PHYTOSOCIOLOGICAL AND ENVIRONMENTAL CHARACTERISTICS OF SOME PLANT COMMUNITIES IN THE UMIAT REGION OF ALASKA[1]

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INTRODUCTION

The purposes of this investigation were to determine some of the kinds of plant communities which make up the vegetation in the Umiat area of Alaska, to analyze the communities phytosociologically, to study some of the relationships of such communities to environmental conditions, and to obtain information for aerial photographic interpretation.

Umiat is located at 69° 22′ N, 152° 08′ W. The elevation on the floodplain at Umiat is approximately 340 feet as reported by the U. S. Weather Bureau (1952a). Elevations of the ridges and tops of hills of the upland extend to 950 feet.

Very little is known of the various kinds of plant communities of the Umiat area, especially regarding cover and frequency of constituent species, interrelations of communities, and environmental relationships. Lepage (1949), Retallick (1950), and Spetzman (1951) described briefly some broad vegetation types. Sufficient knowledge of the communities would probably permit the use of such communities as indicators of environmental conditions. Because of the complexity of communities of this area, detailed qualitative and quantitative data are required to understand the interrelationships of the communities. They are also needed as a basis for developing a reliable aerial photographic interpretation technique.

Data on the floristic composition, cover, frequency and environment were collected for 80 stands during July and August, 1951. Quantitative data had never been obtained in this area and the amount of such data on plant communities in Alaska is very limited, therefore no attempt was made to establish successional trends or to devise a classification system similar to those in use in Scandinavian and other European countries.

On the basis of phytosociologic analysis of association tables and indices, the stands are grouped into 5 types, 1 of which is divided into 4 subtypes and another into 2 subtypes. Selected stands of each type and subtype are discussed in detail, association tables of some of these stands and of each subtype and type are included and each subtype and type is discussed as such.

PROCEDURES AND METHODS

Field procedures

The field work was performed during July and August, 1951. Herbarium specimens were collected and those of vascular plants have been deposited in the Langlois Herbarium of The Catholic University of America.

The stand was used as the unit of study. The tundra vegetation of the Umiat area displays in many cases variation within a few feet or inches, probably as a result of the variation in environmental conditions accompanying a few inches difference in microrelief and resulting in a micromosaic of microstands. Each stand has a homogeneity of micromosaics that is distinctive over a given area and is dissimilar to the distinctive homogeneities of adjacent areas. The stands are numbered in the order of analysis in the field.

The selection of stands for analysis was based on the study of all available aerial photographs of the area and on ground reconnaissance, that is, by homogeneity of appearance of each stand both on aerial photographs and on the ground. Analysis was also made of stands which were perceptibly different on aerial photographs yet appeared similar on the ground, and those which were nearly identical on aerial photographs yet dissimilar on the ground. Frequently adjacent communities,

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especially of the upland, were very similar and the zones of transition from one to another were so gradual and over a sufficiently great distance that detection by only ground reconnaissance would have been very difficult and time consuming. With respect to similarity and zones of transition the communities resembled the continuum described by Curtis and McIntosh (1951). In several cases, significant differences between adjacent communities were readily detected on aerial photographs although the differences were not readily detected by ground reconnaissance. At times, only after comparison of detailed sample analysis data were the differences detected; post-sampling ground reconnaissance confirmed the differences.

The vegetation of each stand was analyzed on 10 one-meter square quadrats which were systematically located as uniformly and widely as possible but restricted so that transitional areas into adjacent stands were avoided. The cover of each species of vascular plants, grouped mosses, grouped lichens, and area of bare ground was estimated by a modified Hult-Sernander scale (Nordhagen 1943, Hanson 1953), as follows:

Cover class	Cover
1	to 1/16
2	1/16 to 1/8
3	1/8 to 1/4
4	1/4 to 1/2
5	1/2 to 3/4
6	3/4 to 4/4

The Hult-Sermander and similar cover scales have been used extensively in Scandinavia and other parts of Europe (Braun-Blanquet 1932, Dahl 1953a). Objections have been made to cover class 5 of the Hult-Sernander scale, which is from 1/2 to 4/4 of the area, as being too large. For that reason the cover class 5 was divided into classes 5 and 6 in the modified scale. Analysis by the modified Hult-Sernander scale was adequate to sample the cover and the homogeneity of micromosaics within each stand and was particularly appropriate for both phytosociological analysis and aerial photographic interpretation purposes.

A cover-frequency reconnaissance method was tried on an experimental basis at the close of the field season. In the reconnaissance method, the cover is estimated directly for the whole stand and the frequency of each species is estimated on a scale of 10 classes so that such estimates can be compared directly with detailed analysis date of other stands. The reconnaissance method, if further developed, should have considerable merit because it yields comparable data to that obtained by detailed cover analyses on 10 one-meter square quadrats. The reconnaissance method can be readily checked for accuracy by making detailed analysis on 10 one-meter square quadrats within the stand in question.

A soil profile of each stand was described by layers without naming or identifying the horizons since so few profiles had been previously described and analyzed in the arctic. Little is known concerning the morphology and there has been little development of nomenclature of tundra soils. A special terminology may be needed for tundra soils (Nikiforoff 1951).

Analysis of data

The floristic-characteristic-species-combination (Raabe 1950) consists of those species of a community with the highest frequency, the number of such species being equal to the average number of species per sample area, per square meter in this investigation. Determination of this floristic-characteristic-species-combination for each stand and a preliminary grouping of stands on the basis of this combination were of assistance in the preliminary analysis of data. The Central European ecologists have found that the kind and number of species which make up this combination are distinctive and that this combination characterizes the community (Raabe 1950). Additional data on the communities of the Umiat area would be required to determine whether the floristic-characteristic-species-combination could be one criterion for a classification of the communities.

There are numerous coefficients which can be computed to determine the degree of relationship between two communities. The coefficient of affinity, based on the average difference of frequency in common of all species in the two stands being compared (Sörenson 1948) was also computed. According to Dahl (1953b), the Sörenson coefficient is more sensitive and analysis of the Umiat data tended to confirm this.

Raabe (1952) described a homogeneity value which is the average frequency value of the floristic - characteristic - species - combination; the higher this value, the more homogeneous the community. This homogeneity-index is given for each stand in each type and subtype association table. Dahl (1953a) described a homogeneity test which is readily computed in the field. If the number of all species with a frequency of 81 to 100%, class V, is greater than the number of species with a frequency of 61 to 80%, class IV, then the community is considered to be homogeneous. At times even though this test is nega-

tive for homogeneity it may be desirable to use the analysis of the stand; for example, in aerial photographic interpretation. This frequency-homogeneity test is also given for each stand in the type and subtype association tables. Either or both homogeneity tests aid in the analysis of data and are of value as indices for the analysis of homogeneity of registration of stands on aerial photographs.

While these procedures were useful in analyzing data and grouping stands, final analysis and grouping were dependent primarily upon thorough study of the association tables.

Environmental Data

Geology

The Umiat area is within the Northern Foothills section of the Arctic Foothills province on the slope north of the Brooks Range. Due to relatively simple structure there is a great regularity of topography, with ridges, mesas, and hills that are of very similar altitude (Payne, *et al.* 1951). The general topography of the upland is gently rolling hills and moderately flat valleys (Smith and Mertie 1930). Polygonal ground occurs on poorly drained areas (Black and Barksdale 1948).

The Umiat area was divided by Black and Barksdale (1948) into the bedrock hills or upland and the floodplain of the Colville River; the latter was divided into the high terrace and the low terrace. The high terrace is from 6 to 8 feet above the low terrace and is characterized by poor drainage, numerous lakes and ponds and well-developed polygonal ground. The low terrace is generally less than 10 feet above the Colville River and is characterized by the presence of abandoned channels, oxbow lakes, and poorly developed polygonal ground. Black and Barksdale stated that: "The floodplain deposits of the Colville River in the Umiat area consist of lenticular bars of silt, sand and gravel formed along active channels, and muck and silt deposits in abandoned drainage channels." They also pointed out that the low terrace is subject to flooding during the spring break up.

The upland plant communities studied were located on the Umiat anticline which has predominantly low dips on both flanks and is modified near its axis by a monoclinal flexure approximately parallel to the crest of the anticline (Stefansson and Whittington 1947). The rocks in this area are of Upper Cretaceous age. The description of the upper 1,100 feet of the formations of this anticline by Stefansson and Whittington covers the area of study. The sequence consists predominantly of silt shale and clay shale with numerous interbeds of sandstones, some of which are highly calcareous. There are some interbeds of pyroclastics (bentonite and tuff) present.

Climate

The climate of the Umiat area is rigorous. The average annual temperature is 10.7°F; the lowest recorded temperature was —63° during February, the highest 85° during July, and the mean monthly temperature is below 0° for the period December through April. The averages are for the period April 1, 1945, through October 31, 1952, 7 years for November through March and 8 years for April through October (U. S. Weather Bureau 1952a, 1952b).

The average monthly temperature has been above 32.0° only during the period June through September. The data concerning the mean number of days per month when the maximum temperature has been equal to or greater than 70° and equal to or less than 32°, and the mean number of days when the minimum temperature has been equal to or less than 32°, have greater significance than the averages. These data on means indicate that in April only 2 days can be expected with a maximum temperature above 32° and in May, 10 days. Freezing temperatures occurred each day in May. During the period June through August, the maximum temperature was not below 32° but freezing temperatures have been recorded on an average of 14 days during June, 2 during July, and 8 during August. During September, the average number of days with a maximum temperature above 32° was 22, minimum temperatures of 32° or less occurred on 24 days, and 0° or less on 1 day, and during October the average number of days with a maximum temperature above 32° was 3. Since a freeze-free season cannot be expected, the species of plants which occur in the area must have a high tolerance to cold. It may be assumed that vegetative growth on the average could begin in May and continue through part of August, possibly extending into September to a very small degree.

Long-enduring subfreezing temperatures of great intensity during most of the year and relatively low average summer temperatures account for the frozen ground at depths of 6 to 18 inches even at the time of maximum ground thaw. On gravelly and sandy soils, frozen ground is encountered at greater depths. The temperature gradients in mineral soil from the surface to the frozen soil are very steep and even though sufficient moisture is present for plants, the absorption

rate, except in the uppermost portion, must be low. The presence of frost scars and polygonal ground is visual evidence associated with the intensity and frequency of freezing.

Regardless of the low annual precipitation, 5.79 inches, the climate is not arid with respect to plants since the temperatures and evaporation rate are low and relative humidity is high. The dense cover of vegetation, accumulation of organic matter, and microrelief tend to favor absorption and to retard runoff.

Little is known concerning the nature of snow cover during the winter. However, examination of a sortie of winter aerial photographs revealed a complete snow cover and examination of a sortie of early summer photography revealed some snow banks not yet melted, indicating drifting snow as a result of wind action during the winter. The degree of exposure to prevailing winds during the winter would thus determine the variable depth of snow and accompanying insulation effect on the various sites.

It was noted that the upper 6 to 9 inches of terminal portions of willows which had reached about 3 feet in height on the upland had been killed, probably as a result of either wind desiccation or the abrasive effect of wind-blown snow during the winter.

The direction and degree of slope are undoubtedly of great importance on the effect of exposure to winds during the winter, the accumulation of snow, the rate of snow melt due to the incidence of solar radiation, the rate of surface runoff, and the amount of solar radiation received and available for ground thaw and for growth of plants during the summer.

Discussion of Communities

On the basis of floristic composition the stands are classified into 5 major groups as follows:

I. Dwarf Shrub Heath Type
II. Frost-Scar Collective Type
III. Salix Type
IV. *Alnus crispa* Type
V. *Carex aquatilis*—Marsh Type

Summary association tables are included for each type or subtype.

I. Dwarf shrub heath type

The dwarf shrub heath type is classified into subgroups according to differences in the frequency, cover, and in some cases the occurrence of certain species. In the first subtype (Table I), *Eriophorum spissum* is of outstanding importance; however, it is replaced by *Eriophorum vaginatum* in Stand 27. The nearly equal frequency of *Eriophorum spissum, Carex lugens,* and *Arctagrostis latifolia* in the second subtype is an important characteristic. The third subtype has as a prominent characteristic the presence of *Carex* spp. The relatively high frequency of *Arctagrostis latifolia* is the outstanding characteristic of the fourth subtype.

1. *Eriophorum Tussock-Dwarf Shrub Heath Subtype.*—Twenty-two stands are grouped in this subtype (Table I) on the basis of high or moderately high frequency of *Eriophorum* spp. and dwarf shrub heath species and associates, especially *Betula nana* ssp. *exilis, Empetrum nigrum, Ledum decumbens* and *Vaccinium vitis-idaea.* In the first 18, *Carex lugens* is associated with *Eriophorum spissum* and with *E. vaginatum* in Stand 27. The last 3 stands form a subgroup because of the replacement of *Carex lugens* by *C. consimilis* but with respect to *Eriophorum spissum* and dwarf shrub heath species they belong to this subtype. The Eriphorum Tussock-Dwarf Shrub Heath Subtype has a widespread distribution on the upland, slopes and floodplain. Representative stands are selected for detailed discussion.

Stand 20. *Alnus crispa-Eriophorum spissum*-dwarf shrub heath

This stand, located on the upland 1.5 miles north of Umiat, had a south exposure and was on a slope of 10°. Lateral microrelief, essentially on the contour, had a maximum of 14 inches and an average of 6 inches, while the microrelief of the slope had a maximum of 18 inches and an average of 10 inches. The microrelief resulted from the presence of mounds up to 4 feet in diameter which had abrupt down-slope faces and more rounded up-slope faces, the whole having the appearance of dissected small contour terraces. The presence, arrangement, and shape of the mounds were indicative of soil movement. Surface drainage was well-developed, the microchannels being from narrow with high gradient to broad with low gradient. The site was generally dry. Vegetation characteristics (Table I) of this stand are the high frequency of *Alnus crispa, Eriophorum spissum,* 5 dwarf shrub species, mosses and lichens.

Stand 70. *Salix pulchra-Eriophorum spissum-Carex lugens*-dwarf shrub heath

This stand, 0.8 mile northwest of Umiat, was located on the flood-plain, near the edge of the low terrace, adjacent to a meander scar. The site was level, exposed to winds from all directions and no development of surface drainage was apparent. The area was dry because of the gravel and sand constituents of the terrace. There was

TABLE I. *Frequency and cover of species in the Eriophorum Tussock-Dwarf Shrub Heath Subtype. Cover is given as an exponent of frequency*

Species	Stand 70	Stand 28	Stand 2	Stand 63	Stand 15	Stand 73	Stand 54	Stand 12	Stand 59	Stand 58	Stand 41	Stand 20	Stand 53	Stand 74	Stand 10	Stand 62	Stand 65	Stand 69	Stand 27	Stand 50	Stand 3	Stand 29
Eriophorum spissum Fern.	100^{2-}	100^{1+}	100^{1+}	100^{3-}	100^{1}	100^{2}	100^{1+}	100^{1+}	100^{1+}	100^{1+}	90^{1+}	90^{1}	100^{2}	70^{1}	100^{1+}	100^{4-}	100^{3+}	40^{1}	.....	100^{1+}	100^{1+}	100^{1}
Eriophorum vaginatum L.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	70^{1}	.....	.....	.....
Eriophorum angustifolium Roth.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....
Carex lugens Holm.	100^{2-}	90^{1}	70^{1}	70^{1+}	90^{1}	80^{1}	30^{1}	20^{1}	40^{1}	100^{1}	30^{1}	10^{1}	100^{1}	100^{2-}	100^{1}	20^{1}	+	50^{1}	100^{1}	+	.....	.....
Carex capillaris L.	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	.....	.....	.....	+	.....	.....	.....	.....	.....	.....	.....	.....
Carex consimilis Holm.	.....	.....	.....	.....	.....	.....	.....	.....	+	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	80^{1}	60^{1}	20^{1}
Carex rariflora (Wahl.) J. F. Smith	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	.....	.....	.....	.....	.....	.....	.....	.....
Carex aquatilis Wahl.	+	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Luzula confusa Lindeb.	.....	10^{1}	.....	.....	.....	40^{1}	+	.....	.....	30^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....	10^{1}	.....	.....
Luzula nivalis (Laest.) Beurl.	.....	.....	.....	10^{1}	.....	.....	.....	40^{1}	30^{1}	.....	10^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Juncus albescens (Lge.) Fern.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10^{1}	.....	.....
Juncus castaneus J. E. Smith	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10^{1}	.....	.....
Arctagrostis latifolia (R. Br.) Grieseb.	10^{1}	10^{1}	.....	.....	10^{1}	40^{1}	+	20^{1}	20^{1}	20^{1}	.....	10^{1}	+	.....	.....	.....	.....	10^{1}	20^{1}	10^{1}	10^{1}	10^{1}
Hierochloe alpina (Sw.) Roem. & Schult.	+	.....	.....	.....	.....	.....	.....	.....	40^{1}	.....	40^{1}	10^{1}	.....	.....	.....	.....	.....	.....	.....	20^{1}	.....	.....
Poa arctica R. Br.	20^{1}	.....	.....	.....	.....	10^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10^{1}	.....	.....
Ledum decumbens (Ait.) Lodd.	100^{1+}	100^{1}	100^{1}	100^{2-}	100^{1}	100^{1+}	100^{1}	100^{1}	100^{1+}	90^{1}	90^{1}	100^{1}	60^{1}	90^{1}	100^{1}	100^{1+}	100^{2+}	100^{2-}	100^{1+}	100^{1}	100^{1}	100^{2-}
Vaccinium vitis-idaea L.	100^{2-}	100^{1}	100^{1}	100^{2-}	100^{1}	100^{2-}	100^{1}	100^{1}	90^{1}	90^{1}	100^{1}	100^{1}	70^{1}	80^{1}	90^{1}	100^{1}	100^{3+}	100^{3}	100^{1}	100^{1}	100^{1}	100^{1+}
Vaccinium uliginosum L.	100^{2-}	20^{1}	50^{1}	30^{1}	40^{1}	.....	30^{1}	.....	20^{1}	40^{1}	80^{1+}	100^{1}	100^{1}	10^{1}	20^{1}	.....	.....	.....	40^{1}	50^{1}	100^{1}	.....
Betula nana L. ssp. *exilis* (Sukatch.) Hult.	100^{1+}	100^{1}	90^{1}	90^{1+}	90^{1}	100^{1}	100^{1}	100^{1}	100^{1}	100^{1}	100^{1+}	90^{1+}	60^{1+}	70^{1}	100^{1}	20^{1}	100^{1+}	90^{1}	100^{1}	100^{1}	100^{1}	100^{1}
Arctostaphylos alpina (L.) Spreng.	10^{1}	80^{1}	.....	60^{1}	80^{1}	80^{1}	10^{1}	.....	20^{1}	10^{1}	50^{1}	100^{1}	70^{1}	.....	30^{1}	10^{1}	10^{1}	.....	70^{1}	80^{1}	.....	80^{1}
Cassiope tetragona (L.) D. Don.	.....	40^{1}	90^{1}	10^{1}	90^{1}	90^{1}	50^{1}	100^{1}	80^{1}	90^{1}	50^{1}	70^{1}	100^{1}	.....	100^{1}	+	.....	.....	.....	60^{1}	100^{1}	.....
Empetrum nigrum L.	100^{2-}	100^{1}	90^{1}	90^{1}	70^{1}	80^{1}	100^{1}	70^{1}	70^{1}	70^{1}	100^{1}	90^{1}	40^{1}	100^{1}	.....	+	50^{1}	30^{1+}	70^{1}	90^{1}	90^{1}	90^{1}
Rubus chamaemorus L.	50^{1}	70^{1}	.....	.....	.....	70^{1}	.....	+	.....	.....	.....	10^{1}	.....	60^{1+}	20^{1}	90^{1}	90^{1+}	100^{3-}	10^{1}	+	.....	.....
Andromeda polifolia L.	.....	40^{1}	.....	.....	.....	.....	.....	.....	.....	.....	40^{1}	.....	.....	100^{1}	40^{1}	10^{1}	.....	.....	10^{1}	.....	20^{1}	.....
Alnus crispa (Air.) Pursh.	10^{1}	30^{1}	10^{1}	.....	.....	.....	.....	.....	.....	+	40^{1}	80^{1+}	.....	.....	.....	.....	.....	.....	50^{1+}	.....	80^{1+}	30^{1}
Salix glauca L.	.....	.....	.....	.....	10^{1}	.....	.....	.....	.....	+	.....	.....	+	.....	.....	.....	.....	.....	.....	+	.....	.....
Salix pulchra Cham.	100^{1+}	50^{1}	.....	.....	.....	10^{1}	80^{1}	90^{1}	60^{1}	90^{1}	.....	.....	.....	20^{1}	.....	.....	.....	.....	30^{1}	50^{1}	.....	.....
Salix phlebophylla Anderss.	.....	.....	.....	.....	.....	.....	.....	.....	30^{1}	.....	10^{1}	.....	.....	.....	.....	.....	.....	.....	.....	60^{1}	.....	.....
Salix niphoclada Rydb.	.....	.....	.....	.....	.....	.....	.....	.....	.....	70^{1}	.....	.....	30^{1}	.....	.....	.....	.....	.....	+	.....	.....	.....
Salix brachycarpa Nutt. var. Mexiae Ball.	20^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salix pulchra Cham. var. *Palmeri* Ball.	.....	.....	80^{1}	.....	100^{1}	.....	.....	.....	.....	.....	.....	.....	70^{1}	.....	90^{1}	.....	.....	.....	+	.....	30^{1}	.....
Salix reticulata L.	.....	.....	.....	.....	.....	.....	.....	.....	.....	30^{1}	.....	.....	60^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salix desertorum Rich.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salix pulchra Cham. var. *yukonensis* Schn.	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	50^{1}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10^{1}
Salix glauca L. var. *glabrescens* (Anderss.) Schn.	.....	.....	30^{2}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE I—*Continued*

Species	Stand 70	Stand 28	Stand 2	Stand 63	Stand 15	Stand 73	Stand 54	Stand 12	Stand 59	Stand 58	Stand 41	Stand 20	Stand 53	Stand 74	Stand 10	Stand 62	Stand 65	Stand 69	Stand 27	Stand 50	Stand 3	Stand 29
Salix fuscescens Anderss. var. *reducta* Ball.														70^{1}								
Salix rotundifolia Trautv.							20^{1}															
Spirea beauverdiana Schneid.											+											
Polygonum bistorta L. ssp. *plumosum* (Small.) Hult.		20^{1}	80^{1}	30^{1}	100^{1}	30^{1}	20^{1}	40^{1}	80^{1}	60^{1}	70^{1}	80^{1}	30^{1}						40^{1}	40^{1}	40^{1}	30^{1}
Pyrola grandiflora Radius.	20^{1}		10^{1}							80^{1}			30^{1}		10^{1}							
Stellaria Laxmannii Fisch.							+		+	10^{1}									20^{1}	10^{1}		
Pedasites frigidus (L.) Fries.	30^{1}				20^{1}	40^{1}		60^{1}					10^{1}		20^{1}				10^{1}			
Pedicularis capitata Adams.	40^{1}	30^{1}	10^{1}		10^{1}								20^{1}		50^{1}				10^{1}	50^{1}	10^{1}	
Pedicularis labradorica Panzer.						30^{1}		30^{1}				10^{1}										
Pedicularis lanata Willd.				20^{1}			40^{1}	40^{1}	10^{1}	50^{1}	50^{1}					20^{1}						
Saussurea angustifolia (Willd.) D. C.	10^{1}				10^{1}			50^{1}		10^{1}			20^{1}									
Lupinus arcticus Wats.									10^{1}											10^{1}		
Senecio frigidus (Richards.) Hook.		10^{1}			+				+	20^{1}			+						10^{1}	+		
Antennaria isolepis Greene							+													+		
Saxifraga punctata L. ssp. *Nelsoniana* (D. Don.) Hult.			20^{1}		20^{1}	40^{1}	+	20^{1}	10^{1}	30^{1}										+		
Arnica lessingii Greene							40^{1}		+	10^{1}												
Rumex acetosa L. ssp. *alpestris* (Scop.) Love.							10^{1}															
Pedicularis sudetica Willd.														20^{1}								
Lycopodium selago L. var. *appressum* Desv.																20^{1}						
Equisetum arvense L. var. *boreale* (Bong.) Ledeb. f. *pseudo-varium* Viet.										+												
Mosses	$100^{5}+$	$100^{5}-$	$100^{4}+$	$100^{4}+$	$100^{2}+$	$100^{5}+$	$100^{3}+$	100^{3}	$100^{6}-$	100^{5}	$100^{3}+$	$100^{2}+$	$100^{4}+$	$100^{6}-$	$100^{3}-$	$100^{5}+$	100^{5}	$100^{6}-$	$100^{3}+$	$100^{5}+$	$100^{3}-$	$100^{3}+$
Lichens	$100^{3}-$	$100^{2}-$	$100^{1}+$	$100^{3}-$	100^{2}	$100^{4}+$	$100^{1}+$	$100^{1}+$	$100^{2}+$	$100^{2}-$	$100^{2}-$	$100^{3}-$	$100^{1}+$	100^{1}	100^{1}	$100^{3}+$	$100^{3}-$	$100^{2}+$	$100^{2}-$	$100^{2}+$	100^{1}	$100^{3}+$
Bare ground								$70^{1}+$	10^{1}	10^{1}	$50^{1}+$											
Total vascular species in quadrats	18	18	15	13	16	17	15	17	18	23	16	16	19	13	14	9	7	8	18	21	14	11
Average number vascular species per quadrat	10	10	10	7	11	10	8	10	9	12	10	10	10	9	10	5	6	5	9	11	99	7
Homogeneity-index	89.0	83.0	85.0	87.1	87.3	84.0	83.8	81.0	80.0	82.5	78.0	90.0	79.0	83.3	85.6	82.0	90.0	88.0	77.8	79.1	92.2	85.7
Frequency-homogeneity test	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V<IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV

TABLE II. *Frequency and cover of species in the* Eriophorum spissum-Carex lugens-Arctagrostis latifolia-*Dwarf Shrub Heath Subtype, Carex-Dwarf Shrub Heath Subtype, and Grass-Dwarf Shrub Heath Subtype*

Species	*Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtype			Carex-Dwarf Shrub Heath Subtype										Grass-Dwarf Shrub Heath Subtype			
	Stand 21	Stand 24	Stand 8	Stand 23	Stand 26	Stand 25	Stand 71	Stand 51	Stand 13	Stand 49	Stand 57	Stand 52	Stand 56	Stand 60	Stand 48	Stand 32	Stand 43	Stand 40
Eriophorum spissum Fern.	7^{0}	5^{0}	5^{0}	1^{0}	1^{0}		1^{0}	1^{0}	3^{0}				1^{0}					
Carex lugens Holm	6^{0}	5^{0}	8^{0}	10^{0}	10^{0}	10^{0}	8^{0}	8^{0}	8^{0}	7^{0}	4^{0}		+					2^{0}
Carex capillaris L.				3^{0}					2^{0}	+	+	+						+
Carex vaginata Tausch.								+				+	5^{0}					+
Carex consimilis Holm														8^{0}				
Carex scirpoidea Michx.												9^{0}						
Carex membranacea Hook.													4^{0}					
Carex obtusata Lilj.				+														
Luzula confusa Lindeb.	+	2^{0}	3^{0}				1^{0}	1^{0}		7^{0}	4^{0}				5^{0}			1^{0}
Luzula nivalis (Laest.) Beurl.											2^{0}	+	+	5^{0}				
Arctagrostis latifolia (R. Br.) Grieseb.	7^{0}	9^{0}	5^{0}	8^{0}	6^{0}	8^{0}	6^{0}	6^{0}	4^{0}	5^{0}	2^{0}	+	2^{0}		10^{0}	10^{0}	8^{0}	6^{0}
Hierochloe plaina (Sw.) Roem. & Schult.	3^{0}	+	5^{0}			1^{0}	2^{0}		4^{0}	4^{0}	+	2^{0}			3^{0}	4^{0}	+	+
Poa arctica R. Br.			+	1^{0}			6^{0}	2^{0}		6^{0}	3^{0}		1^{0}					
Ledum decumbens (Ait.) Lodd.	$10^{0}+$	10^{0}	$9^{0}+$	3^{0}	$10^{0}+$	$10^{0}+$	$10^{2}+$	8^{0}	9^{0}	5^{0}	5^{0}	8^{0}	6^{0}	$9^{0}+$	8^{0}	9^{0}	$10^{0}+$	$8^{0}+$
Vaccinium vitis-idaea L.	10^{0}	10^{0}	$9^{0}+$	1^{0}	9^{0}	9^{0}	$10^{2}+$	10^{0}	$9^{0}+$	7^{0}	8^{0}	2^{0}	7^{0}	10^{0}	10^{0}	$9^{0}+$	$10^{0}+$	$8^{0}+$
Vaccinium uliginosum L.	9^{0}	3^{0}	1^{0}	7^{0}	7^{0}	6^{0}	+	10^{0}	4^{0}	3^{0}	9^{0}	$10^{3}-$	10^{0}	$6^{0}+$	2^{0}			7^{0}
Betula nana L. ssp. *exilis* (Sukatch.) Hult.	$8^{0}+$	$7^{0}+$	1^{0}	$7^{0}+$	10^{2}	$10^{0}+$	$10^{2}-$	10^{0}	$4^{0}+$	3^{0}	9^{0}	$8^{0}+$	$10^{0}+$		10^{0}	$10^{2}-$	$10^{3}-$	10^{3}
Arctostaphylos alpina (L.) Spreng.	9^{0}	10^{0}		$10^{0}+$		5^{0}	3^{0}	4^{0}	1^{0}	$5^{0}+$	6^{0}	2^{0}	5^{0}	$10^{0}+$	$7^{0}+$	2^{0}	1^{0}	$4^{0}+$
Cassiope tetragona (L.) D. Don.			4^{0}	6^{0}	1^{0}	2^{0}		$10^{0}+$	3^{0}	$10^{0}+$	$10^{0}+$	7^{0}	$10^{0}+$	6^{0}			2^{0}	1^{0}
Empetrum nigrum L.	6^{0}	$10^{0}+$	$8^{0}+$	4^{0}	6^{0}	$5^{0}+$	$9^{0}+$	9^{0}	$10^{0}+$	1^{0}	4^{0}	$10^{0}+$	2^{0}	$10^{0}+$				
Rubus chamaemorus L.	2^{0}													1^{0}		4^{0}		1^{0}
Dryas integrifolia Vahl. (var. *canescens*? Sim.)				$5^{0}+$						6^{0}	7^{0}	2^{0}	4^{0}					+
Rhododendron lapponicum (L.) Wahl.				2^{0}						1^{0}								1^{0}
Andromeda polifolia L.														3^{0}				
Alnus crispa (Air.) Pursh.	$6^{0}+$			+	$7^{0}+$	$6^{0}+$		+				$5^{0}+$	$7^{0}+$				$8^{0}+$	6^{2}
Salix glauca L.			$8^{2}-$	7^{0}			+			4^{0}	+					5^{0}	$5^{0}+$	9^{2}
Salix pulchra Cham.		3^{0}			2^{0}	2^{0}	$7^{0}+$		1^{0}				+		1^{0}	5^{0}	1^{0}	
Salix phlebophylla Anderss.		+								$10^{0}+$	3^{0}				2^{0}			
Salix niphoclada Rydb.					$3^{0}+$				$7^{2}+$		+		8^{0}		4^{0}		+	
Salix brachycarpa Nutt. var. *meriae* Ball.		+						$5^{0}+$			9^{0}	6^{0}						
Salix pulchra Cham. var. *palmeri* Ball.			1^{0}				3^{0}											
Salix reticulata L.										4^{0}	1^{0}		1^{0}					
Salix arbusculoides Anderss.						+			$10^{0}+$								2^{0}	+
Salix desertorum Rich.						9^{0}												
Salix richardsonii Hook.									+				+					1^{0}
Salix glauca L. var. *acutifolia* (Hook.) Schn.					1^{0}													
Salix glauca L. var. *alaceae* Ball											+							
Spirea beauverdiana Schneid.															1^{0}	1^{0}		
Potentilla fruticosa L.																		3^{0}
Polygonum bistorta L. ssp. *plumosum* (Small.) Hult.	10^{0}	10^{0}	3^{0}	3^{0}	2^{0}	6^{0}		10^{0}	5^{0}	7^{0}	7^{0}	10^{0}	2^{0}	4^{0}	4^{0}	1^{0}	1^{0}	

TABLE II—*Continued*

Species	*Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtype			Carex-Dwarf Shrub Heath Subtype										Grass-Dwarf Shrub Heath Subtype			
	Stand 21	Stand 24	Stand 8	Stand 23	Stand 26	Stand 25	Stand 71	Stand 51	Stand 13	Stand 49	Stand 57	Stand 52	Stand 56	Stand 60	Stand 48	Stand 32	Stand 43	Stand 40
Pyrola grandiflora Radius			20^{1}	20^{1}	40^{1}	70^{1}	20^{1}		70^{1}		50^{1}	10^{1}	90^{1}					10^{1}
Stellaria laxmanni Fisch.	+	40^{1}					30^{1}				50^{1}	40^{1}	60^{1}			10^{1}	30^{1}	+
Petasites frigidus (L.) Fries		10^{1}	40^{1}		10^{1}		50^{1}	70^{1}	10^{1}			10^{1}					10^{1}	
Pedicularis capitata Adams		+						+		90^{1}	60^{1}		40^{1}			10^{1}		
Pedicularis labradorica Panzer	10^{1}								10^{1}						10^{1}			
Pedicularis lanata Willd.			10^{1}				40^{1}											
Saussurea angustifolia (Willd.) D. C.		+		60^{1}	+	20^{1}	60^{1}	40^{1}	60^{1}	60^{1}	90^{1}	30^{1}	100^{1}					
Lupinus arcticus Wats.		30^{1}		70^{1}			10^{1}			70^{1}	80^{1}		60^{1}					
Senecio frigidus (Richards.) Hook.		10^{1}		20^{1}	+	10^{1}		+			10^{1}		10^{1}					
Antennaria isolepis Greene			10^{1}						30^{1}	20^{1}								
Saxifraga punctata L. spp. *nelsoniana* (D. Don.) Hult.				40^{1}		20^{1}		10^{1}		60^{1}	50^{1}		10^{1}					
Arnica lessingii Greene								+			20^{1}							
Pyrola secunda L. var. *obtusata* Turex.								40^{1}										20^{1}
Rumex acetosa L. spp. *alpestris* (Scop.) Love										+								
Polemonium acutiflorum Willd.				10^{1}	10^{1}	20^{1}			+									
Stellaria longipes Goldie											50^{1}							
Parrya nudicaulis (L.) Regel. spp. *interior* Hult.											+	+						
Cardamine richardsonii Hult.				+				+										
Anemone richardsonii Hook.									+									
Parnassia kotzebuei C. & S.																		10^{1}
Lycopodium selago L. var. *appressum* Desv.									10^{1}									
Equisetum arvense L. var. *boreale* (Bong.) Ledeb.				60^{1}	30^{1}													20^{1}
Equisetum arvense L. var. *boreale* (Bong.) Ledeb. f. *pseudo-varium* Viet.								20^{1}	+									
Mosses	$100^{2}+$	$100^{2}+$	$100^{2}+$	$100^{3}-$	$100^{3}-$	100^{3}	$100^{6}-$	$100^{6}-$	$90^{2}-$	$100^{4}+$	100^{6}	$100^{4}-$	$100^{6}-$	$100^{4}+$	$100^{4}-$	$100^{3}-$	$100^{5}-$	$100^{3}-$
Lichens	$100^{3}+$	$100^{3}-$	100^{1}	100^{1}	$100^{1}+$	$100^{2}-$	$100^{2}+$	$100^{3}-$	$80^{1}+$	$100^{2}+$	$100^{2}+$	$100^{1}+$	$100^{1}+$	$100^{5}+$	$100^{2}+$	$100^{1}+$	$100^{2}+$	100^{2}
Bare ground			10^{1}	20^{1}					10^{1}									10^{1}
Total vascular species in quadrats	14	17	18	25	19	20	19	21	21	24	25	17	24	11	15	14	14	19
Average number vascular species per quadrat	9	9	8	11	9	11	10	12	9	13	13	9	10	7	8	7	7	7
Homogeneity-index	84.4	84.4	71.3	71.8	76.7	79.1	77.0	81.7	78.9	71.5	75.4	81.1	78.3	84.3	78.8	74.3	80.0	67.1
Frequency-homogeneity test	V>IV	V>IV	V<IV	V<IV	V>IV	V>IV	V>IV	V>IV	V>IV	V<IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V>IV	V<IV

FIG. 1. Stand 20, *Alnus crispa-Eriophorum spissum*—dwarf shrub heath.

no evidence of soil movement or freezing and thawing disturbance. The microrelief with an average of 9 inches, maximum 12 inches, resulted principally from the presence of *Eriophorum* tussocks. Distinctive characteristics of this stand are the high frequency of *Salix pulchra, Eriophorum spissum, Carex lugens,* 5 dwarf shrub species, mosses and lichens.

Stand 62. *Eriophorum spissum*-dwarf shrub heath

This stand, 0.7 miles northwest of Umiat, was located on a gravel terrace of the floodplain. The site was medium moist, almost level and exposed to winds from all directions. The microrelief, average 4 inches and maximum 6 inches, resulted principally from the presence of *Eriophorum* tussocks. There was no evidence of soil movement or disturbance as a result of freezing and thawing. No surface drainage development was apparent. Outstanding characteristics of the vegetation are the high frequency of *Eriophorum spissum,* 3 dwarf shrub species, mosses and lichens.

In general, all the stands of this subtype have the significant species of the dwarf shrub heath complex present with high frequency: *Betula nana* ssp. *exilis, Empetrum nigrum, Ledum decumbens,* and *Vaccinium vitis-idaea.* The exceptions are Stand 53 where *Empetrum nigrum, Ledum decumbens* and *Vaccinium vitis-idaea* have medium frequency; Stand 10 where *Empetrum nigrum* is absent; Stand 62 where *Betula nana* ssp. *exilis* and *Empetrum nigrum* are merely present or of low frequency; and Stands 65 and 69 with medium frequency of *Empetrum nigrum.* Other dwarf shrub heath species and associates in the order of decreasing frequency in the stands are *Arctostaphylos alpina, Cassiope tetragona, Vaccinium uliginosum, Rubus chamaemorus, Andromeda polifolia* and *Dryas integrifolia* (var. *canescens*?). These are present in different combinations in the various stands. There is no apparent consistence of association in frequency or in presence of any 2 or more species within this group or with the previously mentioned group of dwarf shrub heath species.

Alnus crispa is present in only 8 of the 22 stands, having high frequency in only Stands 20 and 3. Of the willows, *Salix pulchra* is the most predominant, being present in 9, having a high frequency in 3, and moderately high frequency in 1. Two stands, 58 and 53, have 5 species of *Salix* present, both of which are the only stands with both *Salix niphoclada* and *S. reticulata.* Stands 62, 65 and 69 have neither *Alnus crispa* nor a species of *Salix* present.

In almost all stands, *Eriophorum spissum* has a frequency of 70 to 100% and low to moderately high cover with the exception of Stand 69 where the frequency is only 40% and Stand 27 where it is absent. In this last stand, however, *Eriophorum vaginatum* has a frequency of 70% and low cover. Both *Carex lugens* and *C. consimilis* are variable in frequency and usually the cover is low.

Arctagrostis latifolia is more generally present in the stands than the other species of grasses. All grasses usually have low frequency and only Stands 73 and 41 have a frequency rating as high as 40% and this for 1 species of grass.

Polygonum bistorta ssp. *plumosum* is the forb most prevalent in the stands. The frequency varies from low to high in 15 stands and it is absent in the other stands.

All stands are homogeneous by the frequency-homogeneity test with the exception of Stand 74 where the ratio of class V to class IV frequencies is 4 to 5. With this test, Stand 70 with a ratio of 8 to 0 has the greatest ratio because of the 100% frequency of *Eriophorum spissum, Betula nana* ssp. *exilis, Ledum decumbens, Vaccinium vitis-idaea, V. uliginosum, Empetrum nigrum, Salix pulchera* and *Carex lugens.* It is noteworthy that there is good agreement of the frequency-homogeneity test with the homogeneity-index. The homogeneity-index of 89.0 for this stand is one of the highest. It also has a relatively high total number of 18 vascular species in quadrats and a high average number of 10 vascular species per quadrat. Stand 3 with a homogeneity-index of 92.2 has the highest index and the frequency-homogeneity ratio of 7 to 1 is also one of the highest. This stand has a total number of 14 vascular species in the quadrats, less than Stand 70. However, the 2 stands have an average number of species per quadrat of 9 and 10 respectively.

Stand 74, mentioned above, is heterogeneous by the frequency-homogeneity test due to the class IV frequency of *Eriophorum spissum, Betula nana* spp. *exilis, Vaccinium vitis-idaea, V. oxycoccus* and *Salix fuscescens* var. *reducta* and the class V frequency of *Ledum decumbens, Empetrum nigrum, Andromeda polifolia* and *Carex lugens.* The total number of vascular species in quadrats is 13, relatively low, and the average number of vascular species per quadrat of 9 is relatively high. Although this stand is heterogeneous by the frequency-homogeneity test, it has a higher homogeneity-index than some other stands which are homogeneous by the frequency-homogeneity test. This is due to the particular characteristics of the 9 species with the highest frequencies, all with frequencies of 70% or more but 5 of these have frequencies in class IV. In several other stands with a comparable homogeneity-index and average number of vascular species per quadrat, a smaller number of species with highest frequencies are in class IV, instead more occur with frequencies of 60% or less.

2. *Eriophorum spissum-Carex lugens-Arctagrostis latifolia-Dwarf Shrub Heath Subtype.*— Three stands are included in this subtype on the basis of nearly equal frequency and cover of *Eriophorum spissum, Carex lugens* and *Arctagrostis latifolia,* high frequency of dwarf shrub heath and associated species, especially *Ledum decumbens* and *Vaccinium vitis-idaea,* and varying frequency of *Empetrum nigrum, Betula nana* ssp. *exilis* and *Vaccinium uliginosum.* This subtype has a limited occurrence and was found only on the upland.

Stand 21. *Alnus crispa-Eriophorum spissum-Arctagrostis latifolia-Carex lugens*-dwarf shrub heath

This stand, about 1.3 miles north of Umiat, was located midway up the south-facing slope which extended from the floodplain to the upland. The dry slope was approximately 8°. The site was protected from north winds. The lateral micro-relief averaged 8 inches and the maximum was 12 inches. The micro-relief on the slope was greater, it had an average of 10 inches and maximum of 20 inches. Slump holes and mounds with abrupt down-slope faces resulting from soil movement were numerous in occurrence. Surface drainage was well-developed, consisting of microchannels varying in form from cracks to channels, well rounded in cross section, and with a maximum width of 12 inches and an average of 7 inches. Stands resembling this stand occurred on similar sites of the slope. The characteristics of this stand (Table II) are the high frequency of *Eriophorum spissum, Arctagrostis latifolia, Carex lugens,* 4 dwarf shrub species, *Polygonum bistorta* ssp. *plumosum,* mosses and lichens.

FIG. 2. Stand 21, *Alnus crispa-Eriophorum spissum-Arctagrostis latifolia-Carex* lugens—dwarf shrub heath.

The frequencies of *Eriophorum spissum, Carex lugens,* and *Arctagrostis latifolia* are more similar in Stand 21 than in the other 2 stands. *Vaccinium vitis-idaea, Ledum decumbens, Empetrum nigrum,* and *Betula nana* spp. *exilis* are present with medium to high frequency with the exception of *Betula nana* spp. *exilis* which has low frequency in Stand 8.

Alnus crispa in Stand 21 with no species of *Salix* present, *Salix glauca* in Stand 8 with no *Alnus crispa,* and the lack of *A. crispa* and the low frequency of *Salix pulchra* and presence of 2 other *Salix* spp. in Stand 24 are outstanding characteristics of the respective stands.

Polygonum bistorta ssp. *plumosum* has high frequency in Stands 21 and 25 but low frequency in Stand 8. Stand 21 is very poor in forb species, only 3 are present. Stand 24 with a total of 8 has the largest number of forbs.

Although the mosses and lichens have high frequency, the cover is relatively low.

Stands 21 and 24 with 84.4 have the highest homogeneity-indices and by the frequency-homogeneity test both are homogeneous. Stand 24 has the higher frequency-homogeneity ratio, 6 to 1; Stand 21 has 5 to 3. In Stand 24, the 6 species in frequency class V, *Arctagrostis latifolia, Ledum decumbens, Vaccinium vitis-idaea, Empetrum nigrum, Arctostaphylos alpina* and *Polygonum bistorta* spp. *plumosum,* account for 8.5 times more cover than the 1 species, *Betula nana* ssp. *exilis,* in frequency class IV. In Stand 24, the total number of vascular species in quadrats is 17, the highest of the 3 stands, and the average number of vascular species per quadrat is 9, the same as in Stand 21.

Stand 8 is heterogeneous by the frequency-homogeneity test, the ratio being 2 to 3, and the homogeneity-index, 71.3, is the lowest of the 3 stands. The species in frequency class IV, *Salix glauca, Carex lugens* and *Empetrum nigrum,* have a cover approximately 2 times that of the species in frequency class V. The total number of vascular species in quadrats is 18, the highest of the 3 stands, and the average number of vascular species per quadrat is 8, the lowest of the 3 stands.

3. *Carex-Dwarf Shrub Heath Subtype.*—The results of the analysis of 11 stands are grouped in Table II on the basis of high or relatively high frequency of *Carex* spp.; the frequency of the *Carex* spp. of the respective stands being higher than that of any grass species, and the absence or low frequency of *Eriophorum* spp. Since *Carex lugens* in Stand 57, with a frequency of 40%, has a higher frequency than either *Arctagrostis latifolia* or *Poa arctica,* it is included in this subtype. In the first 8 stands, *Carex lugens* has the highest frequency but it is replaced by other species of Carex in the remaining stands. Dwarf shrub heath species and associates are present in varying combinations. The Carex-Dwarf Shrub Heath Subtype is more limited in occurrence than the Eriphorum Tussock-Dwarf Shrub Heath Subtype.

Stand 25. *Salix desertorum-Alnus crispa-Carex lugens*-dwarf shrub heath

The stand, 1.3 miles north of Umiat, was located on the upper portion of the south-facing slope which extended from the upland to the floodplain. The slope was approximately 12°. It had a limited amount of protection from north winds and the site was medium moist. The microrelief, average 16 inches and maximum 30 inches, resulted from the presence of mounds which were round or elongate, the latter form being parallel to the direction of the slope. The surface drainage was well-developed. The vegetation characteristics of the stand (Table II) are the high or moderately high frequency of *Carex lugens, Salix desertorum,* 3 dwarf shrub species, *Arctagrostis latifolia,* mosses and lichens.

Stand 71. *Salix pulchra-Carex lugens*-grass dwarf shrub heath

The stand, about 0.8 mile west-northwest of Umiat, was on a level portion of the low terrace. The site was medium moist. There was no apparent development of surface drainage and no evidence of soil movement. The microrelief, average 6 inches, maximum 12 inches, resulted from the presence of moss mounds which averaged 15 inches in diameter. The vegetation is characterized by the high frequency of 3 dwarf shrub species, mosses and lichens and the moderately high frequency of *Carex lugens, Empetrum nigrum* and *Salix pulchra.*

FIG. 3. Stand 25, *Salix desertorum-Alnus crispa-Carex lugens*—dwarf shrub heath.

Empetrum nigrum, Ledum decumbens, Vaccinium vitis-idaea and *V. uliginosum* are present in all of the stands analyzed in this subtype. *Betula nana* ssp. *exilis* is not present in Stand 60, *Arctostaphylos alpina* is not present in Stand 26 and *Cassiope tetragona* is not present in Stand 71. *Dryas integrifolia* (var. *canescens*?) is present in 5 stands, *Rhododendron lapponicum* in 2, *Rubus chamaemorus* in 1 and *Andromeda polifolia* in 1. Usually more than 3 of these species are present in each stand with high or moderately high frequency. Stand 49 has 9 of these 11 species present but only *Cassiope tetragona* and *Vaccinium vitis-idaea* are high in frequency.

A species of *Carex* is present in each of the stands and its frequency is higher than the frequency of any one species of grass. *Carex lugens* is present with high frequency in the first 7 stands and *C. capillaris* with low frequency is also present in 2 of these stands.

One or more species of grass are present in each stand with the exception of Stand 60. The frequency of *Arctagrostis latifolia* is usually equal to or higher than that of other species of grass. *Eriophorum spissum* is present in 6 stands, the frequency being low.

Alnus crispa is present in 4 stands with medium to moderately high frequency and occurs in 2 additional stands without cover rating. *Salix reticulata* is present in 3 stands with low to medium frequency and *S. phlebophylla* is present in 2 of these stands with higher frequency. Ten other species of *Salix* are present in 10 of the stands in various combinations and frequencies, at least one species being present with medium to high frequency. In Stand 60, there is neither *Alnus crispa* nor a species of *Salix* present.

A total of 20 forbs is found in these 11 stands, 2 species, *Polygonum bistorta* ssp. *plumosum* and *Saussurea angustifolia,* are present in 10 stands but only the first of these species is present in Stand 60. *Lupinus arcticus,* in this subtype, is present in 5 stands.

In Stand 13, the frequency of mosses is 90% and of lichens is 80%; the cover is low for both. In all other stands, the frequency of mosses and lichens is 100%; the cover of mosses is from medium to high and of lichens is generally low. However, the cover of lichens is medium in Stand 51 and moderately high in Stand 60.

The homogeneity-index of 81.7 for Stand 51 is next to the highest of the 11 stands, and the frequency-homogeneity test indicates homogeneity by a ratio of 6 to 3. This is especially significant since 21 vascular species are found in the 10 quadrats with an average of 12 per quadrat, and 9 of these have a frequency of 70% or greater. Five dwarf shrub heath species and associates, *Empetrum nigrum, Vaccinium vitis-idaea, Betula nana* ssp. *exilis, Vaccinium uliginosum, Cassiope tetragona,* and one forb, *Polygonum bistorta* ssp. *plumosum,* are in frequency class V. This group of species has a cover aproximately 2.5 times that of the group of species in frequency class IV. Stand 60 with 84.4 has the highest homogeneity-index and its frequency-homogeneity ratio of 4 to 1 is also the highest. It has about one-half the total number of vascular species and slightly more than one-half the average number per quadrat compared to Stand 51. Stand 60 also has the lowest total number of vascular species in quadrats and the lowest average number of species per quadrat of the 11 Carex-dwarf shrub heath stands, so it cannot be considered typical for the subtype.

The homogeneity-index of 71.5 in Stand 49 is the lowest in this subtype and the frequency-homogeneity ratio of 3 to 5 is 1 of the lowest, the test indicating it to be heterogeneous. Stand 23 has a homogeneity-index of 71.8 and a frequency-homogeneity ratio of 2 to 5, thus being the second of 2 heterogeneous stands. Stands 49 and 23 have a high total number of vascular species in the 10 quadrats, 24 and 25 respectively, and a high average number of vascular species per quadrat, 13 and 11 respectively. In Stand 49, the cover of the species in frequency class V is slightly greater than the cover of the species in class IV.

4. *Grass-Dwarf Shrub Heath Subtype.*—The most characteristic features of this subtype, in contrast to the preceding subtype, are the high to medium frequency of *Arctagrostis latifolia,* accompanied by the low frequency or absence of *Carex* spp., absence of *Eriophorum* spp., and presence of 5 or more dwarf shrub heath and associate species, 2 of which as a minimum have high frequency. Two of the 4 stands are discussed in detail.

Stand 48. *Arctagrostis latifolia*-dwarf shrub heath

This stand, 1.6. miles northwest of Umiat, was located on a north-northeast slope of 11°. Since the stand was just below the top of a ridge there was no protection from north-northeast winds and only slight protection from winds from other directions. The site was medium moist. Surface drainage was channeled into cracks with abrupt sides and broad microchannels 12 inches wide with gentle side slopes. Frost scars were infrequent. Soil movement was indicated by the frequent occurrence of mounds which had an average diameter of 2 feet. The microrelief, resulting principally from the presence of the mounds, averaged 10 inches with a maximum of 16 inches. The vegetation (Table II) is characterized by the high frequency of *Arctagrostis latifolia,* 5 dwarf shrub species, mosses and lichens.

FIG. 4. Stand 48, *Arctagrostis latifolia*—dwarf shrub heath.

Arctagrostis latifolia and *Hierochloe alpina* are the only grass species present in these Grass-Dwarf Shrub Heath Subtype stands. *Arctagrostis latifolia* is present with medium to high frequency and its frequency is always higher than that of *Hierochloe alpina.*

The dwarf shrub heath and associated species are well-represented, especially by *Vaccinium vitis-idaea, Ledum decumbens, Arctostaphylos alpina* and *Betula nana* ssp. *exilis.* The last species, however, has a frequency of only 10% in Stand 40. *Vaccinium uliginosum, Rubus chamaemorus, Cassiope tetragona, Rhododendron lapponicum,* and *Dryas integrifolia* (var. *canescens*?)

are present in varying combinations, usually with low to moderately low frequency.

Alnus crispa is present only in Stands 43 and 40 with moderately high and medium frequency respectively. *Salix glauca* is present in 3 stands with high to medium frequency; *S. pulchra* is present in 3 stands with low to medium frequency; 4 other species of *Salix* are present in various combinations from mere presence to medium frequency. Mosses and lichens have high frequency in all stands. The cover of mosses is from medium to moderately high and the cover of lichens is moderately low.

Carex spp. are present only in Stand 40, *Carex lugens* has a low frequency and *C. capillaris* and *C. vaginata* are present without cover rating. *Eriophorum spissum* occurs in Stand 48.

Eight species of forbs are present in varying combinations with low to medium frequency.

Two species, *Spirea beauverdiana* and *Potentilla fruticosa,* which are not abundant in this area, occur infrequently in this subtype, the former in 2 stands, the latter in only 1 stand.

Stand 32 has a frequency-homogeneity ratio of 4 to 0, resulting from the presence of *Betula nana* ssp. *exilis, Arctagrostis latifolia, Vaccinium vitis-idaea* and *Ledum decumbens.* These species with mosses dominate the stand. The frequency-homogeneity ratio of this stand is the highest in this subtype; of the 3 stands which are homogeneous by this test, Stand 32 has the lowest homogeneity-index.

Stand 40 is heterogeneous by a ratio of 1 to 3, with the frequency-homogeneity test and its homogeneity-index of 67.1 is the lowest. *Salix glauca* is the chief dominant with *Alnus crispa* next; these 2 species probably are factors in causing variation in the frequency and cover of the dwarf shrub heath and associated species. The ratio of the total number of vascular species in quadrats to the average number of vascular species per quadrat of 19 to 7 is the highest such ratio in this subtype and this may have contributed to the heterogeneity.

Discussion of the Dwarf Shrub Heath Type.— The Dwarf Shrub Heath Type has a very extensive distribution on the upland and less extensive distribution on the high terrace of the floodplain.

Dwarf shrub heaths and associated species characterize the type. The most important species are *Betula nana* ssp. *exilis, Ledum decumbens, Vaccinium vitis-idaea* and *Empetrum nigrum.* The last species tends to be more variable with respect to presence and frequency than the first 3. Other dwarf shrub heaths and associated species occur in varying combinations and with varying frequencies. The frequencies of mosses and lichens are consistently high.

If *Alnus crispa* and a species of *Salix* are both present in the same stand, there is a tendency for one to have a significantly greater frequency than the other. There are very few exceptions where *Alnus crispa* and a species of *Salix* occur in the same stand with approximately equally high frequency.

Polygonum bistorta ssp. *plumosum* has consistently higher frequency than any other forb.

The type is divided into 4 subtypes on the basis of the relative frequencies of *Eriophorum, Carex,* and grass species. In the Eriophorum Tussock-Dwarf Shrub Heath Subtype the frequency of *Eriophorum* spp., usually *E. spissum,* is generally greater than that of the *Carex* spp., usually *C. lugens,* and the frequency of the *Carex* in turn is greater than that of *Arctagrostis latifolia.* This subtype includes the largest number of dwarf shrub heath species and associates. *Betula nana* ssp. *exilis, Ledum decumbens, Vaccinium vitis-idaea* and *Empetrum nigrum* usually have high frequencies. Only 1 stand out of 22 is heterogeneous by the frequency-homogeneity test.

The *Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtype is characterized by equal or nearly equal frequencies of the 3 named species. Fewer species of dwarf heath and associates are present; only *Ledum decumbens* and *Vaccinium vitis-idaea* have consistently high frequencies; *Betula nana* ssp. *exilis* is variable. One of the 3 stands is heterogeneous.

In the Carex-Dwarf Shrub Heath Subtype, the *Carex* spp., usually *C. lugens,* has a higher frequency than *Arctagrostis latifolia* which has a higher frequency than *Eriophorum spissum,* if the latter is present. Fewer dwarf shrub heath and associated species are present than in the above mentioned subtypes. *Ledum decumbens, Vaccinium vitis-idaea* and *Betula nana* ssp. *exilis* have a greater tendency for high frequencies than in the *Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtype but less than in the Eriophorum Tussock-Dwarf Shrub Heath Subtype. Two of the 11 stands are heterogeneous.

The Grass-Dwarf Shrub Heath Subtype is characterized by a grass species, usually *Arctagrostis latifolia,* which has a higher frequency than the species of Carex and *Eriophorum spissum,* if either of the latter is present. *Betula nana* ssp. *exilis, Vaccinium vitis-idaea* and *Ledum decumbens* have consistently high frequencies; *Empetrum nigrum*

TABLE III. *Frequency and cover of species in the Frost-Scar Collective Type, Salix Type,* Alnus crispa *Type, and* Carex aquatilis-*Marsh Type*

Species	Frost-Scar Collective Type				Salix Type		*Alnus crispa* Type		*Carex aquatilis*-Marsh Type		
	Stand 4	Stand 5	Stand 16	Stand 22	Stand 11	Stand 42	Stand 36	Stand 78	Stand 55	Stand 64	Stand 67
Arctostaphylos alpina (L.) Spreng.	$4^{0}1$	$7^{0}1$	$8^{0}1$	$8^{0}1+$				$1^{0}1$			
Cassiope tetragona (L.) D. Don.	$1^{0}1$	$8^{0}1$	$6^{0}1$								
Empetrum nigrum L.			$10^{0}1$	$10^{0}1$	$1^{0}1$	$2^{0}1$		$1^{0}1$			
Vaccinium vitis-idaea L.			$8^{0}1$	$9^{0}1+$		$4^{0}1$	$1^{0}1$				
Betula nana L. ssp. *exilis* (Sukatch.) Hult.			$8^{0}1$	$7^{0}1$	$7^{0}1+$		$1^{0}1$			$1^{0}1$	$2^{0}1$
Ledum decumbens (Ait.) Lodd.			$8^{0}1$	$7^{0}1$		$4^{0}1$	$1^{0}1$	$1^{0}1$			
Vaccinium uliginosum L.			$8^{0}1$	$4^{0}1$	$2^{0}1$	$3^{0}1$	$2^{0}1+$	$5^{0}1$			
Dryas integrifolia Vahl. (var. *canescens*? Sim.)	$10^{0}2+$	$10^{0}2+$									
Rhododendron lapponicum (L.) Wahl.	$1^{0}1$	$1^{0}1$									
Rubus chamaemorus L.					$1^{0}1$	$9^{0}1+$					
Andromeda polifolia L.											$5^{0}1$
Alnus crispa (Air.) Pursh					$2^{0}2$		$10^{0}4+$	$10^{0}5+$			
Salix pulchra Cham.		$6^{0}1+$		$1^{0}1$		$10^{0}2+$	$8^{0}2$				
Salix phlebophylla Anderss.				$9^{0}1+$							
Salix glauca L. var. *glabrescens* (Anderss.) Schn.					$10^{0}3-$			$10^{0}3-$			
Salix glauca L.	$7^{0}1$						$1^{0}1$				
Salix brachycarpa Nutt. var. *mexiae* Ball.			$3^{0}1$								
Salix niphoclaea Rydb.				$3^{0}1+$							
Salix arbusculoides Anderss.						+		$5^{0}2+$			
Salix fuscescens Anderss. var. *reducta* Ball									+	+	$9^{0}1$
Salix desertorum Rich.						$2^{0}1$		$1^{0}1$			
Salix alazensis (Anderss.) Cov.					+						
Salix pulchra Cham. var. *palmeri* Ball.			+								
Caltha palustris L. var. *arctica* (R. Br.) Huth.								$2^{0}1$	$6^{0}1$	+	$10^{0}1+$
Eriophorum spissum Fern.				$1^{0}1$	$1^{0}1$	$2^{0}1$					
Eriophorum angustifolium Roth.									$5^{0}1$	$2^{0}1$	$5^{0}1$
Carex scirpoidea Michx.		$9^{0}1$									
Carex glacialis Mack.	$8^{0}1$										
Carex lugens Holm				$4^{0}1$	$5^{0}1$						
Carex capillaris L.				$1^{0}1$							
Carex consimilis Holm						$8^{0}1$					
Carex aquatilis Wahl.								$6^{0}1$	$10^{0}4-$	$10^{0}4-$	$10^{0}3$
Luzula confusa Lindeb.			$5^{0}1$	$3^{0}1$		$1^{0}1$					
Luzula nivalis (Laest.) Beurl.					$1^{0}1$						
Arctagrostis latifolia (R. Br.) Grieseb.			$4^{0}1$	$8^{0}1$	$4^{0}1$	$6^{0}1$	$9^{0}1$	$9^{0}1+$	$8^{0}1$		$8^{0}1$
Hierochloe alpina (Sw.) Roem. & Schult.			$6^{0}1$	$4^{0}1$	+	$1^{0}1$					
Festuca altaica Trin.	$2^{0}1$	$1^{0}1$									
Poa arctica R. Br.				$3^{0}1$	$3^{0}1$	$6^{0}1$					
Pedicularis lanata Willd.	$7^{0}1$	$5^{0}1$	$1^{0}1$	$4^{0}1$							$3^{0}1$
Lupinus arcticus Wats.	$9^{0}1$	$9^{0}1$	$3^{0}1$								
Polygonum bistorta L. ssp. *plumosum* (Small.) Hult.		$6^{0}1$	$7^{0}1$	$10^{0}1$		$1^{0}1$					
Stellaria laxmannii Fisch.		$3^{0}1$	$2^{0}1$	$6^{0}1$	+	$2^{0}1$	$1^{0}1$	+	$8^{0}1$		
Hedysarum alpinum L. ssp. *americanum* (Michx.) Fedtsch.	$4^{0}1$	$5^{0}1$						$3^{0}1$	$9^{0}1$		
Petasites frigidus (L.) Fries.					$10^{0}1+$	$5^{0}1$	$1^{0}1$	$5^{0}1$			
Saxifraga cernua L.	$1^{0}1$				$2^{0}1$	$4^{0}1$	$2^{0}1$	$3^{0}1$	$9^{0}1$		
Silene acaulis L. var. *exscapa* DC.	$1^{0}1$	$3^{0}1$									
Pyrola grandiflora Radius.	+	$3^{0}1$				$6^{0}1$	$5^{0}1$	$8^{0}1+$			
Antennaria isolepis Greene	$5^{0}1$										
Arnica alpina (L.) Olin & Ladon ssp. *angustifolia* (Vahl.) Maguire	+	$2^{0}1$									
Pedicularis capitata Adams.			$2^{0}1$		$1^{0}1$						
Valeriana capitata Pall.					$7^{0}1$						
Polemonium acutiflorum Willd.								$3^{0}1$			
Cardamine pratensis L.									$3^{0}1$		
Pedicularis labradorica Panzer										$2^{0}1$	
Tofieldia pusilla (Michx.) Pers.		$2^{0}1$									
Potentilla hookeriana Lehm.	+	$1^{0}1$									
Saxifraga punctata L. ssp. *nelsoniana* (D. Don.) Hult.				$1^{0}1$				$2^{0}1$			
Saussurea angustifolia (Willd.) D. C.	+										
Castilleja pallida (L.) Spreng.		+									
Oxytropis sp.		+									
Equisetum arvense L. var. *boreale* (Bong.) Ledeb. f. *pseudo-varium* Viet.					$4^{0}1$	$1^{0}1$	$2^{0}1$	$5^{0}1$			
Mosses	$10^{0}1+$	$10^{0}1+$	$10^{0}1$	$10^{0}2+$	$10^{0}8$	$10^{0}4+$	$9^{0}1+$	$10^{0}3+$	$10^{0}2+$	$10^{0}1$	$10^{0}4+$

TABLE III—*Continued*

Species	Frost-Scar Collective Type				Salix Type		*Alnus crispa* Type		*Carex aquatilis*-Marsh Type		
	Stand 4	Stand 5	Stand 16	Stand 22	Stand 11	Stand 42	Stand 36	Stand 78	Stand 55	Stand 64	Stand 67
Lichens	70^{1}	100^{1}	100^{1}	100^{2+}	60^{1}	20^{1}	.....	50^{1}	.....	.....	.....
Bare ground	100^{2+}	100^{2-}	100^{3+}	20^{1}	.....	.....	100^{6}	100^{5-}	.....	100^{4+}	.....
Water	.....	.....	.....	.....	.....	.....	.....	.....	50^{2+}	.....	100^{4+}
Total vasc. spp. in quadrats	14	17	17	22	16	19	13	18	8	4	9
Average no. vasc. spp. per quadrat	6	8	9	11	6	7	4	8	6	1	6
Homogeneity-index	75.0	62.5	76.7	78.2	75.0	64.3	80.0	72.5	83.3	100.0	78.3
Freq.-homogeneity test	V<IV	V>IV	V<IV	V=IV	V>IV	V=IV	V>IV	V>IV	V=IV	V>IV	V>IV

is not present. There are fewer species of dwarf shrub heath and associates than in the Eriophorum Tussock-Dwarf Shrub Heath Subtype but more than in the other 2 subtypes. One of the 4 stands is heterogeneous.

II. Frost-scar collective type

This type is called collective because of the variety of microstands which occurred in juxtaposition to one another. In the limited time available for field study, it was not possible to segregate and classify the various microstands. On aerial photographs and from the air these areas, marked by frost scars, are distinct in contrast to adjoining vegetation, so it is important in photographic interpretation that they be described and classified. Analyses are made of 4 stands, 2 of which are discussed in detail.

On the basis of phytosociologic analysis (Table III) Stands 4 and 5 form 1 subtype and Stands 16 and 22 form another subtype.

Stand 4. *Dryas integrifolia* (var. *canescens*?) —*Lupinus arcticus*

This stand, 2.0 miles northeast of Umiat, was located on the south side of the crest of a ridge. The slope of the upper portion of the stand was 4° and of the lower portion 9°. The site was dry with well-developed surface drainage consisting of channels that averaged 1 foot deep. The area was exposed to winds from all directions. Elongated mounds lying parallel with the direction of the slope were indicative of soil movement. There were frost scars on almost all mounds. The microrelief averaged 1 foot with a 2 foot maximum. The vegetation was essentially restricted to the channels between the mounds; infrequently, it was present on the perimeters of the relatively flat bare tops of the mounds. Plants occurring here were usually the same species as in the depressions. The vegetation characteristics (Table III) are the high frequency of *Dryas integrifolia* (var. *canescens*?), *Lupinus arcticus,* and *mosses* and the medium frequency of *Salix glauca, Carex glacialis, Arctostaphylos alpina,* 3 forb species, and lichens.

FIG. 5. Stand 4, *Dryas integrifolia* (var. *canescens?*)-*Lupinus arcticus.*

Stand 22. *Salix phlebophylla*-dwarf shrub heath

This frost scar area, 1.4 miles north-northeast of Umiat, occurred about half-way up the slope from the floodplain to the upland. The south-facing slope of 7° was protected from north winds. The site was medium moist although the surfaces of the frost scars were dry when examined. The microrelief averaged 8 inches with a maximum of 12 inches and resulted from the presence of the mounds which averaged 2.5 feet in diameter. The presence of the mounds with their more abrupt down-slope faces and gentle up-slope faces indicated soil movement. The surface drainage was well-developed, the microchannels ranging from 2 inches deep and V-shape in cross-section to 12 inches deep and U-shape in cross-section. The characteristics of the vegetation are the moderately high frequency of *Salix phlebophylla,* 6 dwarf shrub species, mosses and lichens.

FIG. 6. Stand 22, *Salix phlebophylla*—dwarf shrub heath.

Discussion of the Frost-Scar Collective Type.—Even though stands may differ greatly in composition, phytosociologic analysis yields data which form a basis for grouping the stands into categories. In this Frost-Scar Collective Type, the 4 stands can be classified into 2 distinctive subtypes. Stands 4 and 5 are in the *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtype, and Stands 16 and 22 in the Dwarf Shrub Heath Frost-Scar Subtype.

The *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtype is characterized by the high frequency of the named species; *Salix glauca* and *Carex glacialis* have high frequency in Stand 4; *S. pulchra* and *C. scirpoidea* have high frequency in Stand 5; *Lupinus arcticus,* mosses, and lichens have high frequency in both stands. In this subtype, the species of the dwarf shrub heath and associated group are *Arctostaphylos alpina, Cassiope tetragona,* and *Rhododendron lapponicum.* There are several species of forbs and one species of grass, *Festuca altaica.* Only Stand 5 is homogeneous by the frequency-homogeneity test and that by the small ratio of 3 to 2. However, the homogeneity-index of this stand is lower than in Stand 4 which is heterogeneous by the frequency-homogeneity test.

The Dwarf Shrub Heath Frost-Boil Subtype is characterized by the presence and high frequency of *Empetrum nigrum, Vaccinium vitis-idaea, Arctostaphylos alpina, Betula nana* ssp. *exilis* and *Ledum decumbens;* low to high frequency of *Salix* spp.; high frequency of *Arctagrostis latifolia* and *Hierochloe alpina;* high frequency of mosses and lichens; relatively few species of forbs. In Stand 16, there is a much greater area and higher frequency of bare ground as a result of frost scars, indicative of more intensive and extensive freezing disturbance than in Stand 22. The vegetative cover in Stand 22 is approximately 15 times greater than in Stand 16. The total number of vascular species in quadrats and the average number of vascular species per quadrat are slightly less in Stand 16 than in Stand 22.

Stand 22 has a vegetative cover approximately 9 times greater than that of Stand 4. Each of the 2 stands has comparable degrees of heterogeneity. The composition of Stand 22 includes approximately 55% more vascular species in the total number in the quadrats and approximately 80% more vascular species per quadrat than Stand 4.

III. Salix Type

Two stands of the *Salix* Type were analyzed, both were located on the upland and on wet sites.

Stand 11. *Salix glauca* var. *glabrescens-Petasites frigidus*

The stand was restricted to a well-defined small drainage channel on the upland, 1.9 miles north-northeast of Umiat. Water was flowing in the channel during the entire summer. The gradient of the channel was 4° to the east. Although the site was constantly wet, the water was not stagnant. The stand and surrounding communities were exposed to winds from all directions. The microrelief, resulting principally from the presence of moss mounds, mostly *Sphagnum* spp., which had formed or were in the process of forming, reached a maximum of 10 inches and an average of 7 inches. This stand was typical of many small upland drainage channels. Characteristics of this stand (Table III) are the high frequency of *Salix glauca* var. *grabrescens, Rubus chamaemorus, Petasites frigidus* and mosses, especially *Sphagnum* spp.

Discussion of Salix Type.—The outstanding characteristics of the Salix Type (Table III) are the high frequency and medium cover of *Salix*

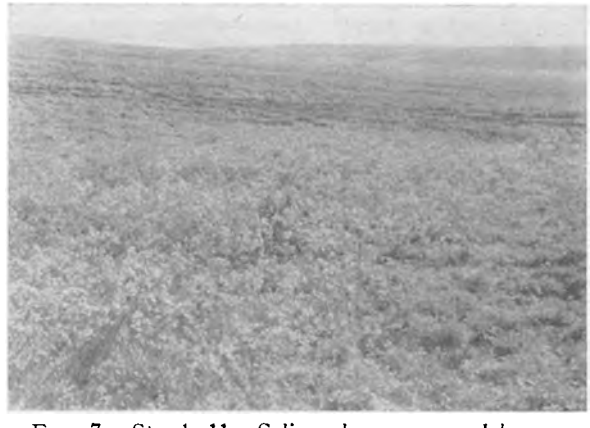

FIG. 7. Stand 11, *Salix glauca* var. *glabrescens-Petasites frigidus.*

glauca var. *glabrescens* and *S. pulchra* and the high frequency and cover of mosses. One or two additional species of *Salix* also occur.

One species of Carex occurs in each stand, *Carex lugens* with medium frequency in Stand 11 and *C. consimilis* with high frequency in Stand 42. *Eriophorum spissum* occurs in both stands with low frequency. One species of Luzula is present in each stand with low frequency, *L. confusa* in Stand 42 and *L. nivalis* in Stand 11. *Arctagrostis latifolia* and *Poa arctica* occur in both stands with low to medum frequency.

The dwarf shrub heath and associated species are present in each stand in varying combinations and frequencies; *Vaccinium uliginosum* and *Empetrum nigrum* are the only species which are present in both stands.

Petasites frigidus occurs with high frequency in Stand 11 and *Pyrola grandiflora* has a medium frequency in Stand 42; these species have the highest frequencies of the forbs in the respective stands.

With the frequency-homogeneity test, Stand 11 is homogeneous and Stand 42 is heterogeneous; the homogeneity-index of Stand 11 is higher than that of Stand 42.

IV. Alnus crispa Type

Two stands of the *Alnus crispa* Type were analyzed, one was on the upland and the other was on the low terrace of the Colville River floodplain.

Stand 36. *Alnus crispa*

The stand was situated in a draw, with a V-shaped cross section, on the south-facing slope which extended from the upland to the floodplain, 1.6 miles north-northeast of Umiat. The stream in the draw was intermittent in flow; the gradient varied from 10° to 15°, descending as a series of steps. The vegetation characteristics (Table III) are the high frequency of *Alnus crispa* which averages 6 feet in height, *Salix pulchra* and *Arctagrostis latifolia,* the latter was uniformly scattered throughout the stand beneath the openings in the crown canopy of high shrubs.

Discussion of Alnus crispa Type.—In both stands, *Alnus crispa* is the principal dominant as a result of high frequency and cover and in each stand one species of *Salix* is a secondary dominant; *S. pulchra* in Stand 36 and *S. glauca* var. *glabrescens* in Stand 78.

The frequency of mosses is high in both stands; the cover is low in Stand 36 and moderately low in Stand 78. Lichens are present only in Stand 78 with medium frequency and low cover. A high percentage of the ground in each stand is bare.

FIG. 8. Stand 36, *Alnus crispa.*

Arctagrostis latifolia has high frequency in both stands. *Carex aquatilis* has medium frequency in Stand 78.

Only 5 species of dwarf shrubs and associates occur in the stands. Their frequencies are low except in the case of *Vaccinium uliginosum* which has medium frequency in Stand 78.

Pyrola grandiflora has the highest frequency of forb species in both stands. There are 3 additional species of forbs in Stand 36 and 6 in Stand 78. *Equisetum arvense* var. *boreale* f. *pseudovarium* occurs with low to medium frequency.

Both stands are homogeneous by the frequency-homogeneity test, Stand 78 having the higher ratio of 3 to 1, but the homogeneity-index of Stand 78 is lower than that of Stand 36 as a result of a greater average number of vascular species per quadrat and dominance of *Alnus crispa* and *Salix glauca* var. *glabrescens.*

V. Carex aquatilis-Marsh Type

Three stands of the *Carex aquatilis*-Marsh Type were analyzed, one was on the upland and the others were on the floodplain.

Stand 55. *Carex aquatilis*-marsh

This marsh, approximately 2.5 miles north-northwest of Umiat, was restricted to a stream channel which was flat in cross section, of low gradient, and flowing to the east. Throughout the entire channel, which varied from 10 to 25 feet in width, water was flowing slowly in numerous shallow channels. These averaged 4 inches in width. The average microrelief was 1 inch, maximum 5 inches. There was no indication of either horizontal or vertical soil movement or freezing disturbance. About 100 yards downstream from the sample area was the head of a thaw gully which was at least 25 feet deep and which had been gradually working upstream in the channel. Examination of the gully face showed numerous

FIG. 9. Stand 55, *Carex aquatilis* marsh.

alternating horizontal layers of organic material and mineral material to a depth of at least 6 feet. This indicated the occurrence in the past of alternating periods of deposition of inorganic and organic material. This marsh was typical of numerous stream channels of the upland. Characteristics (Table III) are the high frequency of *Carex aquatilis, Hedysarum alpinum* var. *americanum, Saxifraga cernua, Arctagrostis latifolia, Stellaria laxmannii* and mosses.

Stand 64. *Carex aquatilis*-marsh

This marsh, 0.6 mile northwest of Umiat, was located in an old stream scar about 25 feet wide on the edge of a low terrace adjacent to the high terrace. To the east and west of the area sampled were small bodies of open water which marshes of this type were invading from all sides. The site was very wet and so level that the microrelief was insignificant. No surface drainage was possible. There was a uniformly distributed straw cover with a value of 3+ over the surface. This marsh is characterized by the high frequency of *Carex aquatilis* and mosses.

Discussion of Carex aquatilis-Marsh Type.— *Carex aquatilis* (Table III) with high frequency and moderately high cover, and *Eriophorum angustifolium, Salix fuscescens* var. *reducta* and *Caltha palustris* var. *arctica* with varying cover and frequency are present in the 3 stands. *Betula nana* ssp. *exilis* is present in Stands 64 and 67 which were in the floodplain marshes. There are more species of forbs in the upland marsh than in the 2 floodplain marshes. The moss cover is low in Stands 55 and 64 but moderately high in Stand 67 where approximately 50% of the moss cover consists of *Sphagnum* spp. the occurrence of which might have resulted from the larger area of standing water in this stand. Marsh types are widespread on the floodplain but only 2 stands were selected for study.

By the frequency-homogeneity test, Stands 64 and 67 are homogeneous with ratios of 1 to 0 and 3 to 1 respectively and Stand 55 is heterogeneous with a ratio of 2 to 2. The homogeneity-index of 100.0 for Stand 64 is unusual; however, only one species is concerned. The homogeneity-index of Stand 55 is higher than that of Stand 67, even though Stand 55 is heterogeneous by the frequency-homogeneity test.

DISCUSSION

The field methods were found to be especially applicable to aerial photographic interpretation studies of the Umiat area and would be equally applicable to similar areas. A greater volume of detailed phytosociologic data on plant communities of arctic, subarctic, alpine and subalpine areas is available for central European and Scandinavian areas than for comparable areas in North America. Use of the modified Hult-Sernander cover scale and the association table permits detailed comparison with data from these other areas. In addition, the sampling methods provided the detailed data required for correlation of the registration characteristics of the respective stands on aerial photographs.

Because of the nature of most communities of the Umiat area, *i.e.*, the many combinations of presence and abundance of dwarf shrub heath species and associates, the recognition and analysis of even closely related communities is essential to secure an understanding of the vegetation and to determine the manner in which certain combinations and variations register on the aerial photographs. These different combinations discernible on aerial photographs may be indicative of important environmental conditions. Life-forms of the area are restricted to a few kinds and these are usually intermixed in the dense vegetation. Therefore, on aerial photographs (images reduced 7,500 to 20,000 diameters) the physiognomic characteristics resulting from life-forms cannot serve as adequate criteria for the delimitation of communities in this region.

After considerable detailed field data had been obtained, it was suspected that due to the nature of the communities of the Umiat area, the frequency of selected species present in each community is one of the most important phytosociological characteristics. This is especially true since the cover of each species is class 1 in the majority of stands. The collection of additional field data and subsequent analysis of all data tend to confirm this observation. Several studies (Nordhagen 1928, 1943, Hanson 1953) indicate that usually in the tundra it is not common for all species to be present in cover class 1. For

example, Hanson (1953) shows in several association tables that average cover ranges from 2 to 4 for 2 to 4 species per stand.

The frequency-homogeneity test and the homogeneity-index tend to show relationship to each other in the degree of homogeneity or heterogeneity. Homogeneous stands usually have the higher homogeneity-indices and the heterogeneous stands have the lower homogeneity-indices. However, absolute correlation of these values cannot be expected. Only in relatively few cases are the same number of species included in the compilation of each value. The frequency-homogeneity test is concerned only with those species with frequencies of 61 to 100%. The homogeneity-index includes all species of the floristic-characteristic-species-combination and even though some species may and do have frequencies equal to or less than 60%. Only in Stands 20 and 70, both in the Eriophorum Tussock-Dwarf Shurb Heath Subtype, are all the vascular species of the floristic-characteristic-species-combination present with frequencies greater than 60%. In the majority of cases, the frequency-homogeneity test includes the majority of species of the floristic-characteristic-species-combination so that close correlation of results by both indices results and is to be expected.

Analysis of both the homogeneity-index and the frequency-homogeneity test is of material assistance in the interpretation of aerial photographs. These indices show minute differences of homogeneity or heterogeneity of registration of the respective stands on the aerial photographs.

Two indices are computed for the comparison of the degree of relationship between stands. The coefficient of affinity, as a result of the relative ease of computation, is of assistance in the preliminary comparison and grouping of stands and in determining the pairs of stands for which the more sensitive Sörenson coefficient is to be computed. There is a tendency for the Sörenson coefficient to have a lower value than the coefficient of affinity. Both coefficients are of assistance, not only in indicating the degree of relationship between two stands, but also in determining the relative important of individual species and groups of species with respect to the degree of relationship between 2 stands.

The various indices are of material assistance in the preliminary analysis and grouping of stands into types. No single index or group of indices can be used as firm criteria for grouping into types and subtypes. Final grouping is based upon detailed analysis of association tables supplemented by reference to the various indices; thus the stands are grouped into 5 types and 6 substypes, as follows:

Dwarf Shrub Heath Type
- Eriophorum Tussock-Dwarf Shrub Heath-Subtype
- *Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtype.
- Carex-Dwarf Shrub Heath Subtype
- Grass-Dwarf Shrub Heath Subtype

Frost-Scar Collective Type
- *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtype
- Dwarf Shrub Heath Frost-Scar Subtype

Salix Type

Alnus crispa Type

Carex aquatilis-Marsh Type

The Dwarf Shrub Heath Type is characterized by the greater number and higher frequencies of dwarf shrub heath species and associates. This is also generally the case with the Dwarf Shrub Heath Frost-Scar Subtype which is closely related to the Dwarf Shrub Heath Type. The dwarf shrub heath species and associates also occur in other types but here they are relatively less important. The Dwarf Shrub Heath Type is characterized by the similar occurrence of dwarf shrub heath species in all stands; it is subdivided into 4 subtypes on the basis of the relative frequencies of *Eriophorum, Carex,* and grass species, which is indicated diagrammatically below:

Eriophorum > *Carex* > grass
Eriophorum Tussock-Dwarf Shrub Heath Subtype

Eriophorum = *Carex* = grass
Eriophorum spissum-Carex lugens-Arctagrostis latifolia-Dwarf Shrub Heath Subtype

Carex > grass > *Eriophorum*
Carex-Dwarf Shrub Heath Subtype

Grass > *Carex* > *Eriophorum*
Grass-Dwarf Shrub Heath Subtype

It may be that these 4 subtypes represent phases of a cyclic succession within the Dwarf Shrub Heath Type.

The most important feature of the Frost-Scar Collective Type is the presence of bare frost scars surrounded by vegetation, usually in depressions of the microrelief. The phytosociologically distinct subtypes are the *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtype and the Dwarf Shrub Heath Frost-Scar Subtype. Causes for frost scars have been discussed in a recent paper by Hopkins and Sigafoos (1951).

The Salix Type is characterized by the high frequency, moderately high cover and height of *Salix* spp. The type may be successional, though long-enduring, in which case the other species present may indicate the successional trend toward a dwarf shrub heath type. In northwestern Alaska, similar *Salix* types cover extensive areas (Hanson 1953).

The *Alnus crispa* Type is characterized primarily by the high frequency and cover of *Alnus crispa* and secondarily by the relatively high frequency and moderate cover of *Salix* spp. The dense crown canopy of *Alnus crispa* and *Salix* spp. excludes a well-developed ground cover of other species. Alder communities have been described briefly by Porsild (1939) and Hanson (1951, 1953).

Characteristics of the *Carex aquatilis*-Marsh Type are the high frequency of *Carex aquatilis*, the very wet habitat, and the presence of few other species. Because of the very wet habitat, few other species are to be expected. However, since the type is successional yet long persisting, an analysis of more advanced stages would indicate the course of succession which would probably terminate with a dwarf shrub heath. This type or similar types are widespread in northern regions (Hanson 1951, 1953, Nordhagen 1943).

Some features of the more prominent species are discussed below.

Alnus crispa, besides being the dominant of a distinct type, is widespread within the other types. It does not occur in the Frost-Scar Collective Type, possibly because of the unstable environment, or in the *Carex aquatilis*-Marsh Type, because of the extremely wet habitat.

A total of 17 species and varieties of *Salix* occur in all the types; there is one distinct *Salix* Type. Sixteen species of *Salix* occur in the Dwarf Shrub Heath Type, 12 in the Eriophorum Tussock-Dwarf Shrub Heath, 12 in the Carex-Dwarf Shrub Heath, 6 in the Grass-Dwarf Shrub Heath, and 5 in the *Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtypes. Five species are present in the Dwarf Shrub Heath Frost-Scar and 2 in the *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtypes, 5 in the *Alnus crispa* Type and only 1 in the *Carex aquatilis*-Marsh Type. *Salix pulchra* is the most widespread, occurring in all types and subtypes except the *Carex aquatilis*-Marsh Type. There are 5 species and varieties which occur in only one type: *Salix alaxensis* in the Salix Type, *S. glauca* var. *acutifolia* and *S. glauca* var. *Aliceae* in the Carex Dwarf Shrub Heath Subtype, and *S. pulchra* var. *yukonensis* in the Eriophorum Tussock-Dwarf Shrub Heath Subtype. Generally, if the frequency of either *Alnus crispa* or a *Salix* spp. is high, then the frequency of the other is relatively low.

The dwarf shrub heath and associated species are especially important in the Dwarf Shrub Heath Type and the Dwarf Shrub Heath Frost-Scar Subtype. They are present with less importance in the other types and subtypes. *Betula nana* ssp. *exilis* is present in 8 types and subtypes. It is the only dwarf shrub species in the *Carex aquatilis*-Marsh Type, and is absent from the *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtype. *Arctostaphylos alpina, Ledum decumbens, Vaccinium uliginosum* and *V. vitis-idaea* occur in 7 types and subtypes. *Vaccinium oxycoccus* is present in only the Eriophorum Tussock-Dwarf Shrub Heath Subtype. *Dryas integrifolia* (var. *canescens*?) and *Rhododendron lapponicum* are present only in the Carex-Dwarf Shrub Heath, Grass-Dwarf Shrub Heath, and the *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtypes. *Cassiope tetragona* is not present in the Salix, *Alnus crispa* and *Carex aquatilis*-Marsh Types, probably indicating a lack of tolerance for shading and excessive moisture.

Eriophorum spissum is the most common species of this genus. Its occurrence is most prominent in the Eriophorum Tussock-Dwarf Shrub Heath and the *Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath Subtypes. It is not present with a cover rating in the Grass-Dwarf Shrub Heath and *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtypes, and the *Alnus crispa* and *Carex aquatilis*-Marsh Types. *Eriophorum vaginatum* replaces *E. spissum* in 1 stand of the Eriophorum Tussock-Dwarf Shrub Heath. *E. angustifolium* is present in the *Carex aquatilis*-Marsh Type.

Carex lugens has the greatest occurrence in almost all types and subtypes. It is not present in the *Dryas integrifolia* (var. *canescens*?) Frost-Scar Subtype and the *Alnus crispa* and *Carex aquatilis*-Marsh Types. Other species of *Carex* are also present in some of the types and subtypes. In 3 stands of the Eriophorum Tussock-Dwarf Shub Heath Subtype, *Carex consimilis* replaces *C. lugens* in importance and in 3 stands of the Carex-Dwarf Shrub Heath Subtype, *C. lugens* is replaced in importance by *C. scirpoidea, C. consimilis, C. vaginata* and *C. membranacea*.

Arctagrostis latifolia, usually sparse, has the most general occurrence of the grasses. It does not occur in the *Dryas integrifolia* (var. *canes-*

cens?) Frost-Scar Subtype and the *Carex aquatilis*-Marsh Type. *Hierochloe alpina* and *Poa arctica* are commonly associated with *Arctagrostis latifolia* in the types and subtypes.

Stellaria laxmannii is the only forb which is present in all types and subtypes. *Polygonum bistorta* ssp. *plumosum* and *Pyrola grandiflora* are also widespread in occurrence, each being present in 7 types and subtypes *Polygonum bistorta* ssp. *plumosum* is not present in the *Alnus crispa* and the *Carex aquatilis*-Marsh Types; *Pyrola grandiflora* is not present in the Dwarf Shrub Heath Frost-Scar Subtype and the *Carex aquatilis*-Marsh Type. *Lupinus arcticus* is present in 3 Dwarf Shrub Heath Subtypes but not in the Grass-Dwarf Shrub Heath Subtype; it is present in both Frost-Scar Subtypes but not in the remaining types. The greatest number of forb species occur in the Dwarf Shrub Heath Type and the *Dryas integrifolia* (var. *canescens?*) Frost-Scar Subtype.

Summary

1. The general aspect of the Umiat area, located between the Brooks Range and Barrow, Alaska, results from the presence of gently rolling hills with dense vegetation generally 6 to 12 inches high consisting of dwarf heath shrubs, dwarf birches and willow, intermingled herbaceous species and, in places, alders and willows from 3 to 8 feet high. The tall alders and willows occasionally form thickets, especially on slopes and on the flood-plain.

2. The environment of the Umiat area is rigorous, annual precipitation is very low, the winters are long and severe, and the summers are cool and short. No freeze-free season can be expected, and permanently frozen ground underlies the area at usually shallow depths.

3. Eighty stands of various plant communities were investigated during the summer of 1951 in the Umiat area of Alaska. Quadrat analysis and soil profile descriptions were made in each stand.

4. Aerial photographs were found to be useful in differentiating, delineating, and selecting stands for detailed analysis since differences were more readily detected on aerial photographs than on the ground.

5. Frequency is one of the most important phytosociological characteristics because the cover of each component species of a stand is usually low to an equal degree.

6. Association tables and phytosociological indices are useful in analyzing stands, in comparing stands, in determining relationships of stands and in evaluating the phytosociological importance of species.

7. The stands are grouped into 5 types. The most widespread type, the Dwarf Shrub Heath, is divided into 4 subtypes, Eriophorum Tussock-Dwarf Shrub Heath, *Eriophorum spissum-Carex lugens-Arctagrostis latifolia*-Dwarf Shrub Heath, Carex-Dwarf Shrub Heath and Grass-Dwarf Shrub Heath. The Frost-Scar Collective Type is divided into the *Dryas integrifolia* (var. *canescens?*) and the Dwarf Shrub Heath Subtypes. The other three types are the *Salix*, the *Alnus crispa* and the *Carex aquatilis*-Marsh Types. Microhabitats, and therefore the microcommunities which they determine, are characteristic of the first 2 types so that these types could be considered as mosaics of microcommunities. These types display a homogeneity which results from the uniformity of distribution of microcommunities within the stand.

8. The most important vascular species with regard to cover and frequency are *Alnus crispa, Arctostaphylos alpina, Betula nana* ssp. *exilis, Cassiope tetragona, Dryas integrifolia* (var. *canescens?*), *Empetrum nigrum, Ledum decumbens, Vaccinium uliginosum, V. vitis-idaea, Salix glauca, Carex aquatilis, C. lugens, Eriophorum spissum, Arctagrostis latifolia, Lupinus arcticus, Polygonum bistorta* ssp. *plumosum, Pyrola grandiflora* and *Stellaria laxmannii.*

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REGULATORY MECHANISMS OF HOUSE MOUSE POPULATIONS: SOCIAL BEHAVIOR AFFECTING LITTER SURVIVAL[1]

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This paper presents data on the social environment of house mice which accompanies crowding and which influences litter survival. Five aspects of the social environment are considered: aggressiveness, gregariousness, intermingling of sexes, nest destruction, and abnormal communal nesting.

Poor litter survival was found to be the major controlling mechanism of confined populations of wild house mice supplied with unlimited food (Southwick 1955). This poor survival resulted primarily from improper parental care: such behavioral traits as cannibalism, desertion, trampling or scattering of the young. No attempt is made in this paper to assess the relative importance of these specific behavioral traits. It was often impossible to disentangle them and assign only one as the actual cause of death. Some young, when found dead, were partially consumed, but others were intact or possessed only minor wounds, and could have died from a number of causes including being trampled, deserted, or bitten. Hence, the behavioral traits of cannibalism, desertion, trampling, etc. are all considered in this paper under the general heading of improper parental care.

Many workers have observed improper parental care to be an important mechanism of population control under crowded conditions (Alverdes 1935; Solomon 1949). It has been particularly noted in house mice (Brown 1953; Crew and Mirskaia 1931), Norway rats (Calhoun 1949), British voles (Chitty 1952; Ranson 1941), muskrats (Errington 1939), and rhesus monkeys (Carpenter 1942). Considerable challenge exists, therefore, to study the social environment in which improper parental care occurs.

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METHODS

Six experimental populations of house mice were each confined in an uncovered pen six feet wide and 25 feet long. Each pen contained 48 nest boxes, 2 x 3 x 6 inches in dimensions, and an abundance of food, water, and nesting material. The pens were lined with sheets of galvanized iron 24 inches high which effectively contained the mice.

On November 22, 1950, four pairs of wild house mice, trapped from natural infestations on the University of Wisconsin campus and selected as healthy young adults, were released into each of the six pens. In three of the pens, A, C and E, the nest boxes were crowded at one end and the food and water facilities were placed in large con-

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