

THE UNIVERSITY OF MANITOBA

THE WINTER ECOLOGY OF CAPE CHURCHILL CARIBOU
(Rangifer tarandus ssp.)

by

Mitch William Campbell

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BY

MITCH WILLIAM CAMPBELL

A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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ABSTRACT

THE WINTER ECOLOGY OF CAPE CHURCHILL CARIBOU (RANGIFER TARANDUS ssp.)

by

Mitch W. Campbell

Aspects of snow conditions, plant community use, and feeding habits were examined for caribou occupying the Cape Churchill Wildlife Management Area. Studies were carried out over each of the 1989-90 and 1990-91 snow seasons. Attempts were made to interrelate feeding habits and plant community use with changing snow conditions based on 7 snow stations set up within four taiga and three tundra plant communities. Fundamental differences between taiga and tundra snow conditions are also discussed.

Plant communities were described based on quadrat and point quarter methods, prior to snowfall, within each of four taiga and three tundra plant community snow stations. Snow conditions at snow stations and caribou feeding sites were quantified through the excavation and examination of snow profiles. Aspects of thickness, hardness, and a mathematical index incorporating eight snow variables (Varrio Snow Index (VSI)) were examined for each profile.

Aspects of plant community use were quantified through tracking and the examination of feeding sites. Feeding habits were quantified through the analysis of feeding crater contents, pellet groups, and rumen samples.

Taiga and tundra snow conditions are fundamentally different. This was primarily due to the effects of wind on the more exposed tundra and the relative lack of wind in the taiga. The occurrence of rain, freezing rain, wet snow, and a thick snow cover had the net effect of elevating taiga VSI's while wind and periods of rain and freezing rain largely controlled tundra VSI's. Cape Churchill caribou reacted to elevated VSI's in part by shifting to communities with lower VSI's. A shift to communities with harder and/or thinner snow was also apparent and primarily related to feeding site access. Despite shifts in plant community use related to changing snow conditions, preferred forage species changed little either within or between snow seasons. Lichens were the most prominent plant group selected by Cape Churchill caribou as forage.

Cape Churchill caribou displayed a wide use of plant communities that varied both throughout the snow seasons and between them. Snow conditions within taiga plant communities differed both between themselves over both snow seasons, and differed between the two snow seasons. Tundra

plant communities also displayed variability over the same periods though not as severe as taiga sites. Cape Churchill caribou did however remain in feeding sites beyond threshold levels if suitable alternate plant communities were not available. These data imply that conventional wildlife management techniques used to determine caribou range tend dramatically to underestimate actual requirements. Through the long term field monitoring of representative plant community snow conditions and winter habitat use by caribou, a more realistic estimate of caribou range can be achieved.

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TABLE OF CONTENTS

	<u>Page</u>
Abstract	i
Acknowledgements	iv
List of Tables	xi
List of Figures	xii
Key to Abbreviations	xv
1.0 Literature Review	
1.1 Introduction	1
1.2 Snow Study	2
1.2.1 The Collection And Modification Of Snow	3
1.2.2 Snow (Api) Thresholds	6
1.2.3 Feeding Site Selection	11
1.2.4 Crater Form	13
1.2.4 Snow Study Conclusions	13
1.3 Status And Distribution	14
1.3.1 The Kaminuriak Caribou Herd	15
1.3.2 The Penn Island Caribou Herd	16
1.3.3 Cape Churchill Caribou	16
1.4 Life History	18
1.5 Plant Community Use	19
1.5.1 Woodland Caribou	19
1.5.2 Barren-ground Caribou	21

1.5.3	Cape Churchill Caribou	22
1.6	Feeding Habits	23
1.6.1	Woodland Caribou	24
1.6.2	Barren-ground Caribou	25
1.6.3	Forage Intake	27
1.6.4	Feeding Habits Conclusion	27
1.7	Weather	28
2.0	Objectives and Hypothesis	30
3.0	Study Area	
3.1	General Description	32
3.2	Plant Communities	36
4.0	Methods	
4.1	Snow Study	40
4.1.1	Snow Stations	40
4.1.2	Api Profiles	43
4.2	Plant Community Analysis	46
4.3	Tracking	49
4.4	Feeding Site Analysis	54
4.5	Feeding Habits	
4.5.1	Crater Analysis	56
4.5.2	Rumen Analysis	58
4.5.3	Pellet Group Analysis	60
4.5.4	Data Analysis	61
5.0	Results	
5.1	Plant Community Structure	62

5.1.1	Ordination Of Plant Communities	....	62
5.1.2	Taiga Community Structure	.....	73
5.1.3	Tundra Community Structure	.....	77
5.2	Taiga And Tundra Snow Conditions	.....	80
5.2.1	1989-1990	.....	80
5.2.2	1990-1991	.....	85
5.3	Community Snow Conditions		
5.3.1	Early Winter	.....	94
5.3.2	Mid-Winter	.....	97
5.3.3	Late Winter	.....	98
5.3.4	Differences Between Snow Seasons	...	99
5.4	Plant Community Use Based On Tracking	.....	102
5.4.1	1989-1990	.....	103
5.4.2	1990-1991	.....	106
5.5	Plant Community Use Based On Feeding Sites		
5.5.1	1989-1990	.....	107
5.5.2	1990-1991	.....	110
5.6	Feeding Site Snow Conditions	.....	111
5.6.1	1989-1990	.....	112
5.6.2	1990-1991	.....	118
5.7	Feeding Habits	.....	123
5.7.1	1989-90 Craters	.....	124
5.7.2	1989-90 Pellet Groups	.....	126
5.7.3	1990-91 Craters	.....	128
5.7.4	1990-91 Pellet Groups And Rumens	...	130

5.7.5	Pooled Winter Feeding Habits	132
6.0	Discussion	
6.1	Taiga And Tundra Snow Conditions	135
6.1.1	Taiga Snow	136
6.1.2	Tundra Snow	138
6.1.3	Taiga And Tundra VSI's	141
6.1.3	Differences Between Snow Seasons ...	145
6.2	Plant Community Use	148
6.3	Feeding Site Availability	156
6.4	Api Thresholds	158
6.5	Crater Site Selection	161
6.6	Feeding Habits	163
7.0	Conclusions	169
8.0	Management Recommendations	175
9.0	Some Final Words	179
10.0	Literature Cited	182
11.0	Appendices	204
Appendix A.	.....	205
Appendix B.	.....	210
Appendix C.	.....	214

LIST OF TABLES

	<u>Page</u>
1. Early, mid. and late winter differences in thickness, hardness, and log VSI between 4 taiga and 3 tundra snow stations over the 1989-90 and 1990-91 snow seasons	96
2. Plant community use based on tracking data and plant community use based on feeding crater plant communities versus log VSI values within corresponding plant community snow stations	104
3. Percent species composition from early, mid, and late winter feeding craters and pellet groups (1989-90)	125
4. Percent species composition from early, mid, and late winter feeding craters, pellet groups, and rumen samples (1990-91)	129

LIST OF FIGURES

	<u>Page</u>
1. The Cape Churchill study area	33
2. The Cape Churchill study area showing plant community snow station locations	41
3. The Cape Churchill study area showing field camp locations	50
4. Principal components diagram showing the spatial separation of 7 Cape Churchill plant communities	64
5. Percent frequencies of dominant tree species from 7 Cape Churchill plant communities	66
6. Percent frequencies of dominant graminoids from 7 Cape Churchill plant communities	67
7. Percent frequencies of dominant lichens from 7 Cape Churchill plant communities	68
8. Percent frequencies of dominant misc. plants from 7 Cape Churchill plant communities	69
9. Percent frequencies of dominant evergreen shrubs from 7 Cape Churchill plant communities	70
10. Percent frequencies of dominant deciduous shrubs from 7 Cape Churchill plant communities	71
11. Percent frequencies of dominant forbs from 7 Cape Churchill plant communities	72
12. Log VSI and climatological data for taiga and tundra plant community snow stations (1989-90)	81
13. Total thickness and climatological data for taiga and tundra plant community snow stations (1989-90)	83
14. Hardness of the hardest layer and climatological data for taiga and tundra plant community snow	

stations (1989-90)	84
15. A comparison of hardness of the hardest layer values between the 1989-90 and 1990-91 snow seasons	86
16. A comparison of total thickness values between the 1989-90 and 1990-91 snow seasons	87
17. Climatological comparison between the 1989-90 and 1990-91 snow seasons	88
18. Log VSI and climatological data for taiga and tundra plant community snow stations (1990-91)	90
19. Total thickness and climatological data for taiga and tundra plant community snow stations (1990-91)	91
20. Hardness of the hardest layer and climatological data for taiga and tundra plant community snow stations (1990-91)	92
21. A comparison of log VSI values between the 1989-90 and 1990-91 snow seasons	95
22. Feeding crater snow conditions comparing hardness, thickness, and log VSI with control profiles	113
23. Feeding crater snow conditions comparing hardness, thickness, and log VSI with control profiles over early, mid, and late winter (1989-90)	114
24. Comparison of early, mid, and late winter feeding crater snow conditions (1989-90)	116
25. Comparison of early, mid, and late winter feeding crater and plant community snow station snow conditions (1989-90)	117
26. Feeding crater snow conditions comparing hardness, thickness, and log VSI with control profiles over mid and late winter (1990-91)	119
27. Comparison of mid and late winter feeding crater snow conditions (1990-91)	121

28. Comparison of mid and late winter feeding
crater and plant community snow station
snow conditions (1990-91) 122

4.0 KEY TO ABBREVIATIONS

BR	=	Beach Ridge
BSP	=	Black Spruce Palsa
CCC	=	Cape Churchill Caribou
CCH	=	Cape Churchill Caribou Herd
CCWMA	=	Cape Churchill Wildlife Management Area
CR	=	Feeding crater
E/EW	=	Early Winter
HLT	=	Hummocky or Lichen Heath Tundra
L/LW	=	Late winter
M/MW	=	Mid-winter
RU	=	Rumen contents
SC	=	Scat/Fecal material
ST	=	Sedge or Graminoid Tundra
TF	=	Tamarack Fen - Shrub Thicket - Meadow Marsh
TWS	=	Tamarack - White Spruce Forest
WSF	=	White Spruce Forest

1.0 LITERATURE REVIEW

1.1 Introduction

Within the taiga, forest-tundra, and tundra regions, winter is the most critical period for wild ruminants (Ferguson and Mahoney 1991, Klein 1969, Miller 1976, Pruitt 1959, Russell and Martell 1984, Stardom 1975, Swift et al. 1980, Vernadski 1933).

Formozov (1946) was one of the first boreal ecologists to recognize the selective forces manipulating boreal species of plants and animals during the snow season. Formozov suggested that animals could be divided into species that do not inhabit snowy regions and as a result avoid them (Chionophobes), species that can withstand winters with considerable snow (Chioneuphores), and species whose ranges lie completely, or almost completely, in regions of hard continuous winters (Chionophiles). Caribou (Rangifer tarandus ssp.) are highly adapted to snow covered environments and as a result are termed chionophiles (Formozov 1946, Pruitt 1959, Russell and Martell 1984).

Early man's intrusion into the North American arctic interior was directly connected to caribou, more specifically barren-ground caribou (Rangifer tarandus

groenlandicus) and their ability to bridge the gap between the primary producers and the tertiary consumers within the arctic food chain. In times as recent as 1986 over 8000 people in the Keewatin district alone depended on caribou as their main source of food and winter clothing (Tennenhouse 1986).

Caribou numbers and movements in northern Canada rival those of ungulates living on present-day African savannas. This is surprising when one considers that the Canadian tundra produces an average standing crop of only 0.17-2.5 kg/km² compared to 170-200 kg/km² typically found on African savannas (Bliss et al. 1973, Klein 1969). Despite the low productivity, diversity and rate of nutrient cycling, the tundra range makes up the most wide spread grazing system in the world. These findings suggest that caribou and their habitats deserve a great deal more attention and concern than they are currently being given (Chapin 1980).

1.2 Snow Study

Vernadski (1933) was the first to recognize the importance of snow to northern animals; "The presence of an ice and snow cover in the biosphere is, in its direct and

indirect results, one of the most important factors in nature". Another pioneer in snow ecology, Formozov (1946), concluded that reindeer, of all Scandinavian deer, are best adapted to snow, where representatives of the species are distributed in tundra and taiga regions with snow thickness varying from a maximum of 20 cm to greater than 100 cm. Increasingly, ecologists are finding that the collection and analysis of snow morphological data provides critical information concerning caribou movement and forage selection within boreal and arctic communities. In fact, studies have shown a convincing link between the characteristics of a snow cover and caribou population fluctuations (Bergerud 1974a, Bergerud 1980a, Gaare and Skogland 1975, Lent 1986, Loughrey and Kellsall 1970, Miller 1976, Pruitt 1979, 1985, Russell and Martell 1986, Stardom 1975, Telfer and Kellsall 1979). Both Pruitt (1959) and Bergerud (1974c) did, however, suggest that in the absence of extreme nival conditions (extremely hard and/or thick snow) caribou select communities primarily for suitable forages and secondarily for suitable nival conditions.

1.2.1 The Collection And Modification Of Snow

Barren-ground and, in some cases, woodland caribou encounter snow as an integral part of their environment for

at least 8 months of the year (Pruitt, 1959). Pruitt (1979) recognized 7 important periods during the snow season, each containing specific snow morphological characters to which caribou have adapted; 1. Fall critical period; 2. Pre-threshold period; 3. Threshold period; 4. Self-induced movement period; 5. Sub-marginal period; 6. Api-maturation period; 7. Spring critical period. As these periods are often difficult to identify, a more general division of a snow season into 3 ecologically important periods has been made by, among others, Russell and Martell (1984) and include; 1. Early winter (November through December); 2. Mid-winter (January through February); 3. Late winter (March through April).

The onset of snow cover is governed by the precise succession of meteorological events that bring the correct mass of moist air in contact with cold air making the arrival of a snow cover highly variable from year to year (Pruitt 1970). These same events are in part responsible for the differences between taiga and tundra snow. Pruitt (1984) described two different forms of tundra snow; 1. Upsik-Siqoq, where wind worked snow becomes consolidated into a mass (upsik), and Siqoq is the moving snow or windborne snow; 2. Zaboi-Vyduv, where a zaboi forms when a concave topographic surface fills with siqoq resulting in a large mass which persists well into the summer, and vyduv

represents a convex surface blown clear to reveal the substrate. Taiga snow also occurs in two forms (Pruitt 1984); 1. *Api*, or snow on the ground; 2. *Qali*, or the snow collected on trees. Both forms remain relatively unworked by wind due to the sheltered nature of most taiga communities (Pruitt 1984). These features of taiga and tundra communities often account for their variation in plant community structure. Plant communities are highly correlated with mean duration and thickness of the snow cover (Lent 1986). Gaare (1986) found that lichen communities are determined by the duration of the snow cover while their growth rates depend on the moisture regime during the snow free period. Communities with dense shrubs often trap wind-blown snow and as a result can become snow collection areas (Bergerud 1974a). Lent (1986) found the best lichen growths on reindeer ranges to be associated with moderately thick snow cover because of the protection and moisture offered. These conditions are most apparent within the taiga and forest ecotone and within concave surfaces (snow collection areas or *zaboi*) on tundra sites.

Only Soprovich (1989) has conducted community-based snow work within the Cape Churchill Wildlife Management Area. These studies were conducted on beach ridge (BR) (elevated marine gravel deposits isolated inland through

isostatic rebound), fen and modified (transition between beach ridge and fen) community types. Within the beach ridge community snow was relatively thin near the apex (the flattened top of the deposited marine gravel) and thick near the periphery (sloping sides of the marine deposit), values which averaged between 11.8 cm in January and 20.3 cm in March. The fen community averaged 27.3 cm in January and 40.0 cm in March, while the modified community averaged 27.3 cm in January and 41.6 cm in March. Hardness values were lower towards the apex and higher towards the periphery of beach ridge communities. Hardness values within the fen and modified communities varied considerably but remained greater than the beach ridge apex (Soprovich 1989).

1.2.2 Snow (Api) Thresholds

The two most ecologically important properties of a snow cover, when considering mammals, are hardness and thickness (Pruitt 1959). Although snow density has been used by many authors as a gauge to caribou range quality, it is currently considered too variable and misleading as it bears no statistical correlation to hardness (Pruitt 1990). Snow hardness and thickness generally increase from early to late winter on Caribou range (Adamczewski et al. 1988, Pruitt 1979, Schaefer 1988, Skogland 1978).

According to Carruthers et al. (1986) and Pruitt (1979) caribou have the ability to react to these changes by progressing down a gradient to regions with thinner and softer snow. This can cause extensive winter movements. The ability of caribou to detect differences in snow hardness and thickness is based on thresholds (values of snow hardness and thickness above which any given community becomes largely unavailable to caribou) to these characters that they will not transgress (Carruthers et al. 1986, Pruitt 1981).

The earliest recorded thresholds for snow thickness were presented by Formozov (1946) and Nasimovich (1955) who found that beyond 50-60 cm reindeer would move out of an area seeking thinner snow cover. These data could, however, be based on the smaller domestic reindeer and thus a lower tolerance for snow thickness. Today generally accepted thickness thresholds range between 60 and 70 cm (Henshaw 1968, Pruitt 1959, 1965, Russell and Martell 1984, Thomas 1990). Russell and Martell (1984) and Stardom (1975) found woodland caribou to have a higher threshold to snow thickness (65-74 cm) compared to barren-ground caribou (50 to 60 cm) a finding likely related to their larger size. Bergerud and Nolan (1970) found exceptions to the above values as they documented a reduction in number of feeding crater excavations when snow thicknesses exceeded

25 cm. Another extreme was observed by Brown and Theberge (1990) who found mean crater depth in Labrador between 58.3 and 118.2 cm.

Hardness thresholds for both barren-ground and woodland caribou are very complex and change with time of year, snow thickness and modification, exposure to wind, solar energy, and plant community. As a result, hardness thresholds (hardness values above which create conditions less desirable to caribou activity) recorded in the literature show a wide range from 6.5 g/cm² in the taiga to 9000 g/cm² in the tundra and above (Adamczewski et al. 1988, Pruitt 1981, 1965, Stardom 1975). Caribou will, however, increase their threshold of tolerance to hardness and thickness if softer and thinner snow is not available within suitable habitats (Pruitt 1979). Nonetheless, caribou avoid habitats with thick and hard snow if similar or adequate forage is available within habitats of thinner and softer snow (Bergerud and Nolan 1970, Fancy and White 1985, LaPerrier and Lent 1977, Miller et al. 1982, Pruitt 1959, 1979, 1981, Russell and Martell 1984, Skogland 1978, Stardom 1975).

Snow hardness may also have a dramatic effect on caribou movement. Collins and Smith (1991) noted that time spent walking generally increased with increased snow hardness. However, where the hardened snow is restricted

to a thin surface layer or crust, the energy costs of locomotion are higher than on uncrusted or softer snow with similar sinking depths (Fancy and White 1987). Hard snow can also increase the energetic cost of foraging while excavating feeding craters. The mean cost per digging stroke in light uncrusted snow by caribou was 118 J/stroke, while in dense snow with a thin hard crust the mean cost was 219 J/stroke (Fancy and White 1985). In addition Skogland (1978) found stroke rate to decrease with increasing hardness. These findings suggest that changing snow conditions can have a dramatic effect on energy expenditure by caribou and likely their use of plant communities. The fact that these parameters vary temporally, suggest a more cautious interpretation when used as an index to the energetic cost of foraging (Pruitt 1959, Soprovich 1989).

It was, in part, for these reasons that Pruitt (1979) developed the Varrio Snow Index (VSI) which incorporated snow morphological values, including thickness and hardness, with caribou activity. When modified to address local conditions, the VSI has the ability to simplify the complex nature of snow cover. In formulating log VSI Pruitt (1979, 1981) successfully related the characteristics of the snow cover with caribou use of their winter range. The mathematical relationship as described

by Pruitt (1979, 1981) is as follows:

$$\text{VSI} = (H > 1/2 (\text{Hb} * \text{Tb}) + (\text{VTs}) + (\text{Hh} * \text{Th})) * \text{Ta} / 1000$$

WHERE: $H > 1/2$ = hardness of hardest layer more than half way up in the profile.

$\text{Hb} * \text{Tb}$ = hardness times thickness of basal layer.

$\text{V} * \text{Ts}$ = vertical hardness times thickness of surface layer.

$\text{Hh} * \text{Th}$ = hardness times thickness of hardest layer (if not $\text{Hb} * \text{Tb}$). If basal layer is the hardest then term $\text{Hb} * \text{Tb}$ drops out.

Ta = total thickness of api.

When using VSI the log of the index value (VSIL) is inversely proportional to nival quality of caribou range including both forage availability and ease of movement. There are, however, conditions that can defy the VSI if not understood. Within communities of hard-packed snow (VSIL = 5.00-8.00) and a layer of pukak (basal layer of loosely packed crystalline snow with hardness values between 10 and 500 g/cm²) caribou can expose underlying vegetation with a lower expenditure of energy than hardness values alone would predict (LaPerriere and Lent 1977). Snow in this

state is easily fractured into slab-like pieces with a series of sharp blows. Despite this exception the VSI has the potential of becoming a very powerful tool to predict caribou's use of their winter range.

1.2.3 Feeding Site Selection

Sight and smell are likely the main senses used by caribou to locate food beneath the snow (Bergerud 1974a, Bergerud 1974b, Bergerud and Nolan 1970, Brown and Theberge 1990, Helle 1984). Caribou cratering activity (the excavation of snow to access forage) is generally preceded by walking with their nose near the snow surface then stopping and moving their muzzle closer to or against the snow (Collins and Smith 1991). The purpose of this behaviour is thought to be an attempt to detect forage beneath the snow through smell. Pruitt (1959) also suggested that this behaviour also served a second purpose, to test the vertical hardness of the snow as a prelude to cratering. In the absence of protruding plant stems creating holes through the snow, caribou are considered unable to detect the presence of lichens through a snow cover greater than 25 cm (Bergerud 1974b, Bergerud and Nolan 1970). Exceptional circumstances have been reported by Helle (1984) where caribou have detected lichens at a depth of 72 cm with no apparent air holes, and by Brown and

Theberge (1990) who found evidence of Labrador caribou visually distinguishing snow-covered terrain containing preferred forage items. Once located, the forage species are made available for consumption through excavation or cratering.

Caribou cratering sites are found in areas of less snow thickness and hardness than found generally within the feeding site (Feeding site = an area delineated by the outer most craters of a group of craters) (Collins and Smith 1991, LaPerrier and Lent 1977). Number of craters and total area cratered increase with decreasing site hardness while cratering time per active period increases linearly with hardness (Collins and Smith 1991, Skogland 1978). This increase in cratering time is usually at the expense of bedding time (Collins and Smith 1991). Mean bottom area of craters (area of ground exposed through cratering activity), however, was not found to be a function of thickness or hardness for reindeer (Collins and Smith 1991). In extreme cases reindeer can continue to expand craters, in soft deep snow, over periods of several days or even weeks (Helle 1984). Russell and Martell (1984), however, disagreed with the above suggesting that in fact time spent within craters increases with increased site hardness and thickness resulting in the excavation of larger craters as these values climbed.