 km north of Vancouver, B.C. and covers 6750 km², surrounding the Glades Lake Ecological Reserve (33 km). The terrain is primarily mountainous, but the rugged relief in many areas of the park gives way to open alpine plateaus and wide glacier-shaped valleys. Many rivers and lakes are found throughout the area.

The climate of the Spatsizi is generally cloudy, moist, and cool (Polar, 1976). Winters are long and cold with mean January temperatures below freezing from October to April, and summers are cool and cloudy. At Cold Fish Lake, in the centre of the park, but north of the mean temperature range, mean monthly temperatures reach a high of 10°C in July (mean maximum 10-14°C) and a low of -20°C in January (mean minimum -24.7°C). Although Grant (1971) recorded 22 consecutive rain days in August 1962.

[12]
Total precipitation is not high (150 mm) and it is spread fairly evenly through the year. The lowest precipitation occurs in March-June.

There is a gradient of temperature and precipitation in the area, with the warmest and driest part being in the north and northeast along the lower Stikine and Spanzie Rivers. The snow cover here is 30-50 cm in depth. In the higher mountain ranges to the southwest, precipitation is higher and snow cover is 150-200 cm. The southeast of the Spanzie Park and Tatlatui Park area higher and therefore colder than the northwest of the study area.

We surveyed the region by systematic aerial reconnaissance using the methods described in Sinclair (1972), Pennyruick (1970), and Maddock (1970). Over the wide valleys and flat plateau regions, we drew parallel transects 5 km apart. In the narrow valleys, we flew along them but ensured that every block on the map was surveyed. After the initial survey of the whole area in February 1976, we excluded the steep, rugged alpine terrain of glaciers and vertical faces not suitable for Caribou and Moose. A CASA185 aircraft was used with pilot and navigator in front and two observers in the back. Each observer surveyed his side of the aircraft up to 1 km from the plane. We also counted all animals within a transect of approximately 150 km width that formed an inner sub-sample of the 5 km width. Ten 1 km transects were delineated by a mark on the aircraft struts, and the 150 m inner transects bore similar marks with strings attached. We calibrated the transects by the methods described in Sinclair (1972) and Norton-Griffiths (1978). The data...
We used the most detailed contour maps available, these having a scale of 1:250,000. The entire Spanishi map (sheet #104H, National Topographic Series, Department of National Defence, second edition, 1974), the southern portion of Gry Lake (sheet #104I), the western portion of Toosedige River (sheet #94E), and the northern portion of McConnell Creek (sheet #94D) were divided into grid blocks. Each block was 5 km wide and identified by column and row coordinates. These were subdivisions of the map 10 x 10 km grid. Since our survey path was about 2 km wide, we covered 40% of the 5 km wide block.

Four aerial surveys were conducted over the Spatsizi area: 5-8 March 1976, 25-27 May 1976, 20-21 September 1976, and 1-3 March 1977. The number of kilometers flown on each survey was 2057.72 km, and 1800 km respectively. Most of the transects were concentrated in the park, but some flights were made to the north, east, and south of it to see if caribou were also using these areas. The observers recorded the grid coordinates, and the number of each species of ungulate seen, using three recorders and the data were subsequently transcribed onto computer sheets.

To relate the distribution of Caribou and Moose to their habitats, the vegetation of each grid block in the park was obtained from forest cover maps (Resources Analysis Branch, Ministry of the Environment, British Columbia). Within each block, the percent cover of each vegetation type was classified according to a modified Domus Scale (Kershaw 1973). The scale used had the following classes:

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<td>7.5</td>
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The forest cover types on these maps were condensed to the classes outlined below. The proportion of the Spatsizi survey area covered by the various plant communities is shown in Figure 2. Our description of the vegetation in these communities is taken from Pojar (1976).

ALPINE: This cover type is the dominant one in the Spatsizi area. It includes all land above the timberline (approximately 1725 m) whether it is vegetated or not. The forest cover maps made no distinction between rock and vegetation for this class. Pojar (1976) describes the alpine zone as including: (a) heath dominated by White Mountain Heather (Cassiope tetragona), Mountain Aven (Dryas integrifolia), Dwarf Willows (Salix reticulata, S. polaris), and bryophytes (b) tundra with the same Dwarf Willows, grass (Fusaria alpinus), edes (Carex spp.), and, most importantly for Caribou, lichens.

SUB-ALPINE FOREST: This is the second most abundant class and all cover types in which Sub-alpine Fire (Picea engelmannii), Lodgepole Pine (Pinus contorta), or any combination of these, in general, the Abies community occurs at higher elevations and forms the tree line. The climax conifer Sub-alpine Fir include Fraser moss, while montane areas support Dwarf Birch (Biruta glandulosa) and Crowberry (Empetrum nigrum). Ground lichens are common.

SPRUCE: All cover types in which White Spruce forms a major component of the vegetation are included. Spruce may be associated with any one or combination of the following minor species (10-19%) of gross volume on the cover maps: Sub-alpine Fir, Trembling Aspen (Populus tremuloides), Lodgepole Pine, Black Spruce (Picea mariana). The few situations in which Black Spruce forms a major component of the cover are also included in this class because it is always associated with White Spruce as the other major component of the vegetation. Black Spruce accounts for only 0.82% of the entire study area.

Spruce forest is normally found on lower slopes and valley bottoms up to about 1400 m. The stands are open and associated with a well-developed shrub layer of Dwarf Birch and Grey Willow (Salix glauca). The ground level includes dwarf shrubs such as Crow-
berry, Soapberry (Sapindus samarangensis), Mountain Bilberry (Vaccinium vitis-idaea), and Labrador Tea (Ledum groenlandicum) and herbs such as Lapins arnicae, Goliath arnica, and Lithodora hieracioides. Among others, mosses and lichens are common, the species being similar to those in the Lodgepole Pine cover type.

**SPRUCE/PINE**: In this type, White Spruce and Lodgepole Pine form approximately equal components of the cover. The herb and shrub vegetation is similar to the spruce and pine cover types.

**FINÉ**: Lodgepole Pine forms the major component of the cover in this type, but can be associated with the following minor species: White Spruce, Black Spruce, or Trembling Aspen.

The frequent seedlings and saplings of White Spruce in this area indicate the size of the spruce community. The shrub layer is not well developed, although Dwarf Birch and Grey Willow are most abundant, and lichens, especially those eaten by Caribou: Cladonia mitis, C. rangiferina, and C. alpestris. Epiphytic lichens are also abundant.

**BRUSH**: In this type, few or no trees are found and the vegetation is dominated by Dwarf Birch and various willow species (S. alaskensis, S. barroides, and S. glaucescens).

**BURNS**: In this area, regeneration of trees had not yet occurred to a significant extent after a fire. Shrubs were poorly developed but similar to spruce and pine types.

**ASPEN**: Trembling Aspen forms the major component in this type, but it is also associated with other cover types; e.g., White Spruce, Lodgepole Pine or Balsam Poplar (Populus balsamifera). Aspen communities are common on drier sites along the major valleys, especially on south-facing slopes of the Spatsizi, Stikine, and Klepak Rivers. Some dense stands of unburned aspen (2.5 m height) reach 1500 m. The shrub layer includes Salix scouleriana, Soapberry, Poplar, Birch (Betula pumila), and Bearberry (Arctostaphylos uva-ursi). Lichens and mosses are uncommon, as are epiphytes.

We also include in this type the few stands of Balsam Poplar. Poplars occupy moist sites than aspens and well-developed stands are found only in the northwest of the study area on flood plains of the Kyuquot and lower Kappan rivers. The shrub stratum is sparse, but the herb layer is rich with broad-leaved forbs (e.g., Delphinium glaucum, Lithospermum arnicae). Lichens are almost absent. Snow cover is in both the Balsam Poplar and aspen stands is deeper than in the conifer cover types. Although neither the forest cover mass nor Pojar (1976) mentions White Birch (Betula papyrifera), we noticed it throughout the area, particularly in the aspen types.

**SWAMP AND MUSKEG**: This type includes all boggy areas which support little or no tree cover.

**RIVER**: The larger river systems associated with the Stikine River are found mainly in the north of the survey area. Lakes are more common in the southeast of the area (Figure 1).

In general, the most common cover type in the Spatsizi survey area is alpine plateau (49%) (Figure 2). Coniferous forest dominates the forest cover, with Subalpine Fir and White Spruce being the most common. Below timberline, there is relatively little open ground (not including rivers and lakes), areas with brush, burns, and swamps; muskeg accounts for only 6.5% of the total area.

To determine whether Caribou and Moose selected for specific vegetation classes, only grid blocks which were actually flown over in a particular survey were included in the analysis. Each of these blocks was classified according to the presence of a particular vegetation class in it and to the presence of Caribou or Moose. A vegetation class was regarded as present in a block if it covered at least 3% of the area. We measured the degree of association of either Caribou or Moose with a vegetation type by using Cole's (1949) coefficient of association following the technique reported in Sinclair (1977). Although Harburtin's (1970) coefficient of association was calculated at the same time, we did not use it since both coefficients were very similar. Cole's coefficient ranged from +1 (maximum positive association) to -1 (maximum negative association), with zero indicating random association. The major shortcoming of our analysis resulted from the large size of the blocks we used. We could not reduce the blocks because of the small scale of maps that were available to us. Our blocks sometimes included many vegetation types, and were, therefore, more heterogeneous than we would have liked. The mountainous terrain, with the rapid changes in altitude, made the vegetation to be heterogeneous over short distances. Nevertheless, we did find major patterns of association between the herbivores and vegetation classes.

**Results**

Cole's coefficient of interspecific association between Caribou and the vegetation classes is shown in Figure 3 and their distribution over the park is shown in Figure 4. Because the swamp and muskeg class was rare and the rivers lakes class ubiquitous but generally covering only a small portion of the area, either were included on Figures 3 and 5. Both the March 1976 and 1977 surveys took place in late winter when temperatures fluctuated around -10°C. Snow cover was around 50 cm in depth in the conifer
area south of Caribou Hide camp on the upper Siskine River, in the southeast of the study area. This area is higher and colder, and snow showers were frequent. Caribou were scattered in small groups throughout the north, centre, and east of the area (Figure 4), and, unlike the March surveys, no large groups were seen. They were moving south in lines through Lawyers Pass at the edge of the snow. It appeared they were following the snow melt southwards. Under these conditions, Caribou showed a significant preference for brush (P < 0.005), herbs (P < 0.005), and spruce-pine stands (P < 0.025) only (Figure 3).

In late September 1976, winter was approaching and snow showers were occurring in the alpine area, although it was still raining below the tree line. Caribou showed a significant preference for the alpine zone (P < 0.05) and a significant avoidance of spruce (P < 0.01), and spruce-pine (P < 0.01) forests (Figure 3). The largest concentrations were seen on the Spratni Plateau above Cold Fish Lake (70), in the alpine and sub-alpine zones of Mt. Tumtum (herd of 150) and 240, and in the alpine zone north of Brothers Lake (231). Smaller herds (43, 38, 32) were also seen in the alpine zone east of Lawyers Pass. The fur was extended north of the Siskine following the Pimmam and Tucho Rivers, but no Caribou were seen. We surveyed Tatlatau Park and south of it to Thutadue Lake; six Caribou were sighted in the alpine zone just south of Thutadue Lake. Therefore, at this time of year, Caribou were primarily concentrated in the alpine zones in the large herds. At the height of the run occurring around 15 October. We estimated this state by back extrapolating from the sighting of the first calf in late May.

MOOSE: Moose showed no significant preference for any vegetation type in March 1976, although their preference for spruce-pine forests and burns approached significance (P < 0.10) (Figure 5). Many of the Moose were associated with valley bottoms and the largest concentrations were seen in the lower Ross River. In March 1977, there was a significant avoidance of the alpine areas (P < 0.005) and a significant preference for pine forests (P < 0.025) and for brush (P < 0.001) with spruce and spruce-pine forests approaching significance. The two largest concentrations were seen on the upper Ross River and on the Dawson River, both locations where they were not seen in 1976 (Figure 4). In contrast, relatively few were found on the lower Spatni. No Moose were seen on the flight into Tatlatau Park and south to the Siskine River. In the flight north of the Siskine (see Caribou section), only two Moose were seen, again on the Tumtum River. In May 1976, Moose showed a significant preference for spruce forests (P < 0.05) and the preference...
Figure 4: The distribution and abundance of Caribou (□) and Moose (▲) in the Splugen area during our aerial surveys.
for burns approached significance (P < 0.10) (Figure 5). They were widely distributed throughout the area with no large concentrations seen anywhere but only one moderately large concentration seen on the Spat-
siti River. No Moose were seen in Taltatusiak during our survey.

In September 1976, there was a significant avo-
dance of alpine areas (P < 0.01) and a significant preference for brush (P < 0.025) (Figure 5). They were widely distributed with no major concentrations seen anywhere (Figure 4).

Discussion

This type of survey technique has a number of inherent biases, a major one being the visibility of the ungulates (Caughley 1974; W. C. Gasaway personal communication). LeRouche and Raths (1974) found that even under ideal conditions, experienced observers were able to see only 60% of the Moose present. Novak and Gardner (1975) estimate 90%; visibility of Moose in aerial surveys over streets in Ontario. All of our surveys were conducted with peo-
ple who had ground experience with the various ung-
lates and most had experience with aerial surveys as well. In addition, all surveys were conducted when leaves were absent from deciduous trees. Neverthe-
less, estimates of Caribou and Moose in the conifer-
ous stands are probably too low. However, we believe that the broad picture is correct.

The Caribou populations in the Spat-siti area under went seasonal shifts over the four time periods exami-
ned in our study. In late winter (the March surveys), they were concentrated in the north-west half of the park with the largest concentrations occurring in the sub-alpine zone. But Caribou did not use this zone exclusively; all other vegetation types were occupied in proportion to their presence on the area. More frequent surveys during the winter may show up sig-
nificant habitat preferences at other times in the win-
ter. As present our results indicate that Caribou have no site preference for any particular habitat in late winter.

In contrast to our results, both Edwards and Rietey (1959) in Wells Grey Provincial Park, and Freddy (1979) in southern British Columbia and northern Idaho found the Caribou exclusively occupying sub-

alpine spruce-fir forest, using primarily albearl

lichen. Alviviensi and Edwards and Rietey (1966). Bergedorf (1974) found that Newfoundland Caribou, which also tended to occupy minioousos habitat, chose a variety of habitats, depending on snow cover conditions. During winters of thick snow cover, they sought high, exposed, wind-swept ridgetops. At other times, sub-alpine areas with few trees and exposed lichen woodland provided the best habitat. Their diet consisted primarily of arborial lichens and evergreen

shrubs. In the low altitude study in Manitoba, Star-
dom (1975) described Caribou feeding on arboral lichens in tamarack (Larix laricina) bogs in early winter

under windless snow cover conditions. Once a snow crust had developed with windy conditions, the Caribou moved to Jackpine (Pinus banksiana) rock ridges where they fed on ground lichens. These ground lichens were more important than tree lichens as win-
ter food in Manitoba, because hard and deep snow inhibits use of the main tree lichen areas for 60% of the snow season (Stardom 1975). This main conclu-
sion that rival conditions dictated where and on what Caribou fed, suggests that the Caribou in our study may have been forced out of the southern end of the park because it was higher in elevation and had thicker snow cover.

The late May survey took place just prior to the calving period. One cow with a calf, was actually sighted in a Dwarf Birch — willow meadow. The significant selection of burns and brush vegetation suggests that they were looking for more open habitats, perhaps in which to calve. In the Gladys Lake Ecological Reserve region of Spat-siti, Jent (1971) noted that Caribou cows gave birth in the highest mountain ridges, again suggesting their need to seek secluded sites perhaps less vulnerable to predators and insect attack. All the cows monitored during the study of Showers and Storey (1972) calved on islands where predators were less abundant. However, cows did not seek secluded sites in the study of Bergedorf (1976), where no wolves occur, nor in the studies on the barren land Caribou by Lent (1966) and Kelhais (1968), where wolves do occur.

In the fall, Caribou showed a pronounced selection for the alpine zone and an avoidance of tansy and

spruce-pine forests. This coincided with the annual rut. Similar use of high exposed areas on mountains has been found by Bergedorf (1973) on Mt. Albert, Quebec. In Newfoundland, Bergedorf (1974) indicated that Caribou used open areas for the rut but did not

specify where these open areas were. Bergedorf (1973) suggested that alpine zones were used because they facilitated herd formation and allowed females to breed with the most dominant male.

Habitat selection by Moose in the Spat-siti was similar to their reports in other studies. In fall, Moose selected open habitats with brush in them, but avoided alpine areas. In winter and late spring, Moose selected burns and brush heavily forested habitats of spruce and pine, and in one case (March 1977), again showed a significant avoidance of alpine areas.

The importance of early winter stage plant communi-

ties to Moose populations has been well documented (Hauser 1950, Phillips et al. 1973, Kreiling 1974, Ken

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Figure 3. Cole's coefficients of association of Moose with different forest cover types on the four aerial surveys. Asterisk indicates significant association at P < 0.05.
1975; Peck et al. 1974), for they provide an abundance of browse species such as willow (Salix spp.). Logging can also result in an absence of these browse species. Near Prince George in north-central B.C. (600 km southeast of our study), Eastman (1978) found that willows, Red-osier Dogwood (Cornus sericea), and grasses were the dominant foods in fall; willow, White Birch, and Red-osier Dogwood were dominant foods in early winter; and Sub-alpine Fir, willow, and White Birch were dominant foods in late winter. The shift in late winter is eating some conifers due to a shift in habitat; because of the snow cover in late winter, Moose moved to heavily forested areas at this time. The shift in coniferous forest in late winter has also been reported for other areas across North America (Edwards and Rieck 1955; Telfer 1970; Keshall and Prescott 1971; Kreiling 1974; Peck et al. 1974; Roley and Knox 1980).

The selection for open and forested habitat in late winter and spring in our study suggests that vegetation diversity may be an important variable. In Alaska, Leith (et al. 1974) found the vegetation heterogeneity characterized winter moose habitat. Eastman (1978) found that partially logged sites were preferred over all other sites. Similar findings have been reported by other workers (Press, 1968; Peck et al. 1974). Moose in our study were usually found near rivers or streams in March and May (note that Figure 1 and 4 indicate only the larger rivers). These habitats provide high vegetation diversity because of river flooding, erosion changes in stream channels, and ice damage (Peck 1974). Riparian habitat was also used extensively by Moose in Alaska (Moor 1979) and in Montana (Peck et al. 1974).

The technique described here for monitoring movements, distribution, and habitat preferences of large mammals, such as Caribou and Moose, is a difficult and inescapable challenge in efficient in time, manpower, and cost, compared to alternative ground studies. The surveys described here for monitoring movements, distribution, and habitat preferences of large mammals are necessary, because they provide information about major habitat in the northeastern Spaniard under the prevailing nival conditions.

Acknowledgments

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