ARCTIC
VOL. 33, NO. 1 (MARCH 1980), P. 73-99

A Classification of the Vegetation of Boothia Peninsula and the Northern District of Keewatin, N.W.T.

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ABSTRACT. The vegetation of Boothia Peninsula and the northern District of Keewatin (212,500 km^2) was surveyed, and a vegetation classification suitable for synoptic level surveys of wildlife habitat was produced. A total of 45 plant communities was recognized on Boothia Peninsula. Principal components and discriminant function analysis were used to identify seven significant groupings of these communities. These seven groups, designated as the vegetation groups for Boothia Peninsula, were: Sedge Meadows, Willow Hummocks, Lichen-*Dryas* Plateaus, Seepage Slopes, Moss Tundra, Purple-Saxifrage Plains, and Rock Barrens. Forty-two plant communities were recognized in the northern District of Keewatin. The six significant groupings which resulted, and which were designated as the vegetation groups for the northern District of Keewatin, were: Sedge Meadows, Willow-Sedge Meadows, Orthophyll Shrub, Lichen-Heath Plateaus, Lichen Uplands, and Barrens. The species composition and relationship to the physical environment for each of these vegetation groups is described.

RÉSUMÉ. L'auteur examinait la vegetation de la Péninsule de Boothia et du district septentrional de Keewatin (212,500 km^2); il produisait une classification de la vegetation, convenable pour des examens, au niveau synoptique, de l'habitat sauvage. Un total de 45 familles de plantes était inventoriées sur la Péninsule de Boothia. Les principaux composants et une analyse des fonctions distinctes permettaient d'identifier sept groupements significatifs de ces familles. Désignés comme les groupes vegetatifs de la Péninsule de Boothia, ces sept groupements étaient: Prairies de joncs, mamelons à saules, plateaux à lichens 'Dryas,' Talus à suintements, Toundra à mousses, Plaines à 'saxifrage' pourpre et landes rocheuses. Dans le district septentrional de Keewatin, 42 familles de plantes étaient inventoriées. Il en resultait six groupements significatifs de vegetation dans le district septentrional de Keewatin, c'étaient les Prairies de joncs, celles de saules et joncs, les arbustes 'orthophylles,' les plateaux à lichens et bruyères, les 'hauts' à lichens et les landes. L'auteur décrit la composition des espèces et leurs rapports avec l'environnement physique pour chacun de ces groupes vegetatifs.

Traduit par Alain de Vendigies, Aquitaine Co. of Canada Ltd.

INTRODUCTION

Industrial developments in the Canadian north have resulted in the requirement for data concerning the habitat use patterns of and habitat inventories for arctic wildlife. Studies of wildlife habitat use patterns are commonly employed as a basis for impact assessment and facility site location.

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The classification of vegetation is the initial stage of, and a central problem in, the conduct of any wildlife habitat use study. However, the classification of arctic vegetation presents a greater than usual challenge. Arctic vegetation has been described as being "promiscuous", with the commonest and most characteristic species being not only over bog and fellfield, but also over all habitats of intermediate dryness (Griggs, 1934). Factors such as the youthfulness of the landscape, instability of the substrate, and the broad ecological amplitude of the species have been used to explain this promiscuity (Gelting, 1934; Beschel, 1970). As a result, the classification of arctic vegetation is generally considered unusually difficult, with site differences being reflected more by variations in the relative proportions of species than by changes in the floristic composition (Oosting, 1948; Beschel, 1970).

The classification problem is further complicated since any vegetation classification which is to be useful as a basis for conducting wildlife habitat use studies and habitat inventories, which are conducted as a basis for impact assessment and facility site selection, must satisfy the following requirements: the classification must allow for reasonably quantitative descriptions of the vegetation yet be general enough for use as a synoptic scale survey technique; the vegetation types must be easily and accurately recognizable in the landscape by the various personnel conducting both vegetation mapping and wildlife habitat use studies, and be recognizable without any sampling other than ocular, even for the primary species; and the vegetation types must be meaningful to the wildlife species for which the mapping is being conducted.

The objective of this study was to classify the vegetation of Boothia Peninsula and the northern District of Keewatin as a basis for synoptic level ungulate habitat studies and to describe the resulting vegetation types.

The approach which has been used in this study has been to initially identify a large number of plant communities on a physiognomic and cover class basis. These communities were subsequently grouped on the basis of their species compositions to produce vegetation groups which are described, and related to the physical environment. It should be noted that each of the vegetation groups described is polytypic and that no genetic or successional relationships are implied.

THE STUDY AREA

The area in which vegetation studies were conducted included Boothia Peninsula and the north-central District of Keewatin, N.W.T. (Fig. 1). It was approximately 212,500 km^2 and was located between latitudes 64° N and 72° N (850 km) and longitudes 91° W and 98° W (250 km).

Climate

Most of the study area has a continental climate for more than seven months of the year (October to May) with maritime influences predominating during the remainder of the year (Thompson, 1967). Winters are long and extremely cold; summers are short and cool. Precipitation totals are low.

With the lack of significant amounts of incoming solar radiation, temperatures over the study area average well below -18° C for the months between December and March. The mean daily maximum and minimum temperatures in the southern portion of the study area during February, the coldest month of the year, are -25° C and -33° C (Fremlin, 1974). On Boothia Peninsula, in the northern portion of the study area, mean daily maximum and minimum temperatures in February are -31° C and -38° C.

With lengthening periods of daylight and incoming solar radiation, temperatures begin climbing slowly in March and more rapidly in April. However, above-freezing temperatures generally are not reached until May or early June. The average spring date on which mean temperatures exceed 0° C ranges from 25 May in the south to 15 June in the north (Bird, 1967). Daily temperatures during July and August in the southern portion of the study area average 13° C; in the northern portion, they average 6° C. Mean daily maximum temperatures for July and August approach 17° C in the south and 9° C in the north. Freezing temperatures may occur during any month in the north. By September, mean daily temperatures are again below freezing throughout the study area.

Mean annual precipitation throughout the study area ranges from about 15 cm in the north to 30 cm in the south. In the north, approximately half of the precipitation falls as rain between June and September (Thompson, 1967). The remainder falls as snow during all months of the year. In the south, most of the precipitation occurs as rain between May and October. Mean annual snowfall at Baker Lake is 58.2 cm; the heaviest snowfall occurs in the months of October (10.4 cm) and April (9.4 cm).

Physiography

Two main structural divisions make up the study area: Precambrian Shield and Paleozoic Basins (Dunbar and Greenaway, 1956). The entire portion of the study area within the District of Keewatin except Cape Colville Peninsula (northwest of Shepherd Bay), lies within the Precambrian Shield. South of a line running approximately from Wager Bay to Chantrey Inlet, the terrain is rolling and level with occasional outcrops of bedrock in an otherwise drift-covered landscape. North of this line, the terrain becomes higher and rougher with more exposed bedrock. Cape Colville Peninsula lies within the Paleozoic lowlands and exhibits flat terrain with glacial deposits and patches of weathered limestone.

A north-south oriented belt of Precambrian upland spans the length of central Boothia Peninsula. Rugged, rocky hills characterize the north and southeast with some peaks near 600 m in elevation. The central portion of the Peninsula gradually increases in elevation from the southwestern coastal lowlands until a smooth, rolling, featureless plateau predominates. The Precambrian upland is bound on the northeast and southwest by well-vegetated Paleozoic lowlands. These areas are mostly flat and consist mainly of limestones.

Flora

The vegetation of the study area is tundra characterized by an absence of trees, although shrubs are widely distributed throughout. The Arctic presents an extremely harsh environment for plants with short growing seasons which may be interrupted by frosts at any time. Consequently, the vegetation is dominated by perennials, many of which depend on vegetative reproduction. The availability of water, in addition to temperature, is an important determinant of plant development. The moisture regime is influenced strongly by the presence of permafrost and the consequent restricted drainage. Low areas with fine-grained soils and a shallow active layer are often characterized by more abundant vegetation cover. In many localities, extensive soil movement (i.e., congeliturbation and solifluction) through frost action is a factor which precludes plant development.

Within the Arctic, Polunin (1948) recognized three latitudinal vegetation belts which he classed as High, Middle, and Low Arctic. The High Arctic includes the Arctic Islands north of Boothia Peninsula. It is characterized by a general lack of vegetation cover except in the more favoured localities. The Middle Arctic includes Boothia Peninsula and is characterized by a higher degree of plant cover, but with frequent open areas. The Low Arctic extends from Spence Bay (latitude 69° N) south to the tree line and possesses essentially continuous vegetation cover.

METHODS

In 1976, vegetation studies were conducted on Boothia Peninsula between 3 and 28 July. Field camps were established at Ego and Lunar lakes (Fig. 1). Field camps at Folly and Black Fly lakes between 29 July and 28 August provided the bases from which studies were conducted in northern Keewatin (Fig. 1).

The use of Honda ATC 90 vehicles facilitated a large sampling radius from field camps. Additionally, a helicopter was used for 10 days in each of Boothia Peninsula and northern Keewatin to extend the area of sampling to the entire study area.

Initial Vegetation Classification

Many researchers have devised systems to classify arctic plant communities (Porsild, 1951; Hanson, 1953; Savile, 1961; Barrett and Teeri, 1973; Parker, 1975). However, these systems tend to be either highly specific to the area concerned or extremely general. During this study, the IBP system (Fosberg, 1967) was used to initially classify vegetation in the field to provide a sampling base. However, as the key was devised for use throughout the world, its use in specific arctic situations required several additions (noted later).

The key is based on vegetation cover and plant life form. Initially, a homogeneous area was assigned one of three possible cover classes: closed (plants predominantly touching or overlapping), open (plants mostly discrete

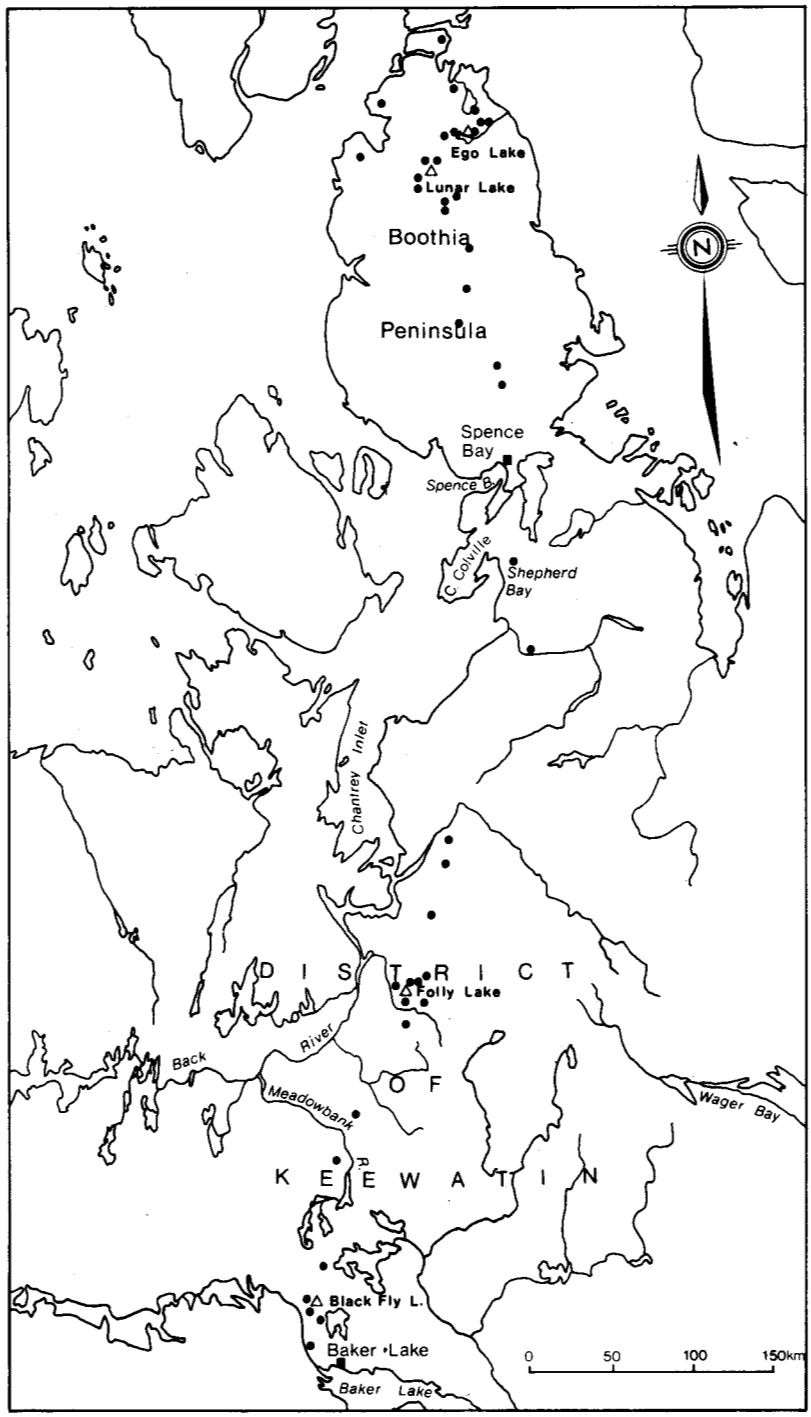

FIG. 1. Locations of field camps (Δ) and sampling sites (•) on Boothia Peninsula and in the northern District of Keewatin.

but separated on the average by not more than twice their diameters), or sparse (plants mostly more than twice their diameter apart). The stand was then further classified on the basis of the dominant life form among plants present. Fosberg (1967) lists six possible life forms; however, no trees or tall shrubs exist in the areas studied. The four life forms present include dwarf shrubs, herbs, lichens, and mosses. Dwarf shrubs take precedence in the key, i.e., a community may be classified as dwarf-shrub type even if another life form with a higher cover-class rating is present.

Vegetation Sampling

The vegetation was sampled by means of line-transects randomly located within a Fosberg plant community-cover class. Randomness in transect location was achieved through random selection of distance and direction of the spacing between transects.

Total vegetation cover within the stand was estimated within a 5 m^2 plot at the beginning of each transect. The coverage scale of Braun-Blanquet (1932) was used: 1(1-5%), 2(5-25%), 3(25-50%), 4(50-75%), and 5(75-100%). Crustose lichens and patina were included in estimates of total vegetation cover. The term 'patina' indicates a ground-holding substance which is probably a black crustose lichen of the genus *Lecidea* in dry upland situations. In wet lowland areas this black crust may be a mixture of lichen, moss, and algae, although no identification of the substance has been made.

The frequency of occurrence of the plant species within the sample stand was then determined by recording the plant species or substrate directly beneath each of 100 points spaced equidistantly along a 25 m line-transect. The transect cord, marked at 25 cm intervals, was pulled taut on the ground. A pencil point was lowered at each interval until it intersected a plant or the substrate. The species or substrate hit was then recorded for each of the 100 points. The percent frequency of species within a community was then calculated based on the total number of points read within that community. Plant specimens were collected and pressed. Voucher specimens were deposited in the Renewable Resources Ltd. herbarium. Voucher specimens of lichens were also deposited in The University of Alberta herbarium. Vascular plant nomenclature was according to Porsild (1964). Lichen nomenclature was according to Hale and Culberson (1970) and bryophytes according to Crum *et al.* (1973).

Synthesis of Vegetation Groups

The most similar Fosberg plant community and cover class combinations were combined to form vegetation groups. To simplify the combination, all 142 species which were encountered on the point line-transects were combined into 14 species groups. The species groups which were used were: Willows; Birch; Deciduous Ericaceae; Evergreen Shrubs; Grasses; Forbs; Sedges, Rushes, and Horsetails; Lichens; Patina; Moss; Algae; Litter; Fungi; and Bare Ground. The selection of these as the species groups was based primarily on the fact that the classification system was being used as a basis

for ungulate habitat studies. It is conceivable that other combinations of species may be preferable for other purposes. Formulation of vegetation groups was then performed following the methods of principal components and discriminant function analysis. The type of principal components analysis used was R-mode without iteration, with oblique rotation and using the direct oblimin criterion following the methods set forth in the computer program FACTOR of the Statistical Package for the Social Sciences--version 6.02. This analysis was applied to each of the Fosberg plant community-cover class combinations, using average percent occurrence of each of the species groups for each combination as the basis for comparison. Significance was set at the 0.05 level. This provided tentative vegetation groups. Discriminant function analysis was then conducted on each of the tentative groups by the stepwise selection method, with the classification of cases and using Wilk's lambda as a measure of group discrimination, following the procedures set forth in the computer program DISCRIMINANT of the Statistical Package for the Social Sciences--version 6.02. Through discriminant function analysis, each transect contributing to a tentative vegetation group was evaluated on the basis of its respective plant species composition and tentative vegetation group designation. The findings allowed refinement of the preliminary vegetation groups, discriminated between the final vegetation groups, and delineated significant plant groups that best defined these vegetation groups.

Finally, the frequency of occurrence of each plant species in each vegetation group was determined as the mean composition of each of the point line-transects which contributed to the group.

RESULTS AND DISCUSSION

Boothia Peninsula

A total of 421 line-transects was run on Boothia Peninsula.

A total of 45 different combinations of Fosberg community-cover classes was encountered on Boothia Peninsula. The results of the principal components and discriminant function analysis identified seven significant groupings of these community-cover class combinations. These seven groups were designated as the vegetation groups for Boothia Peninsula: Sedge Meadows, Willow Hummocks, Lichen-*Dryas* Plateaus, Seepage Slopes, Moss Tundra, Purple-Saxifrage Plains, and Rock Barrens. The classification of the 45 Fosberg community-cover class combinations on Boothia Peninsula is presented as Table 1. Ten species groups were identified as being significant variables describing these vegetation groups; the most significant were evergreen shrubs, willows, and bare ground (Table 2). Based on these 10 variables, the seven vegetation groups differed in varying degrees from each other (Table 3).

Subsequent to the finalization of the vegetation groups, a further discriminant analysis was conducted to compare the proportion of each of the species groups in each individual vegetation transect to the vegetation

TABLE 1. The Fosberg communities and cover classes comprising each vegetation group on Boothia Peninsula. Nomenclature for the Fosberg communities follows Fosberg (1967).

Vegetation Group	Fosberg community	Cover classes
Sedge Meadows	1M21	5
	1M22	5
	1M25[1]	5
Willow Hummocks	1H21	5
	2C21[2]	5,4
	2F22[3]	5,4,3
Lichen-*Dryas* Plateaus	1C12b	5
	1C14[4]	5
	1H14[5]	5
	2C13	5,4
Seepage Slopes	1022	5
	2H21	5,4
Moss Tundra	1012	5
	2H11[6]	5,4
Purple Saxifrage Plains	2G21	4
	2G23[7]	5,4
Rock Barrens	2C13	3
	2C14	4,3
	2C21[2]	3
	2G21	3
	2G23[7]	3
	2H11[6]	3
	2H21	3
	3B11	3,2
	3B12	3,2
	3B23[8]	3,2
	3C13	3,2,1
	3C14	3,2,1
	3C22	3,2

The Fosberg method of classifying vegetation was originally devised for use on a world wide basis. Necessarily, the key is very general and adaptations had to be made for its use in an Arctic situation. Additions to this key are noted in the following footnotes:

[1]1M25 - Seasonal orthophyll short grass meadow.

[2]2C21 - Deciduous orthophyll dwarf steppe scrub.

[3]2F22 - Seasonal orthophyll dwarf shrub steppe savanna.

[4]1C14 - Evergreen sclerophyll dwarf scrub.

[5]1H14 - Open evergreen sclerophyll dwarf scrub with closed ground cover.

[6]2H11 - Moss tundra.

[7]2G23 - Perennial herb steppe.

[8]3B23 - Deciduous orthophyll desert scrub.

TABLE 2. Rank of importance of the species groups in discriminating between vegetation groups on Boothia Peninsula

Rank of importance	Species group	F to enter or remove	Wilk's Lambda	RAO's V	Change in RAO's V	Significance of change
1	Evergreen Shrubs	135.1	0.34	810.7	810.7	0
2	Willows	83.8	0.15	1314.7	504.0	0
3	Bare Ground	57.7	0.08	1686.3	371.6	0
4	Lichens	44.3	0.05	2218.5	532.2	0
5	Forbs	42.1	0.03	2507.6	289.1	0
6	Patina	27.4	0.02	2693.6	186.0	0
7	Moss	31.6	0.02	2925.5	231.9	0
8	Fungi	3.3	0.01	2990.8	65.3	0.000
9	Grasses	1.9	0.01	3017.0	26.2	0.000
10	Algae	1.1	0.01	3029.1	12.1	0.061

TABLE 3. F matrix for the Mahalanobis distance between the vegetation groups on Boothia Peninsula (degrees of freedom 10, 405)

	Sedge Meadows	Willow Hummocks	Lichen-*Dryas* Plateaus	Seepage Slopes	Moss Tundra	Purple-Saxifrage Plains
Willow Hummocks	50.24	-	-	-	-	-
Lichen-*Dryas* Plateaus	73.68	78.93	-	-	-	-
Seepage Slopes	35.90	33.32	53.75	-	-	-
Moss Tundra	31.11	27.18	60.62	15.25	-	-
Purple-Saxifrage Plains	25.12	27.56	45.70	12.36	14.00	-
Rock Barrens	83.88	81.41	69.86	35.58	35.34	31.25

Table 4. The group membership predicted by discriminant function analysis for each individual 100 point line-transect in each vegetation group on Boothia Peninsula

		Predicted group membership						
Actual group	No. of transects	Sedge Meadows	Willow Hummocks	Lichen *Dryas* Plateaus	Seepage Slopes	Moss Tundra	Purple Saxifrage Plains	Rock Barrens
Sedge Meadows	45	42 93.3%	0 0.0%	0 0.0%	0 0.0%	3 6.7%	0 0.0%	0 0.0%
Willow Hummocks	70	5 7.1%	49 70.0%	0 0.0%	4 5.7%	9 12.9%	2 2.9%	1 1.4%
Lichen-*Dryas* Plateaus	69	4 5.8%	3 4.3%	55 79.7%	0 0.0%	2 2.9%	0 0.0%	5 7.2%
Seepage Slopes	35	0 0.0%	0 0.0%	0 0.0%	24 68.6%	2 5.7%	3 8.6%	6 17.1%
Moss Tundra	46	2 4.3%	0 0.0%	0 0.0%	2 4.3%	37 80.4%	5 10.9%	0 0.0%
Purple-Saxifrage Plains	20	1 5.0%	0 0.0%	0 0.0%	2 10.0%	1 5.0%	16 80.0%	0 0.0%
Rock Barrens	136	1 0.7%	0 0.0%	6 4.4%	5 3.7%	4 2.9%	4 2.9%	116 85.3%

Percent of "grouped" transects correctly classified: 80.5%.

TABLE 5. Frequency of occurrence (%) of plant species within the vegetation groups on Boothia Peninsula

Species	VEGETATION GROUP						
	Sedge Meadows (45)[1]	Willow Hummocks (70)	Lichen-*Dryas* Plateaus (69)	Seepage Slopes (35)	Moss Tundra (46)	Purple-Saxifrage Plains (20)	Rock Barrens (136)
Salix reticulata		0.02	0.06				
Salix alaxensis		0.22	0.07				
Salix cordifolia	0.98	8.12	2.43	0.43	0.33	0.40	0.45
Salix spp.	0.38	2.39	0.48	0.06	0.24	0.15	0.16
Dryas integrifolia	0.67	1.54	26.88	0.09	0.09	0.20	2.46
Cassiope tetragona	0.07	0.17	3.20	0.09	0.04		2.43
Total Shrubs	2.10	12.46	33.12	0.67	0.70	0.75	5.50
Oxyria digyna	0.11	0.94	0.01	2.97	1.87	3.85	0.33
Polygonum viviparum	0.11	0.01	0.26		0.02	0.10	0.05
Stellaria longipes	0.40			0.09	0.16		
Cerastium arcticum	0.02	0.01		0.11	0.09	0.15	0.02
Cerastium spp.	0.04	0.07		0.40	0.29	0.75	0.13
Sagina intermedia	0.02			0.17	0.11	0.20	0.04
Ranunculus sulphureus	0.24			0.09		0.10	0.04
Melandrium apetalum	0.36	0.09		0.14	0.11	0.15	0.01
Papaver radicatum	0.18	0.27		0.29	0.42	1.15	0.27
Draba oblongata	0.33	0.48	0.01	1.06	0.38	0.75	0.14
Arabis arenicola		0.03					
Braya purpurascens		0.30	0.04	0.06	0.24	0.50	0.10
Unidentified Cruciferae	0.04			0.03			
Saxifraga caespitosa	0.16	0.03		0.34	0.20	0.55	0.06
Saxifraga cernua	0.02	0.03	0.14	0.06		0.30	
Saxifraga flagellaris		0.07		0.69	0.29	0.70	0.04
Saxifraga foliolosa				0.06		0.05	0.01
Saxifraga hieracifolia					0.02	0.01	
Saxifraga Hirculus	0.33	0.04		0.14	0.11		
Saxifraga nivalis	0.04	0.04		0.20	0.11	0.15	0.07
Saxifraga oppositifolia	0.82	5.40	2.36	8.29	5.71	15.60	2.82
Saxifraga tricuspidata		0.01	0.01				0.07
Saxifraga spp.	0.04						
Potentilla hyparctica		0.06				0.30	0.04
Potentilla Vahliana	0.02						0.11
Potentilla spp.					0.02		
Oxytropis Maydelliana	0.09		0.48		0.02	0.10	0.18
Epilobium latifolium							0.01
Pedicularis arctica			0.01				
Pedicularis lanata	0.13	0.06	0.20				
Unidentified forbs	0.02	0.03	0.01	0.09	0.02		0.01
Total Forbs	3.52	7.97	3.53	15.28	10.19	25.45	4.56
Alopecurus alpinus	0.51	0.07		0.11	0.47	2.95	0.06
Phippsia algida				0.06		0.05	0.04

Arctagrostis latifolia	2.96	0.64	0.43	0.40	0.76	0.40	0.03
Trisetum spicatum							0.02
Poa arctica	0.24	0.04	0.11	0.11	0.04	0.05	0.18
Poa spp.	0.04	0.01			0.09	0.05	
Pleuropogon Sabinei	1.38	0.53	0.10	0.06	0.22		0.12
Dupontia Fisheri	0.80	0.51	0.07	0.26	0.29	0.10	
Festuca brachyphylla							0.01
Agropyron latiglume			0.04	0.03	0.02	0.50	
Unidentified grasses	11.16	3.44	5.06	2.60	4.42	1.95	1.14
Total Grasses	17.09	5.24	5.81	3.63	6.31	6.05	1.60
Eriophorum triste	4.87	1.39	0.13		0.16	0.55	0.04
Eriophorum Scheuchzeri	1.65				0.09		0.15
Carex spp.	20.80	9.33	5.65	0.29	0.80	1.65	0.12
Total Sedges	27.32	10.72	5.78	0.29	1.05	2.20	0.31
Juncus spp.	0.04	0.01		0.11		0.05	
Luzula nivalis	1.56	0.86	0.59	2.31	3.02	3.75	0.65
Total Rushes	1.60	0.87	0.59	2.42	3.02	3.80	0.65
Equisetum variegatum	0.58	0.06	0.06				
Total Horsetails	0.58	0.06	0.06	0.00	0.00	0.00	0.00
Lycopodium Selago		0.01					
Unidentified mosses	21.20	21.74	8.24	15.34	32.43	16.75	9.10
Total Mosses	21.20	21.75	8.24	15.34	32.43	16.75	9.10
Pertusaria coriacea	0.62	3.56	5.72	7.14	5.04	6.65	5.24
Pertusaria dactylina			2.12				
Cetraria delisei	0.26	0.30	0.25	0.46	1.00	0.50	0.41
Cetraria islandica		0.01					0.03
Cetraria nivalis	0.38	0.79	3.08	0.57	1.16	0.45	2.51
Cetraria tilesii		0.17	0.42	0.31	0.31	0.40	0.29
Thamnolia vermicularis	0.44	1.67	2.13	1.49	1.64	1.10	1.40
Alectoria ochroleuca		0.04	0.26	0.71	0.31	0.05	1.04
Dactylina arctica	0.38	0.07	0.03	0.06	0.16		0.02
Cladonia spp.		0.01					
Cornicularia divergens			0.17	0.14	0.07	0.10	0.78
Stereocaulon albicans							
Unidentified lichens	0.09	0.01	0.01		0.07		0.01
Crustose lichens	0.02	0.50	0.52	1.00	1.33	0.50	12.15
Total Lichens	2.19	7.13	14.71	11.88	11.09	9.75	23.88
Rock	1.00	9.89	11.91	15.17	15.60	14.10	41.41
Bare Ground	1.96	6.46	6.09	7.26	8.60	12.15	6.85
Litter (includes shells)	13.11	8.81	3.94	1.86	2.53	2.35	1.00
Algae	3.22	0.16		0.11	0.96	0.05	0.63
Fungi			0.01				
Patina	5.09	8.46	6.24	26.11	7.51	6.60	4.51

[1]Number of 100 point line transects.

composition of each of the defined vegetation groups for Boothia Peninsula. Based upon this analysis, 80.5% of the vegetation transects were representative of the vegetation group to which they were assigned (Table 4). The remaining 19.5% of the transects represent those that were either incorrectly classified initially by Fosberg community in the field or that included areas which were non-representative of the vegetation type (e.g., small inclusions of Sedge Meadow within a Willow Hummock vegetation group).

The species frequency composition of each vegetation group is given in Table 5.

Sedge Meadows

Sedge Meadows occur in areas of poorly-drained organic soils. Wet areas adjacent to rivers, ponds, and lakes, moist valley bottoms, and depressions are generally covered by Sedge Meadows. Standing water is usually present.

Vegetation covers 83.9% of the ground. Sedges, mosses, and grasses are the dominant species group of this vegetation group. Sedges (*Carex* spp. and *Eriophorum* spp.) predominate; they cover 27.3% of the ground. Grasses (*Arctagrostis latifolia, Pleuropogon sabinei,* and *Dupontia fisheri*) generally occur on the slightly drier sites. Mosses form a continuous sublayer throughout. Litter tends to accumulate in Sedge Meadows, especially in the more mesic sites. Algae frequently grow in the areas of standing water. Scattered willows (*Salix* spp.) and evergreen shrubs (*Dryas integrifolia*) are often present along the elevated margins of Sedge Meadows.

Willow Hummocks

Willow Hummocks most frequently occur on hydric to mesic fine-textured soils. Frost boils and hummocks strongly contribute to the microtopography. Hummocky lowlands and gently sloping areas adjacent to Sedge Meadows frequently support Willow Hummock vegetation.

The vegetation, which covers 74.8% of the ground, is characterized by willows (*Salix* spp.), sedges (*Carex* spp.), and mosses. The microtopography markedly affects plant distribution within the vegetation group. Willows (*S. cordifolia, S. arctica*) occupy the elevated, better-drained tops and upper slopes of the hummocks and cover 10.7% of the ground. Sedges (*Carex* spp.) and grasses (*Arctagrostis latifolia, Dupontia fisheri, Pleuropogon sabinei*) grow on the moist lower hummock slopes and between hummocks; mosses and patina predominate in the low, wet areas between hummocks. Algae may occur between the hummocks in areas of standing water. Litter, mainly derived from the willows, collects at the hummock bases. At the more xeric extreme of this vegetation group, hummock tops are invaded by evergreen shrubs.

*Lichen-*Dryas *Plateaus*

Lichen-*Dryas* Plateaus are found on both lower to mid-slopes and well-drained, level, mesic to xeric sites, often upslope from areas of Willow

Hummock vegetation. Lichen-*Dryas* Plateaus are common on tills at low to intermediate elevations on Boothia Peninsula. Cryoturbation, often in the form of sorted stripes, is common. It characterizes the vegetation group and affects the plant distribution within it.

Total vegetation cover in this type averages 78.1%. Evergreen shrubs (chiefly *Dryas integrifolia*), lichens, and bare ground characterize the vegetation in this vegetation group. At the most mesic expression of this vegetation group, *Dryas* covers extensive areas of the upper surfaces of the frost hummocks, stripes, and polygons. Willows, sedges, and mosses occupy increasingly moister sites on the hummock slopes and in the narrow zone between frost features. On progressively drier sites, willows, sedges, and mosses disappear; *Dryas* is found on the more mesic sites on the lower slopes of, and in the areas between, cryoturbation features. Bare ground becomes increasingly common on the xeric surfaces of the microtopographic features. The grey (*Pertusaria dactylina, P. coriacea*) and light-yellow (*Cetraria nivalis*) lichens are common in this vegetation group, as is *Thamnolia vermicularis*. Crustose lichens become increasingly common on the more xeric sites. Concomitant with the decrease in orthophylls is a reduction in the production of litter, which is uncommon in lichen-*Dryas* vegetation.

Seepage Slopes

Seepage Slopes are found on moderate to gentle slopes and level areas adjacent to slopes immediately below late-lying snowbeds. The soil is generally saturated and often spongy. As a result, solifluction is common. Seepage Slopes are common throughout Boothia Peninsula, especially north of Sanagak Lake.

Vegetation cover averages 75.7% but ranges from 41.3% to 92.1% with patina, mosses, and forbs dominating the visual aspect. The moist situation and shorter growing season occasioned by late-lying snowbeds favour patina and mosses which cover 26.1% and 15.3% of the ground, respectively. In this vegetation group, patina is most likely a combination of lichen, moss, and algae which thrive in the moist environment. Forbs are also common; *Saxifraga oppositifolia, Oxyria digyna,* and *Draba oblongata* are the predominant species. Lichens cover 11.9% of the ground; *Pertusaria coriacea* is located primarily on the drier sites while *Thamnolia vermicularis* is distributed throughout the Seepage Slope vegetation group.

Moss Tundra

Moss Tundra is generally located on level sites in bedrock terrain at the higher elevations on Boothia Peninsula. In common with Seepage Slopes, Moss Tundra occurs in areas of late-lying snowbeds; however, soil development is poor in comparison to Seepage Slopes. Soil is often restricted to accumulations in depressions and around the base of rocks. Moss Tundra areas are typically small and localized.

Vegetation covers 73.3% of the ground. Mosses, forbs, and bare rock dominate the aspect with mosses and bare ground averaging 32.4% and 24.2%

cover, respectively. *Pertusaria coriacea, Cetraria delisei, C. nivalis,* and *Thamnolia vermicularis* are the most frequent fruticose lichens in this vegetation group and contribute to the 11.1% lichen cover. Forbs occur infrequently on sites where soil accumulation has occurred.

Purple-Saxifrage Plains

Purple-Saxifrage Plains occur on medium to fine textured tills in gently rolling to undulating terrain. The soils are characteristically wet following snowmelt, and they become drier as the season progresses. Heavy cryoturbation and patterned ground is common. Purple-Saxifrage Plains occur most frequently at the higher elevations on central Boothia Peninsula.

The vegetation, which covers 71.4% of the ground, is dominated by forbs, mosses, and patina. The forb cover is extensive and diverse. Purple Saxifrage (*Saxifraga oppositifolia*), whose cover averages 15.6%, is the predominant vascular plant species giving this vegetation group a distinctive purple tinge. Other forbs which are abundant include: *Oxyria digyna, Papaver radicatum, Cerastium* spp., *Draba oblongata, Braya purpurascens, Saxifraga flagellaris,* and *S. caespitosa,* with others occurring intermittently. Mosses cover 16.8% of the ground; together with patina, they are especially common on the moister sites. Bare ground is generally found in the form of boulders or mineral soil exposed through cryoturbation.

Rock Barrens

Rock Barrens comprise the most common vegetation group on Boothia Peninsula. This vegetation group occurs on xeric, windswept upper slopes and ridge tops, areas of frost-shattered bedrock or boulder-dominated terrain, and steep rocky hillsides.

Vegetation cover averages 50.7% and ranges from 11.6% to 68.9%. Rock crustose lichens contribute 12.2% of the total cover with fruticose lichens adding a further 11.7%. The visual aspect is therefore dominated by bare ground. The lack of an adequate source of moisture, coupled with enhanced desiccation due to constant exposure to wind, contribute to these areas being almost devoid of vascular vegetation. Small patches of snow accumulate in protected sites, and provide sufficient moisture for the growth of evergreen shrubs (*Dryas integrifolia, Cassiope tetragona*). Within these *Dryas* mats, forbs, grasses, and sedges may occur. Between these islands of vegetation, only lichens and isolated specimens of the most xeric species (*Draba* spp.) are found. Rarely, small crevices may collect and hold water, which may allow the growth of mosses and algae.

Factors Influencing the Spatial Distribution of Vegetation Groups on Boothia Peninsula

The environmental factors which influence the spatial distribution of plants, and therefore vegetation groups, have been reviewed in detail by Billings and Mooney (1968), Bliss (1962, 1971), Savile (1972) and Billings (1973).

Murray and Batten (1977) suggest that most of the environmental factors determining the organization of arctic landscapes are integrated along a topographic gradient. As relative position along a slope and available moisture are two factors which may be readily noted in the field they provide convenient benchmarks for the organization of vegetation groups in the landscape. However, as Griggs (1934) notes, many common and characteristic arctic plants are found in bogs and fellfields and in all habitats of intermediate dryness. Thus, site differences in arctic regions are reflected more by variations in the relative proportions of species than by changes in floristic composition (Beschel, 1970). Further, due to a multitude of streams and small water bodies, the irregular topography, and the influences of permafrost, distinct vegetation groups are seldom widespread.

Available moisture and elevation combine on Boothia Peninsula to give a progressional sequence on slopes. In areas where water collects, such as valley bottoms, graminoid plants (sedges and grasses) generally dominate. On better drained lowland sites, such as frost hummocks, willows can gain a foothold. Thus there is often a gradual change from Sedge Meadows on the most hydric sites to Willow Hummocks in the cryoturbated soils of the adjacent areas. Progressing upslope, moisture rapidly becomes limiting and the more xerophytic evergreen shrubs quickly replace willows on the hummock tops. Eventually, in the Rock Barrens vegetation group, even the xerophytic evergreen shrubs occupy only the most mesic areas of microrelief, and the majority of the ground is devoid of vascular plant cover. Thus, there is a gradual progression from Sedge Meadows in the valley bottom through Willow Hummocks on the very bottom of the slopes to Lichen-*Dryas* Plateaus in the lower to mid-slope position. Rock Barrens are located on the exposed upper slopes and ridge tops.

Purple-Saxifrage Plains occur on level areas which, although wet following snowmelt, dry later in the season. A lack of surface water seems to inhibit the growth of sedges in this vegetation group since the presence of surface water is essential in the maintenance of Sedge Meadows (Bliss *et al.*, 1973). Willow growth may be inhibited by both wet soils following snowmelt and the dry, late season conditions. Evergreen shrubs do not generally favour poorly drained, moist areas.

Seepage Slopes form mainly in response to the considerable solifluction which inhibits the development of rooted vasculars. The cool, moist environment of Seepage Slopes favours the growth of moss and patina.

Moss Tundra occurs on moist sites with poor soil development. Mosses grow in the wet rocky areas; patina and vasculars are restricted to the areas of soil accumulation.

Northern Keewatin

A total of 424 vegetation line-transects was sampled throughout northern Keewatin.

Twenty-eight distinct Fosberg communities and 42 different combinations of Fosberg community-cover classes were recognized in northern Keewatin

TABLE 6. The Fosberg communities and cover classes comprising each vegetation group in northern Keewatin. Nomenclature for the Fosberg communities follows Fosberg (1967)

Vegetation Group	Fosberg community	Cover classes
Sedge Meadows	1M21	5
	1M22	5
Willow-Sedge Meadows	1H21	5
	2C21[1]	5,4
Orthophyll Shrub	1C21a	5
	1C24	5
	1H22	5
Lichen-Heath Plateaus	1C12b	5
	1C12c	5
	1C14[2]	5
	2C12	5,4,3
	2C13	5,4
Lichen Uplands	1H13	5
	1H14[3]	5
	1H15[4]	5
	1012	5
	1022	5
	2C14	5,4
	2C22[5]	5,4
	2F12	5,4
	2F14[6]	5,4
	2F22[7]	5,4
	2H11[8]	4
	2H21	5
Barrens	2C14	3
	2H21	4,3
	3B11	3
	3B12	3,2
	3C13	3,2
	3C14[9]	2

The Fosberg method of classifying vegetation was originally devised for use on a world-wide basis. Necessarily, the key is very general and adaptations had to be made for its use in an Arctic situation. Additions to this key are noted in the following footnotes:

[1]2C21 - Deciduous orthophyll dwarf steppe scrub.
[2]1C14 - Evergreen sclerophyll dwarf scrub.
[3]1H15 - Open evergreen sclerophyll dwarf scrub with closed ground cover.
[4]1H15 - Open evergreen narrow sclerophyll dwarf scrub with closed ground cover.
[5]2C22 - Deciduous orthophyll heath steppe scrub.
[6]2F14 - Evergreen microphyll dwarf shrub steppe savanna.
[7]2F22 - Seasonal orthophyll dwarf shrub steppe savanna.
[8]2H11 - Moss tundra.
[9]3C14 - Moss tundra sparse phases.

(Table 6). The results of the discriminant function analysis identified six significant groups of these community-cover class combinations. These six groups were designated as the vegetation groups for northern Keewatin: Sedge Meadows, Willow-Sedge Meadows, Orthophyll Shrub, Lichen-Heath Plateaus, Lichen Uplands, and Barrens. The classification of the 42 Fosberg

TABLE 7. Rank of importance of the species groups in discriminating between vegetation groups in northern Keewatin

Importance	Species group	F to enter or remove	Wilk's Lambda	RAO's V	Change in RAO's V	Significance of Change
1	Sedges	206.5	0.29	1032.3	1032.3	0
2	Deciduous Ericaceae	142.9	0.11	1749.7	717.4	0
3	Willows	83.8	0.05	2241.4	491.7	0
4	Evergreen Shrubs	56.4	0.03	2572.4	331.0	0
5	Birch	32.1	0.02	3031.5	459.1	0
6	Bare Ground	9.8	0.02	3092.6	61.1	0.000
7	Lichens	9.8	0.02	3213.1	120.5	0
8	Forbs	6.7	0.02	3295.3	82.2	0.000
9	Litter	1.7	0.02	3313.9	18.6	0.002

TABLE 8. F matrix for the Mahalanobis distance between the vegetation groups in northern Keewatin (degrees of freedom 9, 410)

	Sedge Meadows	Willow-Sedge Meadows	Orthophyll Shrub	Lichen-Heath Plateaus	Lichen Uplands
Willow-Sedge Meadows	40.61	-	-	-	-
Orthophyll Shrubs	112.45	64.27	-	-	-
Lichen-Heath Plateaus	109.75	77.87	84.60	-	-
Lichen Uplands	103.96	69.80	120.24	25.21	-
Barrens	86.97	65.19	90.34	33.83	16.79

community-cover class combinations which occur in the northern District of Keewatin is presented as Table 6. Nine species groups were identified as being the significant discriminating variables describing these vegetation groups (Table 7); the most significant were sedges, deciduous Ericaceae, and willows. Based on these nine variables, the vegetation groups differed in varying degrees from each other (Table 8).

Prior to the finalization of the vegetation groups, a further discriminant function analysis was conducted to compare the proportion of each of the species groups in each individual vegetation transect which had been run in northern Keewatin to the vegetation groups for northern Keewatin. Based upon this analysis, it appears that 76.2% of the vegetation transects were representative of the group to which they were assigned (Table 9). The remaining 23.8% of the transects represent those that were either initially incorrectly classified by Fosberg community in the field or which included areas that were non-representative of the vegetation group (e.g., small inclusions of Willow-Sedge Meadows within an Orthophyll Shrub vegetation group).

TABLE 9. The group membership predicted by discriminant function analysis for each individual 100 point line-transect in each vegetation group in northern Keewatin

		Predicted group membership					
Actual group	No. of transects	Sedge Meadows	Willow-Sedge Meadows	Orthophyll Shrub	Lichen-Heath Plateaus	Lichen Uplands	Barrens
Sedge Meadows	51	49	0	0	0	2	0
		96.1	0.0%	0.0%	0.0%	3.9%	0.0%
Willow-Sedge Meadows	34	5	24	4	0	1	0
		14.7%	70.6%	11.8%	0.0%	2.9%	0.0%
Orthophyll Shrub	52	2	2	45	1	0	2
		3.8%	3.8%	86.5%	1.9%	0.0%	3.8%
Lichen-Heath Plateaus	78	0	0	2	58	14	4
		0.0%	0.0%	2.6%	74.4%	17.9%	5.1%
Lichen Uplands	166	5	4	1	20	112	24
		3.0%	2.4%	0.6%	12.0%	67.5%	14.5%
Barrens	43	0	0	0	0	8	35
		0.0%	0.0%	0.0%	0.0%	18.6%	81.4%
Percent of "grouped" transects correctly classified: 76.2%							

The species frequency composition of each vegetation group is given in Table 10.

Sedge Meadows

Sedge Meadows occur in lowlands, moist valley bottoms, and in bedrock depressions. Sedge Meadows become increasingly common to the south as bedrock-controlled terrain becomes less extensive.

Sedges and mosses comprise 71.2% of the total 90.7% vegetation cover. Several species of sedges (*Carex* spp.) and cottongrass (*Eriophorum* spp.) are abundant, as well as several rushes (*Juncus* spp.) and the horsetail (*Equisetum variegatum*). Cottongrass tussocks (*Eriophorum vaginatum*) frequently dominate the visual aspect. Mosses form a discontinuous sublayer. Litter covers 6.4% of the ground with organic accumulation generally increasing to the south. *Salix herbacea* and *Phyllodoce coerulea* are frequent shrubs on the turfy sites. *Saxifraga Hirculus* and *Melandrium apetalum* are frequent forbs.

Willow-Sedge Meadows

Willow-Sedge Meadows occur along the edges of ponds and marshes, along upland drainageways and meltwater channels, and along the edges of depressions. Topographically, they are frequently situated on low to mid-slopes adjacent to Sedge Meadows. Many sites show evidence of intense cryoturbation.

TABLE 10. Frequency of occurrence (%) of plant species within the vegetation groups in Northern Keewatin

Species	VEGETATION GROUP					
	Sedge Meadows (51)[1]	Willow-Sedge Meadows (34)	Orthophyll Shrub (52)	Lichen-Heath Plateaus (78)	Lichen Uplands (166)	Barrens (43)
Salix herbacea	1.18	13.26	0.15	0.30	0.85	0.14
Salix Richardsonii	0.04	0.03		0.01	0.04	
Salix reticulata	0.04	0.06	0.19	0.12	0.05	
Salix alaxensis	0.12	0.03	0.06		0.01	
Salex cordifolia		0.06		0.18	0.13	0.05
Salix arctica	0.02				0.02	0.09
Salix spp.	0.94	1.73	2.19	0.89	0.65	0.02
Betula glandulosa	0.17	3.71	18.87	4.09	0.63	
Dryas integrifolia	1.31	0.94	3.12	6.18	1.56	0.42
Empetrum nigrum	0.02	0.29	3.87	5.83	0.76	
Ledum decumbens	0.39	1.35	6.16	12.77	3.64	1.12
Loiseleuria procumbens				0.12		
Cassiope tetragona	0.61	1.35	4.98	8.30	8.65	1.67
Phyllodoce coerulea	0.12	0.03	0.02		0.03	0.02
Rhododendron lapponicum	0.33	0.06	0.98	0.35	0.02	
Arctostaphylos rubra	0.02	0.09	1.38	1.03	0.12	
Vaccinium uliginosum	0.57	1.53	17.79	2.96	0.50	0.02
Vaccinium Vitis-idaea	0.26	0.73	2.96	3.10	1.80	0.49
Total Shrubs	6.14	25.25	62.72	46.23	19.46	4.04
Oxyria digyna		0.15	0.08	0.10		
Polygonum viviparum	0.12	0.03	0.02	0.12	0.02	
Stellaria longipes		0.06			0.01	
Cerastium spp.				0.01		
Sagina intermedia					0.07	
Arenaria spp.				0.39	0.15	
Silene acaulis	0.02	0.03	0.06	0.01		
Melandrium apetalum	0.12					
Eutrema Edwardsii			0.02		0.02	
Saxifraga foliolosa					0.01	
Saxifraga Hirculus	0.26					
Saxifaga nivalis	0.06	0.03			0.01	
Saxifraga oppositifolia	0.02			0.08	0.01	
Saxifraga tricuspidata				0.01	0.01	
Potentilla hyparctica						0.23
Potentila Vahliana					0.01	0.16

Table 10, continued.

Potentilla spp.			0.03									
Astragalus alpinus							0.42		0.03			
Oxytropis arctica									0.01			
Oxytropis spp.		0.12		0.18		0.85		0.53		0.05		
Hedysarum Mackenzii		0.09		0.03		0.31		0.18				
Epilobium latifolium						0.06		0.03		0.01		
Pyrola grandiflora				0.03		0.04		0.05				0.07
Castilleja pallida										0.01		
Pedicularis arctica		0.02		0.06				0.03				
Pedicularis lapponica		0.02				0.02						
Pedicularis lanata				0.03						0.01		
Pedicularis sudetica		0.02		0.03								
Antennaria spp.										0.01		
Artemisia spp.								0.01				
Saussurea angustifolia		0.12		0.06		0.58		0.40		0.02		
Unidentified forbs						0.06		0.01				
Total forbs	0.99		0.75		2.10		2.38		0.47		0.46	
Arctagrostis latifolia		0.59		1.09		0.11		0.13		0.53		0.02
Hierochloe alpina		0.12		1.23		0.15		0.54		1.89		1.44
Poa arctica				0.23								
Poa spp.						0.09						
Pleuropogon Sabinei		0.33						0.02		0.01		
Dupontia Fisheri								0.01		0.01		
Unidentified grasses		1.92		2.77		3.31		1.86		2.29		0.93
Total Grasses	2.96		5.32		3.66		2.56		4.73		2.39	
Eriophorum angustifolium		1.45		0.41		0.42				0.01		
Eriophorum triste		4.29		1.41				0.03		0.33		0.05
Eriophorum Scheuchzeri		8.49		0.03		0.06		0.03		0.42		
Eriophorum vaginatum		0.02				0.06						
Eriophorum spp.		7.14		0.21								
Carex stans				1.62						0.01		
Carex spp.		38.71		22.94		9.37		3.51		4.89		0.84
Total Sedges	60.10		26.62		9.91		3.57		5.66		0.89	
Juncus biglumis												
Juncus spp.		0.26		0.12		0.11		0.05		0.07		0.02
Luzula Wahlenbergii		0.06										
Luzula nivalis		0.22		0.24				0.03				
Luzula confusa										0.25		0.12
Total Rushes	0.54		0.36		0.11		0.08		0.32		0.14	
Equisetum variegatum		0.08				0.02		0.03				
Total Horsetails	0.08		0.00		0.02		0.03		0.00		0.00	
Sphagnum spp.		0.76		0.12						0.01		

Lycopodium selago		0.04		0.03					0.04	
Unidentified mosses		10.31		14.65		2.77		3.26	9.13	3.95
Total Mosses	11.11		14.80		2.77		3.26		9.18	3.95
Pertusaria coriacea		0.06		0.35		0.23		0.52	1.00	1.30
Pertusaria dactylina									0.07	
Cetraria delisei		0.67		2.23		0.33		0.22	0.55	0.23
Cetraria islandica		0.22		1.00		0.67		0.15	0.48	0.12
Cetraria nivalis		1.84		2.15		4.14		4.65	8.01	3.67
Thamnolia vermicularis		0.04		0.03		0.33		0.37	0.32	0.30
Alectoria ochroleuca		0.47		0.65		2.23		7.09	17.05	14.35
Dactylina arctica		0.14		0.18		0.21		0.15	0.16	
Cladonia amaurocraea		2.00		3.06		2.35		3.96	6.13	1.49
Cladonia bellidiflora								0.03	0.05	0.10
Cladonia chlorophaea		0.02						0.03	0.03	0.05
Cladonia coccifera		0.01							0.03	
Cladonia rangiferina		0.01								0.01
Cladonia verticillata										0.10
Cornicularia divergens		0.16		0.44		2.83		6.63	9.08	13.14
Cladina alpestris		0.04		0.23		0.06		0.33	1.11	0.42
Sphaerophorus globosus		0.12		0.18		0.13		0.27	0.42	0.33
Siphula spp.		1.02		1.82				0.03	0.31	
Stereocaulon albicans		0.41		0.29		0.02		0.04	0.28	
Unidentified lichens		0.12		0.06		0.02		0.01	0.17	0.12
Crustose lichens		0.25		2.88		1.37		10.77	7.55	37.49
Total Lichens	7.60		15.55		14.92		35.25		52.80	73.22
Rock		0.61		3.82		0.65		3.60	3.52	11.07
Bare Ground		2.29		0.88		0.33		1.44	1.15	3.00
Litter (includes shells)		6.37		5.59		2.77		1.41	1.93	0.67
Algae		0.33		0.03					0.05	
Fungi		0.04						0.01		
Patina		0.84		1.03		0.04		0.15	0.73	0.17

[1]Number of 100 point line-transects.

Vegetation covers 89.7% of the ground surface; sedges and cottongrass tussocks dominate the visual aspect. Cottongrass tussocks occur less frequently in Willow-Sedge Meadows than in Sedge Meadows, although they are a major feature of both vegetation groups. In marked contrast to their low occurrence in Sedge Meadows, willows cover 15.2% of the ground, although they are frequently obscured by the taller vegetation. There is also a noticeable increase in the occurrence of other woody species, many of which are restricted to more mesic sites, notably the tops and sides of the cottongrass tussocks. The most prominent subordinate shrubs in the northern areas are *Dryas integrifolia, Ledum decumbens,* and *Cassiope tetragona,* with *Betula glandulosa, Vaccinium Vitis-idaea,* and *V. uliginosum* becoming increasingly prominent to the south. In areas where cryoturbation is not intense, lichens may become important. The lichen species of major importance include: *Cladonia amaurocraea, Cetraria nivalis, C. delisei, C. islandica,* and *Siphula* spp.

Orthophyll Shrub

The Orthophyll Shrub type is well developed only in the most southerly portion of northern Keewatin. Characteristically, it occupies mesic sites on mid-slopes of medium textured well-watered tills. Frost action is evident in the form of earth mounds and hummocks.

In the southernmost locations, the visual aspect is dominated by *Betula glandulosa* and *Vaccinium uliginosum; Cassiope tetragona, Empetrum nigrum,* and *Salix* spp. are prominent secondary shrubs. North of the Meadowbank River the importance of *Betula, Empetrum, Vaccinium,* and *Salix* spp. declines markedly while the occurrence of the evergreen Ericaceae and lichens increases. This shift in composition is likely due both to the increasingly severe climate and the typically coarse shallow soils and to the more exposed nature of the terrain. Sedges (*Carex* spp.) are locally abundant. The forb cover is diverse; *Oxytropis* spp., *Hedysarum mackenzii,* and *Saussurea angustifolia* are prominent. In areas of lichen abundance, *Alectoria ochroleuca, Cornicularia divergens, Cetraria nivalis,* and *Cladonia amaurocraea* are the main species.

Lichen-Heath Plateaus

Lichen-Heath Plateaus are a major vegetation group throughout northern Keewatin. In the south, lichen-heath vegetation occurs on the thin medium to coarse-textured soils of crests and upper slopes. In the north, Lichen-Heath Plateaus are located on the more mesic mid-slopes, in areas where the typically thin coarse soils retain enough fines to support shrubs.

Vegetation cover is generally complete, averaging 90.7%. Fruticose lichens (*Alectoria ochroleuca* and *Cornicularia divergens*) co-dominate the aspect with *Cassiope tetragona* and *Ledum decumbens*. Crustose lichens cover a majority of the exposed rock surfaces. In the more protected sites, especially south of the Meadowbank River, *Betula glandulosa, Empetrum nigrum, Vaccinium uliginosum,* and *V. Vitis-idaea* increase in importance as do the *Cetraria* and *Cladina*

lichens. The grass *Hierochloe alpina* occurs regularly, especially on the more xeric sites of the Meadowbank River.

Lichen Uplands

Lichen Uplands form a major vegetation group in northern Keewatin. They occur on the thin sandy to coarse-textured rapidly drained soils in exposed situations. Lichen Uplands are especially common on the sandy soils and exposed ridges east of the Back River and north of the Hermann River.

Lichen Uplands are totally dominated by lichens which cover 52.8% of the ground. Green and black lichens (*Alectoria ochroleuca* and *Cornicularia divergens*) co-dominate. These species create the colour pattern which is characteristic of the vegetation group. The lichen cover generally occurs as a loose intertwined mat of the dominant species and typically includes many other species. The diverse lichen flora includes: *Pertusaria coriacea, Cetraria nivalis, C. islandica, C. delisei, Thamnolia vermicularis, Cladonia amaurocraea, Cladina alpestris, C. rangiferina, Sphaerophorus globosus,* and *Stereocaulon albicans* together with other less frequently encountered species. The most notable difference between the Lichen Uplands and Lichen-Heath Plateaus is the marked reduction in shrubs in the Lichen Uplands. The heath shrubs *Ledum decumbens* and *Cassiope tetragona* are only important in the most protected sites. The grass *Hierochloe alpina* is moderately abundant and characteristically conspicuous; it is generally the tallest species present.

Barrens

Barrens occur only on the most windswept exposed terrain and in areas of natural disturbance. They are most frequent in the northern areas, and become increasingly infrequent as the rough bedrock-dominated terrain and the climate moderate to the south.

Vegetation covers an average 85.3% of the ground ranging from <5% up; however, rock crustose lichens comprise 37.5% of this vegetation. Fruticose lichens cover 35.7% of the ground; *Alectoria ochroleuca* and *Cornicularia divergens* are the dominant species. *Cassiope tetragona,* together with *Ledum decumbens,* is locally important in protected sites. The grass *Hierochloe alpina* is widespread but never abundant.

Factors Influencing the Spatial Distribution of Vegetation Groups in Northern Keewatin

Moisture availability, which is governed by the same factors in northern Keewatin as on Boothia Peninsula, seems to be the major factor controlling the local distribution of plants. Thus, as on Boothia Peninsula, the vegetation of northern Keewatin may best be discussed with respect to its moisture-substrate relations.

Sedge Meadows occur on the poorly drained flats and lowland areas where water availability is generally the greatest. Willow-Sedge Meadows occur on slightly drier, but imperfectly drained areas. Thus, Willow-Sedge Meadows will often occur in the low to mid-slopes adjacent to and grading into Sedge

Meadows. Ecologically, Willow-Sedge Meadows occupy a position on the moisture gradient between the Sedge Meadow and Orthophyll Shrub vegetation groups.

The Orthophyll Shrub vegetation group occurs on moderate, well-drained, medium-textured, well-watered tills, characteristically on mid-slope. The development of the Orthophyll Shrub type is very restricted in northern Keewatin; it is virtually absent north of the Meadowbank River. This is undoubtedly due to the increasingly exposed nature of the terrain coupled with the severity of the climate. The distribution of many shrubs is controlled by the over-winter survival of buds and twigs (Gubbe, 1976). The reduction of the Orthophyll Shrub type in northern Keewatin is probably due to winter snow abrasion (Savile, 1968).

In the south, the Orthophyll Shrub type typically grades into the Lichen-Heath type which occupies the adjacent upper slope position. In the north, Lichen-Heath vegetation often occurs on low to mid-slopes. Soils associated with the Lichen-Heath type are coarse, but retain enough fine-textured material to support shrubs. On the drier more exposed sites and in areas with little fine material the occurrence of dwarf shrubs declines noticeably. Lichen-Heath vegetation therefore appears to occupy a position on the moisture gradient between the Orthophyll Shrub and Lichen Upland types.

Lichen Uplands are characteristic of the driest sites found on rapidly drained areas of coarse materials.

Barrens are restricted to exposed bedrock-controlled terrain with little soil accumulation and to areas where natural disturbance, such as substrate erosion or deposition, will not allow the development of vascular vegetation. The Barrens type occurs most frequently in the northern portions of northern Keewatin.

Regional Trends in Distribution of Vegetation Groups

The vegetation of Boothia Peninsula shows both similarities and differences to that of northern Keewatin. From north to south, the terrain becomes progressively less exposed and bedrock-controlled and the climate becomes progressively less severe. As a result, the vegetation cover becomes increasingly more complete and diverse with more species, notably *Betula glandulosa* and *Vaccinium* spp., occurring. Further, the distribution of many life forms becomes increasingly promiscuous.

Sedge Meadows are found in the lowland areas of both Boothia Peninsula and northern Keewatin. Their composition is relatively similar in both areas with the exception of sedges, which become increasingly abundant to the south. The distribution of Sedge Meadows becomes less restricted in northern Keewatin. Whereas Sedge Meadows are generally small on Boothia Peninsula, large areas of Sedge Meadows become increasingly common farther south.

Willow Hummocks and Willow-Sedge Meadows occupy the same relative position on the moisture gradient on Boothia Peninsula and in northern

Keewatin. However, they show important differences in their topographic distribution. On Boothia Peninsula, because of the general coarseness of the soils, water availability generally declines rapidly with the slightest elevational increase. In northern Keewatin, the increased vegetation cover and litter accumulations result in moist conditions tending to persist much farther upslope. Therefore, Willow Hummocks on Boothia Peninsula generally occur only in the better drained lowland sites and they seldom extend upslope. In contrast, the Willow-Sedge Meadows of northern Keewatin frequently occur on the low to mid-slopes.

The Lichen-*Dryas* Plateaus of Boothia Peninsula seem quite similar to the Lichen-Heath Plateaus of northern Keewatin. *Dryas*, a pronounced calciphile, declines in abundance as soon as the limestone fraction is lost from the soil (Gubbe, 1976). This occurs just south of Shepherd Bay. *Dryas* is replaced mainly by *Ledum* and *Cassiope*.

The Rock Barrens of Boothia Peninsula give way in part to the Lichen Uplands in northern Keewatin as a result of the decreasing severity of the exposure and climate. Barrens in northern Keewatin are restricted to only the most severe or disturbed environments.

Moss Tundra and Seepage Slopes are extremely limited in northern Keewatin.

Application of the Vegetation Classification

One of the common difficulties involved in comparing data gathered during different wildlife habitat studies and similar environmental research stems from the fact that various authors have collected their data using habitat types unique to their studies. The major objective of this study was to produce a vegetation classification useful as a common basis for conducting wildlife habitat use studies and habitat inventories on the Boothia Peninsula and in the northern District of Keewatin. As Murray and Batten (1977) have noted, the perspective which has been used to develop various vegetation classifications has depended upon the intensity of the studies and the scale of mapping. The objective of our studies required a physiognomic type level classification (IVth level of Murray and Batten's 1977 hierarchy) which could be accurately applied by various field personnel making their evaluations entirely by eye without any sampling, other than ocular, even for the primary species. The classification system was also required to allow for quantitative descriptions of the species composition of the habitat, and to be applicable over large enough areas to be useful as a synoptic-scale (i.e., 1:100,000) survey technique.

The vegetation groups that have been described have proven to be meaningful for habitat studies of barren-ground caribou (Fischer *et al.*, 1977). By conducting a series of pellet-group transects within each of the vegetation groups it was possible to describe significant differences in the use of various habitats in the study area by caribou (Fischer *et al.*, 1977, Thompson and Fischer, in prep.). These data were subsequently used to prepare caribou habitat maps of a portion of the study area at a scale of 1:100,000.

Quantitative descriptions of species compositions of the vegetation groups were obtained. The vegetation groups which resulted from this classification were easily recognizable in the landscape by various field personnel using Fosberg's (1967) keys and could be applied with a high degree of accuracy (76-80%). It would therefore appear that this vegetation classification would be useful to other workers conducting wildlife studies and inventories in the low to middle arctic regions of the Canadian North.

ACKNOWLEDGEMENTS

The data for this work were obtained and analysed as part of a larger study undertaken by Renewable Resources Consulting Services Ltd. under contract to the Polar Gas Project. Co-ordination of logistics was capably handled by B. Ross of the Polar Gas Project. Field assistance was provided by C. Fischer, P. Thompson, B. Wooley, L. Fisher, G. Klassen, D. McInnes, A. Wroot, J. Mannilauq, and M. Teeluktah. G. McGonigal handled the computer programming and assisted with the statistical tests associated with the data analysis. Dr. D. Vitt of the University of Alberta provided assistance in the identification of lichens and bryophytes. K. McCourt, C. Fischer, and L. Doran reviewed an earlier draft of this paper.

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