RANGE TYPES AND THEIR RELATIVE USE BY PEARY CARIBOU AND MUSKOXEN ON MELVILLE ISLAND, NWT

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Abstract: In 1974, landscape on eastern Melville Island was classified into range types and sampled for vegetative cover and standing crop. The primary objective was to compare relative past use of range types by Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) as measured by fecal densities. Assessing the relative importance of range types to caribou and muskoxen was one step in helping to understand their ecology and conservation as developments encroached on former wilderness. Data on the relationship between cover and standing crop of many important forage species revealed that cover was an adequate measure of vegetation abundance. We found that, in winter, caribou made intensive use of sparsely vegetated upland ridges where *Luzula* spp. and lichens were relatively abundant. Such exposed ridges have shallow snow or are free of snow. In summer, caribou used a variety of mesic range types where lichens, *Salix arctica, Luzula* spp., and forbs such as *Papaver radicatum* and *Stellaria longipes* were relatively abundant. In summer and winter, muskoxen made most use of wetland meadows where *Carex aquatilis stans, Eriophorum* spp., and *Dupontia Fisheri* were relatively abundant. Those observations were supported by significant correlations between densities of winter and summer types of feces and the cover and standing crop of plant species. We conclude that, at the time of our study when population densities were low in relation to the absolute abundance of food, there was no competition between the two herbivore species because fecal densities were negatively associated, there was almost no overlap in major dietary species, relationships with certain forage species contrasted significantly, and caribou primarily used mesic and xeric sites whereas muskoxen primarily used wet meadows.

Key words: fecal densities, habitats, *Ovibos moschatus*, plant cover and biomass, range types, *Rangifer tarandus pearyi*, relative use of range types.

Résumé: En 1974, le paysage de l'est de l'île Melville a reçu une classification selon les genres d'aire de répartition et a fait l'objet d'un échantillonnage du couvert végétal et de la biomasse mesurable. Ces travaux visent premièrement à comparer l'utilisation relative passée des genres d'aire de répartition par le caribou de Peary (*Rangifer tarandus pearyi*) et le bœuf musqué (*Ovibos moschatus*), telle que mesurée d'après les densités fécales. L'évaluation de l'importance relative des différents genres d'aire de répartition pour le caribou et le bœuf musqué est la première étape d'une étude en vue de mieux comprendre l'écologie et la conservation de ces aires à un moment où les aménagements empiètent sur un milieu autrefois sauvage. Les données concernant les rapports entre le couvert végétal et la biomasse mesurable de nombreuses espèces importantes de fourrage permettent de constater que le couvert végétal donne une mesure convenable de l'abondance de végétation. Nous constatons qu'en hiver, le caribou utilise intensivement les crêtes montagneuses à végétation éparse où il y a abondance relative de spp. de *Luzula* et de lichens. Ces crêtes exposées ne retiennent qu'une mince couverture de neige ou n'en ont pas du tout. En été, le caribou fréquente diverses aires de répartition mésoïques où poussent en abondance relative les lichens, le *Salix arctica*, les spp. *Luzula* et les herbes non graminéennes telles que le *Papaver radicatum* et le *Stellaria longipes*. Durant l'été et l'hiver, le bœuf musqué utilise surtout les prairies des milieux humides où se retrouvent en abondance le *Carex aquatilis stans*, les spp. d'*Eriophorum* et le *Dupontia Fisheri*. Ces observations sont approuvées par des corrélations entre, d'une part, les densités des matières fécales de l'été et de l'hiver et, d'autre part, le couvert végétal et la biomasse mesurable d'espèces végétales. On remarque une relation négative importante entre l'utilisation des zones par le caribou et par le bœuf musqué. Il y a un certain degré de chevauchement dans l'utilisation des genres de site par le caribou et par le bœuf musqué, surtout en été, mais aucun signe de compétition entre les deux sur le plan de la nourriture puisque celle-ci est abondante compte tenu des faibles densités de population de ces deux ongulés.

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1.0 INTRODUCTION

In 1972, petroleum exploration was at a peak in the Canadian Arctic Islands and natural gas discoveries in the Sverdrup Basin induced petroleum officials to consider pipelines to southern markets. As early as the autumn of 1972, Panarctic Oils Limited contracted consultants to conduct preliminary studies to identify ecological problems associated with generalized gas pipeline routes from the High Arctic to southern Canada. An application to Government from a proponent to build a pipeline by the late 1970s was considered a distinct possibility.

The Canadian Wildlife Service (CWS) proposed a series of studies in 1973-74 to develop efficient techniques to inventory wildlife and their habitats in the Arctic. There was a dearth of knowledge of arctic biological systems in a vast remote area. Long-term studies were necessary to unravel ecological relationships and in particular the effects of weather extremes. Sustainability of hunted populations was a concern and some populations could be endangered because of their rarity and vulnerability to adverse weather. In 1974-75, planning began for extensive and detailed studies, some interdisciplinary, by Government agencies,

We were assigned tasks of (1) testing and evaluating methods of estimating vegetation cover, composition, and above-ground standing crop, with emphasis on forage species used by Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*); (2) assessing present and past use of various habitats by muskoxen and caribou; and (3) testing and evaluating photographic techniques aimed at facilitating vegetation (particularly forage) mapping and interpretation in conjunction with habitat studies.

This report pertains to the first and second tasks. Work on the air photo study, "task force" obligations (Loken 1974), and unfamiliarity with techniques of vegetation analyzes necessitated contracting a professional botanist with arctic experience. Dr. Ross Wein, University of New Brunswick was contracted to:

> "conduct tests to determine the most efficient methods of measuring vegetational cover and productivity of forage in habitats represented on three study areas, two on Melville Island and one on Bathurst Island, NWT."

Study regions at Little Point, Sabine Bay, and Sherard Bay on Melville Island were selected by CWS because: (1) they contained a diversity of range types and assemblages of vegetation, (2) they were used by caribou and muskoxen, (3) they were near campsites to be used in summer 1973 by government agencies, and (4) they were study regions selected for testing aerial photographic techniques and data obtained on the ground would assist interpretation of the photographic data.

In summer 1973, Ross Wein selected several sites within each of the three study areas to test various techniques for estimating cover and standing crop of vegetation species. The CWS suggested that techniques of vertical photography be tested (Pierce & Eddleman 1973, Ratliffe & Westfall 1973). Wein and his students concluded that estimates of plant cover were obtained most efficiently from color photographs of 0.25 m^2 plots and by the point method (Wein et al. 1974, Wein and Rencz 1976). Standing crop was estimated more efficiently using 25 cm x 50 cm or 20 cm x 100 cm sample plots than 50 cm x 100 cm plots.

In 1973, the Federal Government decided that industrial proponents should be responsible for almost all environmental studies. The government would maintain research programs sufficient to be able to evaluate the results and conclusions of a proponent. About the same time, exploration and cost analyses indicated that oil and gas reserves did not justify high costs of moving petroleum to southern markets. Consequently, by 1974-75, this study on range use by caribou and muskoxen was scaled down. In summer 1974, we applied techniques recommended by Wein et al. (1974) to estimate plant cover and standing crop on representative range types on eastern Melville Island. From the densities of fecal groups on the same sites, we evaluated intensity and season of past use by caribou and muskoxen. Planned exclusive use of a fixed-wing aircraft in August did not materialize because poor weather prevented its release from another CWS project. Therefore, most of the sites were located near camp locations at Sabine Bay and Little Point. Nevertheless, a wide range of vegetation types was sampled.

Some results of this study, relating to lack of competition between caribou and muskoxen, were published (Thomas & Edmonds 1984). This report contains more-detailed data and statistical analyses of cover and standing crop of vegetation at each site, on relationships between cover and standing crop (phytomass), and on relative use of sites and range types by caribou and muskoxen.

1.1 Study areas

Melville Island is in the Parry Islands or western group of the Queen Elizabeth Islands located north of 74° N and the "northwest passage" (**Fig. 1**). The climate (Thompson 1967) is similar to that of Mould Bay and Resolute but less severe than at Isachsen, the closest climatological stations for which long-term (20-25 year) records were available. Records were available for Rae Point, on the east coast of Melville Island, after its establishment in 1959.

Mean temperatures at Resolute for the coldest (February) and warmest (July) months were -33.5°C and 4.3°C, respectively. Corresponding means for Mould Bay were -33.5°C and 3.7°C; for Isachsen -36.4°C and 3.3°C. Mean annual precipitation at Resolute was 136 mm with about half (69 mm) falling June-August, most (79%) as rain. In contrast, Mould Bay received only 86 mm of precipitation annually.

Melville Island is part of the Sverdrup Basin, formed largely in the Palaeozoic and Mesozoic periods and overlain by more-recent veneers of silt below the marine limit at 75-90 m above the present mean sea level (Tozer & Thorsteinson 1964, Barnett et al. 1975).

Sabine Peninsula (**Fig. 2**) lies in a physiographic region described as "lowlands and plateaux development on gently folded or horizontal Upper Palaeozoic to early Tertiary rocks" while the remainder of eastern Melville lies in another physiographic region described as "ridges and plateaux developed of folded Paleozoic rocks" (Tozer & Thorsteinson 1964). Bedrock boundary corrections and considerable detail on geomorphology, surface materials, vegetation, wildlife, and terrain sensitivity appeared in Barnett et al. (1975).

Figure 1

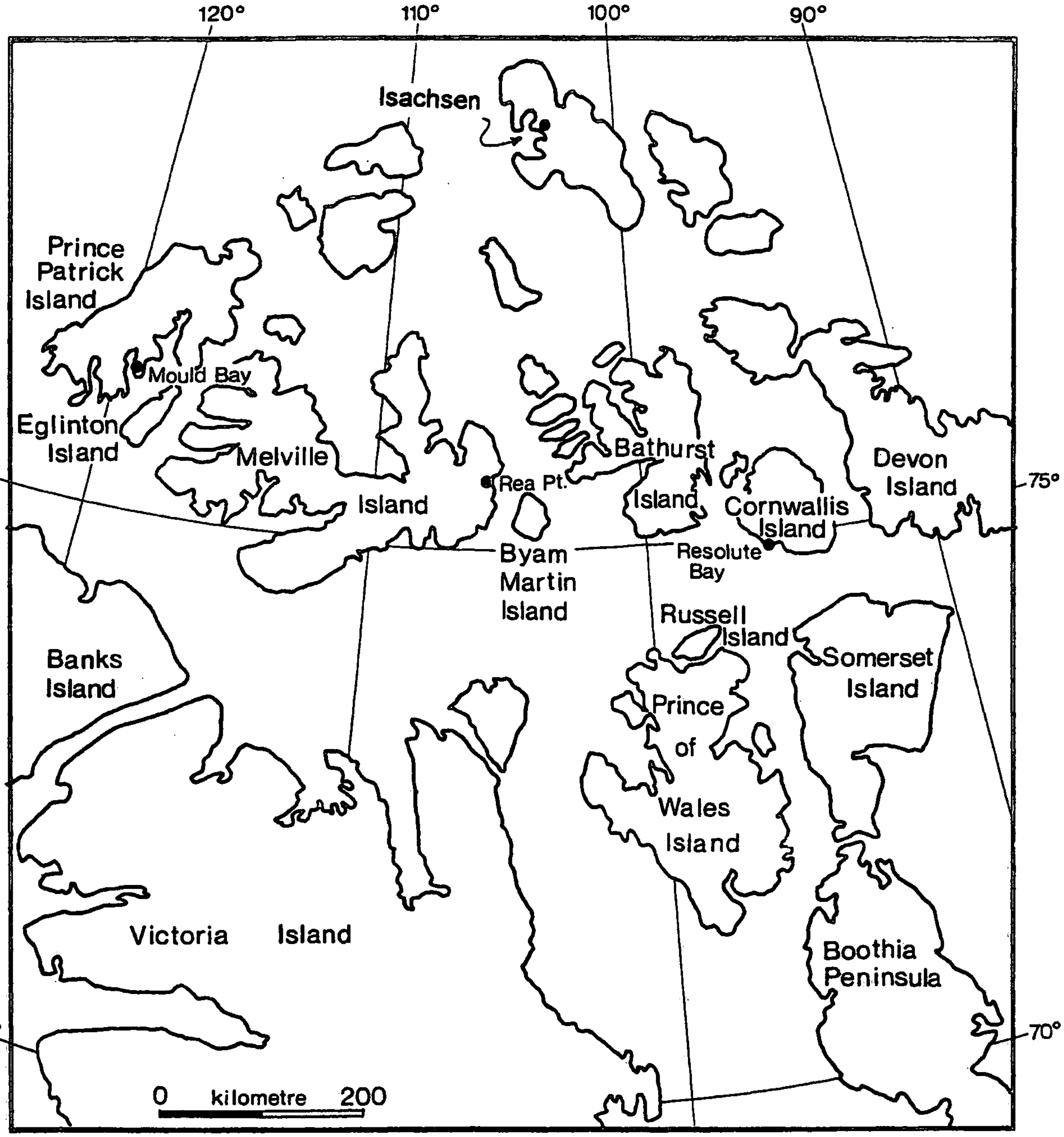


Figure 1. Location of Melville Island in the western Queen Elizabeth Islands, Northwest Territories, Canada.

Figure 2

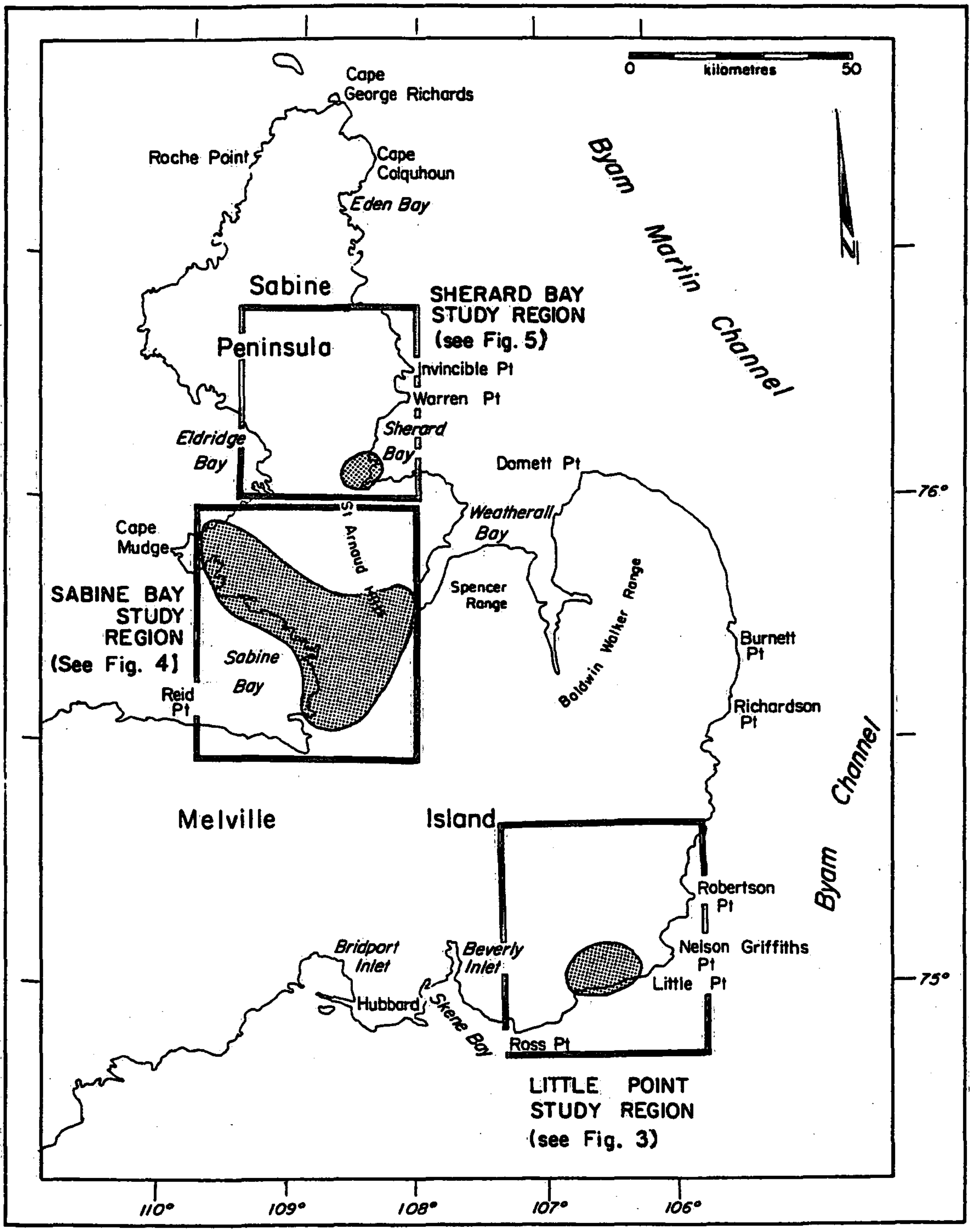


Figure 2. Study areas on eastern Melville Island, Northwest Territories.

The above data along with the terrain classification and evaluation mapping of Sproul & Associates Ltd. (1974), a generic (origins) classification of surface features, provided more information about the landscape than was available for most regions of the Arctic. Additional information on the vegetation of eastern Melville Island, including disturbance studies, was available (Kuc 1972). Range units, vegetation species, and flowering phenology of Bailey Point on the south coast of western Melville Island was described by Parker and Ross (1976). Parker (1978) also provided data on summer and winter forages eaten by caribou and muskoxen on Melville and other islands in the Queen Elizabeth Islands.

Data on the numbers, distribution, and movements of caribou and muskoxen on Melville Island included a 1961 aerial survey by Tener (1963), five aerial surveys in 1972-74 by Miller and Russell (1973, 1974, 1976), Miller et al. (1977a), several surveys by consulting firms after 1973 (Renewable Resources Consulting Services 1975, Slaney & Co. Ltd. 1975, Fischer & Duncan 1976, McLaren et al. 1977), and reconnaissance flights by Thomas et al. (1975, 1976, 1977) and Thomas and Joly (1981). Some information was available on movement patterns of caribou (Miller et al. 1977b) and muskoxen on Melville Island (Parker & Ross 1976, Miller et al. 1977a & 1977 b, McLaren et al. 1977).

1.2 **Terminology**

We sampled *range types* (Parker 1975), which we defined as units of the landscape with a characteristic assemblage and cover of plant species and geomorphological surface features associated with certain landforms, moisture regimes, drainage patterns, and topographies. The primary criterion was vegetation type and density, with emphasis on dominant species eaten by caribou and muskoxen. Boundaries were arbitrary in many locations because the vegetation graded gradually and uniformly from one type to another in response to gradual changes in moisture regime, topography, and substrate. There is little development of soils in the High Arctic and substrate often is referred to as parent material.

Factors that determine the flora change abruptly at some locations, resulting in distinct range-type boundaries. Where micro-topographic differences were great (e.g., seepage slopes, ice wedges, stripes, polygons, beach ridges), mosaics of vegetation types occurred and it was necessary to complex those types into range types characterized by geomorphological pattern. Examples were high- and low-center polygons and beach ridges.

Cover was the percentage of ground covered by aerial parts of plants, when viewed vertically, with multistory values added to yield cover over 100% at some sites and range types. Therefore, a three dimensional aspect is implicit in cover values. Percent cover in two dimensions can be derived by subtracting the percentages of bare ground and rocks from 100.

Standing crop was the oven-dried weight of above-ground vegetation, including stems of shrubs and excluding moss, crustose lichens, and algae.

Productivity was not estimated because it should be measured at the end of a growing season (Muc 1972), which varies among sites and years. It is the dry weight of annual growth above ground and is the key variable sought by range ecologists to calculate the "stocking rate" of herbivores. Standing crop of shrubs such as *Salix arctica* may be 50-100 times annual growth. Phytomass is always changing with new growth, death and curing of existing material (Svoboda 1972), and loss and decomposition of plant material. Central stems of some monocotyledons such as *Carex aquatilis* remain green all winter (Svoboda 1972) and are sought by herbivores because of relatively high protein (Nieminen & Heiskari 1989) and high digestibility (Thomas & Kroeger 1980). Cured parts of some species such as monocotyledons persists for several years (Svoboda 1972) and become important subsistence food for herbivores when green material is limited or is not available. Differences between productivity and standing crop not only varies with each species but also seasonally and among years.

A *fecal group*, was six or more individual pellets from caribou and muskoxen and judged to be from one defecation in autumn and winter or clumps of pellets ranging into amorphous masses (summer type). Names of plant species are after Porsild (1957), Porsild and Cody (1980), and Thompson (1984).

2.0 METHODS

2.1 Site selection

Selection of sites within the three study areas was based on the following criteria, general to specific:

1. Sites were selected to sample several of the *terrain units* delineated and described by Barnett et al. (1975), in their hierarchal terrain classification system for eastern Melville Island.
2. Terrain units were subdivided into smaller units based on tonal and surface-feature differences on 23 cm x 23 cm, ca. 1:60 000 scale, monochromatic air photos taken about 1960, in 50 cm x 50 cm enlargements of original negatives of the same imagery, or on 1:10 000, 1:5 000, and 1:2 000 color and color infrared strip mosaics obtained by CWS in 1973.
3. *Range types* were recognized in the field as rather uniform assemblages of vegetation characterized by one or more dominant species and by relatively uniform topography and moisture conditions. Those criteria differ only slightly from those used by Parker (1975) and suggested by Rowe in Lacate (1969).
4. Several sites were selected in areas where medium or large-scale photography in color or color infrared was obtained in 1973.
5. A few sites were selected where high densities of pellet groups were found or where muskoxen and caribou were observed in late winter 1974.

Within this framework, the sequence of sampling was south to north, Little Point to Sherard Bay, in keeping with latitudinal differences to plant phenology. Sites distant from camps were reached by tricycle all-terrain vehicles.

2.2 Sample design for vegetation cover

At a random location within a range type, a tent peg was tossed over a shoulder to locate the starting point and direction of a baseline, a 100 m plastic chain graduated in centimeters. The number of samples required (*N required*) to give the necessary precision (95% probability and 20% sampling error) was estimated for the major species of higher taxa, e.g., monocotyledons and lichens. We formulated the following guide for *N required* based on Wein et al.'s (1974) results and our calculations where statistics derived from visual estimates of percent cover of major species in sites 1-3 were substituted in the formula:

$N\ required = [(t_{.05})^2 s^2]/d^2$ where t is tabular student t for alpha = 0.05, s^2 is the variance, and d is 20% of the sample mean.

Number of quadrats (plots) required were approximately as follows:

Hydric and hydric/mesic range types (lowland meadows)	20
Mesic range types (e.g., upland meadows)	40
Mesic/xeric range types (e.g., *Salix*-lichen ridges)	80
Xeric range types (including polar desert)	120

Numbers 1-100, equal in number to estimated *N required*, were chosen from a random numbers table (Steel & Torrie 1960) and ranked. Those numbers gave the starting points for 25 m laterals at right angles to the baseline. Similarly, numbers 1-20 were obtained at random to give the location of plots on laterals. Laterals and plots were to the left for even numbers and to the right for odd numbers. To save time at a site, random numbers were obtained and recorded before setting out to sample vegetation. Once a plot was located, a 25 cm x 50 cm quadrat was placed on the ground and a paper bag, inscribed with site and plot number, was placed beside the quadrat. Then a vertical photograph of each quadrat and its plot number was taken at a distance of 90-100 cm (waist height) with a 35 mm single lens reflex camera equipped with a 55 mm lens and Ektachrome X color positive film.

Percent cover of all species in a plot was estimated visually and recorded on data sheets. Then, all above-ground vegetation in a plot, except crustose lichens, mosses, and litter was collected, placed in a numbered paper bag, and air dried in a net suspended under the roof of a heated tent or Parcoll for later analysis in the laboratory. A species list of all vegetation at each site was made, moisture status was evaluated subjectively, and we measured past use by caribou and muskoxen by counting fecal groups.

Some sites were sampled to estimate only percent cover by a *random throw* technique. A researcher wandered at random through a range type oblivious to the vegetation and cast quadrats behind and lateral at various distances until the required number of plots were photographed. This technique was used when time was limited and where a range type occupied a small area or it was highly irregular in distribution or when a complex of vegetation types occurred within a range type (e.g., low-center polygons).

2.3 Sample design for counting fecal groups

Most sites where vegetation was sampled were also surveyed to determine density of pellet groups defecated by muskoxen and caribou. Random numbers, appropriate to the 200-300 m length of the baseline, located several 100 m laterals. Those numbers were drawn and ranked in camp to save time at a site. Along the laterals, plot locations were at predetermined 25 m intervals after the first plot was located by random numbers, 1-25. Where sites contained a mosaic of two or three range types, each range type was noted beside each plot number and each type was sampled until it was judged that an adequate number of samples were obtained. Usually we sampled 25-50 plots in a given range type at each site but we had no way of estimating *N required* for pellet-group densities. According to Bell (1973), one plot per 16-18 ha should be sampled to ascertain relative use of habitats by ungulates.

A wood stake, 35 cm in length, with a nail projecting from its top was placed in the ground at the location of each plot. A steel tape with a steel terminal loop was placed over the nail and the ground was searched for caribou and muskox pellet groups in ever increasing radii to a maximum of 5 m. When the pellet group closest to the center stake was encountered, the center was marked with a second stake and nail combination and the distance to the center stake was recorded to the nearest centimeter (ND = nearest distance). Then a second stake, one for each ungulate species, became the center for a second search to find and record distance of the pellet group (of the same species) closest to it (NN = nearest neighbor), with a maximum radius of 5 m. Each pellet group was classified as winter or summer type based on morphology of its pellets. Pellets of the *winter type* (deposited about September-May) were individual entities of characteristic shape whereas *summer-type* (mid June-August) feces ranged from one or more amorphous masses to intermediate types. Intermediate types were masses of individual, mis-shaped pellets. Presumably they were produced in spring (late May-early June) and autumn (late August-early September) and were assigned to the summer period.

2.4 **Percent vegetation cover from photographs**

In the laboratory, developed positive film was viewed at 6x magnification with a stereo microscope equipped with a fine lined ocular grid (20 x 20 lines) and plant species at each grid intersection were recorded. Trials were conducted at the outset to determine how many intersections must be checked to provide an accurate ($\pm$ 5%) estimate of percent cover of major forage species in a plot. Mean percent cover values for several species were plotted against sample size, i.e., number of grid intersections examined. Sample size was adequate when the mean percent cover for a species stabilized. We found that 50-100 intersections must be examined, depending on type and distribution of the major species in a plot.

Mean percent cover estimates for sites obtained by the photographic method were compared with visual field estimates at the same site. It was not possible to compare results on a plot by plot basis because visual estimates and standing crop estimates were not always from the same plots (quadrats) at a site.

2.5 **Plant standing crop**

In the laboratory, plants from each plot were separated to species and oven dried for 1 day at 70° C. Relationships between standing crop and percent cover for major species or higher taxa of species were determined for sites, range types, and combinations of similar range types. Regression data were used to estimate the percent cover of major species at sites where photographs were overexposed because of a faulty camera setting.

2.6 **Calculation of fecal densities and season of deposition**

We calculated pellet group densities using formulae (**App. 1** from Bell 1973) developed by Batchelor (1973) and others. All densities were expressed as number of fecal groups per hectare. For each species, the "expected" number of winter pellet groups was 0.75 (9/12 months) times the number of fecal groups observed (counted) in each range type. Observed and expected numbers of pellet groups at each season were compared for significance with a chi-square test. Use of observed numbers is preferable to use of densities, which are classed as indices or ratio values.

2.7 **Statistical analyses**

Raw data were used for the relationship between percent cover and standing crop of vegetation because it produced linear results. For other statistical tests, distributions were examined by normal probability plots and, if non linear, various transformations were performed until the best linear fit was obtained for the majority of species. Natural logs produced the best fit and were better than arc sine for percent cover.

The relationships between fecal densities and plant cover and standing crop of vegetation were examined with correlation and regression analyses using natural log transformed data. Inclusion or exclusion of zeros had a large influence on the results. In extreme cases, a positive correlation containing several zeros became a negative one when zeros were excluded and the converse.

Stepwise multiple regression was employed to explore relationships between more than one plant species and fecal densities in winter, summer, and both seasons. Plant species with t values >2.0 and low probabilities were worked in and out of normal multiple regression until the highest adjusted regression coefficient and the lowest overall probability were obtained. Probabilities for each species change, sometimes considerably, as different plant species are entered in a multiple regression. That is why stepwise regressions may not select the best mix of plant species. Our results include constants, which generally were near zero. Where they were high, their removal produced high R, R^2, adjusted R^2 values, and probabilities.

Removal of the constant forces the line through the origin, which may make biological sense unless threshold amounts of vegetation are required before a herbivore will use a site to forage on a plant species. Such statistics are not real and must be viewed with caution (Wilkinson et al. 1992). Our analyses confirmed the importance of examining all distributions in correlations and residuals in regressions. They also demonstrated the profound influence of zeros, which has the effect of forcing the line through the origin similar to omitting the constant in regressions.

3.0 RESULTS

3.1 Range types

The three study regions on eastern Melville Island were located at Little Point, Sabine Bay, and Sherard Bay (**Figs. 3-5**). Coordinates of each site, sampling dates, range types, and site data on visual cover, photo cover, standing crop, and density of pellet groups are in **Table 1**.

We grouped the 36 sites, for which we had quantitative data, into 11 range types and added five others which we described but did not sample (**Table 2**). Criteria for classification of range types were: (1) cover and standing crop of plant species or species groups, (2) general appearance (physiognomy), (3) moisture evaluation, and (4) topography and micro-topography. In the field, we sampled a variety of sites based on obvious differences, grouped some of these in the field on the basis of obvious similarities, and did the final discrimination objectively using cover and standing crop data. General descriptions of range types are in **App. 2**.

3.2 Plant cover and standing crop and relationships between them

Percent cover (**Tables 3 & 4, App. 3 & 4**) was estimated (1) by the photographic method (24 sites including 11 where standing crop was also measured), (2) by conversion of standing crop data to percent cover values (11 sites) using mean ratios obtained from sites where percent cover and standing crop were obtained (**Table 5, App. 5-8**), and (3) by adjusting visual estimates by correction factors (**Table 6**) obtained by comparing visual estimates to values obtained by the photo

Figure 3

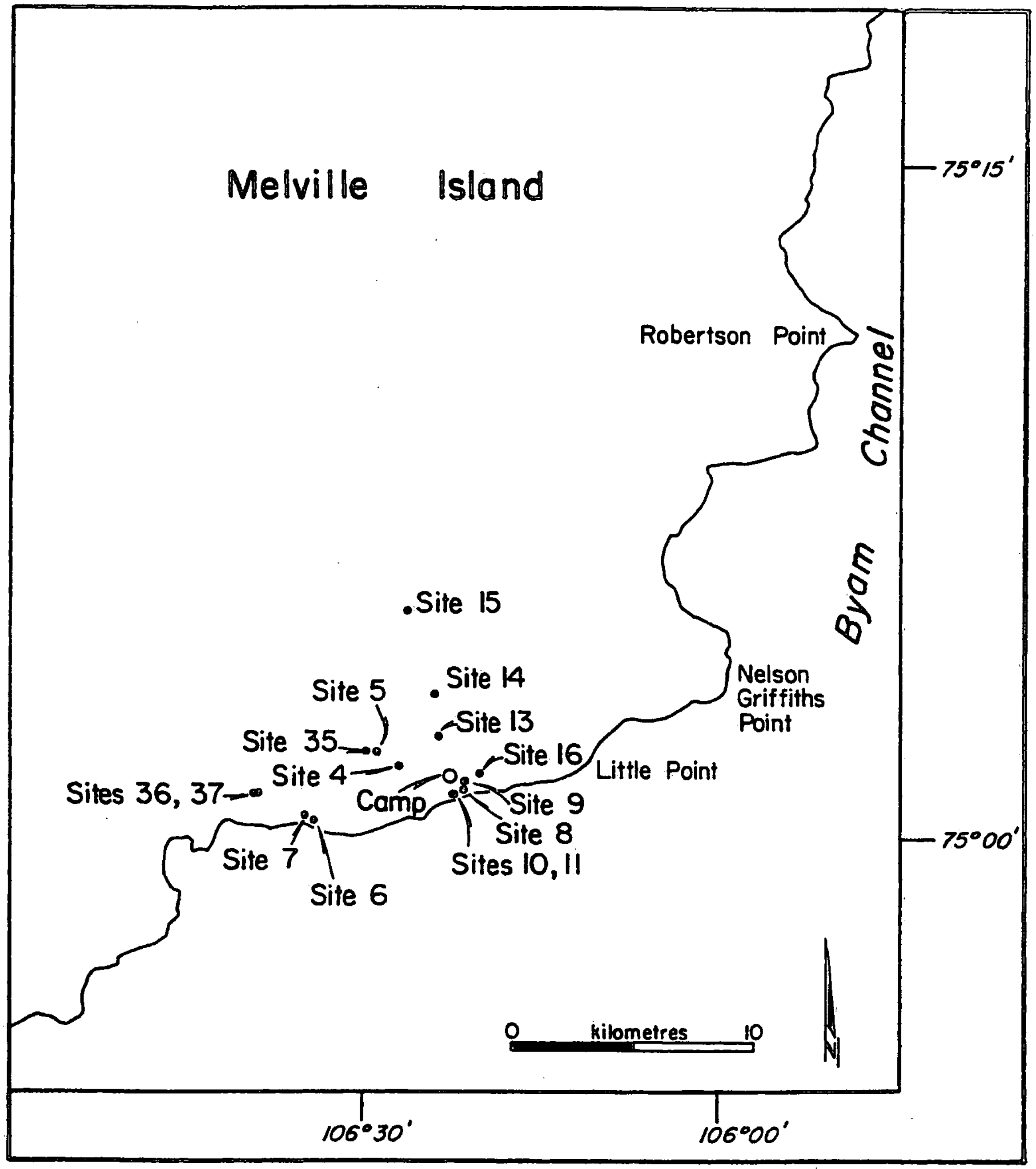


Figure 3. Location of sites sampled at Little Point, Melville Island, Northwest Territories.

Figure 4

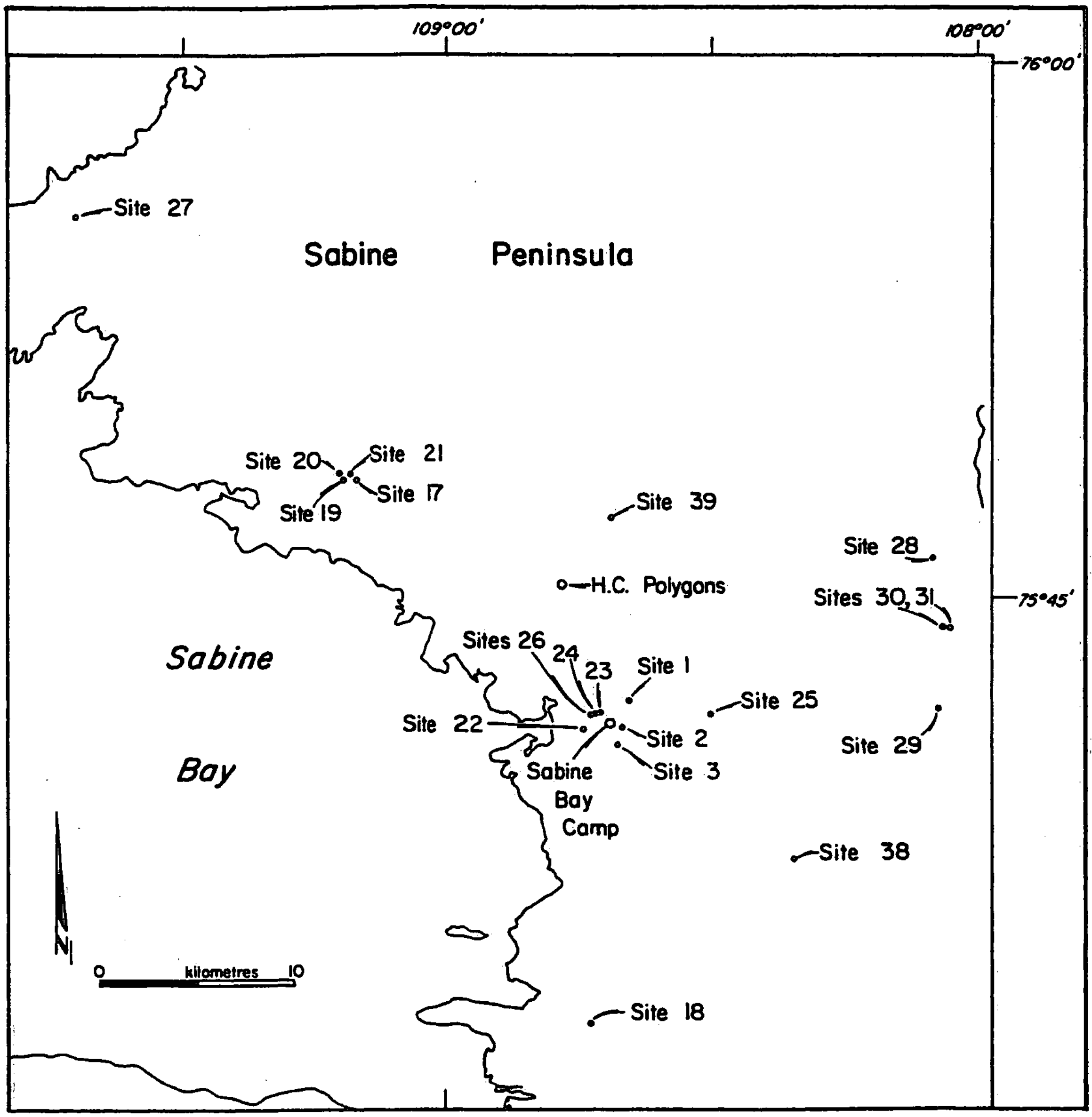


Figure 4. Location of sites sampled at Sabine Bay, Melville Island, Northwest Territories.

Figure 5

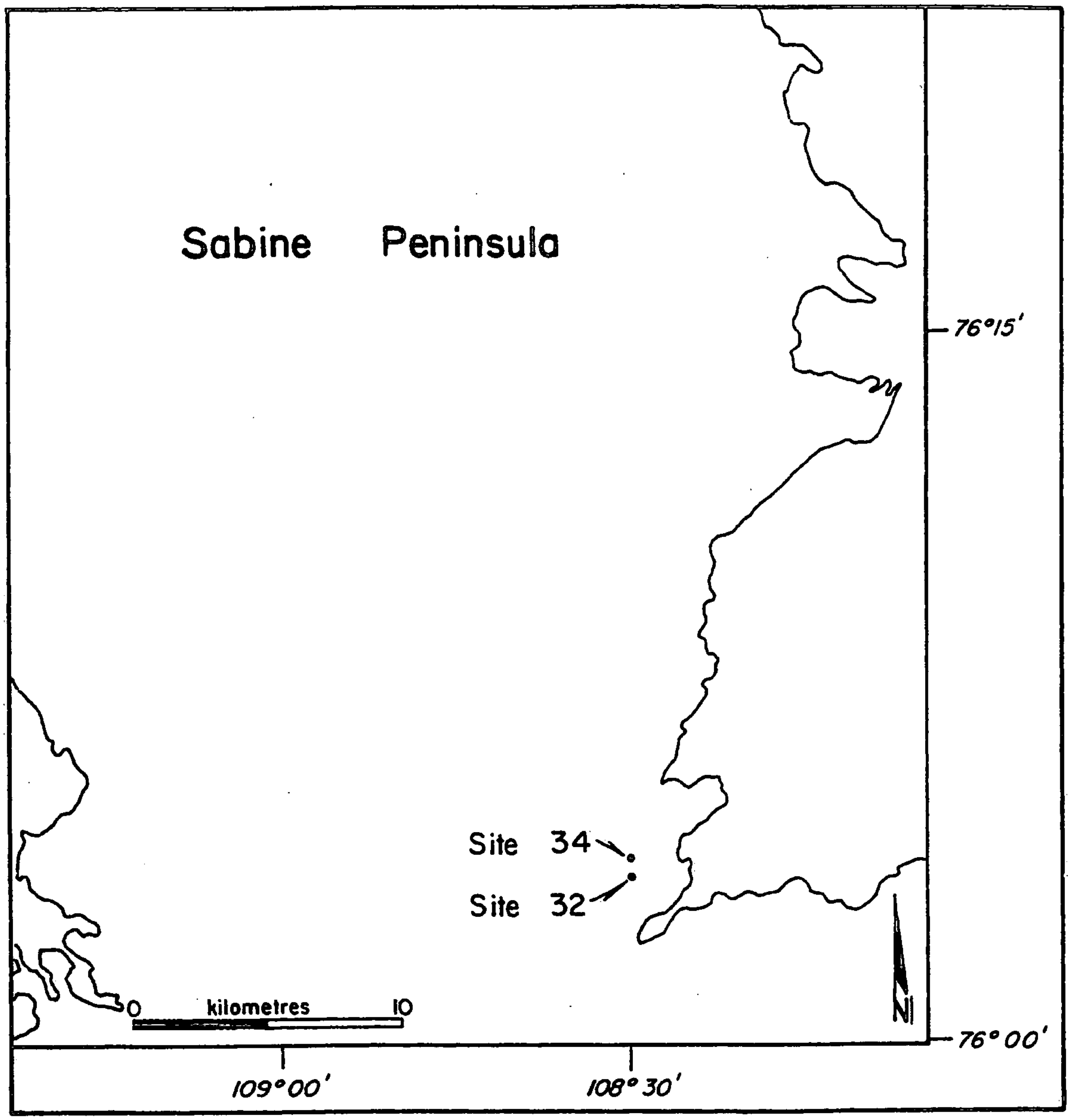


Figure 5. Location of sites sampled at Sherard Bay, Melville Island, Northwest Territories.

Table 1. A summary of data collected on eastern Melville Island, July-August 1974, including number of plots sampled for visual and photographic cover, biomass, and fecal densities.

Site no.	Date	Study region	Lat. North	Long. West	Range type	Visual cover	Photo cover	Biomass (g/m^2)	Fecal counts
1	24 July	Sabine Bay	75 42	108 40	*Salix*-Lichen Ridge	80	(80)[1]	60	38
2	25 July	Sabine Bay	75 41	108 41	Wet Meadow: Sedge-*Salix* Subtype	20	(40)[1]	20	20
3	26 July	Sabine Bay	75 41	108 42	*Luzula* Tussocks	30	30	29	52
4	28 July	Little Point	75 02	106 27	*Salix-Dryas*-Lichen Ridge	40	(40)[2]	40	32
5	28 July	Little Point	75 02	106 30	*Luzula* Tussocks	10	(10)[2]		
6	29 July	Little Point	75 00	106 34	Wet Meadow: Sedge Subtype	20	20	20	25
7A	30 July	Little Point	75 01	106 35	Luzula Tussocks	50	45	50	23
7B	30 July	Little Point	75 01	106 35	Grass-*Salix* Slope				
8A	31 July	Little Point	75 01	106 22	Wet Meadow: Sedge Subtype	20	20	20	50
8B	31 July	Little Point	75 01	106 22	*Salix*-Lichen Ridge				
9	31 July	Little Point	75 01	106 22	*Sax. oppositifolia-Salix* Ridge	80	78	76	40
10	1 Aug	Little Point	75 01	106 23	*Salix*-Lichen Ridge		18		
13	1 Aug	Little Point	75 02	106 24	Grass-*Salix* Slope		30		
14	1 Aug	Little Point	75 03	106 24	Wet Meadow: Sedge-*Dupontia*		18		
15	1 Aug	Little Point	75 03	106 27	Grass-*Salix* Slope		19		
16	2 Aug	Little Point	75 02	106 21	Grass-*Salix* Slope	50	46	49	56
17	6 Aug	Sabine Bay	75 47	109 10	Grass-*Luzula* Plain	30	(30)[2]	30	
18	7 Aug	Sabine Bay	75 33	108 44	Wet Meadow: *Dupontia* Subtype	15	15	14	
19	8 Aug	Sabine Bay	75 46	109 13	Low-Centre Polygon: Center	15	(15)[2]	15	8
20	8 Aug	Sabine Bay	75 46	109 13	Low-Centre Polygon: Ridge	20	(20)[2]	20	22

Site no.	Date	Study region	Lat. North	Long. West	Range type	Visual cover	Photo cover	Biomass (g/m^2)	Fecal counts
21	8 Aug	Sabine Bay	75 46	109 11	Grass-*Luzula* Plain	25	(25)[2]	25	21
22	9 Aug	Sabine Bay	75 41	108 45	Wet Meadow: Sedge-*Salix* Subtype	20	(20)[2]	18	
23	14 Aug	Sabine Bay	75 41	108 43	*Salix-Dryas*-Lichen Ridge	75	65	72	40
24	18 Aug	Sabine Bay	75 41	108 43	*Salix*-Lichen Ridge	30	27	30	40
25	9Aug	Sabine Bay	75 42	108 32	Wet Meadow: Sedge-*Salix* Subtype		20	25	41
26	20 Aug	Sabine Bay	75 41	108 43	Wet Meadow: Sedge-*Dupontia*	20	(20)[2]	20	40
27	21 Aug	Sabine Bay	75 55	109 43	Grass-*Luzula*-Lichen Plain	20	(20)[2]	20	
28	20 Aug	Sabine Bay	75 46	108 07	*Luzula*-Lichen Slope and Crest		30		
29	21 Aug	Sabine Bay	75 42	108 06	*Luzula*-Lichen Slope and Crest		40		
30	22 Aug	Sabine Bay	75 44	108 05	*Luzula*-Lichen Slope and Crest		39	34	40
31	22 Aug	Sabine Bay	75 44	108 05	*Luzula*-Lichen Slope and Crest		30		
32	25 Aug	Sherard Bay	76 04	108 28	Grass-*Luzula* Plain		(8)[2]	36	20
34	25 Aug	Sherard Bay	76 04	108 28	Sparse, Grass-*Luzula* Plain		15		20
35	1 Aug	Little Point	75 02	106 30	*Luzula* Tussocks		30		
36	1 Aug	Little Point	75 01	106 39	Wet Meadow: Sedge-*Salix* Subtype		20		
37	1 Aug	Little Point	75 01	106 39	Wet Meadow: Sedge Subtype		20		
38	14 Aug	Sabine Bay	75 37	108 22	Grass-*Salix* Slope		30		
39	15 Aug	Sabine Bay	75 47	108 42	Wet Meadow: Sedge-*Salix* Subtype		30		
2a	15 Aug	Sabine Bay	75 41	108 41	Wet meadow: Sedge-*Salix* Subtype	20	20	20	
23a	19 Aug	Sabine Bay	75 41	108 43	*Salix-Dryas*-Lichen Ridge		24		40

[1] Photographs lost and not used to estimate cover.
[2] Photographs overexposed and not used to estimate cover.

Table 2. Range types and subtypes recognized on three study areas on eastern Melville Island, summer 1974, including site numbers, moisture evaluation, topography, and elevation.

Range type	Site numbers	Surface moisture	Topography	Elevation (m asl)[1]
1. Wet Meadow:				
1.1 *Dupontia*	18	hydric	flat	30
1.2 Sedge-*Dupontia*	14,26	hydric	flat	24, 9
1.3 Sedge	6,8A,37	hydric	flat	5, 5, 6
1.4 Sedge-*Salix*	2,22,25,36,39	hydric-mesic	flat to 0.5 m	6,6,12,6,105
2. Low-Center Polygons				
2.1 Center	19	hydric	flat to 1 m[2]	24
2.2 Ridge	20	mesic	flat to 1 m[2]	24
3. Grass-*Luzula*-Lichen Plain[3]	27	mesic-hydric		30
4. Grass-*Luzula* Plain[3]	17,21,32	mesic	<10%	29, 29, 15
5. Grass-*Salix* Slope	7B,13,15, 16,38	mesic	gentle	36, 24, 29, 27, 60
6. *Luzula*-Lichen Slope & Crest	28,29,30 31	mesic	flat to gentle slope	70, 125, 185, 175
7. *Luzula* Tussock Meadow	3,5,7A,35	mesic-xeric	flat to gentle slope	6,66,36,66
8. Sparse Grass-*Luzula* Plain	34	mesic-xeric	flat to gentle slope	9
9. *Salix*-Lichen Ridge	1,8B,10,24	xeric-mesic	flat to gentle slope	23, 5, 6, 11
10. *Salix-Dryas*-Lichen Ridge	4,23	xeric-mesic	gentle to 10-20% slope	27, 12
11. *Salix*-Saxifrage Ridge	9	xeric	flat-gentle slope	27
12. High-Center Polygons		variable	micro-relief to 2 m	
13. Felsenmeer		variable	flat-moderate	
14. *Salix* Flat		xeric-mesic	gentle slope	
15. Barrens		xeric	variable	
16. Not Vegetated		xeric	variable	

[1] Meters above sea level, in order of site number.
[2] Approximate average vertical distance from center to top of ridge.
[3] Range type 3 was omitted and range type 4 was combined with range type 8 in Thomas & Edmonds (1984).

Table 3. Average percent cover, obtained photographically, of plant species and species groups in wet meadow range subtypes on eastern Melville Island, summer 1974. Species-specific data for each site are in App. 3.

Plant species & (sample size)	**Range subtype (top row) and site number (below)**				
	1.1	1.2	1.3	1.4	All = 1[1]
	18	14, 26	6, 8A, 37	2,22,25, 36,39	All
Salix arctica		1.8	0.6	4.5	1.7
Dryas integrifolia				1.0	0.3
Cassiope tetragona				0.7	0.2
Sedges	1.1	38.3	59.7	42.5	35.4
Rushes	0.3	1.4	0.5	0.5	0.7
Grasses	67.5	12.7	2.5	2.0	21.2
Lichens (except crustose)		0.6	0.1	1.1	0.5
Saxifraga oppositifolia				0.1	Trace
Forbs	0.3	0.8	1.2	0.4	0.7
Mosses	92.1	83.4	90.9	74.7	85.3
Crustose lichens		0.2	2.2	2.2	1.2
Total plant cover	161.4	135.9	157.4	129.1	146.0
Bare ground/water		16.5	18.2	5.6	10.1
Shrubs		1.8	0.6	6.2	2.2
Monocotyledons	69.0	49.5	62.7	44.9	56.5
Vasculars + lichens	69.3	52.4	64.5	52.2	59.6
(Number of quadrats)	15	38	60	110	223
(Number of sites)	1	2	3	5	11

[1] Unweighted average for the four sub-types.

Table 4. Average percent cover, obtained photographically, of plant species and species groups in 11 range types sampled on eastern Melville Island, summer 1974. Species-specific data for each site are in App. 3 and 4.

Plant species (sample size)	**Range type**										
	1	2	3	4	5	6	7	8	9	10	11
Salix arctica	1.7	1.7		1.6	14.6	1.0			15.4	11.5	11.5
Dryas integrifolia	0.3				Trace				0.4	3.3	2.3
Cassiope tetragona	0.2				Trace	0.4			0.1	0.3	
Sedges	35.4		0.3	0.5	2.3	Trace	Trace		1.3	0.1	
Rushes	0.7	4.3	8.4	11.9	10.1	17.9	25.6	20.6	2.7	2.0	0.1
Grasses	21.2	5.6	10.9	11.7	5.3	2.1	2.1	10.0	1.9	0.4	0.2
Lichens (not crustose)	0.5	0.6	3.2	1.7	1.5	3.5	0.1	3.0	5.1	4.0	0.9
Saxifraga oppositifolia	Trace	0.3		0.4	1.3	0.3			0.1	0.1	4.3
Forbs	0.7	0.8	0.2	2.6	2.1	2.1	0.8	0.2	2.0	1.5	0.8
Mosses	85.3	86.7	69.0	48.5	59.4	61.3	81.4	94.8	26.0	18.8	11.2
Crustose lichens	1.2			16.8	18.3	20.1	18.1	0.2	35.4	40.6	22.0
Total plant cover	146.0	99.9	92.0	95.7	116.5	108.7	130.9	157.7	90.4	82.6	53.3
Bare ground/water	10.1	12.2			7.2	5.2		3.9	18.2	24.1	50.8
Shrubs	2.2	1.7		1.6	14.7	1.4			15.9	15.0	13.8
Monocotyledons	56.5	9.9	19.6	24.1	17.7	20.0	27.7	30.6	5.9	2.5	0.3
Vascular + lichens	59.6	13.2	23.0	13.6	38.8	27.3	28.6	33.8	29.0	22.4	20.1
(Number of quadrats)	223	50	20	63	179	133	70	15	128	115	80
(Number of sites)	11	2	1	3	5	4	3	1	3	2	1

Table 5. Factors used to convert percent cover to standing crop (g/m^2), and vice versa, based on mean ratios at sites where cover was obtained photographically (App. 5-8).

Plant species	Site numbers	Conversion factors	
		Cover (%) to standing crop	Standing crop to % cover
Salix arctica	7, 9, 16, 23, 24, 25	1.71	0.58
Dryas integrifolia	9, 25	2.80	0.36
Cassiope tetragona	25	9.54	0.10
Carex aquatilis	6, 25	1.04	0.96
Eriophorum spp.	6	0.76	1.32
Luzula spp.	3, 7, 16, 24[1]	1.24	0.81
Arctagrostis+Alopecurus	7, 24	1.29	0.78
Dupontia Fisheri	18	0.52	1.92
Thamnolia vermicularis	7, 23, 24	2.32	0.43
Cetraria spp.	23, 24, 30	3.48	0.29
All lichens[2]	7, 16, 23, 24, 30	2.71	0.37
Saxifraga oppositifolia	3, 9, 16	4.88	0.20
Forbs[3]	3, 9, 16, 23, 24	1.85	0.54

[1] Omitted site 30 because the mean was far removed from others for unknown reasons.
[2] Except crustose lichens.
[3] Excluding *S. oppositifolia*, which is included in the forb class by some authors.

Table 6. Degree by which percent cover of plant species was underestimated visually assuming that the photo method was accurate.

Plant species	Number of sites	Ocular estimate as % of photo estimate		Conversion factor, visual to photo
		Mean	Range	
Salix arctica	6	69	58-90	1.5
Dryas integrifolia	1	52		1.9
Carex aquatilis	1	65		1.5
Eriophorum Scheuchzeri	1	18		5.5
E. triste	1	35		2.9
Luzula spp.	4	39	24-53	2.6
Arctagrostis latifolia	2	32	15-50	3.1
Alopecurus alpinus	1	33		3.0
Poa spp.	1	62		1.6
Dupontia Fisheri	1	8		13.0
Monocotyledons	1	28		3.6
Thamnolia vermicularis	3	25	12-40	4.5
Cetraria deliseii	1	63		1.5
Saxifraga oppositifolia	3	66	52-81	1.4
Oxyria digyna	2	52	43-60	2.1

method (1 site). Visual cover estimates of all tested species were low, assuming that the photographic method was accurate. Those relationships were supported by a comparison of visual percent cover and cover values obtained by converting standing crop data to percent cover (**Table 7, App. 8**) using conversion factors (**Table 5**). Only forbs were overestimated in cover by visual procedures.

We obtained oven-dry-weight standing crop data (1) by collecting all above-ground vegetation except mosses, crustose lichens, and algae from plots at 22 sites (**Table 8 & 9, App. 9**) and (2) by calculating the amount of standing crop (**Table 10)** from percent cover data obtained by the photographic method (**Table 3 & 4, App. 3**) using cover/standing crop ratios (**Table 5**). Standing crop obtained by clipping vegetation (**Tables 8 & 9, App. 9**) was pooled with estimates of standing crop from percent cover (**Table 10, App. 10 & 11**) to yield standing crop estimates for all 36 sites (**Tables 11 & 12**, **App. 12**).

Cover of moss and standing crop of major plant groups for 11 range types are illustrated (**Fig. 6**). In this figure, and **Fig. 7-12**, the sequence is from wettest in upper left panel to the driest in the lower right panel. Moss abundance generally decreased with decreasing moisture, whereas *Saxifraga oppositifolia* was abundant only in the driest range type. Forbs, shrubs, and lichens occurred in all moisture classes. Standing crop of monocotyledons was dominated by sedge in the wet range type, whereas standing crop of grasses generally declined with decreasing moisture and standing crop of rushes increased with increasing moisture and then decreased (**Fig. 7**). Of the three shrub species, *Salix arctica* grew under all moisture conditions, whereas *Dryas integrifolia* grew best in xeric conditions (**Fig. 8**). Among the most abundant sedges, *Carex aquatilis* grew only in wet areas, whereas *C. misandra* and *Eriophorum* spp. also grew in mesic range types (**Fig. 9**). The grass *Dupontia Fisheri* only occurred where there was or had been standing water, whereas *Arctagrostis latifolia* grew best in mesic types, *Poa* spp. in all moisture classes, and *Puccinellia* spp. in mesic-xeric moisture conditions (**Fig. 10**). Among the most common lichens, *Peltigera* spp. occurred in hydric-mesic range types, whereas the other four species in **Figure 11** occurred in mesic to xerix sites.

Table 7. Visual estimates of percent cover as percentages of cover estimated from standing crop using photo cover/standing crop (g/m^2) ratios at other sites (Table 5).

	Visual cover as % of cover estimated from standing crop										
	Site number										
Plant species	**1**	**2**	**4**	**17**	**19**	**20**	**21**	**22**	**26**	**27**	**Mean 1**
Salix arctica	68	93	90	95		64	149	138	108		101
Dryas integrifolia			57								57
Cassiope tetrag.	106										106
Carex spp.	30	43						36	29		35
Eriophorum spp.		43					25	23	30		30
Luzula spp.	75	108	103		61	39	42	49	45	19	58
Arctagro.+Alo.[2]	72	20	20	22	34	52	39	26	41	50	38
Poa spp.			115	59							87
Dupontia Fisheri		5						50	14	101	52
Thamnolia verm.	31	6	78	62			101	54	27		51
Cetraria spp.	70		15			125					70
S. oppositifolia				75	133		100				103
Forbs							185	132			159
Ranunculus spp.		231			400		285	617			383
Papaver radicat.	60		25		300						128
Draba spp.	45				250		222	926			361
Oxyria digyna	360		230								295
Potentilla spp.			180				202				191
Stellaria longipes	30		150		100		195	195		542	202

[1] Mean for sites containing that species.
[2] *Arctragro.* = *Arctragrostis* sp. & *Alo.* = *Alopecurus* sp.
An example of calculations to obtain values in this table: in site 1, average cover of *Salix arctica* was estimated visually as 10%. The cover estimate based on standing crop was 14.7% (25.26 g/m^2 x 0.58, Table 5). Then 10/14.7 = 0.68.

Table 8. Average clipped standing crop (g/m²) of major plant species and species groups in sampled quadrats in wet meadow range subtypes on eastern Melville Island, summer 1974. Species-specific data for each site are in App. 9.

Plant species (sample size)	**Standing crop (g/m²)** in range type (top shaded row) & site number (2nd shaded row)				
	1.1	1.2	1.3	1.4	All 1[1]
	18	26	6, 8A	2, 22, 25	All
Salix arctica		7.1	1.1	7.4	3.9
Dryas integrifolia				2.7	0.7
Cassiope tetragona				8.1	2.0
Sedges	0.2	39.9	38.4	37.0	28.9
Rushes	0.6	0.3	0.7	0.7	0.6
Grasses	34.0	6.2	2.5	2.0	11.2
Lichens[2]	0.5	2.7	0.7	1.8	1.4
Saxifraga oppositifolia				T[3]	T
Forbs	T[3]	0.2	1.0	0.4	0.4
Vasculars + lichens	35.4	56.3	44.5	60.2	49.1
Shrubs		7.1	1.1	18.2	6.6
Monocotyledons	34.8	46.4	41.7	39.7	40.7
(Number of plots)	14	20	40	63	137
(Number of sites)	1	1	2	3	7

[1] Unweighted average for the four sub-types. Grouping is not justified statistically for some plant groups because of large differences within the wet meadow subgroups.
[2] Excluding crustose lichens.
[3] T = trace = <0.05 g/m².

Table 9. Average standing crop (g/m²) of major plant species and species groups obtained by clipping vegetation at 22 sites in 10 range types on eastern Melville Island, summer 1974. Species-specific data are in App. 9.

Plant species (sample size)	**Standing crop (g/m²) in range type (top shaded row) and site number (2nd shaded row)**									
	1	2	3	4	5	6	7	9	10	11
	Table 8	19, 20	27	17, 21, 32	7, 16	30	3	1, 24	4, 23	9
Salix arctica	3.9	2.9		2.7	14.7			28.9	23.3	21.7
Dryas integrifolia	0.7				2.2			1.8	19.8	4.8
Cassiope tetragona	2.0							1.1	1.8	
Sedges	28.9			0.4	1.0			0.1	Trace	
Rushes	0.6	5.3	10.3	14.6	26.8	60.6	48.4	2.6	2.3	0.1
Grasses	11.2	7.1	14.4	15.1	2.8	0.7	1.4	2.1	0.4	0.5
Lichens (not crustose)	1.4	1.7	11.9	4.8	4.4	5.8	0.7	14.3	13.0	1.0
Saxifraga oppositifolia	Trace	1.6		1.8	8.1		8.4	0.5	0.4	37.7
Forbs	0.4	1.3	0.3	4.9	2.2	1.3	10.6	2.5	3.0	4.1
Vasculars + lichens	49.1	20.0	36.9	44.2	47.9	68.3	69.4	53.9	64.0	69.8
Shrubs	6.6	2.9		2.7	17.0			31.7	44.9	26.5
Monocotyledons	40.7	12.5	24.8	30.1	16.3	61.2	49.8	4.8	2.7	0.5
(Number of plots)	137	35	20	91	99	34	29	90	112	76
(Number of sites)	7	2	1	3	2	1	1	2	2	1

Table 10. Average standing crop (g/m^2) of major plant species and species groups in range types on eastern Melville Island, summer 1974, calculated from percent cover (photo method, Table 3, App. 10) using percent photo cover/ standing crop ratios where cover was estimated photographically (Table 5).

Plant species (sample size)	Standing crop (g/m^2) in range type (top shaded row) and site number (2nd shaded row)								
	1.2	1.3	1.4	All 1[1]	5	6	7	8	9
	14	37	36, 39		13,15,38	28,29,31	5, 35	34	10
Salix arctica	0.0	1.2	9.8	3.7	28.2	2.2	0.0	0.0	20.6
Cassiope tetragona	0.0	0.0	0.0	0.0	0.4	5.4	0.0	0.0	0.0
Sedges	34.2	74.8	43.2	50.7	2.2	Trace	Trace	0.0	4.4
Rushes	3.2	0.0	0.4	1.2	10.6	23.2	24.7	25.5	4.6
Grasses	7.9	0.4	1.1	3.13	7.7	2.7	3.0	12.9	0.0
Lichens (not crustose)	0.0	0.0	1.3	0.4	3.1	9.4	6.0	0.2	4.2
Saxifraga oppositifolia	0.0	0.0	1.2	0.4	0.0	4.7	0.4	0.0	0.0
Forbs	2.5	0.4	1.1	1.3	4.1	4.5	7.9	1.5	6.8
Vasculars + lichens	47.8	76.8	57.8	60.8	56.2	52.1	41.9	40.1	40.6
Shrubs	0.0	1.2	9.8	3.7	28.6	7.6	0.0	0.0	20.6
Monocotyledons	45.3	75.2	44.6	55.0	20.4	25.9	27.7	38.4	9.0
(Number of plots)	18	20	50	88	79	100	40	15	18
(Number of sites)	1	1	2	4	3	3	2	1	1

[1] Unweighted average of the three subtypes is not valid statistically for some species and species groups.

Table 11. Average standing crop of plant species and species groups in wet meadow range subtypes on eastern Melville Island, summer 1974, pooling data for weighed standing crop (Table 9) and standing crop estimated from percent cover (Table 10).

Plant species (sample size)	**Standing crop (g/m²) in wet meadow range sub-types**				
	1.1	1.2	1.3	1.4	All 1[1]
Salix arctica		3.5	1.1	8.4	3.3
Dryas integrifolia				1.6	0.4
Cassiope tetragona				4.9	1.2
Sedges	0.2	37.1	50.6	39.5	31.8
Rushes	0.6	1.7	0.5	0.6	0.9
Grasses	34.0	7.1	1.8	1.6	11.1
Lichens (not crustose)	0.5	1.4	0.5	1.6	1.0
Saxifraga oppositifolia				0.5	0.1
Forbs	Trace	1.3	0.8	0.7	0.7
Vasculars + lichens	35.4	52.1	55.3	59.2	50.5
Shrubs		3.5	1.1	14.8	4.9
Monocotyledons	34.8	45.9	52.9	41.7	43.8
(Number of plots)	14	38	60	113	225
(Number of sites)	1	2	3	5	11

[1] Unweighted average for the four subtypes. Grouping is not justified statistically for some plant groups because of large differences within the wet meadow subgroups.

Table 12. Average standing crop (g/m^2) of major plant species and species groups in 11 range types on eastern Melville Island, summer 1974, pooling data for weighed standing crop (Table 9) and standing crop estimated from percent cover (Table 10).

Plant species (sample size)	**Standing crop (g/m^2) in range type:**										
	1	2	3	4	5	6	7	8	9	10	11
Salix arctica	3.3	2.9		2.7	22.8	1.7			26.1	23.3	21.7
Dryas integrifolia	0.7				0.9				1.8	19.8	4.8
Cassiope tetragona	1.2				0.2	4.1			0.7	1.8	
Sedges	31.8			0.4	1.7				1.6		
Rushes	0.9	5.3	10.3	14.6	17.1	32.5	32.6	25.5	3.3	2.3	0.1
Grasses	11.1	7.1	14.4	15.1	5.7	2.2	2.5	12.9	1.4	0.4	0.5
Lichens (not crustose)	1.0	1.7	11.9	4.8	3.6	8.5	4.2	0.2	10.9	13.0	1.0
Saxifraga oppositifolia	0.1	1.6		1.8	3.2	3.6	3.0		0.4	0.4	37.7
Forbs	0.7	1.3	0.3	4.9	3.3	3.7	8.8	1.5	4.0	3.0	4.1
Vasculars + lichens	50.5	20.0	36.9	44.2	52.9	56.1	51.0	40.1	49.5	64.0	69.8
Shrubs	4.9	2.9		2.7	23.9	5.7			28.0	44.9	26.5
Monocotyledons	43.8	12.5	24.8	30.1	18.8	34.8	35.1	38.4	6.2	2.7	0.5
(Number of plots)	225	35	20	91	178	134	69	15	108	112	76
(Number of sites)	11	2	1	3	5	4	3	1	3	2	1

Note: Shaded columns are range types where pooling occurred.

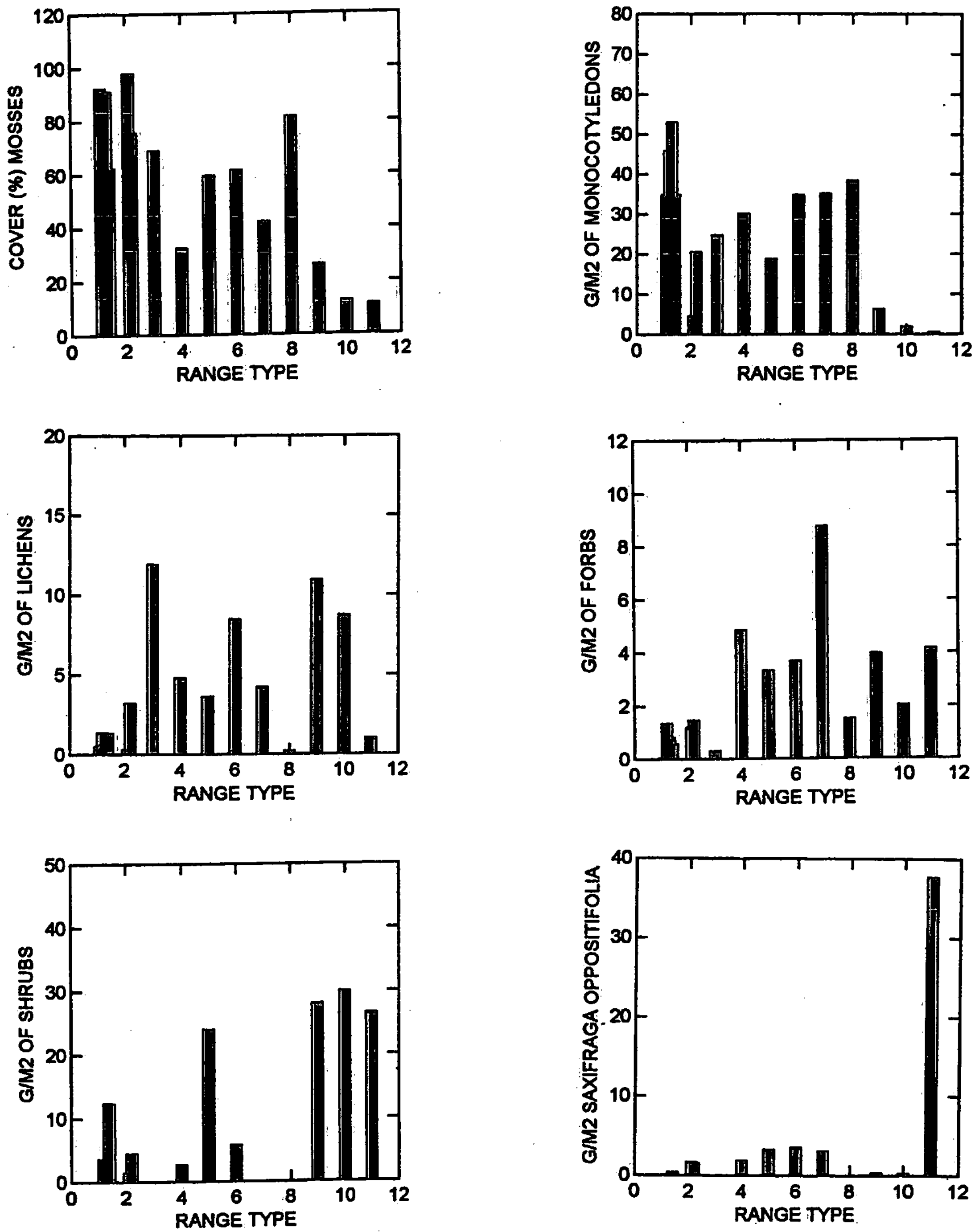


Figure 6. Percent cover of mosses and standing crop of monocotyledons, lichens, forbs, shrubs, and *Saxifraga oppositifolia* in 11 range types sampled on eastern Melville Island in 1974. As in Fig. 7-12, site moisture conditions were progressively drier from left to right within each panel.

Figure 7

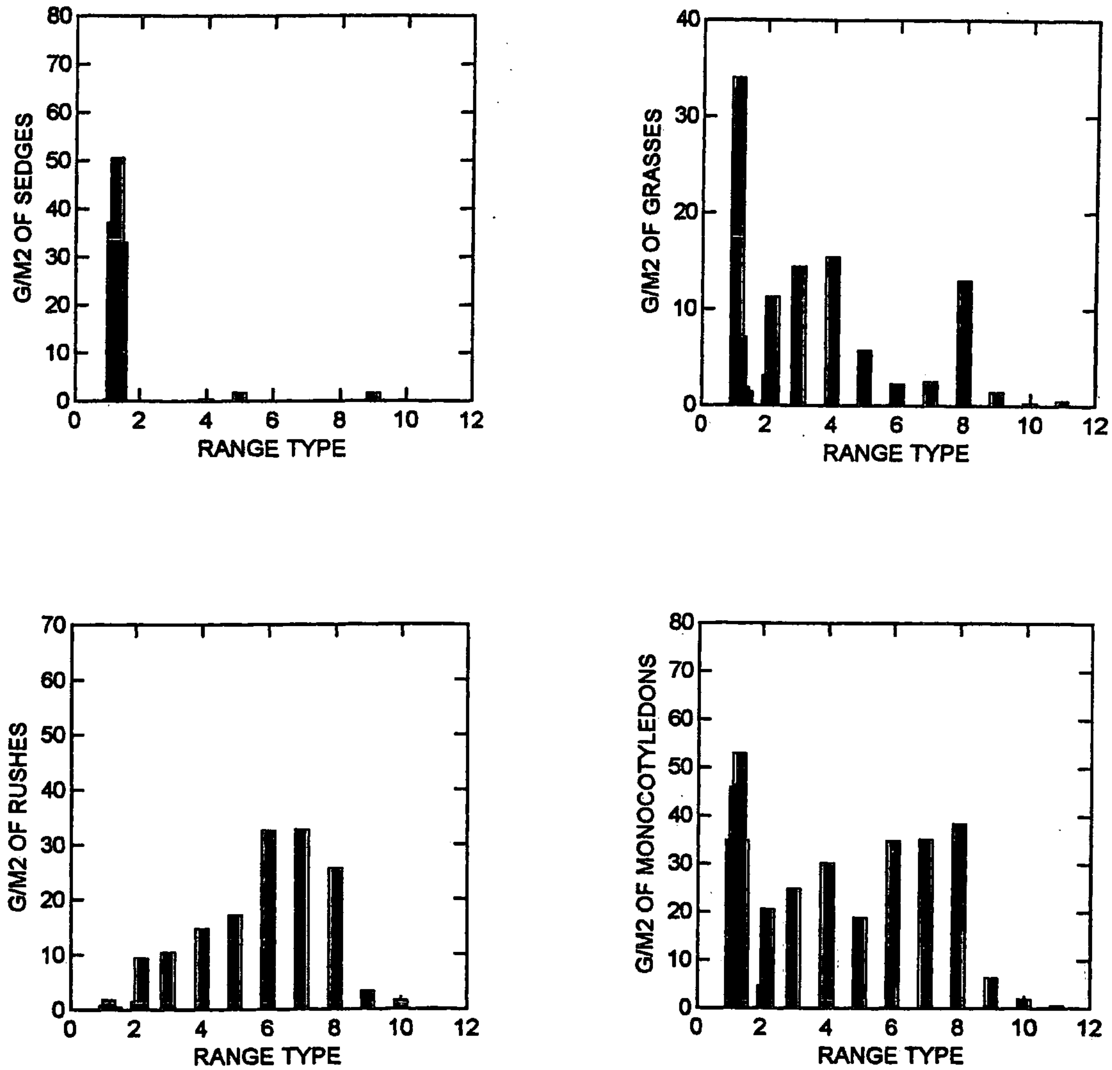


Figure 7. Standing crop of sedges, grasses, rushes, and all monocotyledons in 11 range types on eastern Melville Island.

Figure 8

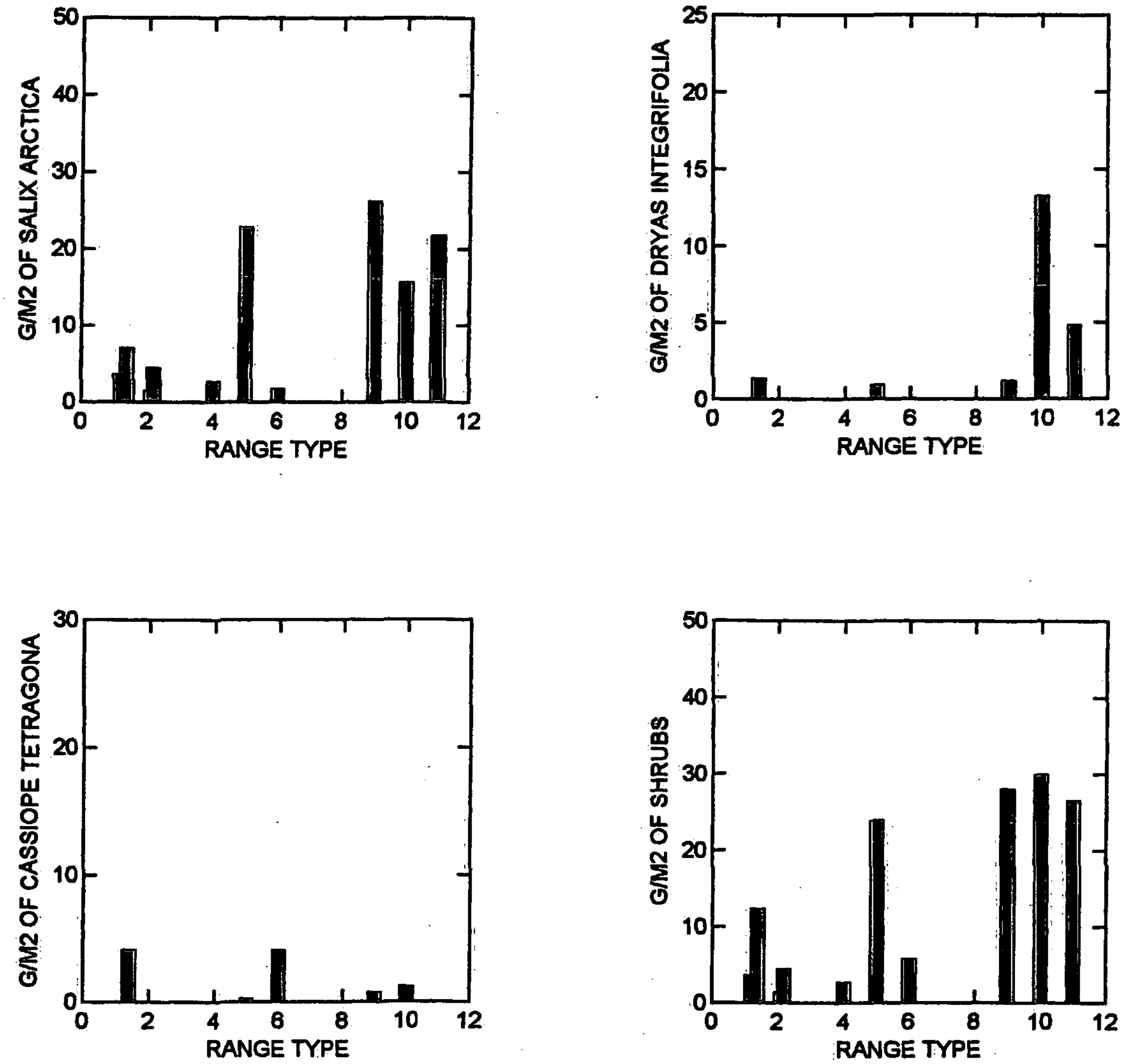


Figure 8. Standing crop of *Salix arctica*, *Dryas integrifolia*, *Cassiope tetragona*, and all shrubs in 11 range types on eastern Melville Island.

Figure 9

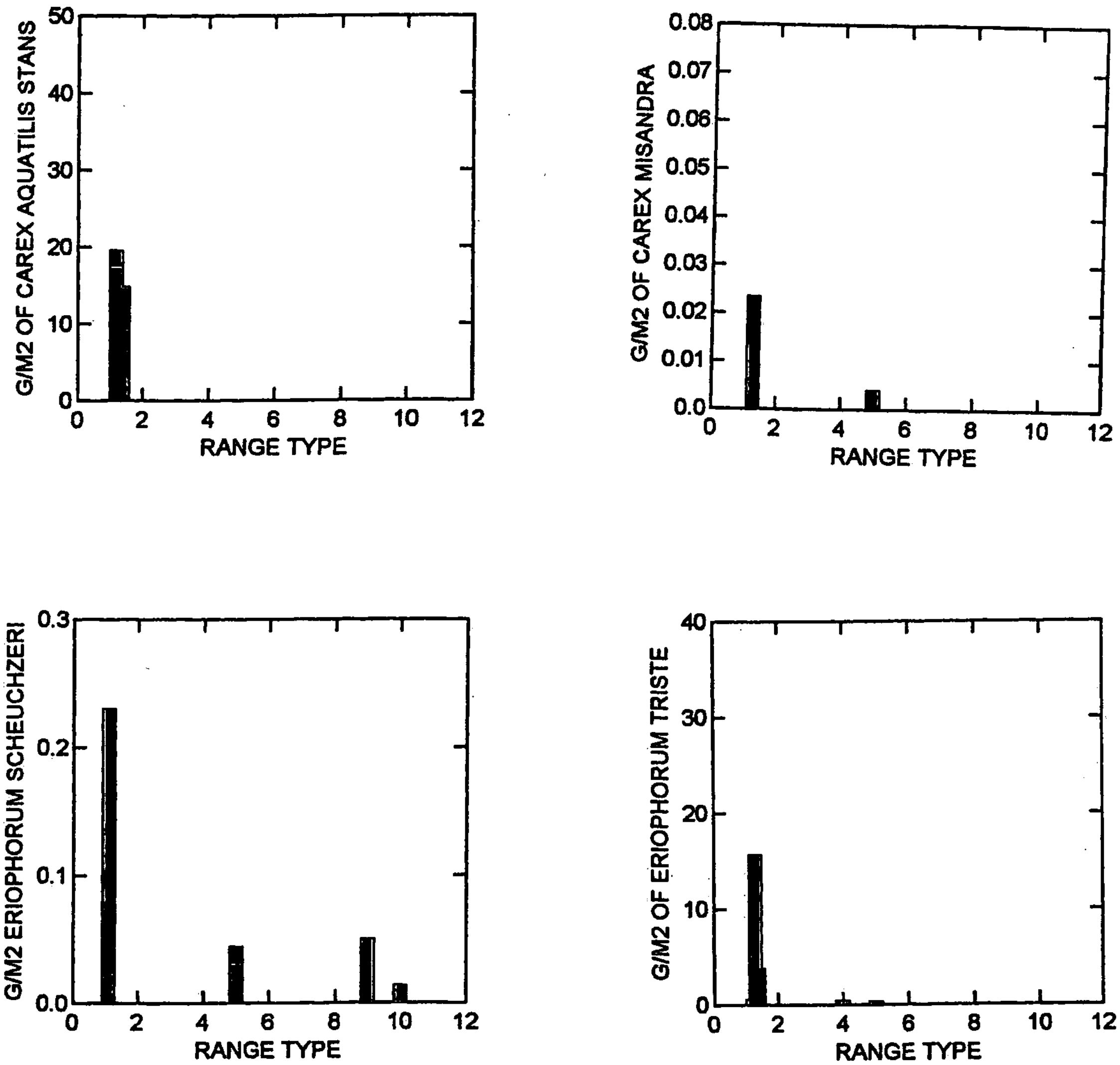


Figure 9. Standing crop of *Carex aquatilis*, *C. misandra*, *Eriophorum Scheuchzeri*, and *E. triste* in 11 range types on eastern Melville Island.

Figure 10.

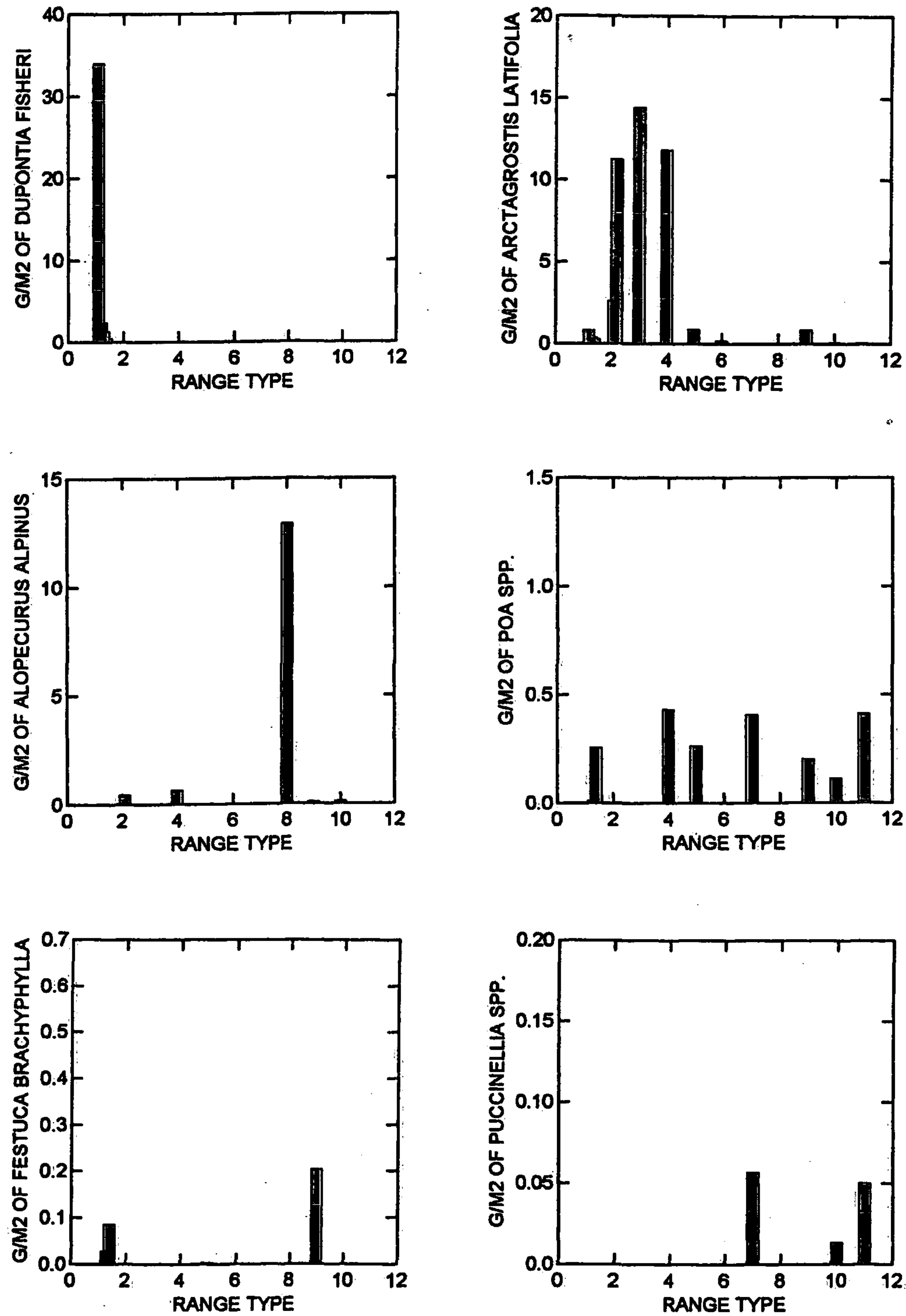


Figure 10. Standing crop of grass species *Dupontia Fisheri*, *Arctagrostis latifolia*, *Alopecurus alpinus*, *Poa* spp., *Festuca brachyphylla*, and *Puccinellia* spp. in 11 range types on eastern Melville Island.

Figure 11

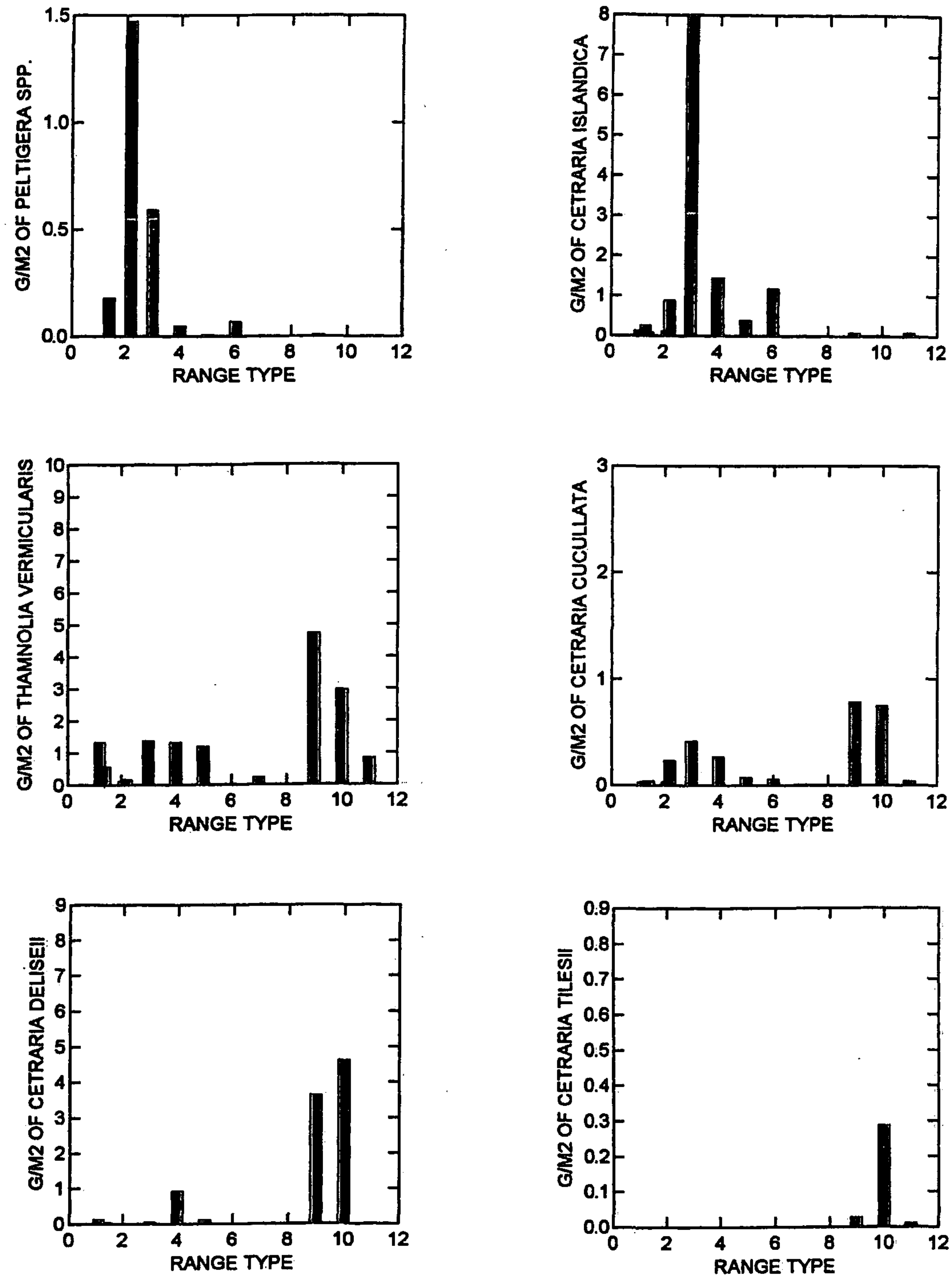


Figure 11. Standing crop of *Peltigera* spp., *Cetraria islandica*, *Thamnolia vermicularis*, *C. cucullata*, *C. deliseii*, and *C. tilesii* in 11 range types on eastern Melville Island.

Figure 12

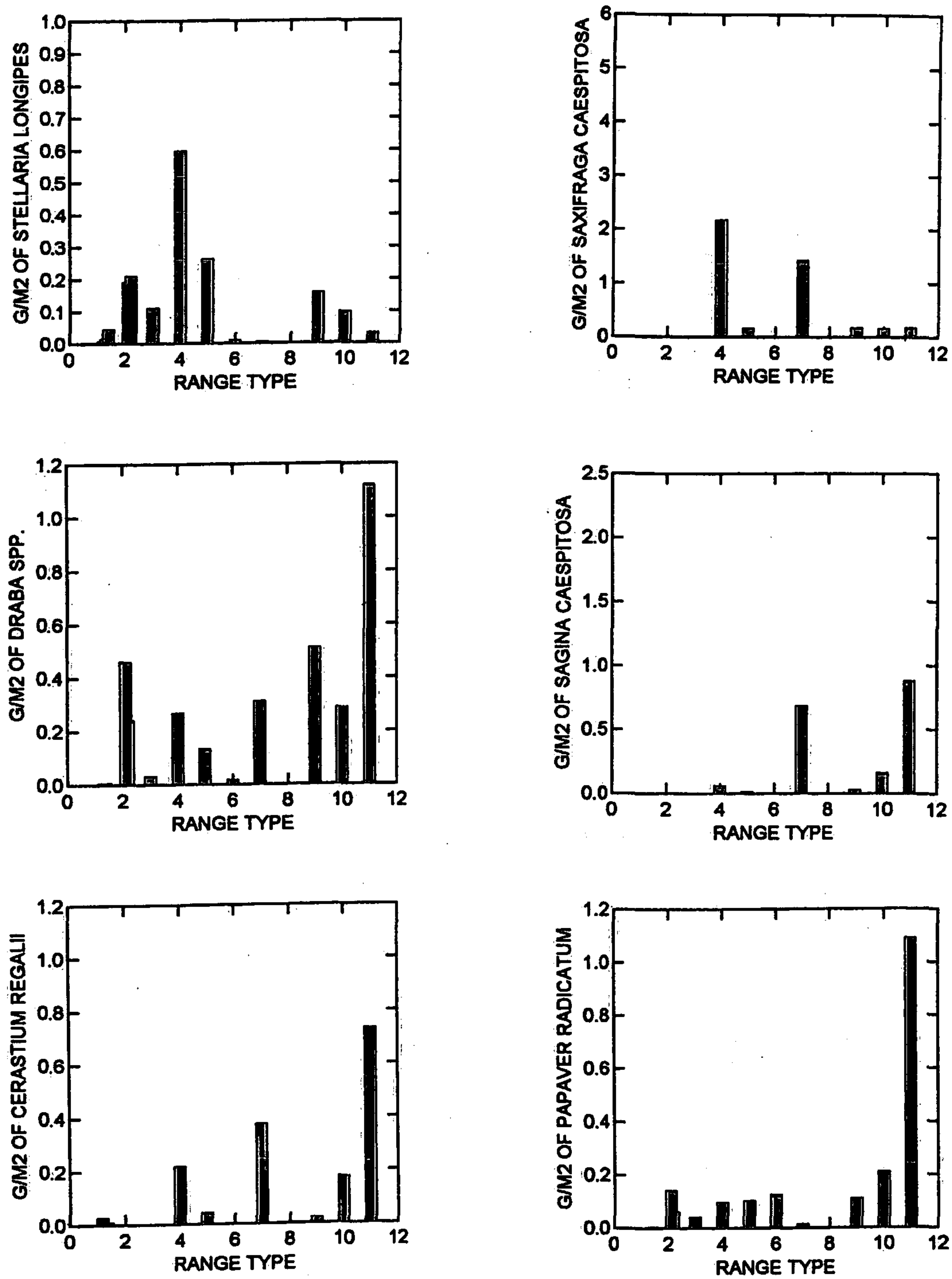


Figure 12. Standing crop of the forbs *Stellaria longipes*, *Saxifraga caespitosa*, *Draba* spp., *Sagina caespitosa*, *Cerastium Regalii*, and *Papaver radicatum* in 11 range types on eastern Melville Island.

In general, lichens were most abundant in mesic moisture conditions (**Fig. 11**). However, there was much variation among species with *Peltigera* spp. favoring relatively moist conditions and *Cetraria deliseii* and *C. tilesii* most abundant in relatively dry conditions.

The most common forbs occurred in all moisture regimes, however, *Draba* spp., *Sagina caespitosa*, *Cerastium Regalii*, and *Papaver radicatum* had the highest standing crop in the driest range type (**Fig. 12**).

Standing crop of *Salix arctica* increased 89% and forb standing crop increased 300% from July 24 to August 15, whereas monocotyledon standing crop only increased 26% (**Table 13**).

Mathematical relationships between percent cover, estimated photographically, and standing crop were established for shrubs, monocotyledons, lichens, *Saxifraga oppositifolia,* and forbs (**Tables 14-18**). Those data were not transformed and zeros were included.

We ordered the 11 range types sampled in the three study regions according to a subjective evaluation of moisture content of substrates (**Table 2**). We divided wet meadows into four subtypes and low-center polygons into two subtypes.

We noted other range types at other locations on eastern Melville Island. Examples were high-center polygons, cliffs, hoodoos, tidal flats, etc. The sampled sites generally were considered representative of a range type but considerable variability was noted within range types. Our described range types are arbitrary steps in a staircase continuum of vegetative types.

Table 13. Changes from 24 July (site 2) to 15 August (site 2A), 1974, in estimated standing crop (g/m²) at the same location in a sedge meadow located at Sabine Bay, eastern Melville Island.

Species or group	Standing crop (g/m²) 24 July 74	Standing crop (g/m²) 15 August 74	Percent change
Salix arctica	8.2	15.5	+89
Sedges	31.1	39.1	+26
Rushes	0.7	0.9	+29
Grasses	1.0	1.3	+30
Lichens (except crustose)	2.6	1.8	-23
Forbs[1]	0.2	0.8	+300
Monocotyledons	32.8	41.3	+26
Totals	43.8	59.4	+36

[1] All vascular plants except shrubs and monocotyledons.

Table 14. Regression data for the relationship between percent cover (*x*), estimated by the photo method, and standing crop (*y*) (g/m^2) of shrubs at sites on eastern Melville Island, summer 1974.

Species	Site no.	Sample size[1]	*x*	*y*	*y/x*	R^2	*y* intercept	Slope	Signif.[3]
Salix arctica	7	23	18.81	21.36	1.14	0.92	-2.72	1.28	<0.01
S. arctica	9	28	27.10	47.04	1.74	0.90	-4.00	1.92	<0.01
S. arctica	16	22	27.57	32.80	1.19	0.89	-6.48	1.44	<0.01
S. arctica	23	51	11.73	20.64	1.76	0.45	9.52	0.96	<0.01
S. *arctica*	24	21	24.99	35.12	1.40	0.89	7.76	1.12	<0.01
S. arctica	25	10	7.24	14.40	2.00	0.94	-1.92	2.24	<0.01
S. arctica	all sites	155	19.26	28.80	1.49	0.82	1.92	1.36	<0.01
D. integrifolia[4]	23&25	16	13.58	91.5	6.74	0.86	-63.04	11.36	<0.01
C. tetragona[5]	23&25	14	7.25	53.76	7.42	0.72	16.96	5.04	<0.01

[1] Plots where percent cover and standing crop (g/m^2) were >1.0 for a species & rounded to one decimal place.

[2] *R* is the regression coefficient. Its square is the coefficient of determination.

[3] Probability that slope = 0.

Notes: Standing crop is oven-dried weight of all sampled vegetation on or above ground including stems and dead parts.

The correlation coefficient, *R*, indicates the strength of the relationship between cover and standing crop. Either cover or standing crop could be considered the dependent variable in these regressions, however, cover is easier to obtain so it was designated the independent variable.

To calculate standing crop (*y*) from cover (*x*):

y = constant + slope (x), where (constant = *y* intercept).

[4] *Dryas.*

[5] *Cassiope.*

Table 15. Regression data for the relationship between percent cover (*x*), estimated by the photo method, and standing crop (*y*) (g/m^2) of monocotyledons at sites on eastern Melville Island, summer 1974.

Species/group	Site no.	Sample size[1]	Regression variables *x*	*y*	*y/x*	R^2	*y* intercept	Slope	Signif.[3]
Carex aquatilis	6	15	20.55	18.00	0.87	0.85	-2.16	0.96	<0.01
Carex aquatilis	25	19	45.87	45.68	1.00	0.75	13.68	0.72	<0.01
Carex aquatilis	6&25	34	34.70	33.44	0.96	0.87	1.68	0.96	<0.01
Eriophorum triste	6	18	50.91	37.52	0.74	0.88	-1.04	0.72	<0.01
Luzula spp.	3	28	35.71	50.08	1.40	0.69	-1.44	1.44	<0.01
Luzula spp.	7	43	20.24	21.12	1.05	0.66	-1.60	1.12	<0.01
Luzula spp.	16	30	8.84	7.12	0.81	0.55	4.24	0.32	<0.05
Luzula spp.	24	15	6.53	7.12	1.10	0.84	1.60	0.88	<0.01
Luzula spp.	30	31	15.16	58.80	3.87	0.89	-0.64	3.92	<0.01
Luzula spp.	all sites	147	18.39	30.32	1.65	0.63	3.44	1.44	<0.01
Arctagrostis & Alopecurus	7	19	6.62	5.20	0.79	0.20	4.56	0.08	NS[4]
"	24	13	5.61	4.24	0.76	0.43	1.04	0.56	<0.05
"	7&24	32	6.21	4.80	0.77	0.25	3.76	0.16	NS[4]
Dupontia Fisheri	18	14	65.81	34.00	0.52	0.69	-8.48	0.64	<0.01
Sedges	6,8,25	54	40.12	34.80	0.87	0.84	4.08	0.80	<0.01

[1] Quadrats where cover & standing crop were >1.0 for a particular species rounded to one decimal place.
[2] *R* is the regression coefficient. Its square is the coefficient of determination.
[3] Probability that slope = 0.
[4] NS = not significant.
Note: The correlation coefficient, *R*, indicates the strength of the relationship between cover and standing crop. Either cover or standing crop could be considered the dependent variable in these regressions, however, cover is easier to obtain so it was designated the independent variable. To calculate standing crop (*y*) from cover (*x*): *y = constant + slope (x)* where (constant = *y* intercept).

Table 16. Regression data for the relationship between percent cover (*x*), estimated by the photo method, and standing crop (*y*) (g/m^2) of lichens at sites on eastern Melville Island, summer 1974.

			Regression variables						
Species/group	Site no.	Sample size[1]	*x*	*y*	*y/x*	R^2	*y* intercept	Slope	Signif.[3]
T. vermicularis[4]	7	30	2.46	4.56	1.82	0.10	4.00	0.24	NS[5]
T. vermicularis	23	51	3.45	6.96	1.99	0.48	4.72	0.64	<0.05
T. vermicularis	24	20	6.62	11.04	1.67	0.52	4.88	0.94	<0.01
T. vermicularis	all	101	3.78	7.04	1.85	0.58	3.52	0.96	<0.01
Cetraria spp.	23	50	3.17	10.00	3.13	0.76	-2.08	3.84	<0.01
Cetraria spp.	24	23	4.22	8.48	2.02	0.91	-1.04	2.24	<0.01
Cetraria spp.	30	14	1.91	6.08	3.20	-0.15	6.64	-0.32	NS
Cetraria spp.	all	87	3.24	8.96	2.80	0.73	-0.56	2.96	<0.01
Lichens[6]	7	31	2.45	4.40	1.76	0.10	3.84	0.24	NS
"	16	23	2.40	3.68	1.53	0.03	3.52	0.08	NS
"	23	101	3.31	8.48	2.57	0.64	-0.24	2.64	<0.01
"	24	42	5.43	9.84	1.82	0.79	0.56	1.68	<0.01
"	30	17	2.41	5.52	2.30	-0.11	5.84	-0.16	NS
"	all	214	3.43	7.44	2.19	0.62	0.72	1.92	<0.01

[1] Plots where percent cover and standing crop values >1.0 for a particular species.
[2] *R* is the regression coefficient. Its square is the coefficient of determination.
[3] Probability that slope = 0.
[4] *Thamnolia*.
[5] NS = not significant.
[6] Except crustose lichens.

Note: The correlation coefficient, *R*, indicates the strength of the relationship between cover and standing crop. Either cover or standing crop could be considered the dependent variable in these regressions, however, cover is easier to obtain so it was designated the independent variable. To calculate standing crop (*y*) from cover (*x*):
y = *constant* + *slope (x)* where (constant = y intercept).

Table 17. Regression data for the relationship between percent cover (*x*), estimated by the photo method, and standing crop (*y*) (g/m^2) of *Saxifraga oppositifolia* and forbs at sites on eastern Melville Island, summer 1974.

Species/group	Site no.	Sample size[1]	Regression variables *x*	*y*	*y/x*	R^2	*y* intercept	Slope	Signif.[3]
S. oppositifolia	3	9	11.06	24.88	2.25	0.92	-3.12	2.56	<0.01
S. oppositifolia	9	36	8.73	70.72	8.10	0.91	2.24	7.84	<0.01
S. oppositifolia	16	25	9.55	25.92	2.71	0.82	1.52	2.56	<0.01
S. oppositifolia	all	75	8.80	45.60	5.18	0.75	-1.92	5.44	<0.01
Forbs[4]	3	40	4.42	5.28	1.19	-0.04	5.60	-0.08	NS[5]
Forbs	7	48	1.06	2.08	1.96	0.48	0.08	1.84	<0.01
Forbs	9	15	1.67	3.36	2.01	0.40	-0.16	2.16	NS
Forbs	16	15	2.42	2.48	1.02	0.17	2.16	0.16	NS
Forbs	23	40	2.27	3.20	1.41	0.39	2.24	0.40	<0.05
Forbs	24	11	1.95	3.12	1.60	0.47	0.80	1.20	NS
Forbs	all[6]	206[6]	2.25	2.64	1.17	0.14	2.08	0.24	NS

[1] Plots where percent cover and standing crop values >1.0 for each species.
[2] *R* is the regression coefficient. Its square is the coefficient of determination.
[3] Test of hypotheses that slope = 0.
[4] All vascular species except shrubs, monocotyledons, and *S. oppositifolia.*
[5] NS = not significant.
[6] Includes data where percent cover and standing crop values < 1.0 for each species.
Note: The correlation coefficient, *R*, indicates the strength of the relationship between cover and standing crop. Either cover or standing crop could be considered the dependent variable in these regressions, however, cover is easier to obtain so it was designated the independent variable. To calculate standing crop (*y*) from cover:
y = constant + slope (x) where (constant = *y* intercept).

Table 18 Regression data for the relationship between percent cover (x), estimated by the photo method, and standing crop (y) (g/m^2) of species groups based on 11 means for sites on eastern Melville Island, summer 1974.

Species/group	Include zeros (n)	Regression variables R	y intercept[1]	Slope	Significance[2]
Salix arctica	Yes (4)	0.967	0.570	1.594	0.000
	No	0.931	1.829	1.494	0.002
Sedges	Yes (4)	0.994	-0.068	0.794	0.000
	No	0.992	-0.192	0.797	0.000
Rushes	None	0.845	2.215	1.739	0.001
Luzula spp.	None	0.819	1.410	1.519	0.002
Grasses	None	0.999	0.615	0.495	0.000
Monocotyledons	None	0.672	11.170	0.584	0.024
Lichens	Yes (2)	0.927	-0.499	2.371	0.000
	No	0.992	-1.054	2.478	0.000
Thamnolia vermicularis	Yes (4)	0.986	0.173	1.901	0.000
	No	0.988	-0.011	1.960	0.000
Cetraria spp.	Yes (4)	0.941	0.517	3.065	0.000
	No	0.926	0.741	2.986	0.003
Forbs	None	0.897	0.344	1.265	0.000

[1] Constant.

[2] 2-tailed t test that slope = 0.

Note: The correlation coefficient, R, indicates the strength of the relationship between cover and standing crop. Either cover or standing crop could be considered the dependent variable in these regressions, however, cover is easier to obtain so it was designated the independent variable. To calculate standing crop (y) from cover (x):
$y = constant + slope\ (x)$ where (constant = y intercept).

3.3 **Degree and season of use of range types by caribou and muskoxen**

Fecal densities at sites (**Table 19**) are illustrated in **Fig. 13.** Relative use of sites in 10 range types are ranked in **Table 20**. Relative use of sites by caribou and muskoxen in winter and summer (**Table 21**) is based on an assumption that the ratio of winter-type pellets to the summer type was 3:1, i.e., about proportional to the lengths of the seasons. Hereafter, "expected" numbers of groups in each season is used in a mathematical context; it does not refer to our expectations. Data at sites were averaged to yield fecal group densities for 10 range types (**Table 22**). Those values were then adjusted on a sliding scale according to a subjective evaluation of moisture conditions (**Table 23**). We assumed that feces on a xeric range type persisted twice as long as feces in wet sites (**App. 13**). Finally, we compared observed and expected numbers of fecal groups at each season across range types (**Table 24**).

Range Type 1: Wet Meadow

Use by caribou, which averaged 108 fecal groups/ha, was the lowest of all range types (**Table 22**) and was significantly higher than "expected" in winter; the converse for summer (**Table 24**). Use by muskoxen, at 871 fecal groups/ha, was the highest of all range types (**Table 22**) and what is expected with equal seasonal use (**Table 24**).

Range Subtype 1.1: Dupontia Meadow (site 18)

Fecal densities were not obtained. Muskoxen were observed to feed extensively on this subtype in summers 1973 and 1974, especially north of Sherard Bay, where *Dupontia Fisheri* was the principle forage. Qualitative observations indicated use at both seasons. Use by caribou is unknown, however, observations suggest they tend to avoid such wet habitats in summer and snow would restrict their use of forage in late winter (Dec.-Apr.) unless they forage in craters left by muskoxen.

Range Subtype 1.2: Sedge-Dupontia Meadow (sites 14 and 26)

The lowest density of caribou fecal groups (53 groups/ha) and the highest density

Figure 13

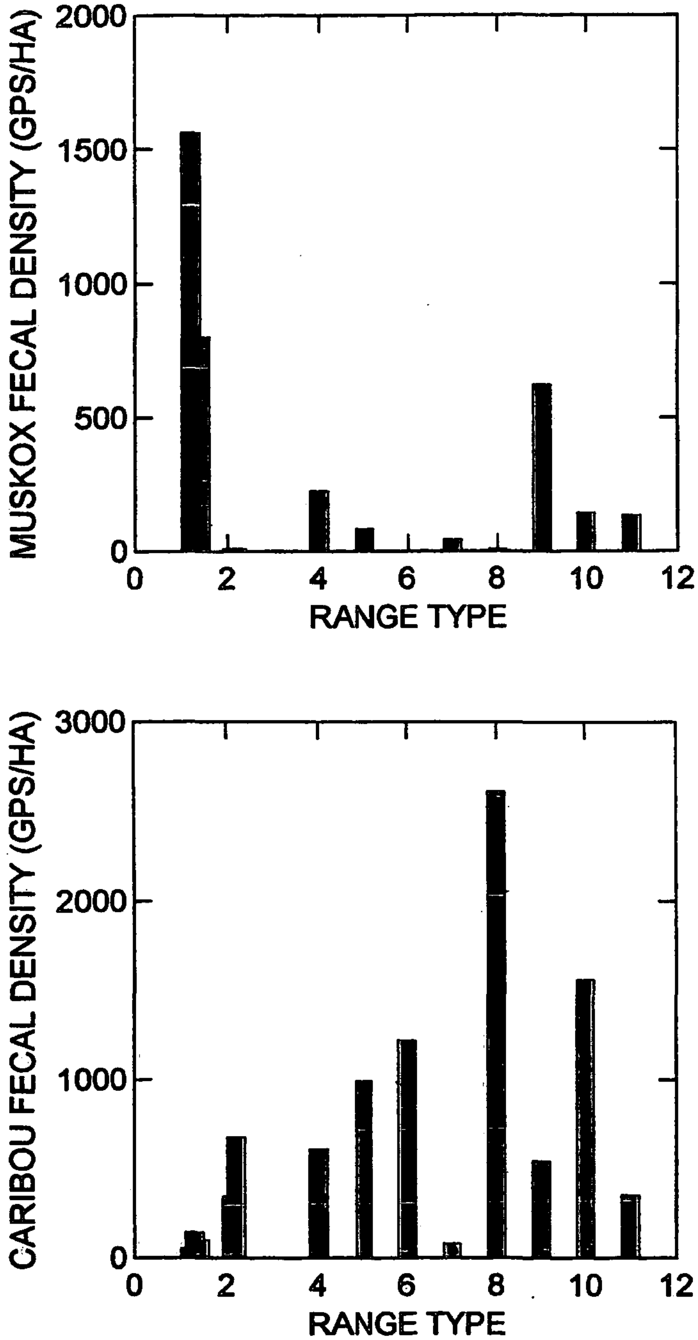


Figure 13. Densities of fecal groups of caribou and muskoxen in 10 range types sampled in 1974 on eastern Melville Island (no data for range type 3).

Table 19. Density of fecal groups deposited by caribou and muskoxen at all seasons and in winter and summer at sites in 10 range types on eastern Melville Island, summer 1974.

Range type/ subtype	Site no.	No. plots	Fecal groups/ha[1] All seasons Caribou	Muskox	Caribou Winter	Sum.	Muskox Winter	Sum.
1. Wet Meadow								
1.2 Sedge-*Dupontia*	26	25	53	1560	53	0	1254	306
1.3 Sedge	6	25	96	712	79	17	527	185
	8A	29	191	482	96	96	386	96
1.4 Sedge-*Salix*	25	41	71	612	59	12	421	191
	2	20	129	989	129	0	878	111
2. Low-Center Polygons								
2.1 Center	19	8	342	8	342	0	8	0
2.2 Ridge	20	22	677	9	611	66	9	0
4. Grass-*Luzula* Plain	32	20	769	3	607	162	3	0
	21	21	451	444	387	64	444	0
5. Grass-*Salix* Slope	7B	12	1020	0	340	680	0	0
	16	56	1570	28	365	1205	28	0
6. *Luzula*-Lichen Slope & Crest	30	40	1220	0	549	671	0	0
7. *Luzula* Tussock	7A	10	415	137	46	369	137	0
	3	52	78	42	34	44	25	17
8. Sparse, Grass-*Luzula* Plain	34	20	2610	6	2610	0	3	3
9. *Salix*-Lichen Ridge	24	40	621	414	311	311	248	166
	8B	20	572	72	286	286	14	58
	1	38	462	829	240	222	676	153
10. *Salix-Dryas*-Lichen Ridge	23	40	2190	175	1971	219	103	72
	4	32	928	110	661	267	105	5
11. *Salix-Saxifraga* Ridge	9	40	352	132	129	223	132	0

[1] Calculated from nearest distance-nearest neighbor (ND-NN) data. The complex formula for calculating pellet group densities is in App. 1. Range type 3 was not sampled.

Table 20. Rank of fecal group densities for caribou and muskoxen at all seasons and in winter and summer at sites in 10 range types on eastern Melville Island, summer 1974 (data from Table 19).

Range type/ subtype	Site no.	Rank of fecal densities: All seasons Caribou	All seasons Muskox	Caribou Winter	Caribou Sum.	Muskox Winter	Muskox Sum.
1. Wet Meadow							
1.2 Sedge-*Dupontia*	26	21	1	19	18	1	1
1.3 Sedge	6	18	4	17	16	4	3
	8A	16	6	16	12	7	7
1.4 Sedge-*Salix*	25	20	5	18	17	6	2
	2	17	2	14		2	6
2. Low-Center Polygons							
2.1 Center	19	15	17	9		17	
2.2 Ridge	20	8	16	4	13	16	
4. Grass-*Luzula* Plain	32	7	19	5	11	18	
	21	12	7	7	14	5	
5. Grass-*Salix* Slope	7B	5		10	2		
	16	3	15	8	1	13	
6. *Luzula*-Lichen Slope & Crest	30	4		6	3		
7. *Luzula* Tussock	7	13	10	20	4	9	
	3	19	14	21	15	14	10
8. Sparse, Grass-*Luzula* Plain	34	1	18	1		19	12
9. *Salix*-Lichen Ridge	24	9	8	11	5	8	4
	8B	10	13	12	6	15	9
	1	11	3	13	9	3	5
10. *Salix-Dryas*-Lichen Ridge	23	2	9	2	10	12	8
	4	6	12	3	6	11	11
11. *Salix-Saxifraga* Ridge	9	14	11	15	8	10	

Note: blanks (no rank) indicate zero pellet densities. Ten range types were sampled for pellets-group densities (range type 3 was not sampled).

Table 21. Number of caribou and muskox fecal groups of each seasonal type observed and "expected" at 21 sites in 10 range types, eastern Melville Island, summer 1974.

Range type & subtype	Site number	**Fecal groups observed and (expected)**[1] Caribou Winter type	Caribou Summer type	Muskox Winter type	Muskox Summer type
1. Wet Meadow					
1.2 Sedge-*Dupontia*	26	8 (6)	0 (2)	45 (42)	11 (14)
1.3 Sedge	6	14 (13)	3 (4)	37 (38)	13 (12)
	8A	**8**[2] (12)	**8** (4)	40 (38)	10 (12)
1.4 Sedge-*Salix*	25	20 (18)	4 (6)	55 (60)	25 (20)
	2	**37**[2] (28)	**0** (9)	**71**[3] (60)	**9** (20)
2. Low-Center Polygons					
2.1 Center	19	**22**[2] (17)	**0** (5)	1	0
2.2 Ridge	20	**28**[2] (23)	**3** (8)	3	0
4. Grass-*Luzula* Plain	32	30 (29)	8 (9)	1	0
	21	30 (26)	5 (9)	**38**[2] (29)	**0** (9)
5. Grass-*Salix* Slope	7B	**8**[3] (18)	**16** (6)	0	0
	16	**27**[3] (87)	**89** (29)	14 (11)	0 (3)
6. *Luzula*-Lichen Slope & Crest	30	**36**[3] (60)	**44** (20)	0	0
7. *Luzula* Tussock	7A	**2**[3] (14)	**16** (4)	7	0
	3	**16**[3] (28)	**21** (9)	12 (15)	8 (5)
8. Sparse, Grass-*Luzula* Plain	34	**40**[3] (30)	**0** (10)	1	1
9. *Salix*-Lichen Ridge	24	**26**[3] (40)	**27** (13)	40 (37)	9 (12)
	8B	**12**[3] (18)	**12** (6)	6 (8)	4 (2)
	1	5[4]	0	**4**[3] (16)	**17** (5)
10. *Salix-Dryas*-Lichen Ridge	23	**72**[3] (60)	**8** (20)	**23**[2] (29)	**16** (10)
	4	42 (44)	17 (15)	**19**[2] (15)	**1** (5)
11. *Salix-Saxifraga* Ridge	9	**26**[3] (53)	**45** (18)	**34**[3] (26)	**0** (8)

[1] These are the actual number of pellet groups counted in nearest distance-nearest neighbor (ND-NN) sampling. For example at site 26, we observed 8 and 56 pellet groups of caribou and muskoxen, respectively. We "expect," statistically, 75% winter type and 25% summer (June, July, and August) type. Number of groups is converted to density (Table 19) by formulae in App. 1.

[2] Chi square $P < 0.05$, where $X^2 = \sum(obs._w - exp._w)^2/exp._w + (obs._s - exp._s)^2/exp._s$ with 1 df.

[3] Chi square $P < 0.01$.

[4] Winter-summer classification system was introduced towards the end of sampling site 1.

Table 22. Average density of fecal groups deposited by caribou and muskoxen at all seasons and in winter and summer in 10 range types on eastern Melville Island, summer 1974. These means were calculated from data in Table 19.

Range type	Fecal groups/ha[1]					
	All seasons		Caribou		Muskox	
	Caribou	Muskox	Winter	Summer	Winter	Summer
1. Wet Meadow	108	871	83	25	693	178
2. Low-Center Polygons	510	9	477	33	9	0
4. Grass-*Luzula* Plain	610	224	487	113	224	0
5. Grass-*Salix* Slope	1295	14	353	943	14	0
6. *Luzula*-Lichen Slope & Crest	1220	0	549	671	0	0
7. *Luzula* Tussock	247	90	40	207	81	9
8. Sparse, Grass-*Luzula* Plain	2610	6	2610	0	3	3
9. *Salix*-Lichen Ridge	552	438	279	273	313	126
10. *Salix-Dryas*-Lichen Ridge	1559	143	1316	243	104	39
11. *Salix-Saxifraga* Ridge	352	132	129	223	132	0

[1] Calculated from nearest distance-nearest neighbor (ND-NN) data. Fecal densities were not obtained in Site 3. The complex formula for calculating pellet group densities is in App. 1.

Table 23. Adjusted average density of fecal groups deposited by caribou and muskoxen at all seasons and in winter and summer in 10 range types on eastern Melville Island, summer 1974. The scaled adjustment compensates for variable decomposition rates through moisture gradients (details in Text and App. 13).

Range type	Adjust-ment factor	Fecal groups/ha[1]					
		All seasons		Caribou		Muskox	
		Caribou	Muskox	Winter	Sum.	Winter	Sum.
1. Wet Meadow	1.0	108	871	83	25	693	178
2. Low-Center Polygons	0.9	459	8	429	30	8	0
4. Grass-*Luzula* Plain	0.8	488	179	390	90	179	0
5. Grass-*Salix* Slope	0.8	1036	11	282	754	11	0
6. *Luzula*-Lichen Slope & Crest	0.7	173	63	28	145	57	6
7. *Luzula* Tussock	0.7	291	96	32	258	96	0
8. Sparse, Grass-*Luzula* Plain	0.6	1566	4	1566	0	2	2
9. *Salix*-Lichen Ridge	0.6	331	263	167	164	188	76
10. *Salix-Dryas*-Lichen Ridge	0.5	780	72	658	122	52	20
11. *Salix-Saxifraga* Ridge	0.5	176	66	65	112	66	0

[1] Calculated from nearest distance-nearest neighbor (ND-NN) data. The complex formula for calculating pellet group densities is in App. 1. Range type 3 was not sampled for fecal densities.

Table 24. Number of caribou and muskoxen fecal groups of each seasonal type observed and "expected" in 10 range types, eastern Melville Island, summer 1974. Data from Table 21.

Range type	**Fecal groups observed and (expected)**[1]			
	Caribou		Muskox	
	Winter type	Summer type	Winter type	Summer type
1. Wet Meadow	**87**[2](77)	**15** (25)	248 (237)	68 (79)
2. Low-Center Polygons	50 (40)	3 (13)	4 (3)	0 (1)
4. Grass-*Luzula* Plain	60 (55)	13 (18)	**39**[3](29)	**0** (10)
5. Grass-*Salix* Slope	**35**[3](105)	**105** (35)	14 (11)	0 (3)
6. *Luzula*-Lichen Slope & Crest	**36**[3] (60)	**44** (20)	0	0
7. *Luzula* Tussock	**18**[3](41)	**37** (14)	19 (20)	8 (7)
8. Sparse, Grass-*Luzula* Plain	**40**[3] (30)	**0** (10)	1	1
9. *Salix*-Lichen Ridge	**43**[3](58)	**39** (19)	**50**[3](60)	**30** (20)
10. *Salix-Dryas*-Lichen Ridge	114 (104)	25 (35)	42 (44)	17 (15)
11. *Salix-Saxifraga* Ridge	**26**[3] (53)	**45** (18)	**34**[3] (26)	**0** (8)

[1] These are the actual number of pellet groups counted in nearest distance-nearest neighbor (ND-NN) sampling. For example at site 26, we observed 8 and 56 pellet groups deposited by caribou and muskoxen, respectively. We "expect," statistically, 75% winter type and 25% summer type (deposited about June 15-Sep. 15). Number of groups is converted to density (Table 19) by formulae in App. 1.

[2] Chi square $P < 0.05$, where $X^2 = \sum(obs._w - exp._w)^2/exp._w + (obs._s - exp._s)^2/exp._s$ with 1 df.

[3] Chi square $P < 0.01$.

of muskox fecal groups (1560 groups/ha) were recorded at site 26 (**Table 19**). All of the apparent use by caribou was in winter, whereas numbers of winter and summer types of muskox fecal groups were about proportional to relative lengths of those seasons (**Table 21**). Use by caribou likely occurs in the early winter before snow accumulates. The high use by muskoxen is explained in part by the location of the meadow. Muskoxen traveling south along the coast would tend to be funneled by the geography into the meadow, the first for many kilometers.

Range Subtype 1.3: Sedge Meadow (sites 6 and 8A)

Densities of caribou pellet groups for all seasons were relatively low at 96 and 191 groups/ha (**Table 19**). Summer use of site 8A (8A was the sedge meadow component, 8B was beach ridges between meadows) by caribou was greater (P <0.05) than "expected" (**Table 21**). In late July of 1974, caribou traveled at a leisurely pace eastward past Little Point. The ridges between sedge meadows provided convenient pathways for caribou traveling close to Parry Channel and some feeding was noted along the edges of meadows.

Densities of muskox feces were high at 712 groups/ha (site 6) and 482 groups/ha (site 8A, **Table 19**). Pellet groups were not counted in site 37, which was accessed by aircraft. Site 6 was more productive than site 8A and the meadow was less divided by ridges, which may explain its higher use.

Muskoxen utilized the two meadows in both seasons with about equal intensity (**Table 21**). Meadow vegetation probably remains accessible to muskoxen during most winters because of snow entrapment by high hills to the north. A sharp elevation change on the northern edge of the elongated meadows causes large amounts of snow to accumulate. Immense snow banks, which provided a source of water throughout much of the summer, were still present in mid-August, 1974.

Muskox fecal groups noted but not counted at site 37 were mostly the summer type. The meadow, in the bottom of a river valley with exposure to the north, would be subject to considerable wind and accumulation of snow in winter. Two muskoxen succumbed near site 6 during the severe winter of 1973-74.

Range Subtype 1.4: Sedge-Salix (sites 36, 25, 2, & 39 - decreasing moisture). We obtained quantitative data on fecal densities (**Table 19**) and seasonality of use (**Table 21**) for sites 25 and 2. Fecal densities were relatively low for caribou (71 and 129 groups/ha) and high for muskoxen (612 and 989 groups/ha).

Almost all use of these moist meadows by caribou was in winter, with a significant ($P < 0.01$) seasonal difference for site 2 (**Table 21**). Site 2 was a large meadow (ca. 11 ha) and flat except for tussocks, whereas site 25 (1.4 ha) was characterized by a polygonal pattern of ridges around wet centers, some with standing water. Early winter use was likely. Snow drifts were deep over those lowland meadows by late winter, as observed at site 2 in late March 1974 and 1975.

Use by muskoxen of site 2 in winter was also significantly greater ($P < 0.01$) than expected statistically (**Table 21**). A CWS camp bordering the meadow restricted its use by muskoxen and that of an adjacent site (22) in summer 1973 and 1974. We forecast use in both seasons as muskoxen move through the region. In contrast, use by muskoxen of site 36 was largely in summer. Fecal groups were not counted at site 36 because access was by aircraft, which resulted in time constraints.

An upland, seepage meadow (site 39) was photographed to estimate percent cover but fecal groups were not counted because of time constraints. Muskoxen were observed at the site in March 1974 during an aerial reconnaissance. In late-winter 1993-94, deep and hard snow had forced most muskoxen from lowland meadows and much mortality occurred. Strangely, the meadow had not been grazed or browsed extensively and the small number of pellets indicated only a brief stay. Caribou fed on the site in early August 1974.

Range type 2: *Low-Center Polygons* (sites 19 and 20)

Use by caribou was almost exclusively (94%) in the winter (**Table 19**), significantly greater ($P < 0.05$) than expected statistically (**Table 21**). Fecal densities for both seasons of 342 groups/ha (centers) and 677 groups/ha (ridges) revealed moderate use of the range type north of Sabine Bay but use was almost negligible at other sites, e.g., in the Sherard Bay Lowlands. In winter, the centers would soon fill with deep snow but forage on the ridges would be accessible in most winters. We suspect, therefore, that use of centers is much less than indicated by the data and the reverse for ridges. In summer, caribou tend to stay out of wet areas, such as these polygon centers.

Range type 3: *Grass-Luzula-Lichen Plain* (site 27)

Quantitative data on fecal densities were not obtained but considerable past use by caribou was indicated by large numbers of fecal groups, cast antlers, skeletal remains. In winter, caribou were observed in the region.

Range type 4: *Grass-Luzula Plain* (sites 32, 21, and 17)

Fecal densities at sites 32 and 21 (**Table 19**) indicated moderate use by caribou at both seasons and winter use by muskoxen at one of the sites (site 21). We suspect that much of the use by caribou at site 32 and surrounding lowlands occurred from late summer to mid-winter (Aug.-Dec.), judging from cast antlers of bulls, reports of caribou present at that time by personnel of Panarctic (station and airstrip 2 km to the north), our sightings of caribou in the region in August 1973, and absence of observations in the general region on several summer and winter surveys and reconnaissances flights (Miller & Russell 1974, 1976; Parker et al. 1975; Renewable Resources Consulting Ltd. 1975; Fischer & Duncan 1976; Thomas et al. 1975, 1976, 1977; Thomas & Broughton 1978). Remains from caribou that died during the severe winter of 1973-74 were found in the vicinity of site 17. Unfortunately, time constraints did not allow us to count fecal groups at that site.

Fecal groups of muskoxen were seldom encountered on extensive walks in the Sherard Bay Lowlands within 7 km of the east coast. While grasses and sedges were not abundant, they occur extensively and greater use was expected. We suspect that establishment of the Sherard Bay station in 1970 and the associated heavy aircraft traffic, generators, motorized equipment, dogs, and people have reduced use of those lowlands within sight and sound of the station.

Range type 5: ***Grass-Salix Slope*** (sites 15, 13, 38, 7B, & 16)

The high degree of use by caribou of sites 7B and 16 (1020 and 1570 fecal groups/ha), predominantly in summer (**Table 19**), is explained in part by the sites being on a migration route through the region in June and July. Use in winter was significantly less than expected statistically (**Tables 21 & 24**); the reciprocal for summer. Nevertheless, that range type supported diverse vegetation including many forage species. Sites 13, 15, and 38 were not sampled for fecal groups because of time limitations. Caribou were noted on several occasions to be feeding on that range type at Little Point. Examination of one such feeding location on July 30 revealed that 36 of 38 observed bites were from of *Salix arctica* leaves; the two others were from *Braya* spp.

Use of range types by muskoxen was restricted largely to severe winters. A bull muskox died at site 16 in winter 1973-74. His stomach contained mostly *Salix arctica*, including stems up to 7 mm (dia.). Another bull died on site 15 in the same winter. Site 38 was sampled because 11 muskoxen were seen feeding there in March 1974 when lowland sites were inaccessible because of deep and hard snow.

Range type 6: ***Luzula-Lichen Slope and Crest*** (sites 28-30)

Those sites received a high degree of use by caribou in winter and summer, with intensity dependent on topography. For example, summer use was greater than expected ($P < 0.01$) at site 30 (**Table 21**), a depression on a hill top. About 200 m away, however, on a southern exposure just below the hill crest, an extremely high density of winter pellet groups, comparable to densities at sites 23 and 34 (**Table 19**) was encountered but not quantified.

We obtained data on vegetation at sites 28 and 30 after seeing caribou feeding on them in late July 1974. By following, on hands and knees, tracks left by some of the many caribou in the general region of site 30, we found that seed heads of *Papaver radicatum* and *Saxifraga nivalis* were selected. Use of lichens, such as *Thamnolia vermicularis*, would go undetected. We had inadequate time to sample fecal groups at site 30, which was accessed by all terrain vehicles.

Range type 7: *Luzula Tussock* (sites 35, 5, 7A, & 3)
Intensity of use appeared to be dependent on topography and location of the range type relative to others. For example, adjacent sites 35 and 5 received relatively light use only from caribou, though fecal densities were not measured, whereas site 7A had fecal densities of 415 caribou fecal groups/ha and 137 muskox fecal groups/ha. The lower than "expected" ($P < 0.01$) use by caribou in winter for sites 7A and 3 (**Table 21**) and the range type (**Table 24**) was attributed to forage inaccessibility because of snow accumulation on the tussocks and migration from Melville Island to Prince Patrick Island in winter (Miller et al. 1977b).

Range type 8: *Sparse, Grass-Luzula Plain* (site 34)
The sampled site had the highest density (2610 groups/ha) of caribou fecal groups at all seasons (**Table 19**). Use by caribou in winter was significantly greater than expected statistically (**Table 21**). Sparse cover and smooth terrain would prevent accumulation of snow in winter. Many of the exclusively winter-type pellet groups appeared to be of the same age, suggesting intensive use in one winter when snow conditions were severe, e.g., 1971-72 or 1973-74. In both winters, caribou were known or suspected to have passed through the Sherard Bay Lowlands.

Range type 9: *Salix-Lichen Ridge* (sites 24, 8B,10, and 1)
Densities of caribou fecal groups on sites 24, 8B, and 1 were 621, 572, and 462 groups/ha, respectively (**Table 19**). Use of sites 24 and 8B and range type 9 in summer was greater ($P < 0.01$) than expected statistically (**Tables 21 & 24**). Seasonal-use data for site 1 was inadequate because the winter-summer classification scheme for fecal types was introduced while sampling that site.

Use by muskoxen of range type 9 was highly variable with fecal densities of 414, 72, and 829 groups/ha (**Table 19**). The high density of 829 fecal groups/ha at site 1 is difficult to explain, except that the ridge may be used as a bedding place by muskoxen after feeding in small raised meadows adjacent to the site and in extensive sedge-*Salix* lowland meadows between a ridge and a large, barren river delta to the south. The pattern of muskox use for site 1, i.e., greater than expected in summer (**Table 21**), supports that explanation. Use of that range type by muskoxen in summer was significantly more than expected ($P < 0.01$) (**Table 24**).

Range type 10: *Salix-Dryas-Lichen Ridge* (sites 23 & 4)

Apparent use by caribou was high at 2190 and 928 fecal groups/ha (**Table 19**). The high density at site 23 probably reflected intensive use in one winter. A preponderance of winter-type pellets ($P < 0.01$, **Table 21**) was characterized by many pellet groups of about the same degree of weathering and probable age. Though there was about equal intensity of use of site 4 at Little Point at both seasons, the known movement of caribou past Little Point in summer, together with their known scarcity in that region in winter, suggests that such range types are important in winter. Overall, for that range type, summer and winter use did not differ significantly (**Table 24**).

Use by muskoxen was low at all seasons (175 and 110 fecal groups/ha, **Table 19**), was less than expected in winter ($P < 0.05$) at site 23 and the reverse at site 4 (**Table 21**). We assume that snow would remain shallow on ridge tops throughout winter. Muskoxen would utilize the willows and monocotyledons mainly in winters of adverse snow conditions. Site 4 definitely was used extensively in the winter of 1973-74, when snow conditions were severe and many muskoxen died in the vicinity. *Salix arctica*, which grew in linear depressions on the site, was almost denuded from localized patches of ground.

Range type 11: *Salix-Saixfraga Ridge* (site 9)

Use by caribou (352 fecal groups/ha, **Table 19**) was predominantly in summer (**Table 21**). High use in summer is explained in part by its location on a major west to east migratory route of caribou. Both dominant plant species were utilized by caribou in summer. The exposed nature of that range type permits use by caribou and muskoxen in winters of general forage inaccessibility. Data for the site and range type at Little Point confirmed there was significantly greater use by muskoxen in winter than expected ($P < 0.01$, **Table 21**).

Range type 12: *High-Center Polygons* (not sampled for fecal densities)

Use of high-center polygons may be as variable as the vegetation associated with them and largely dependent on their location relative to other range types and to mosaics of range types favored by caribou and muskoxen. Few pellet groups were observed on that range type during walks through it.

Range type 13: *Felsenmeer* (not sampled for fecal densities)

Use by caribou and muskoxen of felsenmeer at Little Point and Sabine Bay was observed to be negligible.

Range type 14: *Salix Flat and Slope* (not sampled for fecal densities)

We noted that fecal groups of both large herbivores were scarce on this range type at Sabine Bay, probably because of the lack of plant diversity. Intensive use of willow leaves by caribou in summer (Parker 1978) suggested that use would be higher if caribou were more numerous in the Sabine Bay region in July.

Range type 15: *Polar Desert* (not sampled for fecal densities)

The associated vegetation received occasional use by caribou in summer and winter. Caribou grazed *Saxifraga oppositifolia* and *Papaver radicatum* in late July on a unit of this range type at Little Point.

Range type 16: *Barrens* (not sampled for fecal densities)

The only observed use of non-vegetated units was animals traveling across them.

3.4 Alternative grouping and naming of range types

Our classification of range types was based on visual differences in species composition as well as physiographic similarities and differences, including subjective moisture evaluations. The division of range types were arbitrary cuts in a continuum of change from hydric meadows with standing water to xeric polar deserts. Because mesic range types were quite similar in species and plant group composition, some can be grouped. In an earlier publication (Thomas & Edmonds 1984), for example, site 3 was omitted for lack of data on fecal densities and site 4 was grouped with site 8.

Upon review of summarized data for percent cover (**Table 3**), we regrouped the range types to produce trends in the cover of plant species utilized by caribou and muskoxen (**Table 25**). This new grouping was based on trends in cover and standing crop of *Salix arctica*, sedges, grasses, rushes, forbs, and mosses. It may be better than the original physiognomic grouping. Then we grouped range types that were similar in cover to reduce the number of types from 11 to 7 (**Table 26**). Finally, we produced a listing of three major range types (**Table 27**) by further grouping. We excluded low-center polygons that are uncommon on eastern Melville Island, though numerous in Polar Bear Pass of Bathurst Island. Parker (1978) suggested there were only three basic range types. However, we did not sample polar desert except for site 9 and it was relatively well vegetated for that range type.

We could have used a statistical package such as TWINSPAN to make the groupings retrospectively and we could have calculated variation at the range type level. A statistical division may have less value than one based on ecological relationships between vegetation and caribou and muskoxen. The unequal use of the three major range types by caribou and muskoxen is obvious (**Table 27**) and no test of significance is required. The three range types have hydric to hydric-mesic, mesic, and xeric moisture conditions.

Table 25. Average percent cover of plant species and species groups in 11 range types (Table 4) re-ordered to reflect trends in cover, Melville Island, summer 1974. Pellet-group densities are from Table 22.

Plant species [fecal densities] & (sample size)	Percent cover in range type (shaded below)										
	1	2	7	8	3	6	4	5	9	10	11
Salix arctica	1.7	1.7				1.0	1.6	14.6	15.4	11.5	11.5
Dryas integrifolia	0.3							Trace	0.4	3.3	2.3
Sedges	35.4		Trace		0.3	Trace	0.5	2.3	1.3	0.1	
Rushes	0.7	4.3	25.6	20.6	8.4	17.9	11.9	10.1	2.7	2.0	0.1
Grasses	21.2	5.6	2.1	10.0	10.9	2.1	11.7	5.3	1.9	0.4	0.2
Lichens except crustose	0.5	0.6	0.1	3.0	3.2	3.5	1.7	1.5	5.1	4.0	0.9
S. oppositifolia	Trace	0.3				0.3	0.4	1.3	0.1	0.1	4.3
Forbs	0.7	0.8	0.8	0.2	0.2	2.1	2.6	2.1	2.0	1.5	0.8
Mosses	85.3	86.7	81.4	94.8	69.0	61.3	48.5	59.4	26.0	18.8	11.2
Crustose lichens	1.2		18.1	0.2		20.1	16.8	18.3	35.4	40.6	22.0
Total plant cover	146.0	99.9	130.9	157.7	92.0	108.7	95.7	116.5	90.4	82.6	53.3
Bare ground/water	10.1	12.2		3.9		5.2		7.2	18.2	24.1	50.8
Shrubs	2.2	1.7				1.4	1.6	14.7	15.9	15.0	12.4
Monocotyledons	57.3	9.9	27.7	30.6	19.6	20.0	24.1	17.7	5.9	2.5	0.3
[caribou fecal density]	108	510	247	2610		1220	610	1295	552	1559	352
[Muskox fecal density]	871	9	90	6		0	224	14	438	143	132
(Number of quadrats)	223	50	70	15	20	133	63	179	128	115	80
(Number of sites)	11	2	3	1	1	4	3	5	3	2	1

Table 26. Average percent cover of plant species and species groups where 11 range types were grouped into seven types based on similarities and differences of vegetation (Table 25), eastern Melville Island, summer 1974 (site numbers are in App. 4).

Plant species, [fecal densities], & (sample size)	**Percent cover in consolidated range types (shaded below)**[1]						
	Wet Meadows	Low-Center Polygons	*Luzula* Plains	*Luzula*-lichen plains/uplands	Shrub-*Luzula* transition	Shrub-lichen uplands	Shrub-*Sax*. *opp*. uplands
	1	2	7	3, 4, 6, & 8	5	9 & 10	11
Salix arctica	2.5	1.7	0.0	1.0	14.6	13.8	10.1
Dryas integrifolia	0.5	0.0	0.0	0.0	Trace	1.6	2.3
Sedges	42.7	0.0	<0.1	0.2	2.3	0.8	0.0
Rushes	0.6	4.3	25.6	15.1	10.1	2.4	0.1
Grasses	10.0	5.6	2.1	7.1	5.3	1.3	0.2
Lichens (not crustose)	0.6	0.6	2.0	2.5	1.5	4.6	0.9
Sax. oppositifolia	<0.1	0.3	1.2	0.4	1.2	0.1	4.3
Forbs	0.6	0.8	5.8	1.9	2.1	1.8	0.8
Mosses	82.3	86.7	41.9	54.7	59.4	23.1	11.2
Shrubs	3.3	1.7	0.0	1.1	14.7	15.5	12.4
Monocotyledons	52.8	9.9	27.6	22.5	17.9	4.4	0.2
[Caribou fecal density]	108	510	247	1480	1295	1056	352
[Muskox fecal density]	871	9	90	110	14	291	132
(Number of quadrats)	223	50	70	231	179	243	63
(Number of sites)	11	2	3	9	5	5	3

[1] Mean of means for each range type in Table 25, i.e., not weighted by number of sites in each range type.

Table 27. Average percent cover of plant species and species groups in three major range types obtained by grouping 10 range types based on similarities and differences of vegetation (Tables 25 & 26), eastern Melville Island, summer 1974 (site numbers are in App. 4).

Plant species, [fecal densities], & (sample size)	**Percent cover in consolidated range types (shaded below)**[1]		
	Wet meadows	Luzula plains & uplands	Shrub uplands
	1.1, 1.2, 1.3, & 1.4	3, 4, 6, 7, & 8	5, 9, 10 & 11
Salix arctica	2.5	0.7	13.8
Dryas integrifolia	0.5	0.0	0.9
Sedges	42.7	0.2	1.4
Rushes	0.6	17.7	5.7
Grasses	10.0	5.9	3.0
Lichens (except crustose)	0.6	2.4	2.9
Saxifraga oppositifolia	<0.1	0.6	1.0
Forbs	0.6	2.9	1.9
Mosses	82.3	51.5	38.5
Shrubs	3.3	0.9	14.8
Monocotyledons	52.8	23.8	10.2
[Caribou fecal density]	108	1172	940
[Muskox fecal density]	871	80	182
(Number of quadrats)	223	301	485
(Number of sites)	11	12	11

[1] Mean of means for each range type in Table 25, i.e., not weighted by number of sites in each range type.

3.5 Relationship of log fecal densities and log plant species abundance

3.5.1 *Zeros included for plant species abundance and fecal densities*

Examination of normal probability plots indicated that natural log (ln or log e) transformations normalized fecal densities and cover and standing crop values, excluding zeros, for most plant species. The natural log over-compensated some species such as *Salix arctica* and some groups such as shrubs, monocotyledons, rushes, and mosses. The original values or an arc sine transformation are best for such species and groups. Log transformations under-compensated a few species such as *Alopecurus alpinus, Poa* spp., and standing crop of *Cetraria* spp. A $\log_{10}$ transformation would be better for them. However, individual species transformations for cover and standing crop are onerous when over 100 plant species and groups are involved and natural log transformation was the best overall transformation for all species.

Natural logarithm (ln) plant species/groups abundance that correlated highest with log densities of fecal groups for caribou and muskoxen using the Spearman correlation (**Table 28**) are in **Figures 14 & 15**, respectively. Spearman correlations require no assumptions about data normality or equality of variances. Pearson correlations for fecal densities (**Table 29**) were generated with cover and standing crop values transformed by natural logs.

Data in **Tables 28 and 29** must be viewed with caution for species with zeros for cover and standing crop at many sites. High correlations indicate possible association between use of sites by caribou and muskoxen and plant species abundance across sites. Zeros create many ties in rank tests such as Spearman and preclude normalization of data required for the Pearson analysis. Zeros are important biologically, however, because caribou and muskoxen may tend to avoid range types lacking forage species. Therefore, data in **Tables 28** and **29** are only exploratory and not robust statistically.

Table 28. Spearman correlation coefficients between natural log fecal densities of caribou and muskoxen and natural log plant species abundance, including zeros for plant species, at 19 sites sampled on Melville Island in 1974. Number of sites with recorded plant species cover or biomass (standing crop) are in parentheses.

PLANT SPECIES	CARIBOU		MUSKOXEN	
	COVER	BIOMASS	COVER	BIOMASS
Salix arctica	0.162 (15)	0.123 (16)	0.357 (15)	0.385 (15)
Carex aquatilis	**-0.708**** (5)	**-0.708**** (5)	**0.681**** (5)	**0.695**** (5)
Eriophorum triste	**-0.469*** (10)	**-0.483*** (7)	**0.701****(10)	**0.638**** (7)
Sedges	**-0.582****(11)	**-0.540***(12)	**0.860****(11)	**0.831****(12)
Dupontia Fisheri	**-0.599**** (7)	**-0.690**** (5)	**0.648**** (7)	**0.697**** (5)
Alopecurus alpinus	**0.434*** (10)	0.121 (7)	-0.248 (10)	0.102 (7)
Grasses	0.008 (19)	-0.039 (19)	-0.076 (19)	-0.116 (19)
Luzula spp.	**0.459*** (19)	0.253 (18)	**-0.606**** (19)	**-0.432*** (19)
Juncus biglumis	-0.058 (8)	0.141 (8)	0.305 (8)	0.256 (8)
Rushes	**0.498*** (18)	**0.516***(19)	**-0.625*** (19)	**-0.656****(19)
Thamnolia vermicul.	**0.412*** (16)	0.051 (18)	0.028 (16)	**0.445*** (18)
Cetraria deliseii	**0.494*** (10)	0.365 (9)	-0.087 (10)	-0.002 (9)
Lichens (not crust.)	0.339 (18)	**0.468** (19)	0.095 (18)	0.033 (19)
Papaver radicatum	**0.706****(14)	**0.575****(13)	**-0.658****(14)	**-0.528***(13)
Potentilla hyparctica	**0.501*** (12)	0.038 (13)	-0.203 (13)	0.212 (13)
Stellaria longipes	**0.391*** (16)	0.376 (17)	-0.320 (16)	-0.231 (17)
Forbs exc. *Sax. opp.*	0.259 (19)	0.388 (19)	-0.251 (19)	-0.340 (19)

Note: Probability is < 0.01 (**) for numbers > 0.549 and < 0.05 (*) for numbers > 0.388 and < 0.549 (Table P in Siegel 1956). Log is natural log (ln). Results must be interpreted cautiously where there were many zeros for cover and biomass (standing crop). Correlation between caribou and muskoxen fecal densities was -0.600 ($P < 0.05$).

Figure 14

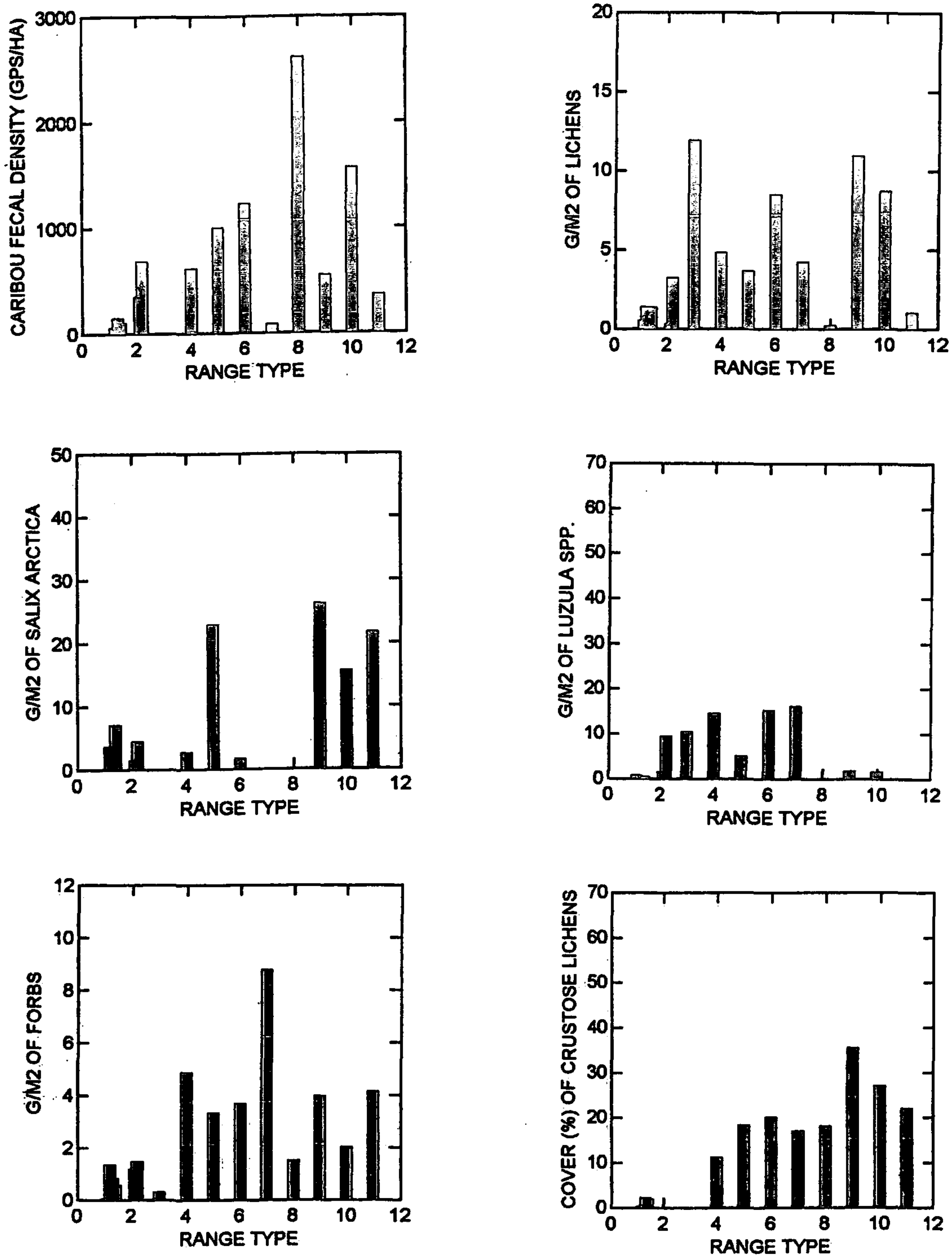


Figure 14. Caribou fecal densities and standing crop of lichens, *Salix arctica*, *Luzula* spp., forbs, and percent cover of crustose lichens in 11 range types on eastern Melville Island. No fecal data for range type 3.

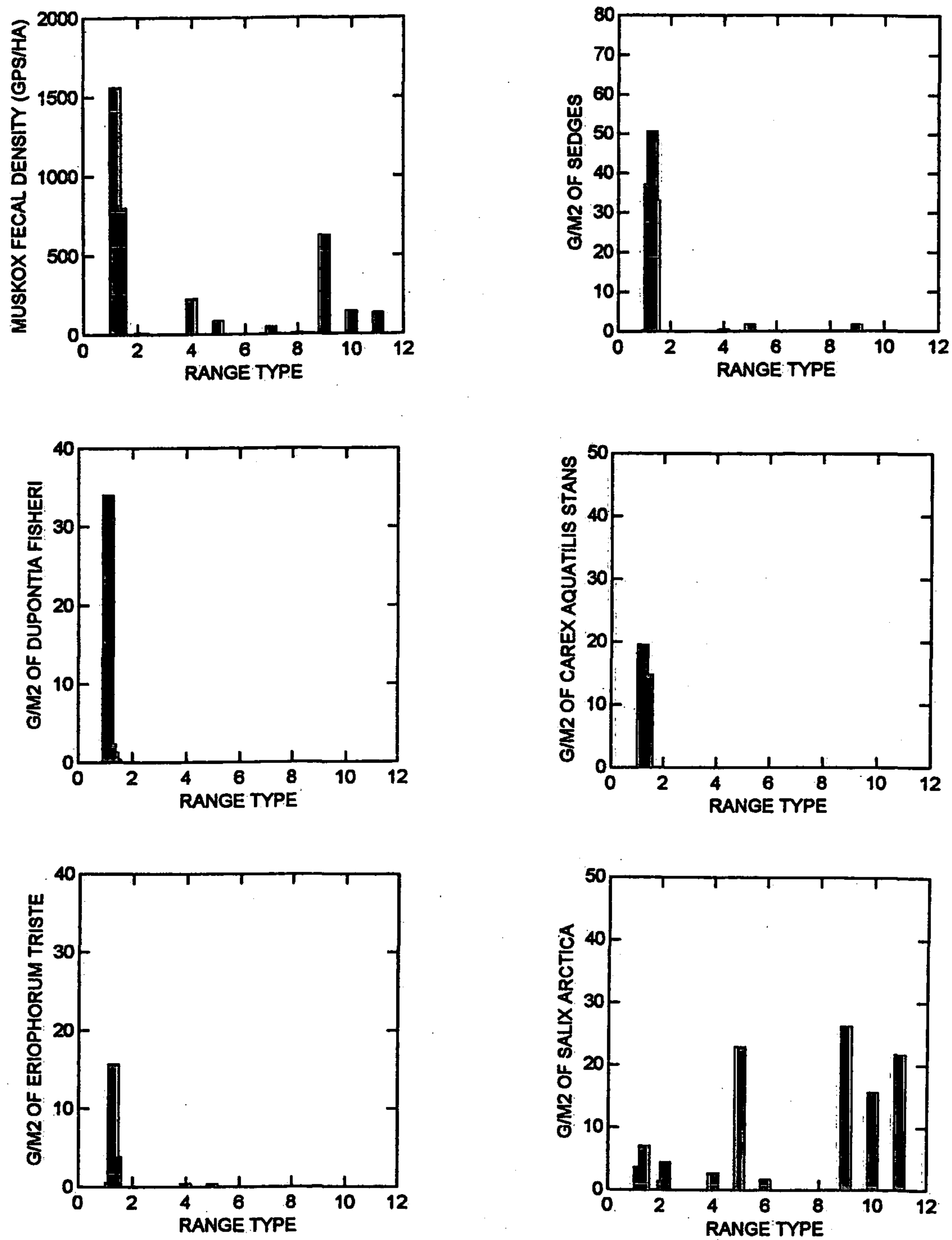


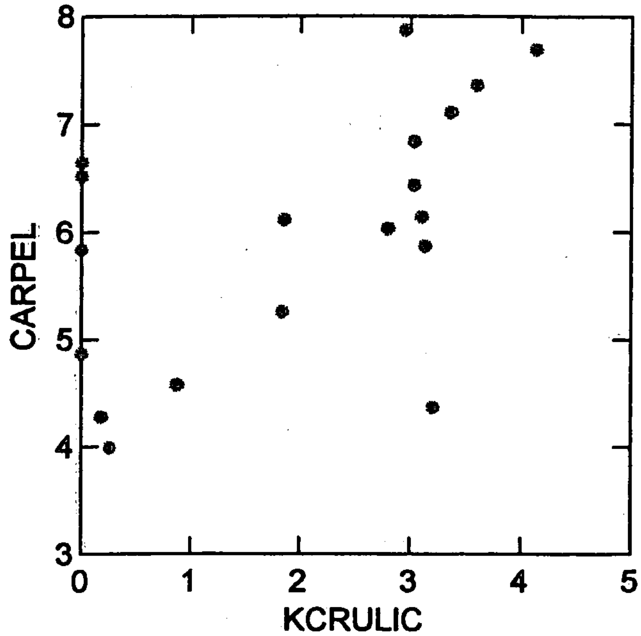
Figure 15. Muskox fecal densities and standing crop of *sedges, Dupontia Fisheri, Carex aquatilis stans*, *Eriophorum triste,* and *Salix arctica* in 11 range types on eastern Melville Island, 1974. The highest correlation was with sedges (Tables 28 & 29).

Table 29. Pearson correlation coefficients between natural log fecal densities of caribou and muskoxen and natural log plant species abundance, including zeros for vegetation, at 19 sites sampled on Melville Island in 1974. Number of sites with recorded plant species cover or biomass (standing crop) are in parentheses.

PLANT SPECIES	**CARIBOU**		**MUSKOXEN**	
	COVER	BIOMASS	COVER	BIOMASS
Salix arctica	0.201 (15)	0.135 (16)	0.439 (15)	**0.493*** (16)
Carex aquatilis	**-0.742**** (5)	**-0.749**** (5)	**0.595**** (5)	**0.598**** (5)
Eriophorum triste	**-0.552*** (10)	**-0.482*** (7)	**0.556***(10)	**0.496*** (7)
Sedges	**-0.741****(11)	**-0.747****(12)	**0.652****(11)	**0.647****(12)
Dupontia Fisheri	**-0.638**** (7)	**-0.683**** (5)	**0.559*** (7)	**0.564*** (5)
Alopecurus alpinus	**0.483*** (10)	0.098 (7)	-0.181 (10)	-0.005 (7)
Grasses	-0.034 (19)	0.041 (19)	-0.078 (19)	-0.139 (19)
Luzula spp.	0.375 (19)	0.179 (18)	**-0.588**** (19)	**-0.490*** (19)
Juncus biglumis	-0.131 (8)	0.196 (8)	0.202 (8)	0.325 (8)
Rushes	0.390 (18)	0.388 (19)	**-0.587****(19)	**-0.616****(19)
Thamnolia vermic.	0.330 (16)	0.145 (18)	0.272 (16)	0.450 (18)
Cetraria deliseii	0.391 (10)	0.433 (9)	0.135 (10)	0.120 (9)
Lichens (not crust.)	0.274 (18)	**0.417*** (19)	0.140 (18)	0.127 (19)
Papaver radicatum	**0.656****(14)	0.403 (13)	**-0.495*** (14)	-0.298 (13)
Potentilla hyparctica	0.152 (12)	-0.090(13)	-0.040 (13)	0.191 (13)
Stellaria longipes	0.300 (16)	0.306 (17)	-0.227 (16)	-0.190 (17)
Forbs excl. *Sax. opp.*	0.086 (19)	0.277 (19)	-0.254 (19)	-0.281 (19)

Note: Probability is < 0.01 (**) and < 0.05 (*).
Calculation was natural log (ln) (variable + 1.0).
Results must be interpreted cautiously for species with many zeros for cover and biomass (standing crop). Correlation between caribou and muskoxen fecal densities was -0.600 ($P < 0.05$).

Figure 16



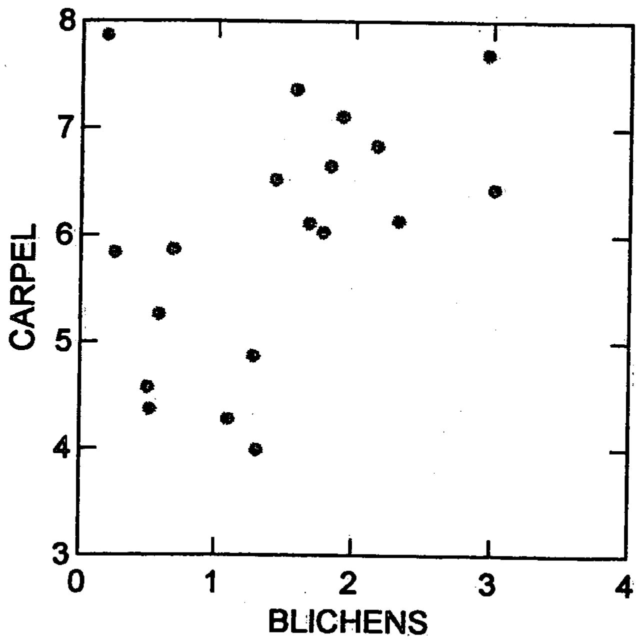


Figure 16. Scatter plot of log caribou fecal density with log percent cover of crustose lichens and log standing crop of non-crustose lichens at 19 locations on eastern Melville Island.

Scatter plots reveal the relationship between log caribou fecal densities and log percent cover of non-crustose crustose lichens (**Fig. 16**). Some crustose lichens such as *Umbilicaria* spp. may be eaten by Peary caribou (Miller et al. 1982), whereas others constitute a thin brown or black patina over surface materials. Fruticose and foliose lichens are eaten when they are available.

Multivariate regression analysis of the relationship between log fecal densities (dependent variable) and log plant species cover and standing crop (independent variables) were conducted with inclusion of sites with zero values (**Tables 30 & 31**). Plant species with higher F or t values and lower probabilities in a group explain more of the variation in fecal densities within groups of variables. However, those probabilities change as variables are moved in and out a regression containing other species. The coefficient of determination (R^2) is the amount of variation in fecal densities that is explained by the listed plant species. Adjusted R^2 is the expected coefficient of determination if the same type of sampling was repeated with the same sample size.

Based on results in **Table 29** for both seasons, we would expect the order of declining influence of cover on caribou fecal densities to be *Papaver radicatum, Alopecurus alpinus,* and *Cetraria deliseii.* In the regression (**Table 30**), *Stellaria longipes* dropped out and rushes entered it.

Inclusion of zeros for plant species abundance and different results for cover (**Table 30**) and standing crop (**Table 31**) for caribou fecal densities suggest that the relationships should be interpreted cautiously. Had we only included data based on standing crop, the reader may have placed too much emphasis on species in those results for each season. In some cases, one plant species can be interchanged with another but adding both of them to a regression produces a F or t value less than the 2.0 for one of them (P ca. 0.05). A minimum t of 2.0 is recommended to retain variables in regression analysis (Wilkinson et al. 1992). Further, there is little or no improvement in adjusted R^2 and overall probabilities. For example, *Carex aquatilis* and *Eriophorum triste* were interchangeable in the regressions for muskox

Table 30. Multiple plant species cover, including zeros, positively associated with degree of use of 19 sites by caribou and muskoxen in winter, summer, and both seasons, eastern Melville Island, summer 1974.

Ungulate/ Season	Plant species (*N*)[1]	*F* or *t* probability	*R*	Multiple R^2	Adjusted R^2	Overall probability
Caribou						
Winter	*Cetraria deliseii* (9)	0.001	0.867	0.749	0.649	0.000
	Thamnolia vermic. (15)	0.006				
	Juncus biglumis (8)	0.012				
	Alopecurus alpinus (9)	0.019				
	Crustose lichens (14)	0.026				
Summer	Lichens (17)	0.009	0.710	0.504	0.438	0.005
	Forbs (19)	0.022				
Both seasons	*Papaver radicatum* (14)	0.018	0.741	0.549	0.459	0.006
	Cetraria deliseii (10)	0.116				
	Rushes (19)	0.186				
Muskoxen						
Winter	Sedge (11)	0.000	0.885	0.783	0.756	0.000
	Salix arctica (15)	0.000				
	Salix arctica (15)	0.000	0.907	0.823	0.772	0.000
	Carex aquatilis (5)	0.018				
	Eriophorum triste (10)	0.023				
	Juncus biglumis (8)	0.049				
Summer	*Carex aquatilis* (5)	0.000	0.875	0.765	0.736	0.000
	Cetraria deliseii (10)	0.000				
Both seasons	Sedges (11)	0.000	0.860	0.739	0.706	0.000
	Salix arctica (15)	0.000				
	Salix arctica (15)	0.000	0.897	0.805	0.749	0.000
	Carex aquatilis (5)	0.017				
	Juncus biglumis (8)	0.025				
	Eriophorum triste (10)	0.056				

[1] *N* is number of sites where cover of the species was recorded.

Note: Statistics from linear regression of natural log fecal densities (dependent variable) on natural log percent cover (independent variables) with 1 added to each variable before transformation. Regression models included a constant (not shown) and zeros for plant cover. Therefore, the statistics are not normally distributed and the results must be treated with caution. Variables producing negative relationships were excluded (see Text).

Table 31. Multiple plant species standing crop, including zeros, positively associated with degree of use of 19 sites by caribou and muskoxen in winter, summer, and both seasons, eastern Melville Island, summer 1974.

Ungulate/ Season	Plant species (*N*)[1]	*F* or *t* probability	*R*	Multiple R^2	Adjusted R^2	Overall probability
Caribou						
Winter	*Cetraria deliseii* (8)	0.004	0.654	0.427	0.351	0.015
	Thamnolia vermic. (17)	0.027				
Summer	*Papaver radicatum* (12)	0.012	0.812	0.659	0.586	0.001
	Luzula spp. (17)	0.039				
	Lichens (18)	0.057				
Both seasons	*Cetraria deliseii* (9)	0.025	0.622	0.387	0.310	0.020
	Rushes (19)	0.037				
Muskoxen						
Winter	*Salix arctica* (16)	0.000	0.884	0.782	0.738	0.000
	Eriophorum triste (7)	0.016				
	Carex aquatilis (5)	0.019				
Summer	*Carex aquatilis* (5)	0.000	0.898	0.807	0.768	0.000
	Juncus biglumis (8)	0.011				
	Cetraria deliseii (9)	0.017				
Both seasons	*Salix arctica* (16)	0.001	0.904	0.818	0.766	0.000
	Carex aquatilis (5)	0.005				
	Juncus biglumis (8)	0.025				
	Eriophorum triste (7)	0.042				

[1] *N* is number of sites where standing crop of the species was recorded.
[2] Cover substituted, as standing crop not measured.
Note: Statistics from linear regression of natural log fecal densities (dependent variable) on natural log standing crop (independent variables) with 1 added to each variable before transformation. Regression models included a constant (not shown) and zeros for plant cover. Therefore, the statistics are not normally distributed and the results must be treated with caution.

fecal densities and plant cover. This occurred in spite of a negative Spearman correlation of 0.818 between the species cover among the ten sites where both occurred. Spearman correlation coefficients between cover of *Carex aquatilis* and *Dupontia Fisheri* were -0.500 ($N = 9$) and 0.273 ($N = 11$) between *Eriophorum triste* and *Dupontia Fisheri.* Entry of standing crops for both *Carex aquatilis* and *Eriophorum triste* in the regression produced slightly better fits for winter and both seasons (**Table 31**) than either one individually. By omitting the constant, some high correlations between fecal densities and plant species were obtained for standing crop. However, there was no justification for removing the constant, which has the effect of forcing the regression line through the origin. A constant may reveal that a threshold cover or standing crop of a plant species is required before muskoxen would feed on it.

3.5.2 ***Zeros excluded from log fecal densities and log plant abundance***

By excluding zero cover and standing crop, we examined the relationship between log fecal densities and log plant abundance only at sites where the particular plant species was present. That procedure reduced sample sizes for some species to unacceptable numbers. Thus, it must be viewed as an exploratory exercise. However, the statistics are valid with the caveat that small samples sizes are a problem.

Correlation coefficients changed in both directions when zeros were excluded from correlations (**Tables 32-35**). For example, the Spearman correlation between log cover of *Papaver radicatum* and log caribou fecal density declined from 0.706 to 0.368 (**Tables 28 and 32**), whereas the correlation coefficient of *Cetraria deliseii* increased from 0.494 to 0.524. In an extreme case, a positive correlation coefficient of 0.501 between cover of *Potentilla hyparctica* and caribou fecal density was reversed to -0.484 when six zeros were excluded. Spearman correlation coefficients between muskox fecal density and monocotyledon species were much lower when zeros were excluded (**Tables 28 & 33**). Inferences about relationships between plant species abundance and indices of ungulate use must

Table 32. Spearman correlation coefficients between natural log fecal densities of caribou and natural log plant species abundance, excluding zeros for plant abundance, at 19 sites sampled on eastern Melville Island in 1974 (number of sites with cover and standing crop are in parentheses).

PLANT SPECIES	SPEARMAN CORRELATION COEFFICIENT					
	COVER			STANDING CROP		
	Both	Winter	Summer	Both	Winter	Summer
Salix arctica	0.350 (15)	0.046 (14)	**0.664****(14)	0.409 (16)	0.157 (15)	**0.609***(15)
Carex aquatilis	-0.600 (5)	-0.800 (5)	0.051 (5)	-0.600 (5)	-0.500 (5)	-0.564 (5)
Eriophorum triste	**-0.600***(10)	-0.479 (10)	-0.426 (10)	-0.288 (7)	-0.214 (7)	-0.288 (7)
Sedges	**-0.888****(11)	**-0.709***(10)	**-0.596*** 10)	**-0.923**** (12)	**-0.782****(11)	**-0.688***(11)
Alopecurus alpinus	0.445 (10)	0.513 (9)	-0.409 (9)	-0.429 (7)	-0.086*(6)	-0.543 (6)
Luzula spp.	**0.459***(19)	0.235 (18)	0.241 (18)	**0.474***(18)	0.282 (17)	**0.440*** (17)
Rushes	**0.498***(18)	0.267 (18)	0.270 (18)	**0.516***(19)	0.279 (18)	0.345 (18)
Thamnolia vermic.	0.174 (16)	-0.063 (15)	**0.497*** (15)	0.263 (18)	0.036 (17)	0.240 (17)
Cetraria deliseii	**0.524***(10)	**0.487*** (9)	0.354 (9)	**0.650*** (9)	**0.762*** (8)	0.310 (8)
Cetraria cucullata	**0.695*** (9)	0.542 (9)	0. 385 (9)	**0.621****(16)	**0.533*** (15)	0.418 (15)
Lichens (not crust)	0.278 (18)	0.125 (17)	**0.580*** (17)	**0.468***(19)	0.331 (18)	**0.692**** (18)
Sax. oppositifolia	-0.265 (11)	**-0.569***(10)	0.116 (10)	-0.309(11)	**-0.552***(10)	0.006 (10)
Papaver radicatum	0.368 (14)	-0.026 (13)	0.470 (13)	**0.489***(13)	0.196 (12)	**0.699*** (12)
Potentilla hyparct.	-0.484 (12)	-0.203 (11)	**-0.628***(11)	0.305 (13)	-0.011 (12)	-0.505 (12)
Stellaria longipes	0.317 (16)	0.081 (15)	**0.573*** (15)	**0.532***(17)	0.388 (16)	0.377 (16)
Forbs exc.*Sax.opp.*	0.259 (19)	-0.071 (18)	**0.544*** (18)	0.388 (19)	0.168 (18)	**0.482*** (18)
Crustose lichens	**0.649****(15)	0.455 (14)	**0.637***(14)	Standing	crop not	measured
Mosses	-0.210 (18)	-0.001 (17)	**-0.486***(17)	Standing	crop not	measured

Note: Probability is < 0.01 (**) and < 0.05 (*) (Table P in Siegel 1956).
Calculation was natural log (ln) (variable + 1.0). Results must be interpreted cautiously because there were many zeros for cover and biomass (standing crop) for many plant species.

Table 33. Spearman correlation coefficients between natural log fecal densities of muskoxen and natural log plant species abundance, excluding zeros for plant abundance, at 19 sites sampled on eastern Melville Island in 1974 (number of sites with cover and standing crop are in parentheses).

PLANT SPECIES	SPEARMAN CORRELATION COEFFICIENT					
	COVER			STANDING CROP		
	Both	Winter	Summer	Both	Winter	Summer
Salix arctica	0.204 (15)	0.107 (15)	0.264(15)	0.059 (16)	-0.047(16)	0.123 (16)
Carex aquatilis	-0.200 (5)	-0.200 (5)	0.600 (5)	0.200 (5)	0.200 (5)	0.600 (5)
Eriophorum triste	**0.564***(10)	**0.600***(10)	0.350(10)	0.286 (7)	0.214 (7)	0.270 (7)
Sedges	0.528 (11)	**0.706***(11)	0.384(11)	**0.587***(12)	**0.769****(12)	0.408 (12)
Dupontia Fisheri	0.643 (7)	0.643 (7)	0.571 (7)	0.300 (5)	0.300 (5)	0.100 (5)
Luzula spp.	**-0.606****(19)	**-0.554**** (19)	**-0.521*** (19)	**-0.432*** (19)	-0.360 (19)	**-0.522*** (19)
Juncus biglumis	0.098 (8)	-0.110 (8)	0.478 (8)	0.595 (8)	0.238 (8)	0.512 (8)
Rushes	**-0.625**** (19)	**-0.584**** (19)	0.270 (18)	**-0.656****(19)	**-0.610**** (19)	**-0.583**** (19)
Grasses	-0.076(19)	0.054 (19)	0.186(19)	-0.116(19)	0.006 (19)	-0.190(19)
Monocotyledons	0.335 (19)	**0.414***(19)	0.371(19)	0.068 (19)	0.144 (19)	0.171 (19)
Thamnolia verm.	**0.455***(16)	**0.430***(16)	0.360 (16)	0.371 (18)	0.282 (18)	0.316 (18)
Cetraria deliseii	0.213 (18)	0.134 (10)	0.410(10)	0.283 (9)	0.167 (9)	0.203 (9)
Lichens	0.225 (18)	0.175 (18)	0.249(18)	0.033 (19)	-0.012(19)	-0.015(19)
Mosses	-0.041(18)	0.083 (18)	0.009(18)	Standing	crop not	measured

Note: Probability is < 0.01 (**) and < 0.05 (*) (Table P in Siegel 1956).
Calculation was natural log (ln) (variable + 1.0). Results must be interpreted cautiously because there were many zeros for cover and biomass (standing crop) for many plant species.

Table 34. Pearson correlation coefficients between natural log fecal densities of caribou and natural log plant species abundance, excluding zeros for plant abundance, at 19 sites sampled on eastern Melville Island in 1974 (number of sites with cover and standing crop are in parentheses).

PLANT SPECIES	PEARSON CORRELATION COEFFICIENT					
	COVER			STANDING CROP		
	Both	Winter	Summer	Both	Winter	Summer
Salix arctica	0.350 (15)	0.057 (14)	0.505 (14)	0.378 (16)	0.160 (15)	0.417 (15)
Carex aquatilis	-0.588 (5)	-0.787 (5)	0.019 (5)	-0.791 (5)	-0.805 (5)	-0.338 (5)
Eriophorum triste	-0.604 (10)	-0.566(10)	-0.431(10)	-0.325 (7)	-0.310 (7)	-0.325 (7)
Sedges	**-0.908**** (11)	**-0.773**** (10)	**-0.745*** (10)	**-0.921**** (12)	**-0.763**** (11)	**-0.806**** (11)
Alopecurus alpinus	**0.667*** (10)	0.664 (9)	-0.367 (9)	-0.243 (7)	-0.148 (6)	-0.650 (6)
Luzula spp.	0.375 (19)	0.211 (18)	0.262 (18)	0.322 (18)	0.137 (17)	0.461 (17)
Thamnolia vermic.	0.163 (16)	-0.016(15)	0.482 (15)	0.295 (18)	0.187 (17)	0.239 (17)
Cetraria deliseii	0.380 (10)	0.481 (9)	0.429 (9)	0.628 (9)	**0.819*** (8)	0.297 (8)
Cetraria cucullata	0.458 (9)	0.475 (9)	0.348 (9)	**0.498*** (16)	**0.535*** (15)	0.339 (15)
Lichens (not crust.)	0.187 (18)	0.103 (17)	**0.544***(17)	0.417 (19)	0.335 (18)	**0.574*** (18)
Sax. oppositifolia.	-0.284 (11)	-0.517(10)	0.265 (10)	-0.284 (11)	-0.448 (10)	0.157 (10)
Papaver radicatum	0.380 (14)	0.130 (13)	0.191 (13)	0.252 (13)	0.038 (12)	0.398 (12)
Potentilla hyparct.	-0.478 (12)	-0.357(11)	**-0.635***(11)	-0.308 (13)	-0.046 (12)	-0.563 (12)
Stellaria longipes	0.205 (16)	-0.167 (15)	0.474 (15)	0.381 (17)	0.137 (16)	0.355 (16)
Forbs exc.*Sax.opp.*	0.086 (19)	-0.125(18)	0.457 (19)	0.277 (19)	0.095 (18)	**0.482*** (18)
Crustose lichens	**0.779****(15)	**0.564***(14)	**0.639***(14)	Standing	crop not	measured
Mosses	-0.123 (18)	0.042 (17)	-0.420(17)	Standing	crop not	measured

Note: Probability is < 0.01 (**) and < 0.05 (*).
Calculation was natural log (ln) (variable + 1.0). Results must be interpreted cautiously because there were many zeros for cover and biomass (standing crop) for many plant species.

Table 35. Pearson correlation coefficients and probabilities between natural log fecal densities of muskoxen and natural log plant species abundance, excluding zeros for plant abundance, at 19 sites sampled on Melville Island in 1974 (number of sites with cover and standing crop are in parentheses).

PLANT SPECIES	PEARSON CORRELATION COEFFICIENT					
	COVER			STANDING CROP		
	Both	Winter	Summer	Both	Winter	Summer
Salix arctica	0.331 (15)	0.275 (15)	0.215 (15)	0.241 (16)	0.191 (16)	0.124 (16)
Carex aquatilis	0.018 (5)	-0.100 (5)	0.506 (5)	0.369 (5)	0.253 (5)	0.691 (5)
Eriophorum triste	0.435 (10)	0.462 (10)	0.312 (10)	0.261 (7)	0.210 (7)	0.400 (7)
Sedges	**0.615***(11)	**0.765****(11)	0.375 (11)	**0.637***(12)	**0.751****(12)	0.482 (12)
Dupontia Fisheri	0.536 (7)	0.552 (7)	0.496 (7)	0.533 (5)	0.534 (5)	0.449 (5)
Grasses	-0.078(19)	-0.026(19)	-0.208(19)	-0.139(19)	-0.098(19)	-0.301(19)
Luzula spp.	**-0.588****(19)	**-0.583****(19)	**-0.566*** (19)	**-0.490*** (19)	**-0.458*** (19)	**-0.507*** (19)
Juncus biglumis	-0.329 (8)	-0.384 (8)	0.100 (8)	0.484 (8)	0.173 (8)	0.641 (8)
Monocotyledons	0.144 (19)	0.185 (19)	0.204 (19)	-0.038(19)	0.002 (19)	0.091 (19)
Thamnolia verm.	**0.504** (16)	0.455 (16)	0.472 (16)	0.398 (18)	0.350 (18)	0.335 (18)
Cetraria deliseii	0.373 (10)	0.258 (10)	0.632 (10)	0.195 (9)	0.158 (9)	0.328 (9)
Lichens	0.246 (18)	0.206 (18)	0.337 (18)	0.127 (19)	0.105 (19)	0.123 (19)
Mosses	-0.077 (18)	0.008 (18)	-0.057(18)	Standing	crop not	measured

Note: Probability is < 0.01 (**) and < 0.05 (*).
Calculation was natural log (ln) (variable + 1.0). Results must be interpreted cautiously because there were many zeros for cover and biomass (standing crop) for many plant species.

be guarded where sample sizes are small. For a few forage species, where sample size was 5-8, positive correlations for cover changed to negative correlations for standing crop and vice versa (**Tables 32-35**). Some positive correlation coefficients between use by muskoxen and cover became negative for standing crop where the sample size was only five sites and vice versa (**Table 33**).

Relative use of sites by caribou and muskoxen could be predicted with a high degree of confidence if plant species with negative correlation coefficients were included in regression models. For example, fecal densities of caribou correlated highest, albeit negatively, with abundance of *Carex aquatilis* (**Tables 28 & 29**). However, our objective was to look for positive associations equivalent to range "selection" and not avoidance, *sensu* Miller et al. (1977a).

3.6 Relationship between fecal densities of caribou and muskoxen

The relationship between log (ln) fecal densities of caribou and muskoxen at the 19 sites where fecal counts were obtained (**Fig. 17**) produced Spearman correlation coefficients of -0.623 ($P < 0.01$), -0.575 ($P < 0.01$), and -0.472 ($P < 0.05$) for both seasons, winter, and summer, respectively. Corresponding Pearson correlation coefficients were -0.582 ($P = 0.009$), -0.549 ($P = 0.018$), and -0.374 ($P = 0.016$).

3.7. Associations among pairs of plant species

Pearson correlations between abundance of two plant species were generated with and without zero values to explore their effect on apparent associations (**Table 36**). Among the 38 sites in the analysis, some plant species occurred in only a few of them. Distributions highly skewed by a large number of zero values, and some small sample sizes, pointing to the need for non-parametric statistical analysis. Analyses where zeros were excluded (**Table 37**) avoid this problem and reveal some significant associations where both species occurred in sites. Four significant relationships between major species and groups are illustrated (**Fig. 18**).

Figure 17.

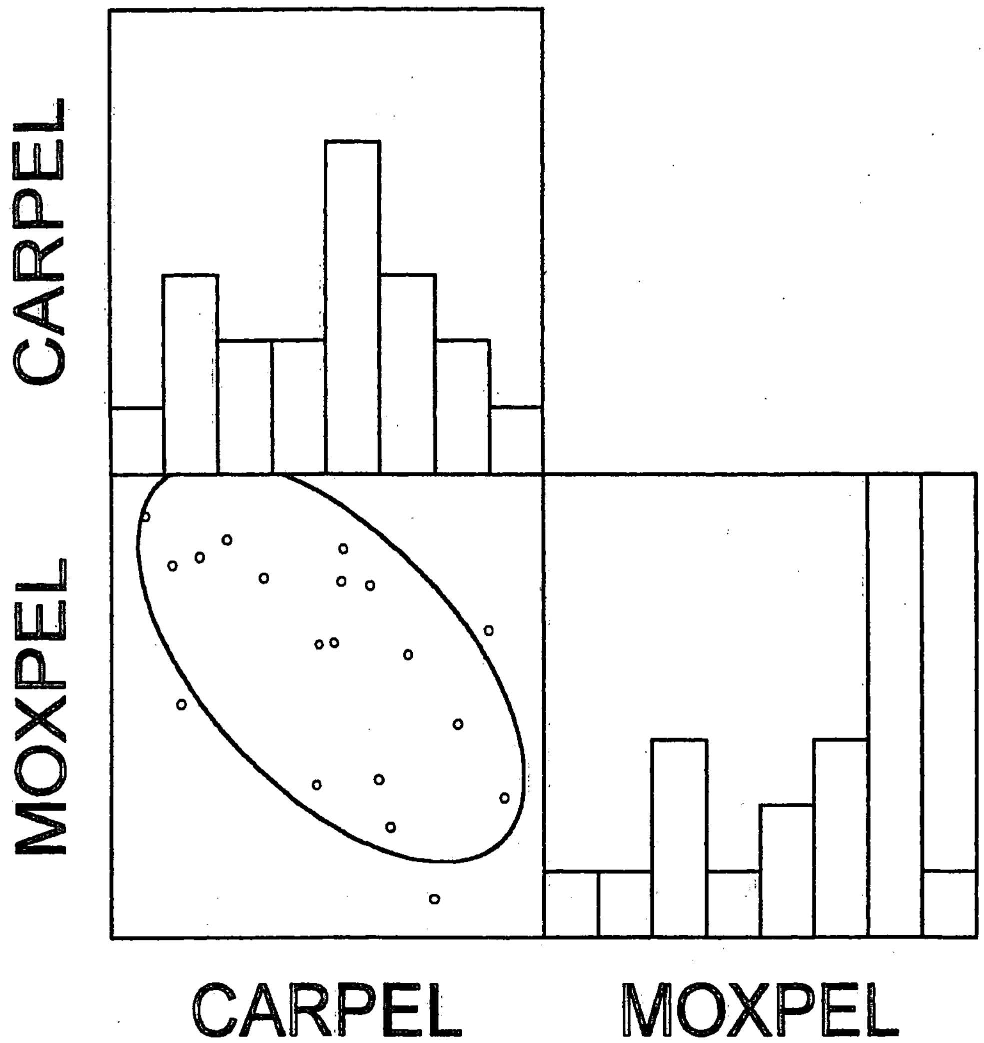


Figure 17. Histograms for natural log fecal densities of caribou and muskoxen and 75% confidence ellipse between them for 19 sites sampled on eastern Melville Island in 1974 (Pearson correlation = -0.582, $P = 0.009$).

Table 36. Pearson correlation coefficients (*R*) and probabilities (*P*) between selected plant species based on natural logs of standing crop, with zeros excluded and included (*N* = 36-38), to reveal their profound effect. Significant values are in bold.

Species 1	Species 2	Zeros excluded *R*	Zeros excluded *P*	Zeros excluded *N*	Zeros included *R*	Zeros included *P*[1]
Salix arctica	*Carex aquatilis*	0.692	0.128	6	0.048	0.776
	Eriophorum triste	**0.740**	0.036	8	-0.051	0.776
	Dupontia Fisheri	-0.122	0.818	6	-0.161	0.334
	Sedges	**0.631**	0.003	20	0.096	0.566
	Luzula spp.	-0.100	0.694	18	-0.095	0.571
	Thamnolia vermicularis	**0.738**	0.000	18	**0.496**	0.002
	Cetraria cucullata	0.442	0.087	16	0.288	0.080
	Cetraria deliseii	0.382	0.311	9	**0.411**	0.010
	Lichens	**0.408**	0.039	26	**0.371**	0.022
	Braya purpurescens	0.594	0.214	6	**0.446**	0.005
	Forbs	0.166	0.407	27	0.156	0.348
Carex aquatilis	Shrubs	0.776	0.070	6	0.084	0.618
	Eriophorum triste	**-0.922**	0.026	5	**0.715**	0.000
	Dupontia Fisheri	0.059	0.912	6	**0.452**	0.004
	Forbs	-0.592	0.216	6	**-0.406**	0.011
	Rushes	-0.495	0.190	6	**-0.425**	0.007
Sedges	Shrubs	**-0.627**	0.003	20	0.073	0.661
	Rushes	**-0.551**	0.010	21	**-0.543**	0.000
	Lichens	**-0.714**	0.000	21	**-0.415**	0.010
	Forbs	**-0.546**	0.007	23	**-0.392**	0.015
Luzula spp.	Lichens	0.293	0.186	22	0.281	0.087
	Thamnolia vermicularis	-0.095	0.683	21	**0.389**	0.016
	Cetraria deliseii	-0.220	0.492	12	0.160	0.339
	Papaver radicatum	-0.318	0.230	16	**0.321**	0.049
	Saxifraga oppositifolia	0.080	0.795	13	0.241	0.145
	Forbs	0.502	0.017	22	0.170	0.309
Lichens	Rushes	0.311	0.078	33	**0.452**	0.004
	Forbs	0.291	0.095	34	**0.399**	0.013
Cetraria deliseii	*Thamnolia vermicularis*	**0.793**	0.004	11	**0.771**	0.000
	Cetraria cucullata	**0.788**	0.007	10	**0.718**	0.000
	Papaver radicatum	0.559	0.093	10	**0.348**	0.032
Papaver radicat.	*Saxifraga oppositifolia*	**0.633**	0.020	13	**0.585**	0.000

[1] Probabilities are unreliable where more than 3-5 zeros occur because distributions are skewed and the linear relationship is forced through the origin, the same effect as deleting the constant.

Table 37. Spearman correlation coefficients (*R*) and probabilities (*P*) between plant species based on cover and standing crop, with zeros excluded from both. Significant values are in bold.

Species 1	Species 2	Percent cover			Standing crop		
		R	*N*	*P*[1]	*R*	*N*	*P*
Salix arctica	*Carex aquatilis*	-0.467	8	NS	**0.829**	6	<0.05
	Sedges	**-0.571**	18	<0.01	**-0.581**	20	<0.01
	Thamnolia vermicularis	**0.488**	21	<0.05	**0.719**	18	<0.01
	Cetraria deliseii	0.205	14	NS	**0.717**	9	<0.05
	Papaver radicatum	0.335	18	NS	**0.553**	13	<0.05
Carex aquatilis	*Eriophorum triste*	**-0.818**	10	<0.01	**-0.900**	5	<0.05
Sedges	Rushes	**-0.522**	21	<0.01	**-0.518**	21	<0.05
	Thamnolia vermicularis	**-0.629**	15	<0.01	**-0.648**	13	<0.05
	Cetraria deliseii	-0.513	10	NS	**-0.833**	9	<0.01
	Lichens	**-0.696**	19	<0.01	**-0.745**	21	<0.01
	Papaver radicatum	-0.442	12	NS	**-0.647**	8	<0.05
	Mosses	**0.612**	23	<0.01	**0.584**	23	<0.01
	Shrubs	**-0.608**	18	<0.01	**-0.658**	20	<0.01
Luzula spp.	Lichens	0.128	31	NS	**0.413**	22	<0.05
	Stellaria longipes	**0.531**	30	<0.01	**0.454**	20	<0.05
Thamnolia ver.	*Cetraria deliseii*	**0.598**	17	<0.01	**0.897**	11	<0.01
	Cetraria cucullata	**0.528**	18	<0.05	**0.474**	19	<0.05
Cet. cucullata	*Cetraria deliseii*	**0.762**	12	<0.01	**0.607**	10	<0.05
Cet. deliseii	*Papaver radicatum*	0.163	15	NS	**0.692**	10	<0.05
Lichens	Mosses	-0.287	31	NS	**-0.407**	33	<0.05
	Shrubs	**0.486**	25	<0.01	**0.440**	26	<0.05

[1] Probabilities from Table P in Siegel (1956).

Figure 18

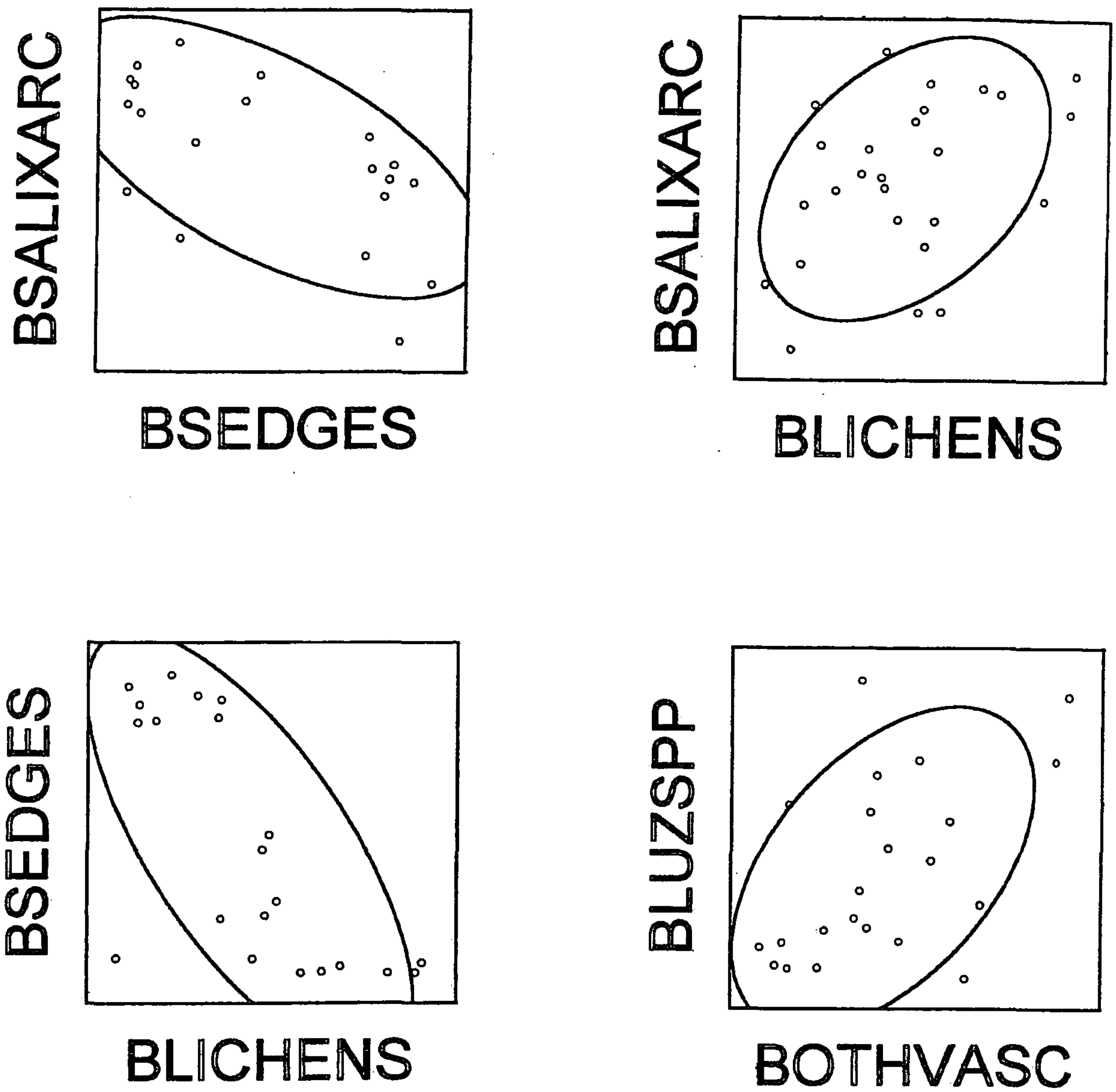


Figure 18. Correlations with 75% ellipses for *Salix arctica* and sedges, *Salix arctica* and lichens, sedges and lichens, and *Luzula* spp. and forbs. Data are natural logs (variable + 1), where variable >0 (i.e., zeros excluded).

DISCUSSION

4.1 Factors affecting apparent use of range types by caribou and muskoxen

We will attempt to explain range use data for caribou and muskoxen in terms of diet, nutritional requirements, effects of snow on forage availability, seasonal movement patterns, and plant associations subject to data limitations and problems with data analyses.

Acquiring sufficient quality food is the most important factor influencing use of range types by caribou and muskoxen on Melville Island. Relative use of range types is better understood if seasonal and annual changes in diet are known. Seasonal diets of Peary caribou can be inferred from personal observations and reported information (Wilkinson & Shank 1974, Wilkinson et al. 1976, Fischer & Duncan 1976, McLaren et al. 1977, Parker 1978, Russell et al. 1978, Shank et al. 1978, Thomas & Edmonds 1983). What we ultimately need to calculate is relative proportionate ingestion by wet weight, which we could then convert to dry weight with some field and laboratory studies. Quantitative information on diet can be severely biased because of technique inaccuracy and differential digestibility and passage times of forages. One option is to attempt to standardize species and species groups by multiplying diet composition by digestibility (Thomas & Kroeger 1980). For example, an *apparent* diet of 50% lichens and 50% mosses would be adjusted to about 88% lichens (70% digestible) and 12% mosses (10% digestible). To assess what herbivores are intending to ingest, we may want to subtract items, such as mosses, that may be consumed incidentally when eating species such as lichens and *Saxifraga oppositifolia* that are intertwined with mosses.

An understanding of the effect of snow and ice layers on forage accessibility is fundamental to comprehension of range use patterns based on fecal densities. In winter 1973-74, assumed freezing rain and snow produced ice over surface vegetation. Those conditions, combined with high snowfall and strong winds, made most vegetation unavailable to caribou and muskoxen. In most winters, foraging by caribou is progressively restricted to areas where snow is shallow because of sparse vegetative cover and elevated terrain, which is blown free of most snow.

Under severe snow conditions, feeding is essentially restricted to exposed ridges. Diet of caribou then is dominated by short monocotyledons (primarily *Luzula* spp.), lichens, *Salix arctica, Saxifraga oppositifolia*, and mosses. Mosses are considered by some researchers to be ingested by caribou incidentally when eating lichens and other plants such as *Salix arctica* and *Saxifraga oppositifolia* growing on and among mosses. Lichens must be sought out by caribou because diet information indicates higher use than would be expected from their sparse cover (**Table 4**). Lichens also are prominent in lists of species that correlate highest with caribou fecal densities at sites on eastern Melville Island (**Table 38**). We are not too concerned about the probabilities associated with correlation coefficients. They are inaccurate and unstable because of problems with sample size, data distributions, and zeros when they are included in the analyses.

In spring (June), flowers of *Saxifraga oppositifolia* are consumed in large quantities by caribou (Parker & Ross 1976, F. L. Miller pers. comm.). Such use has not been reflected in dietary information from caribou rumen and fecal samples. On Prince of Wales Island, *Saxifraga* spp. comprised about 5% of plant fragment densities (apparent diet) in summer and 11-52% in winter (Fischer & Duncan 1976, Thomas & Edmonds 1984). That genus did not emerge as highly important in correlations with caribou fecal density reported herein. The likely explanation is that *Saxifraga oppositifolia* was abundant only in range type 11 (**Fig. 6**), which precludes associations with fecal densities using correlations. Secondly, flowers of *Saxifraga oppositifolia* are eaten in spring and early summer. Therefore, dates of sampling and observations during the summer are important because diet changes throughout the snow-free period.

We predicted that *Salix arctica* would top the lists for use by caribou in summer based on rumen and fecal analyses and field observations (Fischer & Duncan 1976, Parker & Ross 1976, Parker 1978, Thomas & Edmonds 1984). As soon as the leaves of *Salix arctica* appear, they become the primary forage. Protein content of new growth is high and it is easily digested compared with leaves and stems

Table 38. Summary of Spearman and Pearson correlations between natural log fecal densities of caribou and natural log plant species abundance, with zeros excluded for plant species abundance, eastern Melville Island, 1974. Order in each column is decreasing correlation with minimum *R* of 0.350.

1. ***Spearman*** (data in Table 32)

Winter		Summer	
Cover	**Standing crop**	**Cover**	**Standing crop**
Cetraria cucullata	*Cetraria deliseii*	*Salix arctica*	*Papaver radicatum*
Alopecurus alpinus	*Cetraria cucullata*	*Crustose lichens*	*Lichens (not crust.)*
Cetraria deliseii	*Stellaria longipes*	*Lichens (not crust.)*	*Salix arctica*
Crustose lichens		*Stellaria longipes*	*Forbs*
		Forbs	*Luzula spp.*
		Thamnolia vermic.	*Cetraria cucullata*
		Papaver radicatum	*Stellaria longipes*

2. ***Pearson*** (data in Table 34).

Winter		Summer	
Cover	**Standing crop**	**Cover**	**Standing crop**
Alopecurus alpinus	*Cetraria deliseii*	*Crustose lichens*	*Lichens (not crust.)*
Crustose lichens	*Cetraria cucullata*	*Lichens (not crust.)*	*Forbs*
Cetraria deliseii		*Salix arctica*	*Luzula spp.*
Cetraria cucullata		*Thamnolia vermic.*	*Salix arctica*
		Stellaria longipes	*Papaver radicatum*
		Forbs	*Stellaria longipes*
		Cetraria deliseii	

after they acquire lignin and secondary compounds later in the growing season. Use of forbs in summer is grossly underestimated by fecal and rumen analyses. This has the effect of increasing the importance of species such as *Salix arctica* and monocotyledons. Forbs become important forage as they emerge and, as summer progresses, there appears to be increasing use of their seed heads. Lichens and new growth of short monocotyledons are also eaten. *Papaver radicatum* appears to be an important forage item in summer (Parker & Ross 1976, Thomas & Edmonds 1983). It would not appear in the results of rumen or fecal analysis because flowers and seeds may not leave recognizable artifacts in feces.

In summer, Peary caribou must select fine, new-growth parts of plants where the nutrient content is relatively high and it is quickly and highly digested. There are high energy and mineral requirements late in pregnancy and particularly when nursing a calf. Fat and muscle must be accumulated by all caribou during a short summer of about 2 months. Use of forages is closely linked to phenology of species, which varies among range types and seasons because different species are released from snow at different times and because of microclimate and moisture variability.

In winter and spring, diet varies with relative availability of plant species, which are mainly under wind-compacted snow and ice layers. Based on microhistological analysis of rumen contents of caribou collected in March and early April (Thomas & Edmonds 1983), we would predict that *Luzula* spp. would correlate highest with our index of relative use of range types in winter. However, that species does not even appear in the lists for winter (**Table 38**). One reason is that *Luzula* spp., like *Salix arctica,* are relatively abundant and are widely distributed across range types. It would appear to be a staple or survival food in winters such as 1973/74 when most forage was inaccessible because of snow and ice. Digestibility of cured leaves of *Luzula* spp. was 28%, considerably lower than *Thamnolia vermicularis* at 57% and 62% and *Cetraria* spp. at 61-81% (Thomas & Kroeger 1980).

In winter, lichens appear to be sought by caribou (**Table 38**) (Fischer & Duncan 1976, Miller et al. 1982). However, lichens are eaten year-round by caribou because of their high carbohydrate content and rapid digestibility. Lichens were not detected or were under-represented in early analyzes of rumen and fecal samples (Parker 1978). Six samples of caribou were obtained on eastern Melville Island in March and early April, 1974 through 1977 (Thomas & Edmonds 1983). No lichens were found in rumens of caribou collected during the severe winter of 1973-74. The following winter, when snow conditions were favorable, lichens comprised 28% and 37% of relative fragment densities in two samples. In 1975-76 and 1976-77, they made up only 0-2% of fragment densities. Such variability can not be explained with current knowledge. Lichens accounted for 0-1.4% of rumen contents of caribou on Banks Island, suggesting severe under-estimation of lichens in samples or indicating ranges almost devoid of lichens. They are under-represented in all methods of rumen and fecal analyses. Their proportion in the rumen and fecal samples increases substantially if data are adjusted for over-representation of mosses. Proportion of lichens increases even more if mosses are assumed to be ingested incidentally. Conversely, mosses may facilitate digestion by spacing out the nutritionally-important contents of rumen fill.

Winter-green parts of monocotyledons such as *Luzula* spp., *Alopecurus alpinus*, and *Carex misandra* may be important as a protein source in winter. Amino acids or nitrogen facilitates the digestion of lichens that generally contain only 2-4% protein (Thomas & Kroeger 1980). However, 3% protein in lichens may be equal to 12% in a source that is half as digestible and has twice the passage time. Digestibility of central green leaves of *Luzula* spp. was 52%, compared with 28% for dried leaves; corresponding values for *Carex misandra* were 62% and 25% (Thomas & Kroeger 1980). Green parts constituted 13% of total dried weight of *Carex misandra*. Dried parts of monocotyledons are less digestible but are needed for rumen bulk and winter maintenance.

Whether crustose lichens are eaten to any extent in winter or whether they simply are correlated with species sought by caribou is unknown. Crustose lichens (including "patina") correlated highest with caribou fecal densities in another study on eastern Melville Island (McLaren et al. 1977). Some of the species in **Table 38** are significantly inter-correlated (Tables 36 & 37). Therefore, we do not know which species the caribou are seeking and which appear in the list because their abundance is correlated with species selected by caribou. However, there is no reason to believe that any species in the lists are not eaten.

Unlike McLaren et al. (1977), we found no correlation between graminoids (grasses but also used to include all monocotyledons by some authors) as a group and fecal density. Shank et al. (1978) found that grasses comprised 20% to 53% of rumen contents of Peary caribou obtained in August and late winter on Banks Island. Monocotyledons comprised 20% of fragment relative densities in rumens of caribou collected in winter on Prince of Wales Island (Thomas & Edmonds 1983). This result differs widely from 1% monocotyledons reported for that island in summer and winter (Fischer & Duncan 1976).

The role of *Salix arctica* in winter diets of Peary caribou remains uncertain. Its proportion may be under-estimated by the ocular method of rumen analysis and the reverse for microhistological analysis. Parker (1978) concluded that willow was a key winter forage based on correlations between indices of caribou fatness and proportion of "woody" fragments, assumed to be *Salix arctica* stems, in rumens. His data may be biased, however, for his technique did not detect lichens and appeared to under-estimate monocotyledons and over-estimate *Salix arctica* (Thomas & Edmonds 1983, Table 7). There are many other reasons for different fatness across regions, with range quality and snow cover being two critical ones.

Some foods important to caribou were reflected by correlations between plant species and densities of fecal groups (Table 4 in Thomas & Edmonds 1983). In that analysis, zeros were included, data were not normalized, and there were differences in assigning vegetation and pellet-group densities at sites 7A, 7B, 8A, and 8B. Specifically, zeros were entered for lack of vegetation samples at site 7B and vegetation at site 7 was assigned to 7B, when 7A was more appropriate. At both sites, one range type graded into another. Fecal counts were partitioned but vegetation was sampled in the "A" site in each case. Thus, some correlation coefficients in Table 4 of Thomas and Edmonds (1983) differ slightly from data in

Tables 28-35 of this report. Nevertheless, the general conclusions are similar.

Muskoxen on eastern Melville Island were closely associated with wet (hydric-mesic) meadows (**Tables 19, 20, & 22**) and plant species that were abundant there (**Table 39**). Sedges, *Dupontia Fisheri, Eriophorum triste*, and *Carex aquatilis* correlated highest with fecal densities in summer and winter. *Carex aquatilis* and *Eriophorum triste* were negatively correlated with each other (**Tables 36 & 37**) suggesting that each species is sought as forage and its use is proportional to cover and standing crop. *Dupontia Fisheri*, like *Eriophorum Scheuchzeri,* is classed as an emergent, that is, it grows in water. *Carex aquatilis* grows best in damp substrates, whereas *Eriophorum triste* prefers damp to mesic conditions, including seepage slopes. Small sample sizes (5-7) for individual sedge and grass species were a problem in assessing relationships with fecal densities and associations between plant species. In August, groups of muskoxen mostly occupied "graminoid" (monocotyledon) range types where *Dupontia Fisheri, Eriophorum* spp., *Alopecurus alpinus, Luzula* spp., *Carex* spp., *Arctogrostis latifolia,* and *Salix arctica* occurred. On Devon Island, summer forages were *Carex* spp. (mostly *aquatilis and membranaecia), Salix arctica,* and *Pedicularis* spp. (Hubert 1972).

Salix arctica only occurred well down lists of plant species correlated with muskox fecal densities (**Table 39**) and then only when zeros were included. It grows in mesic to xeric moisture conditions. In meadows, therefore, it grows mostly around the periphery and on drier hummocks. It was present in 16 of the 19 sites where fecal densities were also estimated. We saw evidence that *Salix arctica* was eaten in winter 1973-74, when muskoxen were forced out of meadows by deep and crusted snow. Only the roots and the largest of stems were left in runnels where *Salix arctica* grew on mesic-xeric slopes above meadows. Rumens of muskoxen that died of malnutrition contained large quantities of willow stems (*Salix arctica*), some up to 5 mm in diameter. Our results are biased by the unusual winter of 1973-74, when about 69% of caribou and 59% of the muskox population died on eastern Melville Island (Miller et al. 1977a). The correlation with *Salix arctica* would have been lower had we sampled after a less unusual winter. The weak relationship with

Table 39. Summary of Spearman and Pearson correlations between log muskox fecal densities and log plant species abundance, zeros included and excluded, eastern Melville Island, 1974. Order in each column is decreasing correlation with minimum R of 0.350.

1. ***Spearman and Pearson, including zeros*** (both seasons, data in **Tables 28 & 29**)

Spearman		Pearson	
Cover	**Standing crop**	**Cover**	**Standing crop**
Sedges	*Sedges*	*Sedges*	*Sedges*
Eriophorum triste	*Dupontia Fisheri*	*Carex aquatilis*	*Carex aquatilis*
Carex aquatilis	*Carex aquatilis*	*Eriophorum triste*	*Dupontia Fisheri*
Dupontia Fisheri	*Eriophorum triste*	*Dupontia Fisheri*	*Eriophorum triste*
Salix arctica	*Tham. vermicularis*	*Salix arctica*	*Salix arctica*
	Salix arctica		*Tham. vermicularis*

2. ***Spearman, zeros excluded for plant species abundance*** (data in **Table 33**)

Winter		Summer	
Cover	**Standing crop**	**Cover**	**Standing crop**
Sedges	*Sedges*	*Carex aquatilis*	*Carex aquatilis*
Dupontia Fisheri		*Dupontia Fisheri*	*Juncus biglumis*
Eriophorum triste		*Juncus biglumis*	*Sedges*
		Sedges	
		Eriophorum triste	

3. ***Pearson, zeros excluded for plant species abundance*** (data in **Table 35**).

Winter		Summer	
Cover	**Standing crop**	**Cover**	**Standing crop**
Sedges	*Sedges*	*Carex aquatilis*	*Carex aquatilis*
Dupontia Fisheri	*Dupontia Fisheri*	*Dupontia Fisheri*	*Juncus biglumis*
Eriophorum triste		*Sedges*	*Sedges*
			Dupontia Fisheri
			Eriophorum triste

Salix arctica is puzzling in light of estimates of diets of muskoxen (Fischer & Duncan 1976, Wilkinson et al. 1976, McLaren et al. 1977, Parker 1978). Our results are contrary to those of Fischer and Duncan (1976) for Prince of Wales Island, where *Salix arctica* was the principle forage in summer and third in abundance in winter after mosses and *Carex* spp. McLaren et al. (1977) also found dwarf shrubs (essentially *Salix arctica)* to have the highest correlation with fecal density of muskoxen on eastern Melville Island. Tener (1965) concluded that moskox abundance was linked to the abundance of willow and sedge.

More studies are needed to clarify roles of *Juncus biglumis* and *Thamnolia vermicularis* in the diet of muskoxen. Standing crop of *Festuca brachyphylla* was positively associated with muskox fecal densities (R = 0.674 and 0.750 in both seasons and summer, respectively) but sample size was only four. It was common in rumens and feces of caribou and muskoxen on the Queen Elizabeth Islands (Parker 1978).

This short review of dietary information and range use by Peary caribou and muskoxen points to the variability among regions, variation that may reflect different diets, vegetation composition, phenology, and weather. For example, *Saxifraga oppositifolia* is abundant on Prince of Wales Island (Fischer & Duncan 1976), which is reflected in rumen contents (Thomas & Edmonds 1984). Divergent results could also be due in large part to the various techniques used to estimate diets and habitat use, the parts of plants that are measured, timing of sampling, and snow conditions. For example, results differed depending on technique used to analyze the same samples (Thomas & Edmonds 1983). Two sets of results for caribou in winter on Prince of Wales and Somerset islands differed considerably (Fischer & Duncan 1976, Thomas & Edmonds 1983). Date of fecal deposition often is unknown unless caribou or muskox are observed to be defecating or tracks of known age are followed and samples recovered. Caribou diet changes considerably from spring to early winter. Consequently, researchers using the microhistological technique should obtain feces of known deposition dates or intervals.

When assessing standing crop of shrubs, there is a large difference between measuring current year's growth (productivity) and standing crop (total above-ground biomass). Productivity makes more sense ecologically but there are problems identifying current year's growth (Svoboda 1972) and measurements must be taken at the end of the growing season about the end of July. Nevertheless, productivity of willows should be correlated with total above-ground biomass and with different growth forms of *Salix arctica*.

In correlations and regressions, care must be taken to obtain large sample sizes, to standardize data, check data distributions and residuals, check for the influence of zero values, and check for the influence of outliers. Otherwise, the R, R^2, adjusted R^2, and probabilities may be unreliable and outright misleading. In extreme cases, exclusion of zeros had the effect of changing the relationship between fecal densities and plant species (**Tables 28, 29, & 32-35**) and between two plant species from negative to positive and vice versa (**Table 36**). The results of stepwise regressions must be checked with normal regression and correlations run with species and groups of species. Correlations between plant species can confound interpretation of regression data where fecal densities are the dependent variable.

Caribou are constantly on the move, even when available range is severely restricted by snow and ice (Miller et al. 1982). This behavior may be an adaptation by caribou to prevent overuse of plants such as lichens that take decades to re-establish if they are completely removed from a location by fire or consumption by herbivores. (Predator and parasite minimization are alternative hypotheses). This foraging behavior helps to explain why relative use by caribou of sites does not correlate highly with abundance of any one species. As caribou move across the tundra, only trace or small amounts of a species may be obtained at any one location. Time spent at a site is not related to forage abundance (Miller et al. 1982). An exception is in winter when caribou must crater for forage. There is a definite advantage to high abundance of a forage species if considerable energy must be expended to make food available under snow. Even then, bits of exposed lichens can always be found in snow at crater sites. This is not necessarily wastage for it disperses lichens over a wider area.

Our animal use-plant species associations indicate some species that are important as forages (**Tables 38 & 39**) but others with low correlation coefficients and some not listed may be important at certain seasons. Associations between fecal densities at sites and plant species abundance will only detect species that are major contributors to the diet over prolonged periods in an annual cycle. Even then, there may be errors in indexing relative use by fecal densities (**App. 13**). Caribou have a diverse diet that changes throughout the year in response to seasonal changes in plants and climatic variation. We should not expect strong associations between abundance of individual plant species at sites and relative use of those sites by caribou and muskoxen.

4.2 **Relationship between caribou and muskoxen on eastern Melville Island**

We conclude that, at the time of our study, there was no competition between the two herbivore species because fecal densities were negatively associated, there was almost no overlap in major dietary species, relationships with certain forage species contrasted significantly, caribou primarily used mesic and xeric sites whereas muskoxen primarily used wet meadows, and population densities were low. Some caribou feces were found at all sites but those in wet meadows were mostly the winter type. There is a possibility that caribou visit wet meadows cratered by muskoxen and consume some exposed grasses and sedges. Muskoxen feed on mesic sites especially in early summer (Parker & Ross 1976) and they must feed on them when ice and deep snow force them out of lowland wet meadows. For example, in summer 1974, we saw where muskoxen, in winter 1973-74, had removed most *Luzula* spp. from near a meadow and stripped willow from runnels on mesic slopes. There was some overlap in use of *Salix arctica*, some monocotyledon species, and probably one or two forbs. There is no competition, however, unless plant species in a dietary overlap limit numbers of one or both herbivore species.

Parker (1978) concluded there was some overlap of forages in winter but dismissed competition. Russell et al. (1978) came to the same conclusions after studying use of ranges on Prince of Wales and Somerset islands. Wilkinson et al. (1976) and Shank et al. (1978) found no strong evidence for competition on Banks Island. Of course, if densities of caribou or muskoxen were high, competition could occur if a plant species common to both was in short supply. This is likely a rare occurrence for severe winters periodically reduce populations of caribou and muskoxen in the Queen Elizabeth Islands.

4.3. **Cover and standing crop of vegetation and relationships between them**

Significant relationships between cover, measured photographically, and standing crop means that cover is an adequate measure of plant abundance. Relationships between use of range types by caribou and muskoxen and vegetation abundance can be assessed quickly using only cover. Ocular estimates of cover are adequate if observers are trained to estimate it using artificial tokens to represent plant morphologies and reference photographs of quadrats where cover was estimated objectively. Pin frames are a satisfactory method of measuring cover of plants provided there is a calculation of sample size needed to accurately and precisely measure cover of important species. Cover of tall monocotyledons is inadequately measured by all techniques and correlations with biomass can be low for some species.

4.4 **Sampling methods**

The best measure of abundance of forage species in relation to herbivores is annual production. However, it should be measured at the end of a growing season for vascular plants. That means restricting sampling to the first 2 weeks of August in the High Arctic, where growing seasons are short. Measurement of standing crop is an alternative, in which case the relationship between annual production and standing crop should also be measured. There is large annual variation in annual production in the High Arctic because of weather variability. Standing crop is the only option for lichens.

Percent cover, measured photographically, was found to be a good index of vegetation abundance. It was highly correlated with standing crop of many species (**Tables 14-18**). However, lower correlation coefficients for data pooled from several sites means there are different relationships between cover and standing crop among sites. There is no one measure of cover that is adequate for all species. Point vertical measures such as achieved with vertical photography and grid overlay, pin frame (Parker & Ross 1976), and line transect are most suitable for cushion species or those species with a prostrate form. No measure, including ocular estimates, adequately assesses abundance of plants with tall upright stems or leaves. Thus, for many monocotyledon species, cover estimates are low relative to standing crop. Relative to photo estimates, ocular cover estimates were low by factors of 3.5 to 5.5 for monocotyledons and generally 1.4 to 2.1 for other species.

There are large sampling errors with both methods, and, presumably, with all others. Accuracy can not be evaluated. Only the relationship between two methods can be assessed. We conclude that cover is an adequate index of vegetative abundance because (1) photo cover correlated with standing crop (**Tables 14-18**) and (2) correlations between fecal densities and cover and standing crop often were similar where the sample sizes for both were >10 (**Tables 28-35**). For example, Spearman correlations between muskox fecal density and cover and standing crop of *Salix arctica* were 0.36 and 0.39, respectively (**Table 28**).

Scale is important in assessing caribou and muskox range. The largest unit could be considered the *ecoregion* - Northern Arctic. At this level we might compare densities of animal and plant species and communities with the Mid-Arctic, Low Arctic, etc. Ecoregions are divided into *ecodistricts*. The next division has been termed *landscape (terrain) units* with a certain bedrock type, topography, and vegetation (Barnett et al. 1975). We evaluated relative use of terrain units by caribou and muskoxen on eastern Melville Island based on densities of those species found on six aerial surveys by Miller and Russell (1974), Miller and Russell (1976), and Miller et al. (1977a).

Range types are a subdivision of landscape units, which contain broad plant associations. They may occupy linear dimensions of 100 m to several kilometers.

Within range types are *vegetation types* (communities), which are local plant associations across linear dimensions of 10 m to 100 m. At smaller scales there are units that can be termed vegetation *sites* or *ecosites* of only a few meters in linear dimension. Within ecosites are *microsites* with linear dimensions of a few centimeters to a few meters. One example of a microsite is a tussock or hummock. Microsites are important to wildlife but are difficult to sample and to describe. Often it is necessary to stratify microsites, sites, and vegetation communities to reduce variation. Some authors complex them, which means that the area of each subtype within larger units is measured or estimated and proportions of each subtype are listed.

To illustrate, a field of Low Center Polygons, perhaps 500 meters in linear dimension, was termed a *range type*. It was subdivided into two vegetation communities, ridges and centers. There is variation in plant species among low-center polygons depending on wetness of centers, height and extent of ice wedges, and other factors. Thus, we selected a representative *site* in a range type and sampled it. Even within a site there was considerable variation at the *microsite* level.

Studies of lichens on beach ridges on Devon Island showed that cover increased progressively from transition zone to slope and finally to crest (Richardson & Finegan 1972). Major species of lichens were *Thamnolia vermicularis, Cetraria cucullata, Cetraria nivalis, and Umbilicaria lyngei.*

Perhaps quadrat size should be increased as plant species of concern become more sparse and irregular in distribution. The quadrat or ring should be large enough that zeros do not occur or are infrequent. One possibility is to increase sample area until minimum weights of plant species of concern are obtained. Another possibility is presence-absence sampling and use of logistic applications. Wein and Rencz (1976) calculated that up to 2150 quadrats 25 cm x 50 cm were required to adequately sample cover and biomass of major groups of arctic vegetation in some range types. Mean numbers of quadrats required to estimate cover and biomass of lichens were 468 and 388. A quadrat 1 m x 10 m or a circle of diameter 5 m to 10 m may be required to adequately sample cover and standing crop of polar desert vegetation.

4.5. **Classification of range types**

We included, in this report, our original classification made in the field. This classification was ocular or subjective and based on visual differences in species composition as well as physiographic similarities and differences, including subjective moisture evaluations. Range types 4 and 8 were grouped in Thomas and Edmonds (1984) on the advice of one reviewer. This is *a posteriori* grouping after examining data for cover and standing crop. Similarly, we grouped range types in this report to reduce the number of types to seven (**Table 26**) and three (**Table 27**).

Fischer and Duncan (1976) used a universal classification scheme adopted by the International Biophysical Program. They named 19 vegetation communities and combined them into nine range types. McLaren et al. (1977) adapted the system to Melville Island. A problem with the system is use of only shrubs, lichens, forbs, and mosses as major vegetation classes and no focus on individual species. The major groupings of vegetation to the Order and Family taxonomic level is of limited relevance to herbivores. As an example, grouping *Salix arctica, Dryas integrifolia,* and *Cassiope tetragona* and using shrubs as the level of classification in analysis makes no ecological sense. Use of *Dupontia Fisheri* by muskoxen differs radically from use of other monocotyledons and to combine that species into a single class and use that in analysis completely obscures the high value of *Dupontia Fisheri*. Not to isolate *Luzula* spp. from rushes masks the importance of that genus to caribou. Not to isolate *Saxifraga oppositifolia* and *Papaver radicatum* from the forb class is to swamp their contribution as forage for caribou in a host of species that are little used for food. Analyses of diet and indices of use-plant abundance above the species taxonomic level of classification are not useful.

CONCLUSIONS

1. Positive correlations between caribou fecal densities, an index of past use, and cover and standing crop of plant species suggest that *Cetraria deliseii, Cetraria cucullata*, crustose lichens, *Alopecurus alpinus*, and *Stellaria longipes* were most associated with winter use and *Salix arctica*, *Papaver radicatum*, lichens, and forbs were most associated with summer use, whereas there was a strong negative correlation with *Carex aquatilis*, *Dupontia Fisheri,* and *Eriophorum triste.*

2. The same analysis for muskoxen suggested that sedges in general and the species *Carex aquatilis, Eriophorum triste,* and *Dupontia Fisheri* (a grass), were strongly correlated with use of sites, whereas *Salix arctica, Juncus biglumis,* and *Thamnolia vermicularis* were weakly associated and there were strong negative associations with *Luzula* spp. and *Pavaver radicatum.*

3. High fecal densities on the crests of exposed ridges where *Luzula* spp. and lichens were relatively abundant (sites 23 and 34) indicated the importance of those relatively snow-free ecosites to caribou in winter.

4. For feeding, muskoxen used the same wet (hydric-mesic) meadows in summer and winter and, when forced out of them by snow and ice in winters such as 1973-74, they fed on *Salix arctica* and sparse grasses and rushes that grew on mesic and xeric range types.

5. Caribou and muskoxen mostly fed on different plant species and the overlap was predominantly for *Salix arctica*, which occurs widely across range types and is relatively abundant. We conclude there was lack of competition, defined as a shortage of forage or space jointly used by two species that limits one or both.

6. There was a significant negative correlation between use of sites by caribou and muskoxen, as measured by fecal densities.

7. Range types can be identified in the field by a combination of vegetation present, topography, and moisture criteria. If necessary, they can be grouped later using objective or subjective criteria.

8. Relative use of sites and range types by caribou and muskoxen can be assessed by the abundance of fecal groups, which persist for many years in a dry climate with short summers. However, data are needed on differential decay rates of summer and winter fecal groups in hydric, mesic, and xeric moisture regimes. Then, data across moisture classes could be adjusted objectively.

9. There were strong correlations between photographic estimates of cover and standing crop of most plant species and formulae are provided to calculate standing crop from cover.

10. Estimation of cover by a photographic method was sufficient to characterize vegetation abundance at sites. Ocular estimates, relative to photo estimates, were inaccurate for many species but both are questionable for species with tall upright stems or leaves.

11. Our analysis indicated the importance of viewing data distributions graphically and normalizing them for Pearson correlations and regressions, the need to view residuals to detect unequal variances, the danger of zero values for plant abundance in linear regressions, and the unstableness of correlations and regressions where sample sizes were small.

12. Our results can be used by others to help plan a sampling program to further examine relationships among caribou, muskoxen, and abundance of plant species.

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Appendix 1. Equations for calculating pellet group densities (D) (from Bell 1973, Batchelor 1973).

1. $D = d/(1 + 2.5f)\ (1 + 2.7f)^{-A}$

where D is pellet groups per square meter (multiply by 10^4 for groups per hectare).

2. $d = p/\pi[\Sigma r_p^{\ 2} + (N\text{-}p)R^2]$

where:
π = 3.1416
r_p = point distance (meters)
N = sample size (total no. of plots)
p = no. of point distances
R = radius searched (meters) (=5)

3. $f = p/N$

4. $A = (cv/Ecv) /\sqrt{(\Sigma r_p \times n^2 \times N)/(\Sigma r_n \times p^3)}$

where:
cv = equation 5
Ecv = tabular value (Bell 1973:36)
n = no. of neighbor distances
r_n = neighbor distance (meters)

5. $cv = \sqrt{p[\Sigma r_p^{\ 2} - (\Sigma r_p)^2/p]}\ /\Sigma r_p$

Appendix 2. **General description of range types**

1. ***Wet Meadows*** (total percent cover 83-173%, mosses 40-100%, crustose lichens 0-11%, not vegetated 0-33%).

The vegetation was moss dominated because those closed communities were wet throughout the growing season and standing water was common. Such meadows occurred in depressions where water tended to accumulate because drainage was poor, in seepage zones, or between beach ridges. The largest meadows were in flat coastal lowlands and in river valleys. Almost all such meadows were below the prehistorical marine limit (ca. 81 m asl) and therefore were enriched by marine silts. Small wet meadows also occurred in some upland depressions, seepage slopes, between ridges (e.g., beach ridges), and in drainage runnels. Snow accumulates in wet meadows, which affords protection to the plants in winter and supplies moisture in early summer.

Carex aquatilis, Eriophorum triste, E. Scheuchzeri, Luzula nivalis, and *Dupontia Fisheri* comprised a high percent cover (37-77%) of vascular plants over a 40-100% understory of mosses. *Salix arctica* varied in cover from none in the wettest meadows to a high of 7.5% in an elevated (>100 m) seepage meadow located on a bench near the toe of a large hill (site 39). *Salix arctica* was the only shrub noted in wet meadows except for site 25, an isolated, atypical meadow in an area of sand dunes. In that meadow, which lies adjacent to a flood plain of a large river, *Dryas integrifolia* and *Cassiope tetragona* occupied 5.2% and 3.6% cover, respectively.

Typical forbs present were *Melandrium apetalum, Saxifraga Hirculus, S. cernua, Cardamine bellidifolia, Ranunculus sulphureus,* and *Draba lactea* but they contributed little to the total cover. The only abundant lichens were *Peltigera aphthosa* and *P. canina*, though *Thamnolia vermicularis*, *Cetraria cucullata*, and *C. islandica* were present. Wet meadows were the most productive range type encountered on eastern Melville Island. Standing crop values (excluding mosses and crustose lichens) ranged from 35 to 89 g/m^2, of which monocotyledons comprised 33-75 g/m^2 (**Tables 8, 10, & 11**). The 11 sites we classified as wet meadows were subdivided into four subtypes as follows:

1.1 ***Dupontia subtype*** (total cover 161%, mosses 92%, crustose lichens 1%, not vegetated 1%).

This range type, sampled at site 18, was a hydric, low-lying, flat community that occurred among small ponds encircled by emergent *Eriophorum Scheuchzeri*. *Dupontia Fisheri* was the dominant vascular plant with a cover of 68% (**App. 3**) and standing crop of 34 g/m^2 (**App. 9**). *Cerastium arcticum, Saxifraga nivalis,* and *Luzula nivalis* were present. Only a trace of the lichens *Cetraria islandica, C. deliseii, Cladina mitis,* and *Cornicularia divergens* was found on slightly higher and drier ground. Mosses consisted mainly of *Drepanocladus* spp., *Aulacomnium* spp., and *Phylandoides* spp.

Dupontia meadows occurred mainly in patches or runnels between ponds or along small stream beds and never in large expanses. They were common in wet areas on Christopher shale substrates north of Sherard Bay.

1.2 ***Sedge-Dupontia subtype*** (total cover 114% and 158%, mosses 67% and 100%, crustose lichens 1%, not vegetated 1%).

The two sites sampled (nos. 14 and 26) were hydric, low-lying, flat depressions below 30 m elevation. Dominant species were the sedges *Carex aquatilis and Eriophorum triste* (38% and 39% combined cover) and a grass, *Dupontia Fisheri* (9% and 15% cover). Sedges at 38 and 48 g/m^2 and grasses at 2 g/m^2 comprised most of the 48 and 56 g/m^2 standing crop of vascular plants and fruticose and foliose lichens.

Thamnolia vermicularis, Cetraria cucullata, C. islandica, and *Dactylina* spp. totaled only about 1% cover and 2.7 g/m^2 standing crop. Forbs such as *Ranunculus sulphureus, Cardamine bellidifolia, Draba* spp., *Saxifraga cernua,* and *S. Hirculus* comprised 2% cover and 0.2 and 2.5 g/m^2 standing crop. Associated mosses were *Drepanocladus* spp., *Aulacomnium* spp., *Hylocomnium* spp., and *Distichium* spp.

1.3 ***Sedge subtype*** (total cover 134-173%, mosses 81-90%, crustose lichens 0-5%, not vegetated 4%).

Sedge-dominated, coastal meadows (sites 6, 8, & 37) were hydric, low-lying and essentially flat. *Eriophorum triste* and *Carex aquatilis* together contributed 40-76% cover and 29-75 g/m^2 of standing crop. Typical meadowland forbs such as *Melandrium apetalum*, *Ranunculus sulphureus, Cardamine bellidifolia, Saxifraga cernua*, and *S. Hirculus* in total comprised 2% cover or less. Trace amounts of *Cetraria islandica*, *Thamnolia vermicularis,* and *Cladonia* spp. contributed 1 g/m^2 to a total standing crop (excluding mosses) of 36-77 g/m^2. Moss species, including *Aulacomnium turgidum*, *Drepanocladus* spp., and *Tomenthypnum nitens*, averaged 91% cover.

1.4 ***Sedge-Salix subtype*** (total cover 83-159%: mosses 40-98%, crustose lichens 0-11%, not vegetated 4%).

In those meadows (sites 2, 22, 25, 36 and 39), frost action resulted in hummocks and ridges to form a mosaic of mesic and hydric moisture regimes. Those micro-topographic differences accounted for the presence of *Salix arctica* (cover 3-8% and standing crop 5-13 g/m^2) on the drier, raised locations. Sedges, particularly *Carex aquatilis* and *Eriophorum triste*, were the dominant vascular plants with combined cover values of 35-56% (**App. 3 & 4**) and standing crop of 30-57 g/m^2 (**App. 9 & 10**).

There was a diverse array of forbs because of the occurrence of drier hummocks and ridges. *Stellaria longipes, Papaver radicatum, Cerastium Regalii, Polygonium viviparum, Saxifraga caespitosa,* and *Arenaria rubella* occurred along with the common hydric community species such as *Melandrium apetalum, Saxifraga Hirculus, S. cernua, Ranunculus sulphureus,* and *Cardamine bellidifolia*.

The shrubs *Cassiope tetragona* and *Dryas integrifolia* occurred in small quantities except at site 25, an atypical meadow in several respects: (1) it was intermediate in form between low-center polygons and typical wet meadows, (2) it was within the flood plain of a large river (rare inundation), and (3) it was surrounded by sand and sand dunes. Our samples were from raised ridges between the lower, waterlogged centers, where mosses (80-100%) and sedges comprised almost all the vegetation.

The most-abundant lichens in the sedge-*Salix* subtype were *Peltigera* spp. and *Thamnolia vermicularis, Cetraria cucullata, C. islandica, Dactylina arctica, Peltigera* spp., and others occurred in mesic locations. *Dupontia Fisheri, Luzula nivalis,* and *Arctagrostis latifolia* were present in small amounts.

1.5 ***Other subtypes***

There were other subtypes of wet meadows (e.g., *Eriophorum Scheuchzeri* or *E. triste* dominated), which we did not sample because of their infrequency, localized nature, irregular shape, and surface water. Another meadow type occurring in small, irregular shapes was a grass meadow bordering wet areas on sandy substrates, which was comprised of almost pure stands of *Alopecurus alpinus*. That species was abundant at nitrogen-enriched sites such as rock perches used by birds, at fox den sites, and where caribou and muskoxen had died.

2. ***Low-Center Polygons*** (total plant cover 97 and 100%, other cover too irregular to generalize).

We sampled centers (site 19) and ridges (site 20) of that range type separately because of marked differences in their vegetation.

2.1 *Centers*

The depressions were hydric with a shallow active layer, flat or nearly so, and characterized by a closed moss cover and a sparse cover of a few vascular species. *Arctagrostis latifolia, Luzula nivalis, Salix arctica, Alopecurus alpinus, Saxifraga oppositifolia,* and *Draba* spp., along with other herbs in trace amounts, resulted in less than 6% cover and 9 g/m^2 of standing crop.

Cetraria spp., *Thamnolia vermicularis, Peltigera* spp., and *Stereocaulon* spp. totaled only 0.1% cover and 0.3 g/m^2 standing crop. Mosses consisted mainly of

Aulacomnium turgidum, Hylocomnium splendens, and *Tomenthypnum nitens.*

2.2 *Ridges*

The ridges, 10-100 cm above the centers, provided a variety of moisture regimes, exposure, depth of active layer, and a variety of microhabitats. *Salix arctica* (3% cover), *Arctagrostis latifolia* (8% cover), and *Luzula nivalis* (8% cover) dominated vascular cover. A variety of forbs and grasses were present, including *Saxifraga oppositifolia, Draba* spp., *Stellaris longipes, Papaver lapponicum, Potentilla hyparctica, Alopecurus alpinus,* and *Dupontia Fisheri.* Lichens, such as *Stereocaulon* spp., *Cetraria islandica, C. cucullata, Alectoria nitidula,* and *A. ochroleuca,* at 1.1% total cover and 3.2 g/m^2 total standing crop, were 10-fold more common than in the centers.

Standing crop values (g/m^2) of shrubs and monocotyledons on the ridges were much higher than in the centers, e.g., *Salix arctica* 4.4 vs. 1.4; *Luzula* spp., 9.3 vs. 1.4; and *Arctagrostis latifolia,* 11.2 vs. 2.6 g/m^2.

Hydric to mesic moisture regimes were reflected by a 76% moss cover composed largely of *Aulacomnium turgidum, Hylocomnium splendens,* and *Polytrichum juniperinum.*

3. *Grass-Luzula-Lichen Plain* (total cover 92%, mosses 69%, crustose lichens 1%, not vegetated 1%).

We sampled this range type at Cape Mudge (site 27), 2 km from the coast, where a clay substrate resulted in poor drainage. Standing water was common in depressions resulting in hydric to mesic moisture conditions.

Many species of monocotyledons were present but *Arctagrostis latifolia* spp. and *Luzula nivalis* composed nine-tenths of the 20% cover of grasses-sedges and all of the recorded 25 g/m^2 standing crop for that group.

Fourteen species of lichens, mainly *Cetraria* spp. and *Cladina* spp., provided 3.2% cover and 12 g/m^2 standing crop. Forbs, including *Stellaria longipes, Saxifraga cernua, S. nivalis,* and *Draba* spp., occurred in only trace amounts (0.3%

cover). Mosses such as *Aulacomnium turgidum, Distichium* spp., *Dicranum* spp., and *Polytricum juniperinum* dominated the vegetation with 69% cover.

4. ***Grass-Luzula* Plain** (total cover 100% and 104%, mosses 32% and 65%, crustose lichens 5% and 28%, not vegetated 1%).

Two of the three sites sampled (no. 17 and 21) were mesic, flat, and characterized by frost boils on a sandstone substrate named the Assistance Formation (Barnett et al. 1975). The third site (no. 32), on northerly-sloping alluvium in the Sherard Bay Lowlands, was more-sparsely vegetated.

Luzula spp. were the dominant monocotyledons at all sites, with cover values of 7%, 13%, and 16% (**App. 3 & 4**) and standing crop of 8, 16 and 19 g/m^2 (**App. 9**). Cover values of *Arctagrostis latifolia* were only slightly lower and, combined with *Alopecurus alpinus*, cover and standing crop of grasses were about equal to that of the rushes (*Luzula* spp. and *Juncus* spp.).

Salix arctica, the dominant dicotyledon and only shrub, constituted 0.4-2.6% cover and 0.7-4.3 g/m^2 standing crop. Numerous forb species, totaling 0.5-5.1% cover and 1.6-9.5 g/m^2 standing crop, included *Saxifraga cernua, S. caespitosa, Ranunculus* spp., *Arenaria rubella, Papaver radicatum, Oxyria digyna, Potentilla hyparctica, and Stellaria longipes*. In addition, the woody dicotyledon *Saxifraga oppositifolia*, which is excluded from the forb class in this report, was present in small amounts (1.8 and 3.7 g/m^2 standing crop) in two of the sites.

Foliose and fruiticose lichens, including *Cetraria* spp., *Thamnolia vermicularis, Cladina* spp., and *Alectoria* spp. added 1.6-1.8% cover and 4.3-5.2 g/m^2 standing crop. *Racomitrium* spp. dominated all other species including other mosses such as *Polytricum juniperinum, Aulacomnium turgidum, Distichium spp., and Hylocomnium* spp.

5. ***Grass-Salix Slope*** (total cover 98-141%, mosses 41-86%, crustose lichens 4-36%, not vegetated 2-19%).

This range type was found on mesic, gentle slopes largely in upland locations (sites

7, 13, 15, 16, and 38). *Salix arctica* was the dominant vascular species at 7-16% cover and standing crop of 12-44 g/m^2. The variable and diverse monocotyledons occupied 10-30% of the surface and weighed 8-35 g/m^2 after drying. *Luzula* spp. were the most abundant (6-19% cover) along with *Arctagrostis latifolia, Alopecurus alpinus,* and *Poa arctica*, collectively at 1-15% cover. *Eriophorum triste* and *Dupontia Fisheri* occurred in the hydric, moss-covered runnels. *Juncus biglumis* occurred in trace amounts.

Saxifraga oppositifolia, absent from the damper sites, occupied 0.7% and 5.3% cover on drier sites (sites 7 and 16), such as old raised beaches with a gravelly substrate.

A variety of forbs, interspersed among the mosses and willows, contributed 0.6-3.7% cover and 1.2-6.4 g/m^2 standing crop. The list included *Potentilla hyparctica, Stellaria longipes, Draba* spp., *Ranunculus sulphureus, Papaver radicatum, Cerastium Regalii, Saxifraga caespitosa, S. nivalis, S. flagellaris, Oxyria digyna, Arenaria rubella,* and *Braya purpurescens.*

Thamnolia vermicularis and *Cetraria* spp. occurred frequently but foliose and fruticose lichens totaled only 0.9-2.1% cover and 2.2-4.9 g/m^2 standing crop.

The high moss cover (41-86%) and species composition (*Tortula* spp., *Polytrichum* spp., *Distichium* spp., *Aulacomnium* spp., *Tomenthypnum* spp., and *Hylocomnium* spp.) reflected the generally mesic substrate with hydric plant associations in topographic lows. Cryoturbation resulted in some bare ground, which was gradually colonized by crustose lichens.

6. ***Luzula-Lichen Slope and Crest*** (total cover 97-120%, mosses 47-73%, crustose lichens 12-28%, not vegetated 2.3-14.0%).

Four sites (nos. 28-31) sampled on gentle slopes and crests of hills in the uplands between Sherard and Sabine Bays had similar vegetation. The substrate was mesic Griper sandstone, the exposure generally southerly.

Luzula nivalis and *L. confusa* dominated all other vascular species with combined cover values of 14-24% and weights of 18-61 g/m^2. Associated monocotyledons were *Alopecurus alpinus, Arctagrostis latifolia, Eriophorum triste, Poa spp.,* and *Juncus biglumis.*

Ranunculus sulphureus, Potentilla hyparctica, Stellaria longipes, Draba spp., Oxyria digyna, and *Cardamine bellidifolia* were a few of the many forb species which totaled 0.5-4.1% cover.

Non-crustose lichens, consisting mainly of *Thamnolia vermicularis* and *Cetraria* spp., comprised 1.6-5.3% cover and 4.1-14.3 g/m^2 standing crop. Another forage species, *Salix* spp., covered 0-3.5% of the surface and contributed up to 5.9 g/m^2 standing crop, including stems.

Distichium spp., *Hylocomnium* spp., *Polytrichum* spp., and *Aulacomnium* spp. formed solid mats in moist runnels. Frost action resulted in poorly-vegetated areas (0-14% cover) and areas re-colonized by crustose lichens (12-28% cover) between runnels.

7. ***Luzula Tussocks*** (total cover 48-114%, mosses 10-68%, crustose lichens 9-24%, not vegetated 6-16%).

Sandy, xeric substrates, either flat or sloping, produced this range type on alluvium at Sabine Bay (site 3) and on old raised beaches at Little Point (sites 5 and 35). *Luzula confusa* and *L. nivalis*, which grew in tussocks interspersed with a sparse growth of vascular species and mosses, dominated all vegetation at 16-37% cover and 20 and 48 g/m^2 standing crop. *Oxyria digyna* at 0.1-5.8% cover, *Saxifraga oppositifolia* at 0.1-3.5% cover, and *Poa* spp. at 0.4-2.9% cover were the only other vascular species of any significance. Also present were *Juncus biglumis, Saxifraga caespitosa, S. nivalis, Papaver radicatum, Draba spp., Arenaria Rossii, Thamnolia vermicularis, Cetraria spp., Distichium spp.,* and *Polytrichum juniperinum.* This range type was noted elsewhere on the toe of slopes where the soil was sandy.

8. ***Sparse, Grass-Luzula Plain*** (total cover 131%, moss 81%, crustose lichens 18%, not vegetated 1%).

That range type (site 34) was found adjacent to a small creek in the Sherard Bay

Lowlands, where other examples of it also occurred. It was characterized by a light cover of *Luzula* spp. (21%) and *Alopecurus alpinus* (10%) over an understory of mosses (81%) and little else. *Thamnolia vermicularis, Saxifraga caespitosa, Papaver radicatum, Potentilla hyparctica*, and *Cardamine bellidifolia* together contributed <1% cover.

9. ***Salix-Lichen Ridge*** (total cover 52-115%, mosses 8.2-60.0%, crustose lichens 20-65%, not vegetated 0.4-48.0%).

Elevated, old beach ridges and crests of small hills were typical landforms associated with this range type (sites 1, 10, and 24). The exposed ridges have sparse snow cover in winter and xeric moisture status in summer, which combine to produce a low cover of vascular plants with *Salix arctica* dominating at 12-20% cover and 21-32 g/m^2 standing crop.

Luzula spp. (0.6-3.6% cover) and *Oxyria digyna* (0.2-1.4% cover) were the most common vascular plants, which included *Arctagrostis latifolia, Carex misandra, Juncus biglumis, Saxifraga oppositifolia, S. caespitosa, S. flagellaris, S. nivalis, Stellaria longipes, Papaver radicatum, Cerastium arcticum, Draba spp., Braya purpurescens,* and *Potentilla hyparctica.*

Thamnolia vermicularis was most abundant lichen on the range type at 1.8-4.9% cover and 4.2-9.2 g/m^2 standing crop; *Cetraria* spp. were common. Small ice wedges and cracks provided conditions suitable for *Distichium* spp., *Tortula* spp., *Polytrichum* spp., *Tomenthypnum* spp., and *Hypnum* spp.

10. ***Salix-Dryas-Lichen Ridge*** (two sites: total cover 60% and 103%, mosses 17% and 20%, crustose lichens 20% and 61%, not vegetated, 2.9% and 45%).

This range type occurred on the tops of well-drained ridges to produce mesic to xeric moisture conditions. At Little Point, site 4 was located on a southeast facing ridge near the toe of a 30 m hill. At Sabine Bay, site 23 was on the top of a small, windswept ridge. Dwarf shrubs, mostly *Salix arctica* and *Dryas integrifolia*, along with minor amounts of *Cassiope tetragona*, constituted 10% and 13% cover and 43 and 46 g/m^2 standing crop.

Luzula spp., at 1.2% and 2.0% cover (1.9 and 2.5 g/m^2 standing crop), comprised the majority of the monocotyledon component. Foliose and fruticose lichens, mostly *Thamnolia vermicularis* and *Cetraria* spp., covered 2.5% and 5.4% of the ground and added 8 and 18 g/m^2 standing crop. *Racomitrium* spp., *Distichium* spp., and *Polytrichum juniperinum* flourished in moist topographic lows. Numerous forb species occurred but their total cover was only 0.8% and 2.1%; their standing crop 1.3 and 4.8 g/m^2. In addition, *Saxifrage oppositifolia* occurred in small quantities.

11. ***Salix-Saxifraga* Ridge** (total cover 52%, mosses 11%, crustose lichens 22%, not vegetated 51%).

A gravelly substrate, xeric moisture conditions, and exposed topography are conditions resulting in the range type, sampled at Little Point (site 9). The abrasive action of wind-blown snow and soil was evident on the mats of *Saxifraga oppositifolia* and *Dryas integrifolia*. Erosion of the mats obviously progressed from north to south, clear testimony to the direction of prevailing winds.

Saxifraga oppositifolia contributed the most standing crop (37.7 g/m^2) of all vascular species but its cover value (4.3%) was surpassed by that of *Salix arctica* at 10% cover and 21.7 g/m^2 standing crop. The sparse monocotyledon component was "dominated" by *Poa* spp. at 0.2% cover and 0.4 g/m^2. Other species included *Arenaria* spp., *Dryas integrifolia, Papaver radicatum, Cerastium arcticum, Juncus biglumis, Cetraria* spp., and *Thamnolia vermicularis*.

Cover of this type was as low as 5% on "polar desert" on some hills with a coarse gravel substrate. Vegetation was restricted mostly to depressions. Some depressions were linear rills caused by substrate creep on slopes. Exposed clumps of vegetation, such as *Dryas integrifolia,* often was dead on the prevailing wind side because of abrasion from substrate particles and snow.

***Salix* Flat and Slope** (not sampled)

This range type was similar to range types 9 and 10 but it had a smooth surface which resulted in a simple community dominated by large sprawling *Salix arctica* plants. Best examples were north and west of the Sabine Bay camp, areas that appeared black on monochromatic aerial photographs because of extensive growths of black crustose lichens on the xeric-mesic surface materials. Also recorded were *Saxifraga oppositifolia*. Mosses were confined to sheltered locations under the shrubs and in cracks and small depressions.

High-Center Polygons (described but not sampled)

Typical examples were examined in a large area of high-center polygons approximately 14 to 18 km northwest of the Sabine Bay camp. The xeric gravelly tops were only 5% vegetated, with the dominant *Salix arctica* in association with *Papaver radicatum, Oxyria digyna, Draba* spp., *Braya purpurescens, Cerastium* spp., *and Carex misandra.*

The slopes (10% cover) were dominated by *Saxifraga oppositifolia* and *Dryas integrifolia*, in association with the species found on top, and *Thamnolia vermicularis*. The depressions (cover 10-100%) favored growth of mosses along with *Salix arctica, Dryas integrifolia, Oxyria digyna, Polygonum viviparum,* and *Juncus biglumis. Eriophorum* spp., *Carex* spp., *Dupontia Fisheri* , and *Alopecurus alpinus* occurred where water accumulated.

Edlund in Barnett et al. (1975) described the vegetation of high-center polygons on various landscape types of eastern Melville and found considerable variability in cover values and species in accordance with substrate differences. She classified the tops variously as sparse *Saxifraga* barrens, *Luzula-Saxifraga* barrens, *Carex-Luzula* barrens, graminoid (*Luzula-Poa-Carex*) barrens and a graminoid-*Salix* community (most productive). She described a variety of mesic and hydric communities on the sides and depressions of polygons and identified substrate and moisture as the key variables. Most high-center polygons are located below but near the former marine limit, ca. 81 m asl. (Barnett et al. 1975). The ones that we inspected were 1.8 to 3.0 km from the coast. They are clearly visible on 1:60 000 monochromatic air photographs.

Felsenmeer (not sampled)

The range type, clearly visible on 1:60 000 aerial photographs of the region north of Little Point, was highly variable in size, in proportion of soil or substrate suitable for growth of vascular plants, and in moisture regime. In an extensive area north of Little Point, the angular boulders averaged about 1 m in diameter. Travel through the range type was difficult on foot and impossible by all-terrain vehicle. In such a protected situation, mats of mosses flourished, particularly *Racomitrium* spp.

The lichens *Alectoria ochroleuca, A. nitidula, Cetraria cucullata, C. islandica, Sphaerophorus globusus,* and *Thamnolia vermicularis* were abundant in association with the moss mats. Other species noted were *Luzula confusa, L. nivalis, Papaver radicatum,* and *Draba* spp. Total cover among the rocks varied from almost none to ca. 60%.

Appendix 3. Percent cover of plant species at sites on eastern Melville Island, summer 1974, estimated by a photographic method ("p" beside site number), calculated from standing crop (b) using cover/standing crop ratios (Table 5), or from adjusted visual (av) estimates.

Plant species	Percent cover in range type (top row) and site number (2nd row)												
	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	2.1	2.2
	18p	14p	26b	6p	8Ap	37p	36p	25p	22b	2b	39p	19p	20p
Salix arctica			3.5		1.0	0.7	4.0	3.6	3.2	4.0	7.5	0.8	2.6
Dryas integrifolia								5.2	+[1]				
Cassiope tetragona								3.6					
Carex aquatilis		19.6	31.7	15.6	21.9	61.4	50.8	45.7	28.1	15.4	6.3		
C. misandra					0.1								
Eriophorum Scheuchzeri	1.1					10.1				11.7			
E. triste		19.4	5.9	47.8	17.9	4.3	4.8	0.7	10.9	7.5	30.6		
Luzula spp.	0.3	2.6	0.2	1.3	0.2			0.1	0.8	0.6	0.7	1.1	7.5
Juncus biglumus			+		0.2				+				
Arctagrostis latifolia			1.2		1.5				1.2		1.3	2.0	7.5
Alopecurus alpinus					0.2							0.3	0.3
Poa spp.				0.4				1.0	+				
Festuca brachyphylla								0.3					
Dupontia Fisheri	67.5	15.2	8.9	1.3	3.2	0.8	1.0	1.6	1.4	1.9			1.0
Unidentified grass									0.2	0.8	0.4	+	0.1
Thamnolia vermicularis			1.1						+	+		+	0.1
Cetraria cucullata			+						+				
C. deliseii									0.1	+		+	0.3
C. islandica			+										
C. tilesii													+
Alectoria ochroleuca								0.1					
A. nigricans													+
A. nitidula									+				0.1
Dactylina ramulosa			+										
D. arctica										+			

Appendix 3 continued next page

Appendix 3 (continued)

Plant species	Percent cover in range type (top row) and site number (2nd row)												
	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	2	2
	18p	14p	26b	6p	8Ap	37p	36p	25p	22b	2b	39p	19b	20b
Peltigera spp.							0.5	0.6		0.2	0.1	+	0.5
Stereocaulon spp.												+	0.1
Cladina spp.										+			
Cladonia spp.					0.3								
Saxifraga oppositifolia									+		0.5	0.3	0.3
S. nivalis	0.2		+		0.3		0.1		0.1			+	+
S. caespitosa							0.1		+				
S. cernua		0.6	+			0.2	0.3		+		+	0.1	+
S. flagellaris										+		+	
S. Hirculus			+						0.1	+	+		
S. rivularis												+	+
Ranunculus spp.		0.1		0.1					+	+	0.2	0.1	+
Papaver radicatum									+			0.1	+
Cerastium Regelii			+						+	+	+	+	
C. arcticum	0.2												+
Draba spp.		0.1	+	0.1	0.1				+	+	0.1	0.2	0.1
Oxyria digyna													
Polygonum viviparum				0.9	0.7			0.1			+		
Arenaria rubella											+		
Potentilla hyparctica				0.4					+				0.4
Stellaria longipes		0.5	+	0.1				0.1	0.1	+	0.1	0.1	0.1
Cardamine bellidifolia			+						+	+		+	
Melandrium apetalum			+	0.3							+		
Sagina caespitosa									+		0.1		
Unidentified forbs	0.3	1.4	0.1	2.0	1.3	0.2	0.5	0.2	0.4	0.1	0.6	0.7	0.8
Mosses	92.1	100.0	66.7	96.2	81.4	95.2	97.5	94.8	61.9	40.4	79.0	97.8	75.5
Number of plots	15	18	20	20	21	20	20	20	20	20	30	15	20

__________ Appendix 3 continued next page

Appendix 3 (continued)

Plant species	Percent cover in range type (top row) and site number (2nd row)										
	3	4	4	4	5	5	5	5	5	6	6
	27b	32b	21b	17b	15p	13p	38p	7Ap	16p	28p	29p
Salix arctica		0.4	1.7	2.6	16.9	25.5	7.1	9.8	13.6	3.5	0.4
Dryas integrifolia									0.2		
Cassiope tetragona							0.1			0.8	0.9
Eriophorum triste	0.3		1.6		7.4	1.4		2.9	1.1	+	
Luzula spp.	8.4	6.5	12.9	15.8	8.0	7.8	9.4	18.7	6.3	14.2	17.5
Juncus biglumus	+		0.1	0.3	0.2		0.1		+	0.1	0.5
Arctagrostis latifolia	9.5		12.3	12.2		0.9	0.3	4.3	1.5	0.8	0.9
Alopecurus alpinus	+		3.3	1.2	7.3		0.6	0.1	1.7	0.2	0.1
Poa spp.			+	1.0	7.5	0.2	1.3	0.3	0.4		
Festuca brachyphylla				+							
Dupontia Fisheri	1.4										
Unidentified grass		5.2							0.1		
Thamnolia vermicularis	0.6	0.7	0.4	0.7	0.9	1.0	0.5	1.7	1.5	3.5	1.2
Cetraria cucullata	0.1	0.1	0.1	0.1		+		0.1		1.5	0.1
C. deliseii	+	0.8		+		+		0.1	0.1		0.2
C. islandica	2.3		0.8	0.6						+	+
C. tilesii										+	
C. nivalis	+										
Alectoria ochroleuca										0.1	
A. nigricans			+	0.1							
A. nitidula	0.1	+	0.1	0.2							
Dactylina ramulosa									+		
D. arctica	+		+								+
Peltigera spp.	0.2		+	+			0.2	0.1	0.1		
Parmelia spp.	+		+	+							
Stereocaulon spp.		0.1			0.1		0.1	0.1	+	0.1	0.1
Spherophorous globesis	+										

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Appendix 3 (continued)

Plant species	Percent cover in range type (top row) and site number (2nd row)										
	3	4	4	4	5	5	5	5	5	6	6
	27b	32b	21b	17b	15p	13p	38p	7Ap	16p	28p	29p
Cladina spp.	0.5		0.1	+							
Cladonia spp.				+							
Saxifraga oppositifolia		0.7		0.4				0.7	5.3	2.9	
S. nivalis	0.1		0.1	0.1					+	0.1	0.1
S. caespitosa		0.7		2.8	0.1		0.1	0.1	0.1	0.3	0.1
S. cernua	+		+	+			+	0.1	0.1	0.4	0.1
S. flagellaris			+	0.1			0.1	0.1	0.2		
S. Hirculus				+							
S. rivularis			+								
Ranunculus spp.		0.3	0.1	0.1	0.5	+		0.4	+	0.3	0.1
Papaver radicatum	+	0.1	+	0.1	0.2		0.2	0.1	0.3	0.6	0.6
Cerastium Regelii					0.1			+		0.1	
C. arcticum				0.4		+	+		0.1	0.1	+
Draba spp.	+	0.1	0.1	0.2		0.1	+	0.1	0.1	0.2	0.3
Oxyria digyna				+		0.2		0.2	0.5	0.8	0.1
Arenaria rubella				+						+	
Braya purpurescens								0.1	+		
Potentilla hyparctica		+	0.3	1.0	0.6	0.2	3.1	0.3	+	0.4	0.9
Stellaria longipes	0.1	0.4	0.2	0.3	1.0	0.1	0.1	0.7	0.2	0.7	0.2
Cardamine bellidifolia	+		+	+				+	+	+	0.2
Melandrium apetalum				+							
Sagina caespitosa		0.2		0.1					+	0.1	0.1
Unidentified forbs	0.2	1.9	0.8	5.1	2.5	0.6	3.7	2.3	1.6	4.1	2.7
Mosses	69.0	NA	65.2	31.8	85.7	68.6	60.0	40.8	41.9	72.2	53.0
Number of plots	20	8	25	30	19	30	30	45	46	30	40

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Appendix 3 (continued)

Plant species	Percent cover in range type (top row) and site number (2nd row)											
	6	6	7	7	7	8	9	9	9	10	10	11
	30p	31p	35p	5av	3p	34p	24p	10p	1b	23p	4b	9p
Salix arctica							19.6	12.1	14.4	10.0	13.0	10.1
Dryas integrifolia									1.3	1.8	4.7	2.3
Cassiope tetragona									0.2	0.5		
Carex misandra								3.5	0.1	+	+	
Eriophorum triste			+				0.2			+		
Luzula spp.	15.3	23.9	16.2	22.9	36.5	20.6	3.6	3.0	0.6	1.2	2.0	+
Juncus biglumus			0.2	0.5	0.4		0.2	0.7	0.1	0.2		
Arctagrostis latifolia	2.0	3.2	1.2	0.1			1.4		+	0.1	+	+
Alopecurus alpinus				0.1		10.0	1.9		+		0.2	
Poa spp.			0.6	2.9	0.4		0.2		+	0.1	0.2	0.2
Festuca brachyphylla									0.6			
Dupontia Fisheri							1.5					
Thamnolia vermicularis	+	+	2.5	2.2	0.3	0.1	4.9	1.8	2.5	2.7	1.0	0.6
Cetraria cucullata	0.1	0.2		0.1			1.0		0.3	0.5	0.9	+
C. deliseii			0.1	0.1			2.9		1.7	1.8	0.5	
C. islandica	1.2	0.6	+									
C. tilesii									+	0.3		+
A. nitidula											+	
Dactylina ramulosa	0.1	0.1										
D. arctica	0.2	0.1										
Peltigera spp.	0.8	0.1									+	+
Parmelia spp.											+	+
Stereocaulon spp.	0.4	0.2			+						+	0.1
Spherophorous globesis	0.4	0.9					+				+	

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Appendix 3 (continued)

Plant species	Percent cover in range type (top row) and site number (2nd row)											
	6	6	7	7	7	8	9	9	9	10	10	11
	30p	31p	35p	5av	3p	34p	24p	10p	1b	23p	4b	9p
Cladonia spp.	0.5	0.2	+		0.2					0.1		
Unidentified lichens						0.3						
Saxifraga oppositifolia			0.1		3.5		0.2		0.1	0.2	+	4.3
S. nivalis	0.2		+	0.1	0.2				+		0.1	
S. caespitosa			0.2	+	0.3	0.1	0.1	0.4	+	+	+	+
S. cernua	0.1	+	0.2		+			0.1				
S. flagellaris					0.1					+		+
Ranunculus spp.	0.1		0.5	0.1			0.2		+	+		+
Papaver radicatum	0.3	0.2	0.5	0.4	0.1	0.3	0.3	0.5	0.1	0.1	0.2	0.3
Cerastium Regelii			+		0.1				+	0.1	0.1	0.2
Draba spp.+			0.5	0.1	0.2		0.1	+	0.4	0.1	+	0.1
Oxyria digyna			1.4	0.1	5.8		0.3	1.4	0.2	1.5	0.1	0.1
Polygonum viviparum									0.4			+
Arenaria rubella				+				0.2	+	0.2	0.1	
A. Rossii												+
Braya purpurescens								+		0.1	+	+
Potentilla hyparctica	+			0.2	1.1		0.3	0.1	0.5	+	+	0.1
Stellaria longipes	0.1	0.1	2.2	0.2		0.1	0.1	+	0.1	0.1	0.1	
Cardamine bellidifolia	0.4	0.1	0.1	0.1	1.3						+	
Sagina caespitosa			+	0.1				0.2	+	0.1		0.2
Unidentified forbs	1.2	0.5	7.0	2.5	8.0	0.8	1.3	3.7	1.1	2.1	0.8	0.8
Mosses	47.1	73.0	67.7	47.7	10.3	81.4	60.3	9.6	8.2	20.3	17.2	11.2
Litter	2.3	0.4	6.3		16.2		0.4	6.0	48.1	2.9	45.3	50.8
Number of plots	39	30	30	10	30	15	30	18	40	65	40	78

[1] + = trace (<0.05).

Appendix 4. Percent cover of plant species or species groups at all sites sampled on eastern Melville Island, summer 1974. Species-specific data are in App. 3.

Plant species	Percent cover in range type (top row) and site number (2nd row)								
	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4
	18	14	26[1]	6	8A	37	36	25	22[1]
Salix arctica			3.5		1.0	0.7	4.0	3.6	3.2
Dryas integrifolia								5.2	T[2]
Cassiope tetragona								3.6	
Sedges	1.1	39.0	37.6	63.5	39.9	75.8	55.6	46.4	39.0
Rushes	0.3	2.6	0.2	1.3	0.3			0.1	0.9
Grasses	67.5	15.2	10.1	1.8	4.8	0.8	1.0	3.0	2.7
Lichens (not crustose)			1.2		0.3		0.5	3.0	0.3
Saxifraga oppositifolia									T
Other forbs	0.3	1.4	0.1	2.0	1.3	0.2	0.5	0.2	0.4
Mosses	92.1	100.0	66.7	96.2	81.4	95.2	97.5	94.8	61.9
Crustose lichens			0.3	1.4	5.3		10.8	0.2	
Total plant cover	161.4	158.1	113.7	165.1	134.3	172.7	159.0	157.7	108.3
Bare ground/water			33.0	1.2	3.5	>50.0	23.0	3.9	
Shrubs			3.5		1.0	0.7	4.0	12.3	3.2
Monocotyledons	69.0	56.8	42.1	66.5	45.0	76.6	56.6	49.5	42.5
Vascular + lichens	69.3	58.1	46.7	68.5	47.6	77.5	61.5	62.7	46.4

Appendix 4 continued next page

Appendix 4 (continued)

Plant species	**Percent cover in range type (top row) and site number (2nd row)**								
	1.4	1.4	2	2	3	4	4	4	5
	2[1]	39	19[1]	20[1]	27[1]	32[1]	21[1]	17[1]	15
Salix arctica	4.0	7.5	0.8	2.6		0.4	1.7	2.6	16.9
Dryas integrifolia									
Cassiope tetragona									
Sedges	34.6	36.9			0.3		1.6		7.4
Rushes	0.6	0.7	1.1	7.5	8.4	6.5	13.0	16.1	8.2
Grasses	1.9	1.3	2.4	8.8	10.9	5.2	15.6	14.4	14.8
Lichens (not crustose)	1.1	0.5	0.1	1.1	3.2	1.8	1.6	1.7	1.8
Saxifraga oppositifolia		0.5	0.3	0.3		0.7		0.4	
Other forbs	0.1	0.6	0.7	0.8	0.2	1.9	0.8	5.1	2.5
Mosses	40.4	79.0	97.8	75.5	69.0	NA[2]	65.2	31.8	85.7
Crustose lichens						NA	5.4	28.1	3.8
Total plant cover	82.7	137.7	103.2	96.5	92.0		104.9	100.2	141.1
Bare ground/water		0.9		24.4					7.0
Shrubs	4.0	7.5	0.8	2.6		0.4	1.7	2.6	16.9
Monocotyledons	37.1	38.9	3.5	16.3	19.6	11.7	30.2	30.5	30.4
Vasculars + lichens	42.6	47.8	5.4	21.0	92.0		104.9	100.2	141.1

Appendix 4 continued next page

Appendix 4 (continued)

Plant species	Percent cover in range type (top row) and site number (2nd row)								
	5	5	5.0	5	6	6	6	6	7
	13	38	7A	16	28	29	30	31	35
Salix arctica	25.5	7.1	9.8	13.6	3.5	0.4			
Dryas integrifolia				0.2					
Cassiope tetragona		0.1			0.8	0.9			
Sedges	1.4		2.9		T[3]				T[3]
Rushes	7.8	9.5	18.7	6.3	14.3	18.0	15.3	23.9	16.4
Grasses	1.1	2.2	4.8	3.6	1.0	2.0	2.0	3.2	1.8
Lichens (not crustose)	1.1	0.9	2.1	1.7	5.3	1.6	3.6	3.4	2.7
Saxifraga oppositifolia			0.7	5.3	2.9				0.1
Other forbs	0.6	3.7	2.3	1.6	4.1	2.7	1.2	0.5	7.0
Mosses	68.6	60.0	40.8	41.9	72.2	53.0	47.1	73.0	67.7
Crustose lichens	22.3	14.4	15.4	35.5	15.4	25.1	27.9	11.8	18.3
Total plant cover	128.5	97.8	104.3	110.8	119.5	103.7	97.1	115.8	114.0
Bare ground/water	2.2	18.9	4.3	3.7	3.8	14.3	2.3	0.4	6.3
Shrubs	25.5	7.2	9.8	13.9	4.2	1.4			
Monocotyledons	10.3	11.7	26.4	10.9	15.4	20.0	17.3	27.1	18.2
Vasculars + lichens	128.5	97.8	104.3	110.8	119.5	103.7	97.1	115.8	28.0

Appendix 4 continued next page

Appendix 4 (continued)

Plant species	**Percent cover in range type (top row) and site number (2nd row)**								
	7	7	8	9.0	9	9	10	10	11
	5	3	34	24	10	1[1]	23	4[1]	9
Salix arctica				19.6	12.1	14.4	10.0	13.0	10.1
Dryas integrifolia						1.3	1.8	4.7	2.3
Cassiope tetragona						0.2	0.5		
Sedges				0.2	3.5	0.1	0.1	T[3]	
Rushes	23.4	36.9	20.6	3.8	3.7	0.7	1.4	2.5	0.1
Grasses	3.1	1.4	10.0	5.0		0.7	0.2	0.5	0.2
Lichens (not crustose)	2.4	0.8	0.1	8.9	1.8	4.5	5.4	2.5	0.9
Saxifraga oppositifolia		3.5		0.2		0.1	0.2	T[3]	4.3
Other vascular plants	2.5	8.0	0.8	1.3	3.7	1.1	2.1	0.8	0.8
Mosses	47.7	10.3	81.4	60.3	9.6	8.2	20.3	17.2	11.2
Crustose lichens	8.9	23.7	18.1	19.8	65.2	21.3	61.4	19.8	22.0
Total plant cover	88.0	84.6	130.9	115.3	99.5	52.6	103.2	60.4	51.8
Bare ground/water		16.2		0.4	6.0	48.1	2.9	45.3	50.8
Shrubs				19.6	12.1	15.9	12.3	17.7	12.4
Monocotyledons	26.5	38.2	30.6	9.0	7.2	1.5	1.6	2.5	0.2
Vasculars + lichens	31.4	50.6	31.5	35.2	24.8	23.1	21.6	23.4	18.6

[1] Percent cover estimated from standing crop.
[2] NA = not applicable.
[3] T = trace = < 0.05%.

Appendix 5. Mean ratios of standing crop (g/m^2) to percent cover (i.e., standing crop/percent cover) of shrubs at sites on eastern Melville Island, summer 1974, including only plots where both values >1.

Species	**Site number**	**Sample size**	**Mean ratio**	***SE* x *t* $_{05}$**[1]
Salix arctica	7A	23	1.10	0.19
S. arctica	9	28	1.64	0.22
S. arctica	16	23	1.28	0.28
S. arctica	23	51	2.46	0.48
S. arctica	24	21	1.75	0.30
S. arctica	25	10	2.05	0.70
S. arctica	Grouped	156	1.82	0.19
Dryas integrifolia	9	8	4.19	3.64
D. integrifolia	23	6	11.51	4.27
D. integrifolia	25	9	1.40	0.66
D. integrifolia	Grouped	23	5.01	2.25
Cassiope tetragona	25	9	9.54	5.16

[1] Standard error of mean (*SE* x Student *t*) at *P* = 0.05, used to calculate confidence interval and limits.

Appendix 6. Mean ratios of standing crop (g/m^2) to percent cover (standing crop/percent cover) of monocotyledons at sites on eastern Melville Island, summer 1974, including only plots where both values >1.

Species	Site number	Sample size	Mean ratio	SE x $t_{.05}$[1]
Carex aquatilis	6	15	1.00	0.44
C. aquatilis	25	19	1.08	0.23
C. aquatilis	Grouped	34	1.04	0.22
Eriophorum triste	6	18	0.76	0.16
Sedges	6 , 8, 25	54	0.99	0.18
Luzula spp.	3	28	1.57	0.47
Luzula spp.	7A	43	1.11	0.23
Luzula spp.	16	30	1.03	0.22
Luzula spp.	24	15	1.25	0.37
Luzula spp.	30	31	4.38	1.05
Luzula spp.	Grouped	147	1.89	0.32
Arctagrostis & Alopecurus	7A	19	1.62	1.25
	24	13	0.96	0.46
" "	Grouped	32	1.35	0.75
Dupontia Fisheri	18	14	0.52	0.08

[1] Standard error of mean times Student t at P = 0.05, used to calculate confidence interval and limits.

Appendix 7. Mean ratio of standing crop (g/m[2]) to percent cover (standing crop/ percent cover) of lichens at sites on eastern Melville Island, summer 1974, including only plots where both values >1.

Species	**Site number**	**Sample size**	**Mean ratio**	***SE* x *t*$_{.05}$**[1]
Thamnolia vermicularis	7A	30	2.33	0.77
T. vermicularis	23	51	2.63	0.42
T. vermicularis	24	20	1.99	0.52
T. vermicularis	Grouped	101	2.41	0.32
Cetraria spp.	23	50	3.60	0 89
" "	24	23	2.10	0.48
" "	30	14	4.75	1.99
Cetraria spp.	Grouped	87	3.39	0.62
Lichens except crustose	7A	31	2.39	0.75
" " "	16	23	2 07	0.79
" " "	23	101	2 98	0.45
" " "	24	42	2.09	0.34
" " "	30	17	4.00	1.82
" " "	Grouped	214	2.70	0.29

[1] Standard error of mean x Student *t* at $P = 0.05$, used to calculate confidence interval and limits.

Appendix 8. Mean ratio of standing crop (g/m^2) to percent cover (standing crop/ percent cover) of *Saxifraga oppositifolia* and forbs at sites on eastern Melville Island, summer 1974, including only plots where both >1.

Species or group	Site number	Sample size	Mean ratio	*SE* x t_{05}[1]
Saxifraga oppositifolia	3	9	2.59	1.46
S. oppositifolia	9	36	8.97	1.87
S. oppositifolia	16	25	3.07	0.88
S. oppositifolia	Grouped	70	6.04	1.24
Oxyria digyna	3	17	0.47	0.l7
O. digyna	23	25	1.97	0.59
O. digyna	Grouped	42	1.37	0.42
Forbs[2]	3	40	2.39	1.04
"	9	15	2.01	0.56
"	16	15	1.38	0.52
"	23	40	1.78	0 39
"	24	11	1.70	0 83
"	Grouped	121	1.95	0.35

[1] Standard error of mean times Student *t* at *P* = 0.05, used to calculate confidence interval and limits.
[2] Excluding *S. oppositifolia*, which is classed as a forb by some authors and as a shrub by others.

Appendix 9. Standing crop (g/m²) of plant species sampled in quadrats at sites on eastern Melville Island, summer 1974.

Plant species	Standing crop (g/m²) in range type (top row) and site number (2nd row)										
	1.1	1.2	1.3	1.3	1.4	1.4	1.4	2.1	2.2	3	4
	1 8	26	6	8A	25	22	2	19	20	27	32
Salix arctica		7.06	0.06	2.10	8.64	5.48	8.21	1.40	4.42		0.71
Dryas integrifolia					7.93	0.01					
Cassiope tetragona					24.40						
Carex aquatilis		38.90	13.96	15.90	42.49	29.25	16.51				
C. misandra				0.07							
Eriophorum Scheuchzeri	0.23										
E. triste		1.04	33.95	13.00		8.25	14.53				
Luzula spp.	0.63	0.27	1.11	0.23	0.22	1.04	0.74	1.41	9.26	10.34	8.04
Juncus biglumus				0.07		0.05					
Arctagrostis latifolia		1.57	0.01	1.05		1.57		2.60	11.24	14.40	
Alopecurus alpinus				0.07				0.43			
Poa spp.			0.03		1.48	0.05					
Festuca brachyphylla			0.08		0.51						
Dupontia Fisheri	33.97	4.64	1.53	2.30	0.71	0.73	1.00				
Unidentified grass											6.68
Thamnolia vermicularis		2.62	0.20	0.05	1.05	0.43	1.81	0.09	0.17	1.36	1 52
Cetraria cucullata		0.06		0.01	0.08	0.07	0.10	0.03	0.23	0.41	0.20
C. deliseii	0.12				0.15	0.05				0.05	2.71
C. islandica	0.12	0.01	0.45	0.30	0.05	0.25	0.16	0.11	0.87	7.94	
C. nivalis					0.07						
Alectoria ochroleuca									0. 02		
A. nigricans						0.01			0.15		
A. nitidula										0.21	
Dactiylina ramulosa		0.01					0.02				0.08
D. arctica										0.03	
Peltigera spp.					0.59		0.47		1.47	0.59	

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Appendix 9 (continued).

Plant species	Standing crop (g/m^2) in range type (top row) and site number (2nd row)										
	1.1	1.2	1.3	1.3	1.4	1.4	1.4	2	2	3	4
	1 8	26	6	8A	25	22	2	19	20	27	32
Stereocaulon spp.							0.05	0.03	0.18		
Spherophorous globesis											0.22
Cladina spp.										1.29	
Cladonia spp.	0.25								0.09		
Unidentified lichens	0.02				0.02	0.02		0.02			0.49
Saxifraga oppositifolia						0.01		1.64	1.50		3.67
S. nivalis	0.3	0.01	0.06			0.17		0.04	0.09	0.10	
S. caespitosa						0.06					1.36
S. cernua			+[1]			0.02		0.12	0.02		
S. flagellaris							0.04	0.05			
S. Hirculus		0.07	0.16	0.07		0.17	0.06				
S. rivularis								0.04	0.02		
Ranunculus spp.			0.05	0.01		0.06	0.04	0.11	0.09		0.60
Papaver radicatum						0.01		0.14	0.06	0.04	0.18
Cerastium Regelii		0.05			0.05						
Draba spp.				0.01		0.02	0.01	0.46	0.24	0.03	0.19
Oxyria digyna				+							
Polygonum viviparum			0.29	0.35	0.15						
Arenaria rubella						0.03					
Potentilla hyparctica			0.65	0.19	0.13				0.71		0.03
Stellaria longipes		0.01	0.03	0.01		0.19	0.07	0.19	0.21	0.11	0.79
Cardamine bellidifolia				+			0.01	0.02		0.01	
Melandrium apetalum		+	0.16								
Unidentified forbs											0.38
Number of plots	14	20	20	20	25	18	20	15	20	20	36

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Appendix 9 (continued).

Plant species	Standing crop (g/m^2) in range type (top row) and site number (2nd row)										
	4	4	5	5	6	7	9	9	10	10	11
	21	17	7A	16	30	3	24	1	23	4	9
Salix arctica	2.90	4.34	11.86	17.60			32.48	25.26	19.60	27.01	21.67
Dryas integrifolia				4.48				3.49	20.21	19.42	4.79
Cassiope tetragona							0.56	1.62	3.52		
Carex misandra			0.02								
Eriophorum Scheuchzeri				0.22			0.04	0.11	0.01	0.03	
E. triste	1.20		1.66				0.11				
Luzula spp.	15.94	19.46	19.74	5.26	60.56	48.34	4.29	0.76	1.90	2.52	0.06
Juncus biglumus	0.08	0.04	0.01	0.02		0.05	0.03	0.15	0.16		
Arctagrostis latifolia	19.77	15.66	2.79	1.47	0.68		2.50	0.02	0.05	0.03	+
Alopecurus alpinus	0.32	1.51					0.16	0.02	0.01	0.29	
Poa spp.	0.04	1.25	0.10	1.21		1.21	0.58	0.02	0.03	0.30	0.41
Festuca brachyphylla			0.01					0.61			
Thamnolia vermicularis	0.92	1.51	3.53	2.38	0.05	0.65	9.19	4.97	6.25	2.61	0.82
Cetraria cucullata	0.36	0.23	0.27	0.09	0.21	+	2.27	0.70	2.23		0.04
C. deliseii			0.30	0.24		+	7.37	3.49	8.97	4.85	
C. islandica	2.28	2.05	0.71	1.12	4.70	0.01	0.23		0.05		0.07
C. nivalis						+		0.04			
Alectoria ochroleuca		0.02	0.02								
A. nigricans	0.03	0.17								0.11	
A. nitidula	0.20	0.48	0.01		0.09	+					0.01
Dactylina ramulosa			0.04		0.12						
D. arctica	0.03		0.01		0.32						
Peltigera spp.	0.08	0.06	0.02		0.27		+				
Parmelia spp.	0.10	0.13					0.19				
Stereocaulon spp.						+	0.04				
Spherophorous globesis									0.01	0.06	

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Appendix 9 (continued).

Plant species	Standing crop (g/m^2) in range type (top row) and site number (2nd row)										
	4	4	5	5	6	7	9	9	10	10	11
	21	17	7A	16	30	3	24	1	23	4	9
Cladina spp.	0.35	0.04									
Cladonia spp.		0.11			0.02	+					0.03
Unidentified lichens						+				0.08	
Saxifraga oppositifolia		1.79	1.65	14.56		8.40	0.57	0.47	0.62	0.14	37.67
S. nivalis	0.20	0.22	0.05	0.02	0.26	0.06	0.06				+
S. caespitosa		5.13	0.46	0.34		4.26	0.45	0.06	0.44		0.17
S. cernua	0.04	0.09	+	0.01	0.02	0.09	0.03			0.08	0.01
S. flagellaris	0.01	0.11	0.20			0.05	+	0.01			0.01
S. Hirculus		+			0.01		0.02				
S. rivularis						0.03					
Ranunculus spp.	0.13	0.14	0.17				0.01				+
Papaver radicatum	+	0.10	0.16	0.35	0.49	0.04	0.20	0.13	0.27	0.36	1.09
Cerastium Regelii		0.65	0.11	0.10		1.12	0.02	0.04	0.40	0.12	0.73
Draba spp.	0.25	0.36	0.35	0.31	0.06	0.93	0.88	0.65	0.77	0.09	1.12
Oxyria digyna		+	0.09	0.21	0.02	1.82	0.10	0.43	1.72	0.13	0.02
Polygonum viviparum			+								
Arenaria rubella		0.05	0.01	0.06		0.13	0.42	0.33	0.39	0.05	
A. Rossii											
Braya purpurescens			0.04	0.04			0.14	0.27	0.17		0.06
Potentilla hyparctica	0.55	1.79	0.13	+			0.26	0.02	0.05	0.18	0.01
Stellaria longipes	0.38	0.62	0.97	0.34	0.03	0.01	0.37	0.10	0.11	0.18	0.03
Cardamine bellidifolia	+	0.04			0.40				+	0.08	
Melandrium apetalum		0.01	0.02								
Sagina caespitosa		0.17	0.01	0.05		2.05	0.02	0.06	0.47		0.88
Litter							0.88	3.04		0.38	0.18
Number of plots	25	30	50	49	34	29	30	60	72	40	76

[1] + = trace = <0.05 g/m^2.

Appendix 10. Standing crop (g/m^2) of plant species at 14 sites on eastern Melville Island, summer 1974, calculated from percent cover (photo method, Table 4) using standing crop/cover ratios at other sites (Table 5).

Plant species	Standing crop (g/m^2) in range type (top row) and site number (2nd row)													
	1.2	1.3	1.4	1.4	5	5	5	6	6	6	7	7	8	9
	14	37	36	39	15	13	38	28	29	31	35	5	34	10
Salix arctica		1.2	6.8	12.7	28.9	43.7	12.1	5.9	0.7					20.6
Cassiope tetragona							1.1	7.2	9.0					
Carex aquatilis	20.4	63.8	52.8	6.5										
Eriophorum Scheuchzeri		7.7												4.4
E. triste	14.7	3.3	3.7	23.2	5.6	1.1		+[1]			+			
Luzula spp.	3.2			0.8	9.9	9.7	11.7	17.7	21.7	29.6	20.1	28.4	25.5	3.8
Juncus biglumus					0.3		0.1	0.1	0.6		0.2	0.6		0.8
Arctagrostis latifolia				1.6		1.2	0.4	1.0	1.1	2.8	1.5	0.1		
Alopecurus alpinus					9.4		0.8		1.5	1.4		0.1	12.9	
Poa spp.					9.3	0.2	1.6	0.3			0.7	3.6		
Dupontia Fisheri	7.9	0.4	0.5											
Thamnolia vermicularis				0.9	2.2	2.3	1.3	8.1	2.9	0.1	5.8	5.2	0.2	4.2
Cetraria cucullata						0.1		5.4	0.3	0.7		0.2		
C. delisei						0.1			0.6		0.2	0.2		
C. islandica								0.1	0.1	2.0	0.1			
C. nivalis								0.4						
Alectoria ochroleuca						0.1								
Dactylina ramulosa									0.1	0.2				
D. arctica										0.3				
Peltigera spp.			1.4	0.2			0.6			3.0				
Stereocaulon spp.					0.3		0.3	0.2	0.2	0.6				
Spherophorous globesis										2.3				
Cladonia spp.										0.5	0.1			

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Appendix 10 (continued)

Plant species	Standing crop (g/m^2) in range type (top row) and site number (2nd row)													
	1.2	1.3	1.4	1.4	5.0	5.0	5.0	6.0	6.0	6.0	7.0	7.0	8.0	9.0
	14	37	36	39	15	13	38	28	29	31	35	5	34	10
Unidentified lichens					2.0									
Saxifraga oppositifolia				2.3				14.2			0.7			
S. nivalis			0.2					0.2	0.2		0.1	0.2		
S. caespitosa			0.2		0.2		0.1	0.6	0.1		0.3	+	0.2	0.7
S. cernua	1.1	0.4	0.5	0.1			0.1	0.7	0.1	0.1	0.4			0.2
S. flagellaris							0.1					0.2		
S. Hirculus				0.1										
Ranunculus spp.	0.2			0.3	0.9	0.1		0.5	0.2		1.0	0.2		
Papaver radicatum					0.4		0.4	1.1	1.0	0.4	0.9	0.7	0.6	1.0
Cerastium Regalii				0.1	0.2		0.1	0.2						
C. arcticum						0.1		0.2	0.1		0.1			
Draba spp.				0.1		0.1	+	0.4	0.5		0.9	0.3		0.1
Oxyria digyna						0.3		1.5	0.2		2.7	0.3		2.7
Polygonum viviparum				0.1										0.7
Arenaria rubella				0.1				0.1			0.1			0.1
Potentilla hyparctica					1.1	0.4	5.7	0.7	1.6		0.4	2.0	0.6	1.0
Stellaria longipes	0.9			0.1	1.8	0.2	0.2	1.2	0.4	0.2	4.0	0.4	0.1	0.1
Cardamine bellidifolia								0.1	0.3	0.2	0.1	0.2		
Melandrium apetalum				0.1										
Sagina caespitosa				0.2				0.1	0.2		0.1	0.2		0.3
Number of plots	18	20	20	30	19	30	30	30	40	30	30	10	15	18

[1] + = trace = $<0.05\ g/m^2$.

Appendix 11. Standing crop (g/m²) of species groups at 14 sites on eastern Melville Island, summer 1974, calculated from percent cover (photo method, Table 3, App. 3) using standing crop/percent cover ratios from other sites (Table 5).

Plant species	Standing crop in range type (top row) and site no. (below)						
	1.2	1.3	1.4	1.4	5	5	5
	14	37	36	39	15	13	38
Salix arctica		1.2	6.8	12.7	28.9	43.7	12.1
Sedges	34.2	74.8	56.5	29.8	5.6	1.1	
Rushes	3.2			0.8	10.2	9.7	11.8
Grasses	7.9	0.4	0.5	1.6	18.8	1.4	2.8
Lichens[1]			1.4	1.1	4.5	2.7	2.2
Other vascular plants	2.5	0.4	O.9	1.2	4.6	1.2	6.4
Vasculars + lichens	47.8	76.8	66.1	49.5	72.5	59.8	36.3
Shrubs		1.2	6.8	12.7	28.9	43.7	13.1
Monocotyledons	45.3	75.2	57.0	32.2	34.5	12.2	14.6

Plant species	Standing crop in range type (top row) and site no. (below)						
	6	6	6	7	7	8	9
	28	29	31	35	5	34	10
Salix arctica	5.9	0.7					20.6
Sedges	+[2]			+			4.4
Rushes	17.7	22.3	29.6	20.4	29.0	25.5	4.6
Grasses	1.3	2.6	4.2	2.2	3.8	12.9	
Lichens[1]	14.3	4.1	9.7	6.3	5.6	0.2	4.2
Other forbs	7.6	4.9	0.9	11.0	4.7	1.5	6.8
Vasculars + lichens	68.3	43.6	44.4	40.6	43.1	40.1	40.6
Shrubs	13.1	9.7					20.6
Monocotyledons	19.1	24.9	33.8	22.6	32.8	38.4	9.0

[1] Except crustose.
[2] + = trace = < 0.05.

Appendix 12. Standing crop (g/m^2) of plant species in range types where clipped and weighed standing crop (App. 9) was pooled with standing crop estimated from percent cover (App. 10), eastern Melville Island, summer 1974.

Plant species	Standing crop (g/m^2) in range type							
	1.1	1.2	1.3	1.4	1[1]	2.1	2.2	3
Salix arctica		3.53	1.12	8.37	3.26	1.40	4.42	
Dryas integrifolia				1.59	0.32			
Cassiope tetragona				4.88	0.98			
Carex aquatilis		29.65	31.22	29.51	17.99			
C. misandra			0.02		0.01			
Erioph. Scheuchzeri	0.23		2.57		0.51			
E. triste		7.87	16.75	9.94	6.91			
Luzula spp.	0.63	1.74	0.45	0.56	0.68	1.41	9.26	10.34
Juncus biglumus			0.02	0.01	0.01			
Arctagrostis latifolia		0.79	0.35	0.63	0.44	2.60	11.24	14.40
Alopecurus alpinus			0.02		0.01	0.43		
Poa spp.			0.01	0.31	0.08			
Festuca brachyphylla			0.03	0.10	0.03			
Dupontia Fisheri	33.97	6.27	1.41	0.59	10.56			
Unidentified grass								
Tham. vermicularis		1.31	0.08	0.84	0.56	0.09	0.17	1.36
Cetraria cucullata		0.03	0.01	0.05	0.02	0.03	0.23	0.41
C. deliseii	0.12			0.04	0.04			0.05
C. islandica	0.12	0.01	0.25	0.09	0.12	0.11	0.87	7.94
C. nivalis				0.01	0.01			
Alectoria ochroleuca							0.02	
A. nigricans				0.01	0.01		0.15	
A. nitidula								0.21
Dactylina ramulosa		0.01		0.01	0.01			
D. arctica								0.03
Peltigera spp.				0.53	0.13		1.47	0.59

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Appendix 12 (continued)

Plant species	Standing crop (g/m^2) in range type							
	1.1	1.2	1.3	1.4	1[1]	2.1	2.2	3
Stereocaulon spp.				0.01	0.01	0.03	0.18	
Spherophorous globesis								
Cladina spp.								1.29
Cladonia spp.	0.25				0.06		0.09	
Unidentified lichens	0.02			0.01	0.01	0.02		
Saxifraga oppositifolia				0.46	0.12	1.64	1.50	
S. nivalis	0.3	0.01	0.02	0.07	0.10	0.04	0.09	0.10
S. caespitosa				0.05	0.01			
S. cernua		0.55	0.14	0.12	0.20	0.12	0.02	
S. flagellaris				0.01	0.01	0.05		
S. Hirculus		0.04	0.08	0.07	0.05			
S. rivularis						0.04	0.02	
Ranunculus spp.		0.10	0.02	0.08	0.05	0.11	0.09	
Papaver radicatum				0.01	0.01	0.14	0.06	0.04
Cerastium Regelii		0.03		0.03	0.02			
Draba spp.			0.01	0.03	0.01	0.46	0.24	0.03
Oxyria digyna			0.01		0.01			
Polygonum viviparum			0.21	0.05	0.07			
Arenaria rubella				0.03	0.01			
Potentilla hyparctica			0.52	0.03	0.14		0.71	
Stellaria longipes		0.46	0.01	0.07	0.14	0.19	0.21	0.11
Cardamine bellidifolia			0.01	0.01	0.01	0.02		0.01
Melandrium apetalum		0.01	0.05	0.02	0.02			
Sagina caespitosa				0.04	0.01			
Number of plots	14	38	60	113	225	15	20	20

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Appendix 12 (continued)

Plant species	Standing crop (g/m^2) in range type							
	4	5	6	7	8	9	10	11
Salix arctica	2.65	22.83	1.65			26.11	23.31	21.67
Dryas integrifolia		0.90				1.16	19.82	4.79
Cassiope tetragona		0.22	4.05			0.73	1.76	
Carex misandra		0.01						
Erioph. Scheuchzeri		0.04				1.52	0.02	0.02
E. triste	0.40	1.67	0.01	0.01		0.04		
Luzula spp.	14.48	11.26	32.39	32.28	25.50	2.95	2.21	0.06
Juncus biglumus	0.04	0.09	0.18	0.28		0.33	0.08	
Arctagrostis latifolia	11.81	1.17	1.40	0.53		0.84	0.04	0.01
Alopecurus alpinus	0.61	2.04	0.73	0.03	12.90	0.06	0.15	
Poa spp.	0.43	2.48	0.08	1.84		0.20	0.17	0.41
Festuca brachyphylla		0.01				0.20		
Thamnolia vermicularis	1.32	2.34	2.79	3.88	0.02	6.12	4.43	0.82
Cetraria cucullata	0.26	0.09	1.65	0.07		0.99	1.12	0.04
C. deliseii	0.90	0.13	0.15	0.14		3.62	6.91	
C. islandica	1.44	0.37	1.73	0.04		0.08	0.03	0.07
C. nivalis			0.01	0.01		0.02		
Alectoria. ochroleuca	0.01	0.02						
A. nigricans	0.07						0.06	
A. nitidula	0.23	0.01	0.02	0.01				0.01
Dactylina ramulosa	0.03	0.01	0.11					
D. arctica	0.01	0.01	0.16					
Peltigera spp.	0.05	0.12	0.82	0.01		0.01		
Parmelia spp.	0.08					0.06		
Stereocaulon spp.		0.12	0.25	0.01		0.01		
Spheroph. globesis	0.07		0.58				0.04	

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Appendix 12 (continued)

Plant species	Standing crop (g/m^2) in range type							
	4	5	6	7	8	9	10	11
Cladina spp.	0.13							
Cladonia spp.	0.04		0.13	0.03				0.03
Unidentified lichens	0.16	0.04		0.01			0.04	
Saxifraga oppositifolia	1.82	3.24	3.55	3.03		0.35	0.38	37.67
S. nivalis	0.14	0.01	0.17	0.12		0.02		0.01
S. caespitosa	2.16	0.22	0.18	1.52	0.20	0.40	0.22	0.17
S. cernua	0.04	0.02	0.23	0.16		0.08	0.04	0.01
S. flagellaris	0.04	0.06		0.08		0.01		0.01
S. Hirculus	0.01		0.01			0.01		
S. rivularis				0.01				
Ranunculus spp.	0.29	0.23	0.18	0.40		0.01		0.01
Papaver radicatum	0.30	0.26	0.75	0.55	0.06	0.44	0.32	1.09
Cerastium Regelii	0.22	0.10	0.05	0.37		0.02	0.26	0.73
Draba spp.	0.27	0.15	0.24	0.71		0.54	0.43	1.12
Oxyria digyna	0.01	0.12	0.43	1.61		1.08	0.93	0.02
Polygonum viviparum		0.01				0.23		
Arenaria rubella	0.02	0.01	0.03	0.08		0.28	0.22	
A. Rossii								
Braya purpurescens		0.02				0.14	0.09	0.06
Potentilla hyparctica	0.79	1.47	0.58	0.80	0.60	0.43	0.12	0.01
Stellaria longipes	0.60	0.70	0.46	1.47	0.10	0.19	0.15	0.03
Cardamine bellidifolia	0.02		0.25	0.10			0.05	
Melandrium apetalum	0.01	0.01						
Sagina caespitosa	0.06	0.01	0.08	0.78		0.13	0.24	0.88
Unidentified forbs	0.38							
Number of plots	91	178	134	69	15	108	112	76

[1] Unweighted average of standing crop in each subtype of wet meadows.

Appendix 13. Potential biases and errors of assessing relative use of range types from fecal densities.

Apparent use may be in error because of inaccuracies inherent in the pellet-group technique of estimating past use (numbers 13.1-13.10 below) and it may be biased because of other factors largely having to do with behavior of the animals and with the landscape (numbers 13.11-13.16). Potential problems were reported by other authors (Fischer & Duncan 1976, McLaren et al. 1977).

13.1 ***Differential decomposition rates of pellet groups on various range types.*** Disappearance rates of pellets from both species on range types are unknown but we expect increasing rates with increasing surface moisture. At about the same latitude on Devon Island, Booth (1977) calculated disappearance times of 5.6 and 11.7 years for muskox pellet groups on wet sedge meadows and xeric beach crests, respectively. In subarctic transitional forest (taiga), 50% detectability of winter-type caribou pellet groups occurred at 2 and 4 years in moist (moss covered) and xeric habitat types (Thomas and Kiliaan 1998). Decomposition rates of caribou and muskox pellet groups, both winter and summer types, should be monitored in hydric, mesic, and xeric habitats at a permanent station in the High Arctic.

13.2 ***Differential decomposition rates for winter and summer type of pellets.*** No data. We suspect that individual winter-type pellets break down faster than large amorphous masses of feces deposited in summer.

13.3 ***Errors in discriminating between caribou and muskox pellet groups.*** Summer-type feces from calf muskox may be confused with those from adult caribou.

13.4 ***Errors in classifying pellet groups as to winter and summer types.*** Some groups are intermediate in form and some mistakes in assignment are likely.

13.5 *Errors in assigning morphological types of feces to the summer and winter periods.*

Average change-over times for the two types are unknown but we suspect that they coincide with availability of new growth, about the second or third week in June and its curing by natural cyclic processes or by heavy frosts in late August-early September. In other species, there is wide seasonal overlap in production of the two types of feces and intermediate form in spring and autumn (Thomas unpubl. data).

13.6 *Transfer of pellets from one range type to another by water, wind, etc.*

In our opinion this problem is of minor significance.

13.7 *Not detecting groups when they were present.*

The sparse vegetation seldom obscured pellet groups but possible overlooking of groups was a minor problem when caribou defecated in winter while walking. It was sometimes difficult to ascertain the center of such groups, which we termed "trailers".

13.8 *Non detection of pellet groups on a regional basis.*

Some pellet groups will be deposited on frozen lakes, ponds, etc. That was not a serious problem on eastern Melville Island because of the scarcity of lakes but it is potentially a great problem on mainland Canada on winter range.

13.9 *Unequal defecation frequency in winter and summer or on different range types.*

We have no data on defecation rates for Peary caribou or muskoxen at either season.

13.10 *Inadequate sample size.*

We had no way of knowing if our sample size was adequate.

13.11 ***Use disproportional to numbers of pellet groups.***

Use may involve the major (primary) activities of feeding, traveling, and resting plus a number of less common ones such as play, antagonistic behavior, breeding, parturition, etc. The latter uses will be overlooked in the following discussion because they occupy a small percentage of an animal's time in an annual cycle.

Numbers of pellet groups may not be proportional to use of range types as forage sources because animals may feed on one type and defecate on another while resting or traveling. We have observed caribou feeding and resting on the same range types but defecations while traveling certainly biases any temporal relationship between place of feeding and place of defecation. We estimate that bias is small for muskoxen but we know that in summer the feeding and resting places differ because the former are wet. We expect, therefore, that our data underestimate muskox use on wet sites and overestimate use on adjacent mesic sites. Fecal groups are abundant at winter feeding sites of barren-ground caribou and woodland caribou but scarce along tracks and trails between feeding sites (Thomas pers. obs.).

13.12 ***Animal movement patterns.***

Movement patterns in time and space are potentially of great significance in affecting degree and seasonality of use of a given range type. The movement patterns may have evolved in response to other factors in addition to range considerations, e.g., climate, predators, parasites, and disease, insect harassment, and geographical barriers (e.g., rivers, mountain ranges, and deserts).

We must interpret our results of seasonal use in light of known or suspected biases in winter and summer densities of caribou and muskoxen on an island and regional scope. In 1973 and 1974, there was a higher density of caribou on Melville Island in summer than in winter (Miller et al. 1977a, 1977b). Surveys and a dye-marking study indicate that most caribou that winter on Prince Patrick and Eglinton islands, migrate to Melville for the summer months. Perhaps our expected winter:summer ratio should be say 2:1 or 1:1 instead of 3:1.

The Little Point region was frequented by caribou largely in the summer (Miller et al. 1977b). Perhaps the expected winter/summer ratio for that region should be 1:1 or 1:2. We believe that our expected 3:1 ratio for coastal Sabine Bay and Sherard Bay may be valid because they are primarily winter areas. In the uplands between Sabine and Weatherall Bays the expected ratio may be in the order of 1:2.

13.13 *Juxtaposition of range types*

A mesic range type adjacent to large lowland meadows will be used more extensively by muskoxen than such a range type far removed from range types dominated by preferred habitat. Of course, units of a range type on the migratory route of caribou will receive more use that units of the same type off that route.

13.14 *Size of range type*

In general, if a range type is used as a fodder source, the smaller the area of individual units of that range type, the less likelihood of there being little or no use. For example, small isolated wet meadows may receive little or no use by muskoxen but large highly-productive meadows are always used intensively by them.

13.15 *Geography*

Geography affects regional and local climate which influences distributions of animals and it also determines, in part, routes traveled by animals. It can be argued that different climates should produce different range types but this is not so in winter when climate has a great influence on movements and distributions and it can devastate an arctic population. For example, wind intensity, of extreme importance in determining snow conditions, is influenced by regional and local geography. Rain on frozen tundra leading to icing is a geography-related phenomenon which can cause severe forage inaccessibility throughout the winter.

Geography such as major rivers, coastal bays, lakes, mountain passes, cliffs, etc. can cause a funneling effect. Relative use of range types is best done on a local basis if the geographical influence is strong.

13.16 *Topographic variation within a range type*

We noted several times when intensity and seasonality of use were influenced greatly by minor topographical changes. For example, site 30 was excellent summer range for caribou but adjacent site 31 was important winter range. This problem could be resolved by further division of range types but we would end up with an unwieldy number of types and a tremendous sampling problem. Topography is a key variable affecting moisture regime in summer and snow conditions in winter.

Variability in use pattern (intensity and seasonality) in units (sites) of a range type is not surprising in light of all of the above factors which can influence use.

13.17 *Density*

Preference for feeding sites may be poorly reflected where densities are low and there is no competition for food. The same applies to caribou in migration or traveling seasonally. A certain food item may be rare in a range type but still of sufficient abundance to satisfy needs of caribou that travel most of the year. Relative value of range types for a herbivore may be assessed most accurately when populations are high or near maximum "stocking" density. Optimum or maximum densities are not known for Peary caribou and muskoxen on Melville Island.

13.18 *Unequal density among study areas*

Ideally, herbivore density should be about equal in all areas where range types are sampled or animal units per unit of time should be equal. It is unlikely that intensities of use were equal for either species in our three study areas, though potentially all were equally accessible. Sample sizes are too small to conduct analyses in each of the two study areas of Little Point and Sabine Bay.