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# Preliminary analysis of habitat utilization by woodland caribou in northwestern Ontario using satellite telemetry

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*Abstract:* Locational data collected over a one year period from 10 female woodland caribou, *Rangifer tarandus caribou,* collared with Argos satellite collars in northwestern Ontario, Canada were superimposed on supervised Landsat images using Geographical Information System (GIS) technology. Landscape parameters, land cover classifications, and drainage were utilized to create the basemap. Using ARCVIEW software, all digital fixes from collared caribou with information of date, time, and activity status were overlain on the basemap to facilitate a preliminary analysis of habitat use in this species. Results supported the conclusions (1) that woodland caribou in northwestern Ontario select habitats containing high to moderate conifer cover and avoided disturbed areas and shrub-rich habitats, (2) that seasonal changes in habitat utilization occurs in females of this species, and (3) that satellite telemetry technology can be employed in the boreal forest ecosystem to assess habitat utilization by large ungulate species.

Key words: seasonal activity, habitat use, Landsat imagery

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## Introduction

Recent cooperative initiatives between the forestry industry and provinical government to improve the image and efficiency of forest resource management has lead to the development of an integrated forest management policy, which considers the impact of forest harvesting practices on sustaining wildlife populations, and enhancing forest regeneration and harvest rotation time. In this regard, experimentation with new cutting practices has been initiated and research on regeneration and wildlife populations has been ongoing for the past few years. In northeastern Ontario, comparison of the impact of different cutting methods in the black spruce-lichen/moss forest community has indicated that small mammal species diversity and biomass can be maintained, if intermediate impact cutting practices (light residual and heavy residual) were employed (Courtin & Beckerton, 1994). In addition, earlier forest regeneration and shorter rotation periods between harvesting have been associated with these techniques.

However, the impact of various cutting practices on the activity and sustainability of larger boreal mammals is presently unclear. Research has shown that woodland caribou, *Rangifer tarandus caribou,* are the least tolerant of current logging practices and have been extirpated over much of their former range (Stardom, 1977; Chubbs *et al.*, 1993). An overview of habitat utilization by this species in northwestern Ontario would provide government and the forest industry with information required to manage and sustain this species. In addition, an understanding of the interactions associated with current forest harvesting practices, ungulate populations, and their primary predators would also aid in the development of sustainable forest management policy and expand our knowledge of the population dynamics and behaviour of these important species (Edmonds, 1988; Seip, 1992).

Recent advances in remote sensing technologies have presented new opportunities and challenges for researchers working on ungulate species inhabiting large diverse ranges in regions with limited accessi-

bility. To date, few studies have examined the advantages and limitations of satellite telemetry in assessing habitat utilization and movement patterns in ungulates in the boreal forest ecosystem (Thompson *et al.*, 1980; Ferguson, 1991; Pearce, 1992) and only one study has been conducted on woodland caribou (Ellis & White, 1992). The application of GIS technology to research on woodland caribou has been conducted in Alberta (Bergerud, 1989; Chichowski & Banner, 1992) and has begun to be applied in northwestern Ontario (Antoniak, 1993; Cumming *et al.*, 1996).

The objectives of this study were: (1) to obtain preliminary estimates of annual and seasonal habitat utilization by female woodland caribou in northwestern Ontario, (2) to assess variation in seasonal activity patterns in females of this species, and (3) to assess whether satellite telemetry technology was able to identify habitat utilization by ungulates in the boreal forest ecosystem.

## Methods

Three classified Landsat thematic map images with 25 x 25 m pixels were supplied by the Ontario Remote Sensing Office, Toronto, Ontario. Landsat image areas chosen represented locations where caribou fitted with Telonics Argos satellite collars occurred. Nineteen land cover classes were present on each image. Images were projected in pseudocolour and colour-themed using Image Legend Editor, ARCVIEW 2.1 (Stafford, 1994).

Data were collected weekly from 10 female caribou minimizing autocorrelation problems (Nau *et al.*, 1974). Caribou telemetry data were separated into four seasons: (1) Spring: March 1 - May 31, (2) Summer: June 1 - August 31, (3) Fall: September 1 - November 31, and (4) Winter: December 1 - December 31. The n values were as follows; Spring, n = 7; Summer, n = 11; Fall, n = 11; Winter, n = 10. Telemetry locations classified by Service Argos as LQ (Location Quality Index) 1 (+/- 1000 m), LQ 2 (+/- 350 m), and LQ 3 (+/- 150 m) were used. It was assumed that this approach provided a more accurate representation of caribou behaviour as sample size was increased and levels of error would overlap and cancel each other (F. Messier, pers. comm.). Location points were used to create the boundary of each polygon. Habitat use inside each polygon was established by associating the location point of each animal with the corresponding 25 x 25 m Landsat classification pixel (Litvaitis *et al.*, 1994). All latitudes and longitudes were transformed from decimal degrees to Universal Transverse Mercantor (UTM) units to correspond to basemap point locations. The number of satellite collared caribou locations in each habitat were transformed into percentages to estimate trends in seasonal habitat use. The Landsat land cover classifications were: Water/Ice, Shoreline, Wetlands, Open Fen, Shrub-Rich Fen, Treed Bog, Dense Deciduous Forest/Shrub, Dense Conifer Pine, Dense Conifer Spruce, Mixed Forest Deciduous, Mixed Forest Conifer, Sparse Conifer, Sparse Deciduous Cover, Recent Clearcuts, Recent Burns, Old Burns/Cutovers, Bedrock/Sand, Mine Tailings, and Urban/Roads.

Seasonal changes in activity patterns were determined from the telemetry information provided by Argos Service and animals were classified as resting (0 - 5), feeding (6 - 30), walking (31 - 36), and running (> 37).

## Results

*Spring*

During the spring (March 1 - May 31), caribou were found predominately in 5 habitat types: Treed Bogs (22%), Old Burns (17.1%), Sparse Conifer areas (15.3%), Mixed Forest Deciduous areas (11.2%), and Dense Spruce areas (10.2%). These classifications represented 75.8% of the habitat used by caribou during this period.

In contrast, the 5 most under utilized habitats consisted of: Urban/Roads (0%), Mine Tailings (0%), Bedrock/Sand (0%), Dense Deciduous Forest/Shrub areas (0%), Shrub-Rich Fens (0%), and Wetlands (0%). These classifications were not used by caribou in the spring and represent habitats created by disturbance or containing a heavy deciduous shrub component (Fig. 1).

Other habitat types used by caribou ranged between 7.7% and 1% and included: Shoreline (7.7%), Dense Coniferous Pine areas (5.5%), Sparse Deciduous Covered areas (3.4%), Recent Clearcuts (2.6%), Open Fens (2%), Water/Ice (1.4%), Mixed Forest Conifer areas (1.2%), and Recent Burns (0.4%).

*Summer*

During the summer (June 1 - August 31), the 5 most common land classifications utilized by caribou were: Treed Bogs (18.7%), Mixed Forest Deciduous areas (16%), Dense Conifer Spruce areas (14.8%), Shoreline (13.3%), and Dense Conifer

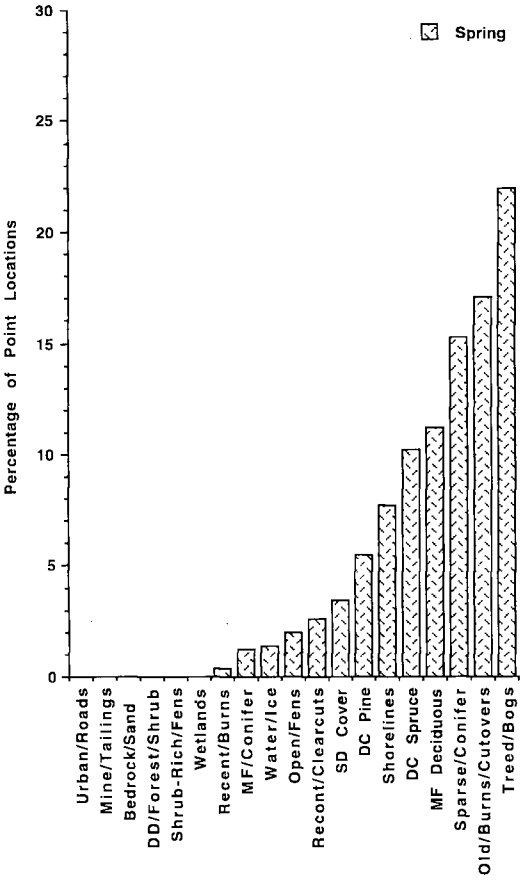


Fig. 1. Percentage of point locations in different Landsat land cover classes for woodland caribou during the spring of 1995 (March 1 - May 31) in northwestern Ontario (DD = dense deciduous; MF = mixed forest; SD = sparse deciduous; and DC = dense conifer).

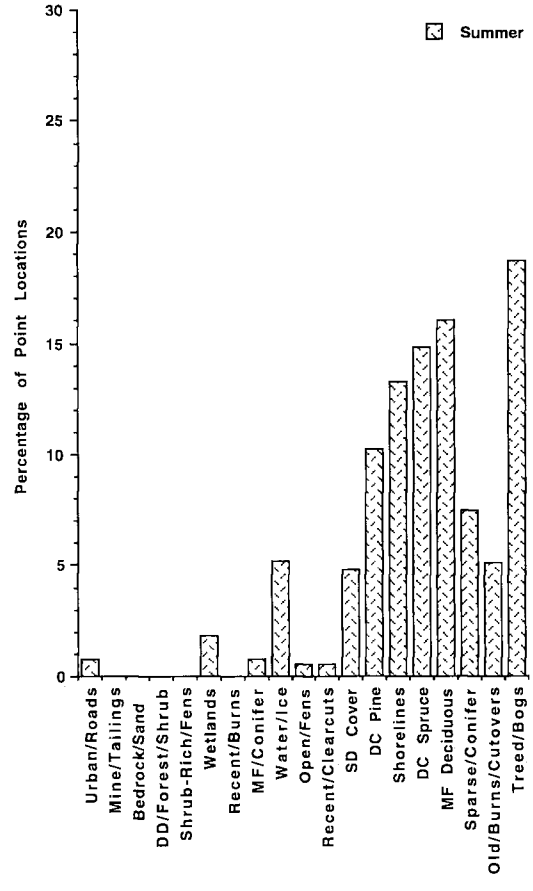


Fig. 2. Percentage of point locations in different Landsat land cover classes for woodland caribou during the summer of 1995 (June 1 - August 31) in northwestern Ontario (DD = dense deciduous; MF = mixed forest; SD = sparse deciduous; and DC = dense conifer).

Pine areas (10.2%). These classifications represented 73% of the habitats utilized by caribou during the summer (Fig. 2) and indicated caribou used both dense canopy cover and open sites during this period.

In contrast, the 5 least important land classifications used were: Mine Tailings (0%), Bedrock/Sand areas (0%), Recent Burns (0%), Dense Deciduous Forest/Shrub areas (0%), and Shrub-Rich Fens (0%). These habitat types were not used by caribou during the summer and represent habitats created by disturbance ot containing a heavy deciduous shrub component (Fig. 2).

Other habitat types utilized by caribou in summer ranged between 7.5% and 0.3% and included; Sparse Conifer areas (7.5%), Old Burns/Cutovers (5.1%), Water/Ice (5.2%), Wetlands (1.8%), Urban/Roads (0.8%), Mixed Forest Conifer areas (0.8%), Open Fens (0.5%), and Recent Clearcuts (0.5%).

*Fall*

In the fall (September 1 - November 31), caribou were found in Dense Conifer Pine areas (29%), Dense Conifer Spruce areas (9.9%), Recent Clearcuts (9.9%), Treed Bogs (8.4%), and Shorelines (7%). These classifications represented 64.2% of the habitats used by caribou in the fall (Fig. 3).

In contrast habitats where caribou were found least included: Mine Tailings (0%), Urban/Roads (0%), Recent Burns (0%), Shrub-Rich Fens (0%),

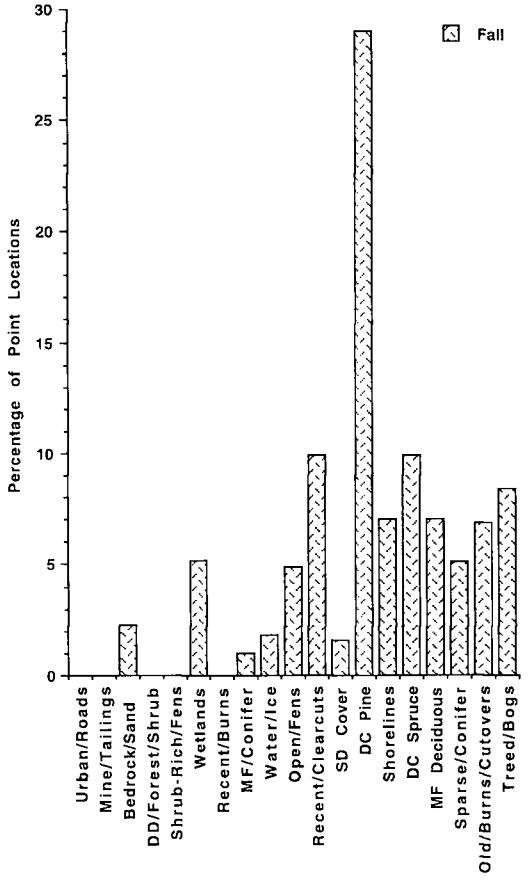


Fig. 3. Percentage of point locations in different Landsat land cover classes for woodland caribou during the fall of 1995 (September 1 - November 31) in northwestern Ontario (DD = dense deciduous; MF = mixed forest; SD = sparse deciduous; and DC = dense conifer).

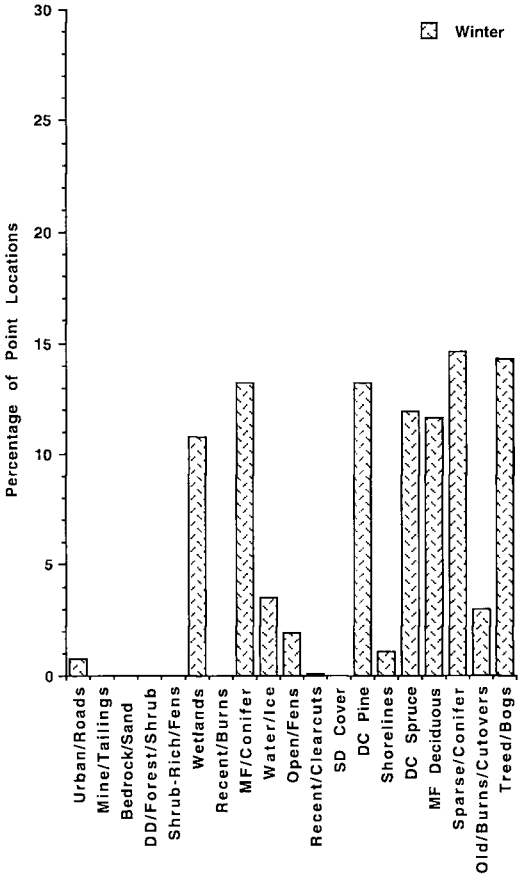


Fig. 4. Percentage of point locations in different Landsat land cover classes for woodland caribou during the winter of 1995 (December 1 - December 31) in northwestern Ontario (DD = dense deciduous; MF = mixed forest; SD = sparse deciduous; and DC = dense conifer).

and Dense Deciduous Forest/Shrub areas (0%). These habitats were areas of disturbance and areas of dense deciduous shrubs (Fig. 3).

Other habitats used by caribou during the fall ranged between 7% and 0.1% and included: Mixed Forest Deciduous areas (7%), Old Burns/Cutovers (6.9%), Wetlands (5.2%), Sparse Conifer (5.1%), Open Fens (4.9%), Bedrock/Sand (2.3%), Water/Ice (1.8%), Sparse Deciduous Cover areas (1.6%), and Mixed Forest Conifer areas (1%).

*Winter*

During winter (December 1 - 31), the 5 Landsat classifications most utilized by caribou were: Sparse Conifer areas (14.6%), Treed Bogs (14.3%), Dense Conifer Pine areas (13.2%), Mixed Forest Conifer areas (13.2%), and Dense Conifer Spruce areas (11.9%). These classifications represent 67.2% of the habitat utilized by caribou during winter (Fig. 4).

In contrast, classifications not used by caribou during winter were Shrub-Rich Fens (0%), Mine Tailings (0%), Bedrock/Sand areas (0%), Recent Burns (0%), Sparse Deciduous areas (0%), and Dense Deciduous Forest/Shrub areas (0%). These classifications represented areas of disturbance or contained heavy deciduous shrub components (Fig. 4).

Other land classifications utilized ranged between 11.6% and 0.25% and included: Mixed Forest Deciduous areas (11.6%), Wetlands (10.8%), Water/Ice (3.5%), Old Burns/Cutovers (3%), Open

Fens (1.9%), Shorelines (1.1%), Urban/Roads (0.8%), and Recent Clearcuts (0.1%).

*Activity*

Annual activity patterns of 10 females are represented in Figure 5. Mean annual percentages for the four behaviours were: resting (25.4%), feeding (37.6%), walking (11.5%), and running (25.5%). Resting activity ranged from 17% to 39%, reaching a peak during the summer months (June, 39% and July, 33%) and again in winter (December, 33%). Feeding represented the highest recorded activity ranging from 26% to 45% and was greatest in March (45%) and May (45%) and lowest in June (26%). Walking was less frequent and ranged between 6 - 22%. Running was most common during the fall (August - October) and ranged from 16% to 35% of the total activity.

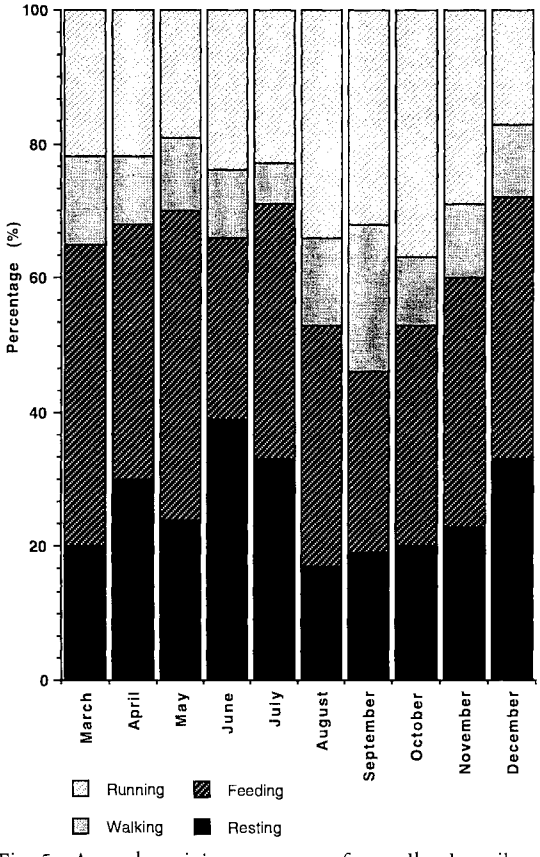


Fig. 5. Annual activity patterns of woodland caribou during 1995. Mean annual percentages for the four behaviours assessed were: resting - 25.3%, feeding - 37.6%, walking - 11.5%, and running - 25.4%.

## Discussion

Although only preliminary data were available, woodland caribou in northwestern Ontario during 1995 appeared to utilize specific Landsat land cover classifications more, while others were avoided. The four Landsat land cover classes most used throughout the year in order of importance were; Treed Bogs (15.9%), Dense Conifer Pine (14.5%), Dense Conifer Spruce (11.7%), and Mixed Forest Deciduous areas (11.5%). These habitats were utilized during all seasons of the year and received 53.6% of all point locations. Similar findings have been reported by Bergerud & Butler (1975) and Cummings & Beange (1987) for woodland caribou herds associated with the Lake Nipigon region. In this area, winter concentration areas were found to occur on sandy flats containing 90% jack pine and 10% white birch, with a lichen understory. Further analysis by Darby *et al.* (1989) and Hyers (1997) indicated that the entire winter range of approximately 180 km2 was estimated to be composed of 61% conifer, 17% mixed forest, 11% deciduous forest, 7% muskeg and open habitat, and 4% water. Stardom (1997) working in Manitoba concluded that woodland caribou preferred open larch or black spruce bogs and intermediate to mature jack pine stands on rocky ridges or sand plains.

In contrast, the three Landsat land cover classes never or minimally utilized were; Mine Tailings (0%), Shrub-Rich Fens (0%), Dense Deciduous Forest/Shrub areas (0%), and Recent Burns (0.1%). These habitats were avoided during all seasons of the year and only received 0.1% of the point locations. Although data on habitat availability were not analyzed, the results support the conclusion that woodland caribou in this region select habitats containing high to moderate conifer cover and avoided disturbed areas (Mine Tailings) and shrub-rich habitats, such as Shrub-Rich Fens, Dense Deciduous Forest/Shrub areas, and Recent Burns. Recent Clearcuts which are known to support heavy shrub layers also appeared to be avoided and received only 3.3% of the point locations. In contrast, Old Burns/Clearcuts received 8% of all point locations. Hyers (1997) studying a caribou herd in northwestern Ontario impacted by winter log hauling and roads concluded that caribou temporarily avoid disturbance and human development, but return once development is completed. Similar results were found by Hill (1985) studying caribou in Newfoundland associated with the construction of a hydroelectric development. In this study, natural

and man-made shrub-rich habitats with high levels of broad-leaf browse have been shown to be avoided by caribou, which is supported by the literature (Darby & Duquette, 1986; Godwin, 1990). These habitats favour moose and consequently increased wolf and black bear numbers, which may make caribou more vulnerable to predation. Bergerud (1983a, 1983b) and Seip (1992) have both presented data supporting this hypothesis.

Although seasons were only defined broadly within this study, trends in Landsat land cover class utilization were observed (Figs. 1 - 4). During the spring period, Treed Bogs, Old Burns/Cutovers, and Sparse Conifer habitats were most commonly used. These habitats have been found to be associated with calving females by other researchers and are thought to allow caribou to separate themselves from moose and associated predators (Shoesmith & Story, 1977, Fuller & Keith, 1981, Brown *et al.*, 1986, Parker, 1997).

During the summer post-calving period, Treed Bogs remained important, while Old Burns/Cutovers and Sparse Conifer habitats declined in importance and were replaced by Mixed Forest Deciduous areas, Dense Conifer Spruce and Pine areas, and Shorelines. In is interesting that the use of Shorelines was maximal during this period, when biting insects reach their greatest numbers. During the fall period, Dense Conifer Pine and Spruce areas were much more utilized than any other habitat type; however, Treed Bogs and Recent Clearcuts were a poor second. This combination of dense cover and open habitat may be associated with the rut, which occurs during this period. Winter habitats selected appeared to be more variable than fall land classifications and included; Sparse Conifer areas, Treed Bogs, Dense Conifer Pine and Spruce areas, and Mixed Forest Conifer areas. Wetlands also became important during this period when the substrate was frozen. As similar annual and seasonal habitat use have been reported by other researchers (Bergerud & Butler, 1975; Shoesmith & Story, 1977; Fuller & Keith, 1981; Edmonds & Bloomfield, 1984; Brown *et al.*, 1986; Cummings & Beange, 1987; Bergerud, 1989; Rominger & Oldemeyer, 1989; Hyers, 1997; Parker, 1997), it was concluded that satellite telemetry technology can be employed to assess habitat utilization by large ungulates in the boreal forest ecosystem.

Mean annual percentages for the four behaviours were: resting (25.4%), feeding (37.6%), walking (11.5%), and running (25.5%). Although these activity data were not calibrated, some trends were apparent. Resting reached a peak during mid-summer (June, 39% and July, 33%), when lactational requirements would be greatest and again in winter (December, 33%), when low quality forage and severe weather conditions would require the conservation of energy. Studies indicate that when forage intake declines, reindeer respond by reducing metabolic rate and energy expenditure (Fancy et al., 1989). In contrast, feeding remained relatively constant and the most frequent activity throughout the year (Collins & Smith, 1989). Walking and running were more frequent during the fall (August - October), when bulls spend most of their energy chasing and herding females (W.J. Dalton, pers. comm.).

In summary, the results support the conclusions (1) that woodland caribou in northwestern Ontario select habitats containing high to moderate conifer cover and avoided disturbed areas and shrub-rich habitats, (2) that seasonal changes in habitat utilization occurs in females of this species, and (3) that satellite telemetry technology can be employed in the boreal forest ecosystem to assess habitat utilization by large ungulate species.

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