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THE UTILIZATION OF VEGETATIVE STRUCTURE IN THE INTERPRETATION AND DIFFERENTIATION OF CERTAIN CANADIAN BOREAL REGIONS

by

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Scope and contents of this thesis:

The development, presentation, and application of technique for interpreting examples of so-called muskeg terrain in Northern Canada. The emphasis is with a view to utilitarian aspects, not necessarily botanical implications, though the medium for the work is vegetal coverage. Illustrated with photographs.

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INTRODUCTION

With ever-increasing infiltration, the Canadian north is gradually losing its identity as a vast unknown hinterland, unexplored and uninhabited. It is difficult to accept it as remote from our own centre of civilization; on the contrary, it is a significant area important in relation to national and international affairs.

The potentialities existing in the boreal regions of Canada are rapidly becoming evident. The additional need for material resources has turned the attention of investigators towards the north in the possibility that new developments may follow there. Engineers have shown a keen interest, particularly because their help is required to solve the engineering problems peculiar to northern conditions. Finally, the north as an inevitable factor in defence problems of Canada and the United States cannot be underestimated. The armed services, perhaps more than any other organized agency, have done more to attract attention to the importance of the north and the need for a greater understanding of it.

For northern infiltration to take place, a knowledge of environmental conditions is essential. Temperature conditions coupled with the presence of permafrost, poor drainage, and the superabundance of organic terrain present an unique combination of characteristics. Superimposed upon this, the unusual features that the vegetation, past and present, displays; and the problems for the engineer and those concerned with everything from trafficability to camouflage—to state nothing of the ordinary difficulties involved in land utilization—are at once recognized as requiring application beyond the normal level of experience that engineers and military experts would ordinarily possess.

One might feel that there would be information concerning what the flora of the region may express as a basis for understanding the conditions of the north, but this does not obtain. It is not known, for instance, how the controlling environmental agents are interrelated. This still remains somewhat of a problem in the south, but obviously more so in the north, for which the backlog of knowledge indicated as evidently essential is relatively almost entirely lacking.

In particular there is a lack of evidence for interpretating effects of these factors on vegetation. The scarcity and discontinuity of meteorological data, from most parts of the north, are examples of obstacles in the way of attempting to relate botanical information with climate. From a large part of Boreal America there are no climatic data. Where these do exist, the relation between the climatic information and vegetation is apparently not understood. The ultimate cause for nanism and other structural adjustments or the actual mechanism by which northern species complete their reproductive cycle in short periods during the telescoping of the northern seasons are some of the many problems still present in several of the relations of northern plants to climatic conditions. Secondly, edaphic factors, like climatic conditions, so important as controlling agents on vegetation in the north have still to receive attention. Much has yet to be learned, for instance, concerning the limitations that permanently frozen sub-soil may place on the vegetation. Thirdly; it is estimated that much of the northern two-thirds of Canada is covered, not by soils—that is, soils as derived from a mineral source—but by organic peat deposits of many sorts and complexities. The slow rate of decomposition of organic remains is one of the notable features of the arctic and subarctic regions. Until quite recently, little has been known about these peat deposits. Investigations in the field of palynology have given us some information as to their composition, (Radforth (11), and Johnson (5)). There still remains, however, a need for correlation between the subsurface and surface vegetation.

It seems not unreasonable to start with a consideration of vegetation as an index of environmental complexity or in the search for environmental organization. In line with this viewpoint, this contribution refers particularly to surface flora as it supplies many of the characteristics and a basis of reference for appreciation of northern environment.

In evaluating the surface flora, an identification of the species found could be undertaken with the result that a list of plants that grow in the area might be presented. Although this check list would serve as a means of identification and comparison, it would not contribute greatly to the interpretation and differentiation of the region. Dansereau (3) has pointed out that floristic and geobotanical relationships are of no great help in the definition or description of the landscape where the biological background is investigated since the flora gives only an historical clue to present day conditions. He states:

> The flora of a locality or a region is the residue of all the plant species which, in the course of geological time, have occupied that territory and have successfully withstood the subsequent climatic and other vicissitudes or have taken refuge elsewhere and more or less recently reinvaded...... On the other hand, the vegetation consists of a definite and unpredictable arrangement of the species involved in the local flora.

It would appear that organization or the semblance of organization in the vegetation as a whole is the important thing to try to interpret and utilize rather than a list or accounting of types present which does not reflect the organization. As well, the dominant and some other characteristic species must be recognized because of their physiognomic prominence and their indicator value. This structural, as against a taxonomic description of vegetation, has long been acknowledged. Schimper (14) and Warming (18) described equivalent formation based on similarities in appearance or characteristic species. These criteria represent an appreciation of vegetation and not flora, although the vocabulary involved reflects some preoccupation with phylogenetic affinities.

Because of importance of vegetative physiognomy it has been here accepted that it is essential to an ultimate understanding of terrain phenomena. This is of special importance, quite apart from the basic aims of this thesis, in that it forms a primary part of the "muskeg"[1] programme. The solution of problems relating to muskeg could doubtless be facilitated if an adequate interpretation of the vegetative cover were forthcoming, since muskeg involves not only subsurface organic content, but also surface conditions and features.

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[1]The expression used in this thesis to indicate organic terrain.

The close relationship between surface vegetation and the organic medium supporting it suggests that reference should be made here to investigations on muskeg and the problems in the general programme that relate to this work. As the conditions governing its formation are not necessarily uniform, different types of muskeg varying in degree of complexity exist. This has meant that muskeg must be typed—an aim of the muskeg research. Investigations in this field are unique in their prerequisites, in that they depend on assessing surface vegetation as the latter is physically part of the muskeg—a condition which does not obtain for vegetation where organic terrain is not involved. Classification of vegetation is therefore of prime importance.

Two primary problems and several attendant secondary questions present themselves relative to the foregoing needs:

1. Range of form and structure of surface vegetation must be interpreted and recorded.

2. A classification of form derived from the records is required to express the degree of organization present in the muskeg.

3. In addition, it is important to satisfy any subsidiary needs that assist in the matter of intelligent appraisal of surface vegetation for botanical, geographical, or utilitarian requirements.

The observations made earlier suggesting that lack of knowledge for the north might well be partly obviated through an understanding of vegetative coverage is thus substantiated in the requirements here set out as related to the special muskeg work. The objectives of the present investigations cannot sensibly avoid these basic needs, and an attempt has been made to recognize them. This necessitates the evolution of a method whereby vegetative structure of plants may be utilized for analysis in classifying regional vegetative coverage for intelligent reference.

The scope of this thesis must include the formulation of such a classification, with one intention being to present as non-technical a classification as possible in order that it may be applied by those other than the botanist. As an experimental area for the application of the classification, the north-eastern section of Canada in the vicinity of Churchill, Manitoba, was selected. It is not the purpose herewith to apply the classification to other than this experimental region, nor to incorporate all environmental factors into the method.

Recognizing, however, the potentialities of the method for northern terrain interpretation in gêneral, it is hoped that the technique might be of use over wide areas and carry more than local value.

BASIS OF ANALYSIS

There are several obvious items, which can be utilized from a broad consideration of the vegetation. For one thing, pattern trends seem apparent in spite of a tendency on the part of some species to tolerate different environmental backgrounds. One may find in an area taxonomically unrelated species closely associated, which on examination have strikingly similar physiognomic relationships. This vegetative pattern is more significant through the fact that a small number of species appear to be dominant in the entire area. Poverty of boreal flora helps to emphasize these dominating species.

The vegetation of this northern region appears, also, to display characteristics that are obvious to even the casual observer. Dwarfing is prevalent. The plants are oppressed to the ground thus bringing the greatest area into a snow coverage. Since the actual growing season is short, being limited chiefly to two summer months, the plants show a corresponding rate of growth from the time the leaves begin to emerge until the dissemination of the seeds, or until the perennating bud completely develops. Unequal distribution of lichen, moss and other mat-forming plants impresses the observer as being characteristic of the northern vegetation.

Vegetal character, particularly distribution, is further influenced by the topography and physiography. The physiography of the region under investigation is that of the Hudson Bay Lowlands. This is the rather narrow belt of flat lying Palaeozoic limestone covered with thick glacial till which circles the lower portion of Hudson Bay within the Precambrian Shield. The land is a very low level plain, sloping gently into Hudson Bay completely covered by organic deposits.

In conjunction with the topography of the region, one becomes aware of a predominance of "barrens", a term applied to areas unbroken except for small ridges and "hummocks"[1]. In such areas the vegetation shows an almost complete absence of tree and shrub-like plants and is dominated for the most part by sedges and mosses.

Finally another item, relating to the physiography and having important implications from a consideration of the vegetation, is that open bodies of water are almost a constant factor in the interruption of vegetation except where wooded areas ramify.

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[1]Ground elevations, varying in extent and width, usually under five feet in height.

DIFFICULTIES ENCOUNTERED IN NORTHERN ECOLOGICAL STUDIES

Procurement of data presents difficulties of one kind or another in any northern ecological study. Accessibility because of the physiographic features is arduous because, in most cases, transportation facilities are still inadequate. Motor transport is scarce and not readily procurable. It is therefore necessary, if any investigations are to be undertaken, that the organic terrain be traversed on foot with hip boots.

In addition, the water component in the muskeg, as well as providing breeding ground for the mosquito and black fly which condition efficient field study, is such that it hampers travel. Progress is therefore impeded. Lack of means of transport and terrain impediments cause limitations on equipment that may be used in the field. Improvised methods have therefore to be resorted to.

One serious difficulty experienced in northern latitudes is that botanical work must be done during the short open season in which spring, summer and autumn conditions are apparently telescoped. Since it is impossible to complete extensive studies in so short a time, sampling and other technical work has to be carefully arranged in order to facilitate investigations from year to year.

Of far greater significance than the above, is the behaviour of boreal American species and the fact that their distribution is often discontinuous. In that the plants show varying degrees of grouping, and a large percentage of the flora consists of what might be termed "fluid" species, showing unexpected form variation regardless of species, many other problems exist for the investigator.

HISTORICAL BACKGROUND

Augmenting the difficulties, historical information of the type required is limited. Early expeditions of discovery frequently included someone with a knowledge of botany who recorded, to some degree of accuracy, the species found in an area. H. G. Simmons (16), botanist to the second Norwegian "Fram" Expedition, made an extensive study of the flora of Ellesmere Island. In 1913 he published a comprehensive survey of the flora of the whole arctic archipelago. In addition to his own material, this was based upon miscellaneous collections gathered from a long series of explorations for the northwest passage. This remained the most useful account of American arctic flora until the publication of Dr. Nicholas Polunin's catalogue of the vascular plants of the Canadian eastern arctic (9). The work of Polunin, besides bringing up to date the listing of available species in the north, contains an exhaustive survey of both exploration and taxonomic literature. It includes among others, material from the field work of the "Fifth Thule Expedition" (1921-24), of J. D. Soper (16) in Baffin Island; M. O. Malte (8) at various points along the route of Government Patrols; G. M. Sutton (17) in Southampton Island; as well as Polunin's own work on Akpotok Island. The area covered lies north of latitude 60° and is, therefore, not typical of the represented areas dealt with in this thesis.

Except for the portion north of latitude 60°, published accounts of the flora of the west coast of Hudson Bay are meagre. Most of the detailed floristic knowledge is still in the form of lists published by early travellers and explorers. Malte (8) and Polunin (9) have both collected in the Churchill district, and in 1931 A. E. Porsild (10) worked in that region. Information on these collections is, however, not available in the literature. Recently a comprehensive collection of the flora of the Churchill region has been made and a list of the known species published.[1]

From the above it is evident that little work has been done on the interpretation of the vegetation other than from floristic discussions. The author can find no record of any detailed study of the vegetation of northern regions where vegetal analysis is emphasized. Nevertheless, the need for such an undertaking has been pointed out, (Raup (13), Dansereau (3), and Radforth (11)). Lack of information is possibly due in part to the fact that no adequate method has been proposed which would be suitable for use in the north.

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[1]Technical Memorandum No. 14, Associate Committee on Soil and Snow Mechanics. National Research Council of Canada. 1950.

PROCEDURE

Experimental Work in the Area

Relative to this thesis, and in conjunction with muskeg work, investigations into the utilization and differentiation of certain terrain areas in the north were begun in the summer of 1947. At that time, areas in the Churchill, Manitoba, region were selected. These areas differ among themselves, but together reflect for the most part that range of physical characteristics confronting the terrain investigator working in the area. The five main areas chosen were peat area one, or P_1, peat area two, or P_2, P_3, P_4, and P_5,—the designation having reference to peat collecting in the Churchill area, (Plate I). Subsequent to the choosing of these, a general description of each was undertaken. This was ameliorated as more information became available.

To acquire reference material for future work, an intensive study into the flora of the locality was commenced. This collecting and identifying of species from each "P" area, and the adjacent regions, provided a crude quantitative appreciation of the flora.

Vegetal interpretation on a structural basis began in 1949 with the use of quadrats. The quadrat method, known also as the sample-plot method is a basic device for many types of ecological investigations. Different types of quadrats varying in size and use are known. The list quadrat, probably the most commonly used, is one in which the species are listed and the number of individuals of each counted. To supplement frequency determination with a knowledge of the association of species with one another, a chart is often made of the quadrat. In addition, photographs may be taken to obtain a better conception of the association, (Plates II and III).

Preliminary investigations consisted of traversing the area and placing, at random, markers along the line of travel in each "field type"[1] location. A quick check of each marker determined the location of quadrats to be used. Each selected quadrat was carefully tabulated to obtain the maximum information available. Where possible a review of the quadrats was made throughout the summer in order to note any change in the vegetation.

Review of Ecological Classification Systems:

Information accumulated from investigations as outlined above required the application of some method classifying vegetation.

Recently, various criteria have been proposed as the basis for such a classification. Many of these are of a taxonomic nature. Weaver and Clements (19) for example, describe the communities of North America in terms of names of dominants of the climax, grouped about a very general physiognomic scheme. The use of the name of the dominant is general and a regular system of nomenclature has been adopted; the suffix "-etum" is added to the generic name of the dominant. Heath and Luckwill (4), on the other hand, utilized vegetative structure by outlining a classification based on a morphological unit such as the root system of plants. Warming (18) previously formulated a system involving the water relation to plants.

Raunkiaer (12) in his life-form classification of plants was one

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[1]A quick method of reference used heretofore by those investigating the terrain.

of the pioneers in digressing from the taxonomic method of classifying vegetation. The classification is based on the single criteria of the position of the bud, or growing point, during the resting period. Considering the position of the perennating bud, six groups can be recognized:

Phanerophytes -	exposed buds, being situated high above the ground surface - trees, shrubs.
Chamaephytes -	perennating bud close to the ground - small shrubs, creeping herbs and woody plants.
Hemicryptophytes -	buds at soil surface in which annual growth dies down to that level - herbs of different types.
Geophytes -	perennating bud is below surface as in many rhizomatous, tuberous and bulbous herbs.
Hydrophytes -	buds permanently under water - all true aquatics.
Therophytes -	buds contained in a seed - annuals.

Raunkiaer's (12) system of life-forms has the advantage of being based on a single principle and having a perfectly consistent nomenclature.

With an aim to its possible use, one of the most recent classifications, that outlined by Kuchler (7) was reviewed. In his classification, Kuchler strives to keep clear of any taxonomic nomenclature as much as possible. Any reference to the taxonomic name of a plant is, in the opinion of Kuchler, of little use to anyone other than the botanist. He further states:

> If nomenclature based on species classification is considered, then confusion at once exists as any simple and concise meaning is lost. Therefore only descriptive terms relating to the physiognomy of plants in an area should be used.

DERIVATION OF A SIMPLIFIED SYSTEM OF CLASSIFICATION

Classification depends on the nature of the need to which it is applicable. The suggestion has previously been made (page 1) that an understanding of the terrain is required by investigators, other than botanists, working in the north. Avoidance of over-technical botanical expressions is, therefore, important. Systems, mentioned previously, even if they were to be used for muskeg, are organized on a basis that is perhaps more complex than is required.

The life-form classification of Raunkiaer (12), while useful to the geobotanist, does not convey much information to others, since a knowledge of morphology is necessary for its proper understanding. Moreover, it cannot be easily used in the interpretation of the vegetation as it is rather hard to apply, since the distinction in bud position whereby Chamaephytes, Hemicryptophytes and Geophytes are separated, may be so slight as to be indeterminable, particularly during the growing season when analyses of vegetation are usually made. However, as the system is chiefly a bioclimatic one, valuable information of a climatic nature could, doubtlessly, be gained through an analysis of a chart showing the distribution of the life-forms in an area, (Plate IV).

Kuchler's (7) system, on the other hand, while definitely related to vegetative structure, is apparently not satisfactory for vegetal analysis, because it fails to distinguish certain forms of plant life. Kuchler includes under one heading grasses and other herbaceous plants. As well as the above, Kuchler's system does not avoid the possibility of confusion when relating the four minor groups to the major divisions.

As no formulated system appeared adequate for use relative to the needs expressed, a new classification was derived. This classification proposed has been attempted with reference to four principal factors affiliated with northern vegetative regions only:

1. Plant Height.

This is the primary background factor involved as degree of tallness of plants comprising any vegetational area is one of the most obvious features. Especially is this the case in the experimental area chosen where the plants, though mature, show a segregation as to height. Whether this is due in part to the adjustment of the vegetative structure to northern environmental and terrain conditions, is not for consideration here.

2. Woody Tissue in the Aerial Portion of the Plant.

It appears possible to segregate certain groups of plants on the basis of prevalence of woody tissue--a condition which perhaps provides the reason for the use of such terms as "tree", "shrub", and "herb". Since this feature is so well accentuated with respect to northern vegetation, it is tempting to use it only. However, it is recognized that other features are equally significant. Therefore, woodiness only partly satisfies the requirements.

3. Space-Growth Relationship.

An additional feature which may be considered, suggests that a distinction can be made among the non-woody plants relative to their habit of growing. Mosses, lichens, and certain sedges are examples of plants which frequently occur in mats or clusters. This is a factor of some import in northern regions where one is confronted with vegetational phenomena in the nature of "niggerheads", a type of hummocky development.

4. Texture of Non-Woody Plants.

In order to discern clearly between the lower plant orders that constitute an important aspect of the vegetational pattern, the texture of the plants had to be considered. The plants may produce a soft, somewhat velvety mat or may form, especially when dry, a hard leathery covering. Flexibility in the latter expression is evident since a change from a hard leathery to soft leathery condition may occur in a few hours, dependent on the amount of moisture available. The prevalence of water also influences the texture. To the botanist this indicates types of lichen thalli, whereas the former refers to mosses.

The author believes that colour, as well as the condition of vegetation at different parts of the season may, when more clearly understood, be incorporated into the system of classification.

Since these reference terms are clear and concise, contain no floral nomenclature or morphological terminology, they can be appreciated by anyone——making them exceedingly useful for investigators who have little botanical knowledge. The classification, because of its simplicity, seems inadequate as other systems are apparently over-complex. However, it has been the author's experience in surveying areas, that one has to come back to the basic factors outlined in the proposed classification and use them as reference terms. Height, woodiness, non-woodiness, are primary in the initial appraisal of an area; whereas space-growth relationship and texture are secondary. The degree to which all categories are prevalent should, nevertheless, be presented. Therefore, the description for appraisal of any sample of vegetation should relate primarily to the first two, and secondly only to the last two. This organization is reflected in the order of the information below, which is a classification system, as proposed on the forementioned basis.

Vegetative Type

Class A - woody plants, 15 feet[1] high or over;examples: spruce, larch.

Class B - woody plants, 5 to 15 feet high; examples: spruce, larch, willow, birch.

Class C - essentially non-woody plants, 2 to 5 feet high; example: wild rice.

Class D - woody plants, 2 to 5 feet high; examples: willow, birch, Labrador tea.

Class E - woody plants, 0 to 2 feet high; examples: blueberry, laurel.

Class F - essentially non-woody plants, 0 to 2 feet high, forming mats, clumps, or patches sometimes contiguous; examples: sedges, grasses.

Class E - essentially non-woody plants, 0 to 2 feet high, growing singly or in loose association; examples: ragwort, lady slipper, orchids.

Class H - non-woody plants, 0 to 4 inches high, and of leathery crisp texture forming continuous mats; example: lichen coverage.

Class I - non-woody plants, 0 to 4 inches high, with soft or velvety texture often forming continuous mats, sometimes hummocked; example: mosses.

The classes as defined relate to vegetative structure, containing examples as named, and which predominate. These vegetative types so

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[1]In the classification, for purposes of simplicity, feet instead of metres is used.

composed, appear in so many locations that it is possible to use them almost exclusively to characterize an area.

The classification to be useful, must be applicable to any area regardless of size. In applying the system, moreover, it is important to realize that an estimate of the size of the area must be given in order to determine the amount of coverage per class. It must be remembered also, that areas may express a cosmopolitan behaviour of plant species, in addition to the prevalence of major species showing distribution habits. It is important, therefore, to correlate coverage with size. In areas of one order of size, the designation of the presence of a class may not appear, but if the order of size were increased, an indication as to its presence would occur. Thus area size is significant in expressing the composition of the vegetation.

From another aspect, it is important to account for each minute change, especially if the area is large. Indeed, if a class type is poorly represented, its presence is not noticed because of the relative abundance and predominance in the landscape of the other classes, which represent a true picture of the area.

Therefore, to acquire a representative picture of the vegetation a minimum coverage may be determined. It is difficult to decide without field tests[1] the minimum figure for coverage. In applying the system,

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[1]No field test could be undertaken. A method was devised from the information available. This consisted of examining photographs of typical quadrats and determining the predominant classes present. Relating this to coverage as determined by count-list and quadrat charts, the satisfactory minimum figure was obtained.

the level of ten percent[1] coverage was at first contemplated. However, where a class is present only to the extent of ten percent, its appearance, by and large, does not change the vegetal character of the area as a whole, any more than if it were not present. Further testing, therefore, indicated that a twenty-five percent minimum was the more practical level, keeping in mind that for this work characterization of the coverage must express the predominant type of coverage, since the latter is apparently the more significant as a reference basis. In noting the coverage the largest percentages are recorded first, as for example, where classes A, E and I each cover twenty-five percent or more of an area. E has the largest percentage, followed by I and A, the notation known as the Coverage Description Formula would be E-I-A. In the formula E would be of the first order of coverage, commonly indicated by the Roman numeral one (I), I of the second (II), and A of the third order of coverage (III). The amount to which each factor in the expression exceeds twenty-five percent is not indicated, as the intention is to express relative abundance only.

It will be noted that a determination can contain no more than four orders of coverage. However, if a smaller minimum percentage were used, the orders could be increased. The degree of detail the investigator requires, will decide the minimum coverage figure.

Another element which it is desirable to reflect in the descriptive formula is dominance. This dominating influence of one group on the vegetation is observed where it affects the progress of other groups in the area, since it does not compete on equal terms with them for light, water

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[1]Estimated.

and other ecological agents (20). In the above example, although not having as large a percentage coverage, Class A is dominant to both E and I. An indication of this is given by the subscript 1 to the letter A; the notation then being E-I-A_1.

APPLICATION OF CLASSIFICATION SYSTEM

Application of the system was made primarily in the experimental "P" areas of the Churchill, Manitoba, district. The procedure consisted of applying the method to the quadrats marked out in each area.

Tabulated results for the five areas are as follows:

P_1 - An area situated along Hudson Bay to the east of the military establishment, containing approximately eight square miles, (Plate I).

P_1 shows the greatest variation in topography as compared with all the areas investigated. A general survey of the area indicates the presence of nine field type divisions (Plate V). The following are the predominant genera found therein: Picea, Larix, Carex, Arctogrostis, Juncus, Triglochin, Habenaria, Salix, Betula, Saxifraga, Vaccinium, Rhododendron, mosses and lichens.

Observation period - July 22-28, 1949.

Quadrat Number	Coverage Description Formula	Field Type
1	F_1-E-I	sedge meadow
2	H_1-D-E	dry hummocks
3	E-H-G	dry hummocks
4	E_1-F	sedge meadow
5	E-H	high dry hummocks
6	A_1-I-H	wooded
7	A_1-E-I	wooded
8	I-F_1-E	wet sedge meadow
9	I-F_1	wet sedge meadow
10	E_1-G	shrub stand

Quadrat Number	Coverage Description Formula	Field Type
11	E-F	sedge meadow
12	I_1-G	low hummocks
13	E-F	sedge meadow
14	I-G	mossy plain
15	E-I	mossy plain
16	D_1-F-H	sedge shrub meadow
17	E-I-G	moss shrub plain

P_2 - Four miles south of military camp bordering on the road to sea-plane base at Lake Farnworth, (Plate I). The topography is a fairly level plain with hummocks reaching a height of almost five feet forming the only interruption. The area is dotted with lakes and small ponds, the latter drying up in the late summer, leaving a bed of organic debris. Three principal field types are found in the area, (Plate VI). The predominant genera found are Picea, Larix, Carex, Scirpus, Epilobium, Betula, Ledum, Vaccinium, mosses and lichens.

Observation period - July 12-13, 1949.

Quadrat Number	Coverage Description Formula	Field Type
1	B-H_1-E	high wooded hummocks
2	F-I	sedge meadow pond areas
3	F_1-B-E	slightly wooded
4	E-H-D	high hummocks
5	H-E_1-B_1	wooded hummocks
6	H-I-B_1	wooded
7	F-D-I	sedge meadow around ponds

Quadrat Number	Coverage Description Formula	Field Type
8	A_1-E-I-H	wooded hummocks
9	B-F	wooded
10	B-H-D	dry hummocks
11	H-E-A_1	hummocks in woods
12	H-E-A_1	hummocks in woods
13	I_1-F-E	lowland sedge meadow pond area
14	I_1-F-E	lowland sedge meadow
15	F_1-B-E	sedge shrub meadow
16	H-E-B_1	wooded hummocks
17	F_1-I	sedge-moss plain
18	I-F_1	sedge-moss plain

P_3 - An area situated part way along the Churchill-camp road, (Plate I).

Approximately 2½ miles in size, it has the general appearance of a sedge shrub meadow, (Plate VII). The predominant genera are _Eriophorum_, _Carex_, _Triglochin_, _Scirpus_, _Betula_, _Salix_, _Vaccinium_, _Empetrum_, mosses and lichens.

Observation period - July 21, 1949.

Quadrat Number	Coverage Description Formula	Field Type
1	F	sedge meadow
2	E_1-G	hummocks
3	H_1-E-G	hummocks
4	I-F	wet sedge
5	H-G-E	high hummocks
6	F_1-I-D	sedge moss plain

Quadrat Number	Coverage Description Formula	Field Type
7	F_1-I-G	sedge moss plain
8	D-F	sedge shrub meadow
9	F_1-E	sedge meadow
10	F-E	sedge shrub plain
11	F-D	sedge shrub plain
12	F-D-E_1	sedge shrub plain
13	D	birch-willow stand
14	F-I	sedge meadow
15	D	birch-willow stand
16	F	sedge meadow

P_4 - Situated approximately four miles south-west of the military camp,

P_4 forms a triangular area approximately 3 miles in extent (Plate I). It has the appearance of a heavily wooded area with scattered clearings, ponds and small streams. In the lower portion, the heavy timber has been cleared, (Plate VIII). Predominant vegetation is Picea, Larix, Juncus, Carex, Salix, Betula, Empetrum, Ledum, Vaccinium, mosses and lichens. Observation period - July 6-10, 1949.

Quadrat Number	Coverage Description Formula	Field Type
1	I-A_1-H	wooded hummocks
2	A_1-I-H-E	wooded
3	F-I-D	sedge meadow near ponds
4	I-H-D-A_1	wooded
5	E-G	shrub stand
6	H-E-A	wooded

Quadrat Number	Coverage Description Formula	Field Type
7	G-F-I	pond areas
8	A_1-F-E	sedge meadow
9	A_1-H-G	wooded
10	G-I-A_1	wooded
11	A-E-I	shrubby woods
12	E-B_1-F	wooded
13	B_1-F-G	wooded
14	B_1-I-F	wooded
15	B-D	wooded
16	B_1-F-E	wooded
17	F-B-G	wooded

P_5 - An area one square mile in size, situated three miles south of military camp. It shows a range ordinarily described as sedge meadow to wooded, (Plate VI). Picea, Larix, Carex, Eriophorum, Scirpus, Betula, Salix, Rubus, Vaccinium, Rhododendron, Ledum, mosses and lichens are the predominant genera found.

Observation period - July 15-20, 1949.

Quadrat Number	Coverage Description Formula	Field Type
1	I-D	low hummocks
2	F	sedge meadow
3	H-E_1	hummocks
4	H-E_1	hummocks
5	F_1-D-I	low sedge hummocks
6	H-E	hummocks

Quadrat Number	Coverage Description Formula	Field Type
7	F_1-D-I	low sedge hummocks
8	H-E	high hummocks
9	B_1-H	wooded
10	A_1-F-I	wooded
11	H_1-E	hummocks
12	G-I	moss plain
13	H_1-E	high hummocks
14	A-E-B	wooded
15	F-I	sedge meadow
16	I-E-H	moss shrub plain
17	E-H	hummocks
18	G-I	moss meadow
19	F-G	sedge meadow
20	E-H	hummocks

TABLE I

Comparison of Classes in "P" Area

Class	Order of Coverage	P_1	P_2	P_3	P_4	P_5
A	I	2	1		4	2
	II				1	
	III		2		2	
	IV				1	
B	I		2		4	1
	II		2		2	
	III	1	3			1
	IV					
C	I					
	II					
	III					
	IV					
D	I	1		3		
	II	1	2	2	1	3
	III		1	1	2	
	IV					
E	I	7	1	1	2	2
	II	2	8	3	2	8
	III	2	2	2	2	
	IV					
F	I	1	6	8	2	5
	II	5	3	2	4	1
	III				2	
	IV					
G	I				2	2
	II	2		2	1	1
	III	2		2	3	
	IV					
H	I	1	7	2	1	6
	II	3	1		2	3
	III	2	2		1	1
	IV		1			
I	I	2	3	1	2	2
	II	2	3	3	4	3
	III	2	2		2	3
	IV					

DISCUSSION AND CONCLUSIONS

In the application of the proposed system to the experimental areas chosen, there is evidence to indicate the usefulness of the method in terrain interpretation. On examining the results of the classification, it is apparent that the formulae obtained may repeat in some areas but not in others, suggesting that uniformity of vegetal coverage may exist in certain regions. Each aggregate of formulae from inspection of Table I (Page 28) shows different class predominance. However, some areas show certain similarities and are, therefore, evidently more closely related. Classes A and B, for instance, are more predominant in areas P_2 and P_4. On the other hand, if only the class most predominant in each quadrat is considered, it is evident at a glance, that the areas are distinguishable. Further consideration of formulae as applied to quadrats within the five areas, reveal the fact of natural association of vegetative types. One readily notices that classes H and E are frequently associated as, also, are classes F and I. This tendency of the vegetative types to form close associations supplies evidence to show that the proposed system is to some extent a natural and not altogether an artificial one.

Where the formula indicates a large percentage coverage of classes A or B, it is apparently obvious that forest conditions prevail. In this respect, also, the type of forest conditions existing may be suggested, if the relationship of these classes to others is examined. The association of Class E with A or B would symbolize an open type of forest since plants comprising the vegetative type E have a certain spacial relationship to each other or to plants of class A or B. This provides a clue to a knowledge of the general habitat of a region.

From an analysis of the results, evidence relating to factors of the habitat, may also be obtained. A consideration of the plants comprising a vegetative type, suggest that if E and H are predominant the topography is more elevated, whereas, if F and I are predominant a low level plain is indicated. Observations substantiating this are illustrated in P_5 where high hummocks show a coverage description formula containing H-E or E-H and the sedge meadow areas F-I or I-F, (Plate II, fig. 2).

The drainage pattern in an area may also be indicated from conditions similar to the above.

Thirdly, inference as to the extent and position of the permafrost contour as well as to some indication of the possible presence of the polygon phenomenon is rendered from an examination of the coverage formulae since the vegetative types covering an area tend to relate condiderably these factors of the terrain.

Since a knowledge of the habitat and its factors can be gained from an interpretation of the system when applied to an area, a ready reference is apparently facilitated for predicting conditions for travel, manoeuvre, and exploration. Maximum resistance to walking is obviously encountered in areas described by formulae in which class D or E are predominant. On the other hand, motorised vehicles would, for the most part, encounter maximum resistance in areas in which A or B show greatest coverage. Change in acceleration, as well as resistance, is apparent from a consideration of class association among the formulae. It would seem, therefore, that increased acceleration should take place in travelling from the area as represented by P_2 quadrat 12 to that represented by quadrat 13.

In addition to supplying information relating to the habitat and problems associated with it, the results obtained from an application of the system to quadrats within an area, serve to point out the inadequacy of the field type designation (Pages 22-27). While providing a ready method, frustration is invariably experienced when the field type expressions are used, in that the area referred to by the same field type label may differ significantly. Quadrats 12 to 17 in P_4, although having a predominant coverage of class B, show distinct differences in formulae. They are, nevertheless, described as wooded. This suggests that a field type description as obtained in survey gives very general aspects only of a region (Plates V, VI, VII, VIII). A quick comparison between the description and the formula, indicating the predominant vegetative types, will illustrate clearly the weakness of field type terminology. One must appreciate, however, that up till now the field type designation has been indispensable even though it is known to be far from adequate.

The classification system proposed expresses in some measure the dominant vegetation in a region. However, where a class has the greatest coverage, it does not necessarily follow that this class forms the dominant vegetation. A quadrat may contain only one tree, comprising at its ground level only a small part of the total area of the quadrat. There is no doubt, however, but what the tree is the dominant member. It appears that if dominance is to be indicated the size of the vegetative unit must be increased, as it influences the analysis which the formula should express.

Besides the above mentioned, simplicity and ease of application appear evident from the application and analysis of the system as applied to the experimental areas.

In the consideration of the results of this investigation, certain conclusions suggest themselves. Some may be substantiated in fact, others in theory. Some have reference to the local picture concerning vegetation in the Churchill area, others are more broadly applicable to the north. It must always be emphasized that with respect to the scope of this work the development of a simple and yet valid and useful method of reference to terrain coverage is the fundamental objective. The results have shown that the proposed classification serves to reflect a range of form within an area, as is shown from an examination of Table I. Field type description definitely does not indicate this fact. Also, relative to the scarcity and disconformity, as well as the peculiar characteristics exhibited by boreal flora, (Page 7), the results show simplicity for vegetative grouping in extreme northern regions.

Furthermore, the classification is adaptable to areas of different sizes. Since the percentage coverage is the important entity, and as this can be obtained from an estimation of the size of the area, there is no set limit to which the classification need be applied. The analysis of the results as applied to the experimental areas prove that the classification can be used to interpret as well as record the vegetal pattern.

The classification, moreover, suggests a theoretical means of relating organic matter to surface vegetation. The vegetative cover governs to some extent the rate of organic decay, since it can affect the absorption rate and aeration of the subsurface. As well as the above, plants belonging to certain vegetative types, class A and B are examples, because of their size and morphology have extensive root systems. These anchoring devices of the vegetative types found in a region determine to some degree the constitution of the subsurface.

On a more general basis, it is evident from the aforementioned remarks that the utilization of vegetative structure, as expressed in the proposed classification, assists in the interpretation and differentiation of certain Canadian boreal regions. Primarily, relative to the needs of muskeg research, it provides a basis for mapping vegetation. The descriptive coverage formula could be plotted for any region in which investigations are carried on. The vegetational map thus obtained would record as well as supply a ready reference for information inferred in the formula for the area. Secondly, the system assists in the interpretation of the expression "muskeg" (Page 4), in that it provides information as to the relation of organic terrain to the surface vegetation, as aforementioned. Similarly, field type expressions such as tundra, heath meadow, sedge meadow, can be adequately interpreted.

These uses are made possible through the inherent nature of the system and its appropriations. Evidence has been presented to show that topographical conditions, as well as factors relating to the habitat, may be interpreted from an application of the system to a region. As the system is presented in an orderly way relative to its four principle factors such an interpretation is possible since it allows for ready reference as well as clarity in understanding the composition of the various vegetative types.

Secondly, the system is short. Where possible the explanations for each class are cut to a minimum. Technical terminology has been avoided successfully. It can therefore be easily understood, thus providing a convenient method for assessing terrain.

One of the principal attributes of the system is the fact that it depends on inspection and estimate only. No knowledge of associations or climax formations is required nor is detailed knowledge of perennating but, root structure, or leaf shape necessary for an application of the system. It cannot be overlooked that it is perhaps in the realm of possibility to obtain information from the results of the classification.

The system can be applied in the field directly or to photographs representing the areas. In the case w here ground photos are used, however, care must be exercised in estimating the size of the area represented. Clarity of the ground photos is also essential as classes composed of plants whose structures are not at once evident may be obscured to such an extent as to be erroneously omitted.

Although the system has many advantages, there are obvious limitations which must be briefly noted. Primarily, the distribution of the class within an area is not emphasized. It is obviously the case, particularly for large areas, that there may be overlapping or superimposing of classes. It seems possible to account for these in the formula. However, it leaves something to be desired.

Furthermore, the system avoids some details which plant ecologists would regard as essential. No species indication is given and therefore it is impossible to separate areas on this basis; for example, black spruce area - white spruce area.

Finally, the system is probably not applicable to the south. Because it was proposed for use in northern regions, it incorporates features peculiar to that area. However, application to test its adequacy for southern terrain has still to be made.

With reference to future consideration of the proposed system, several salient features are noticeable. For one thing, the possibility of applying the system to large scale mapping must not be overlooked, since it would show change in the vegetal pattern from one area to another. Secondly, population density has still to be correlated with the proposed system. Thirdly, the exploitation of the system for specific problems is still to be undertaken. Further application to muskeg interpretation, for instance, is just one of the many interesting investigations to which the proposed system may be applied. Finally, consideration of the possibility that the system provides a fundamental key for other work may be contemplated. Xo for example, in the correlation of low and high altitude photography, photographs at low altitudes, once interpreted, can be used for higher ones.

SUMMARY

1. The need for an adequate system of classification based on vegetative structure, for use by investigators in the north, is explained.

2. An account of the obvious features of the vegetal pattern and the difficulties encountered in defining it are related.

3. A review of the work previously accomplished in the north as related to vegetational analysis is provided.

4. A history of methods previously devised for the classification of vegetation is briefly presented.

5. A new system is presented, based on four factors—plant height, woody tissue in the aerial portions of the plant, space-growth relationship, and texture of non-woody plants.

6. The system was applied successfully in the description of vegetal coverage for "P" areas in the Churchill, Manitoba, region.

7. From the results obtained the system was shown to be useful in designating terrain types and its interpretation.

8. Certain limitations such as the inability of the system to show distribution, and also the possibility that the system is useful for northern regions only are presented.

9. Finally, reference was made to the future possibilities of the proposed system in large scale mapping, correlation of population density, and further application to specific problems, as well as presenting a useful key for other work.

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LIST OF REFERENCES

1. ADAMSON, R. S. The classification of life-forms of plants. Bot. Rev. 5:546. 1939.

2. BRAUN-BLANQUET, J. Plant sociology. (Transl. G. D. Fuller and H. S. Conard). 1932.

3. DANSEREAU, P. A classification of vegetation upon a structural basis with special reference to the taiga. Am. Jour. Bot. 35:740. 1948.

4. HEATH, C. H. and LUCKWILL, L. C. The rooting systems of heath plants. Jour. Ecol. 24:331. 1938.

5. JOHNSON, E. J. Pollen analysis of peat underlying a treeless heath area. (Unpublished M.A. thesis, Department of Botany, McMaster University). 1949.

6. KENNOYER, L. S. Plant physiognomy. Ecol. 10:407. 1929.

7. KUCHLER, A. W. A geographic system of classification. Geogr. Rev. 27 (2):233. 1947.

8. MALTE, M. O. Critical notes on plants of Arctic America, Rhod. 36: 172. 1934.

9. POLUNIN, N. Botany of the Canadian Eastern Arctic, part 1. Pteridophytes and Spermatophytes. Nat. Mus. Can. Bull. No. 92, Biol. Ser. No. 24. 1940.

__________ The vegetation of Akpatok Island, I and II. Jour. Ecol. 22:337. 1934, and 23:161. 1935.

10. PORSILD, A. E. Flora of the Northwest Territories. Can. Dept. Mines and Res., Lands, Parks and Forests Branch. 1937.

11. RADFORTH, N. W. Report on the spore and pollen constituents of a peat bed in the Shipshaw area, Quebec. Trans. R. Soc. Can. 39: 131. 1945.

12. RAUNKIAER, C. The life-forms of plants and statistical plant geography. 1904.

13. RAUP, H. M. Botanical problems in boreal America. Bot. Rev. 7:147. 1941.

14. SCHIMPER, A. F. W. Pflanzengeographie auf physiologische Grundlage. 1898. (Translated 1903.)

15. SIMMONS, H. G. A survey of the phytogeography of the arctic American archipelago. Lunds Univ. Arssk. N.F., Afd. 2, 9(19). 1913.

16. SOPER, J. D. Botanical collections in the north. Unpublished manuscript. Quoted by Polunin, N. Botany of Canadian Eastern Arctic.

17. SUTTON, G. M. Flora of Southampton Island. Unpublished manuscript. Quoted by Polunin, N. Botany of Canadian Eastern Arctic.

18. WARMING, E. Oecology of Plants. 1909.

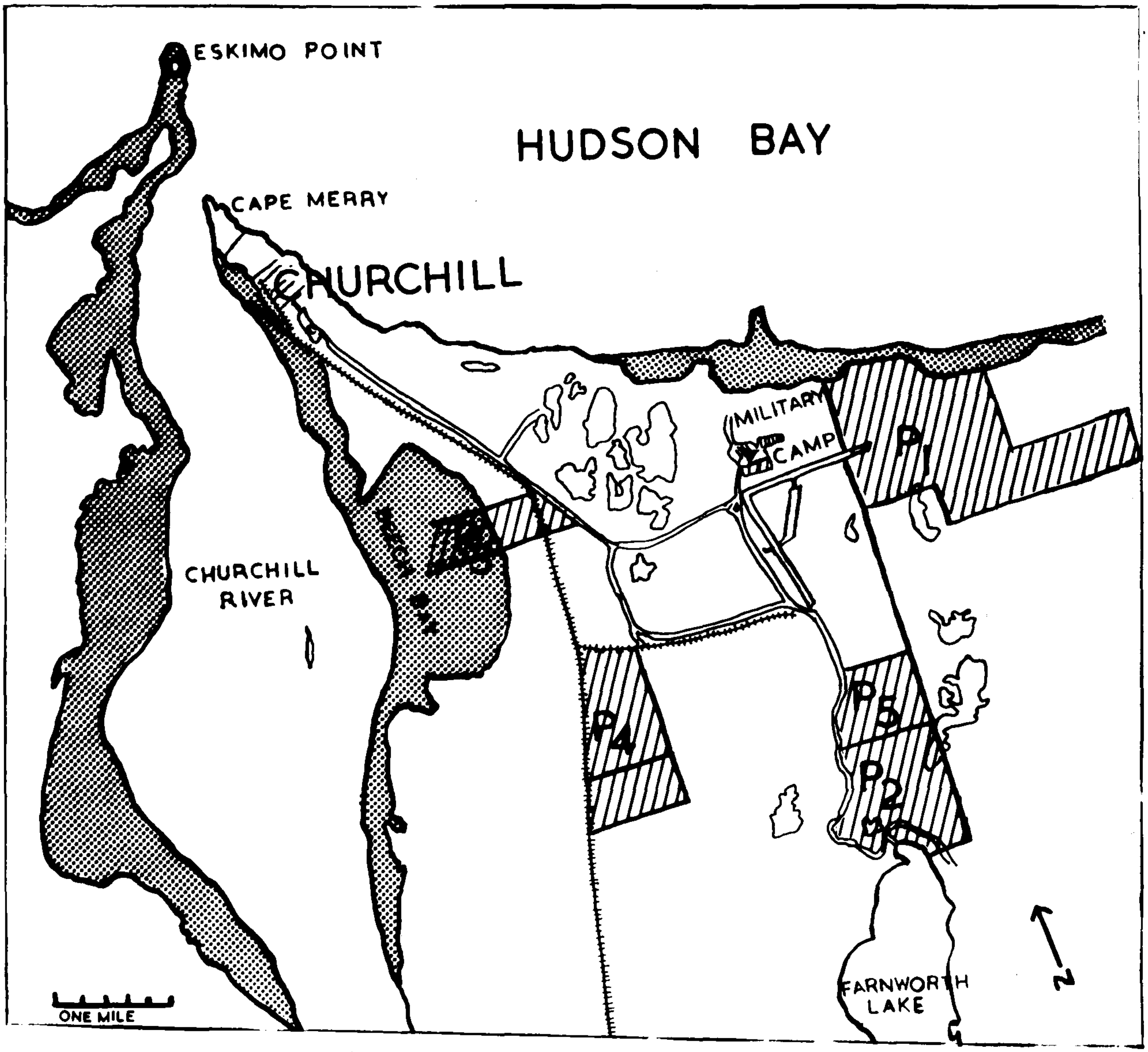
19. WEAVER, J. W. and CLEMENTS, F. E. Plant Ecology. 1929.

EXPLANATION OF PLATE I

Map of the Churchill, Manitoba, district showing positions of "P" areas.

Scale - 1.25 miles to the inch.

PLATE I


ESKIMO POINT
HUDSON BAY
CAPE MERRY
CHURCHILL
MILITARY
CAMP
P1
CHURCHILL
RIVER
P4
P5
P2
FARNWORTH
LAKE
N
ONE MILE

EXPLANATION OF PLATE II

The plate shows examples of typical quadrats in the "P" areas.

Fig. 1. Quadrat No. 14 in P_3 area. This quadret shows a predominant coverage of sedge and graminoid plants with mosses also in abundance. Coverage descriptive formula is F-I.

Fig. 2. Quadrat No. 8 in P_5 with coverage descriptive formula H-5. Also evident in the background is an area whose coverage descriptive formula is F_1-I.

PLATE II

Fig. 1

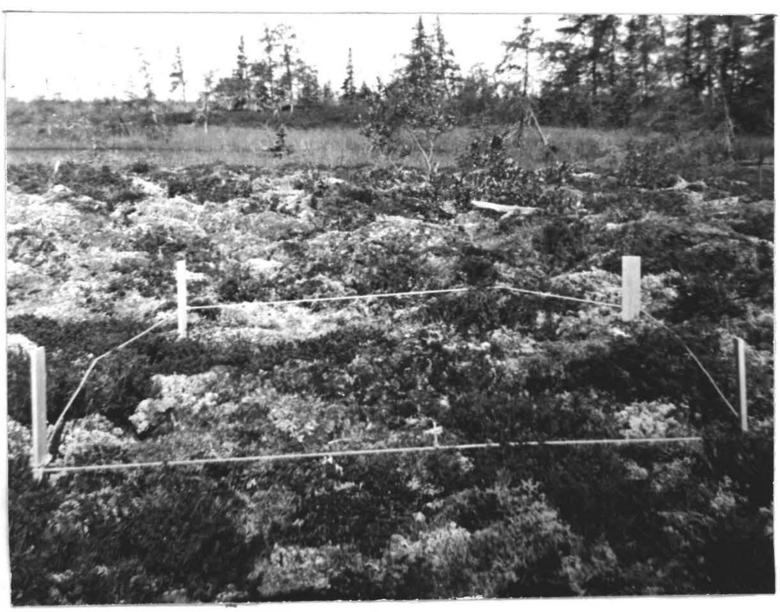


Fig. 2

EXPLANATION OF PLATE III

The plate shows examples of typical quadrats in the "P" areas.

Fig. 1. Quadrat No. 4 in P_2 area. The coverage descriptive formula for the quadrat is E-H-D.

Fig. 2. Quadrat No. 13 in P_5 area. Coverage descriptive formula is H_1-E.

PLATE III

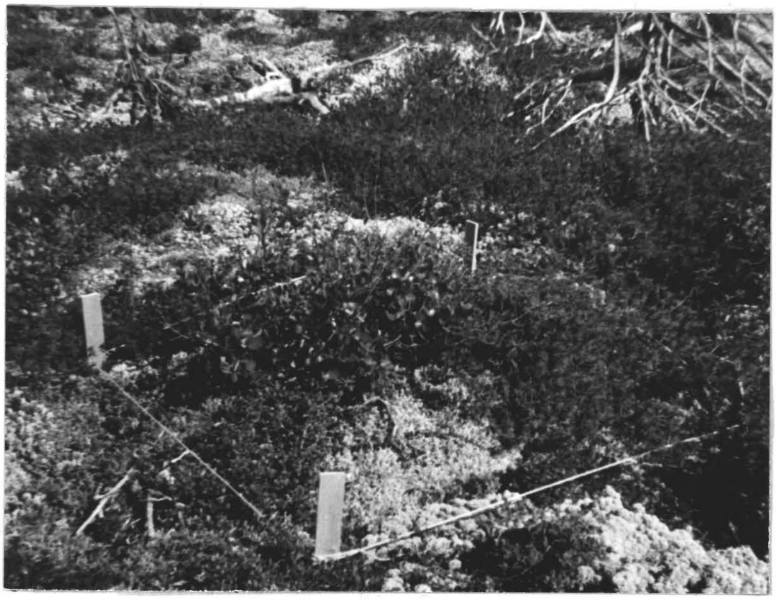


Fig. 1

Fig. 2

EXPLANATION OF PLATE IV

Raunkiaer's life-form classification as applied to species found in Churchill, Manitoba, vicinity is indicated in the isotherms. The following life-forms are shown:

Succulents - S

Epiphytes - E

Mega-Mesophanerophytes - MM

Microphanerophytes - M

Nanophanerophytes - N

Chamaephytes - CH

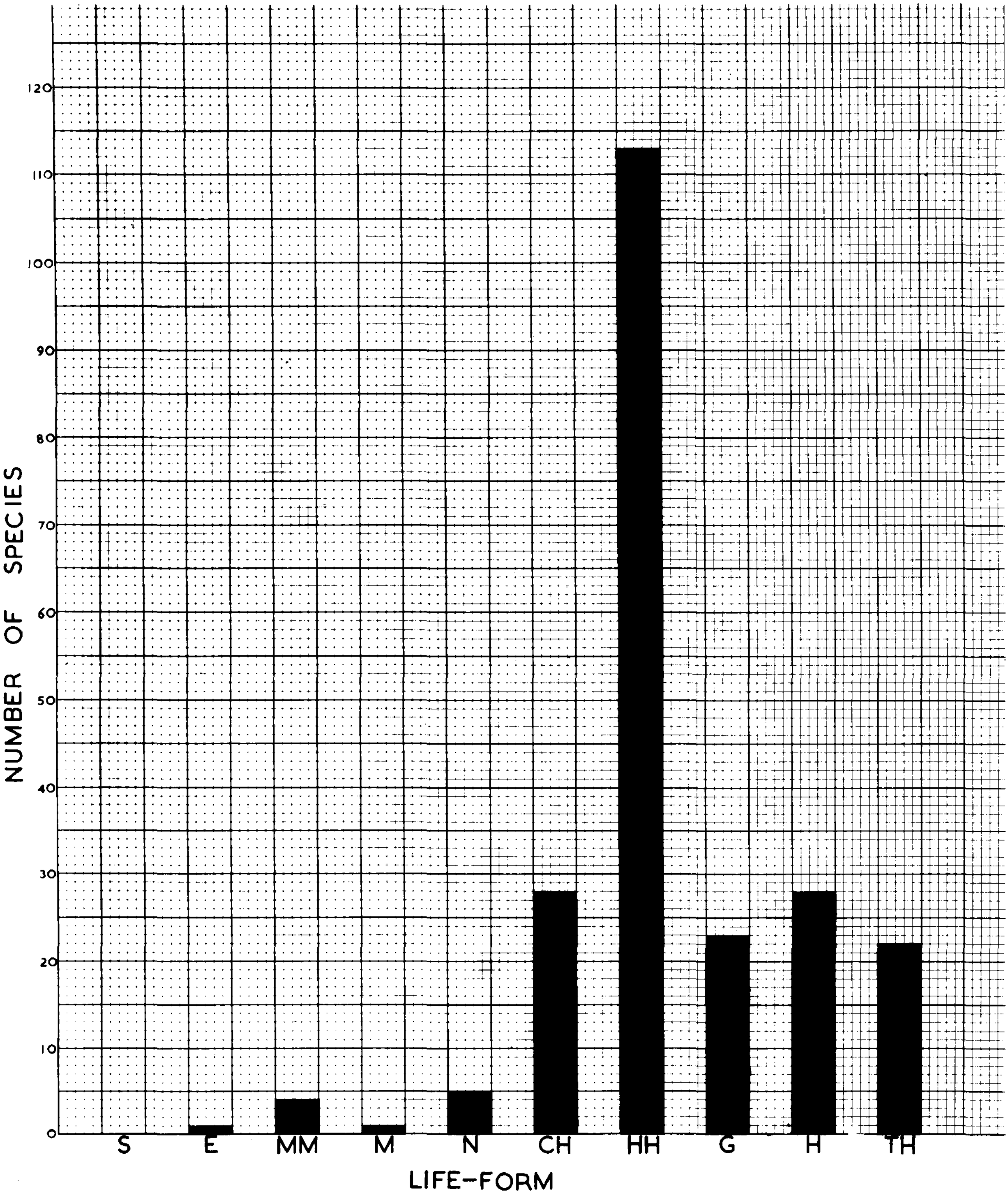
Hemicryptophytes - HH

Geophytes - G

Helo-Hydrophytes - H

Therophytes - TH

PLATE IV

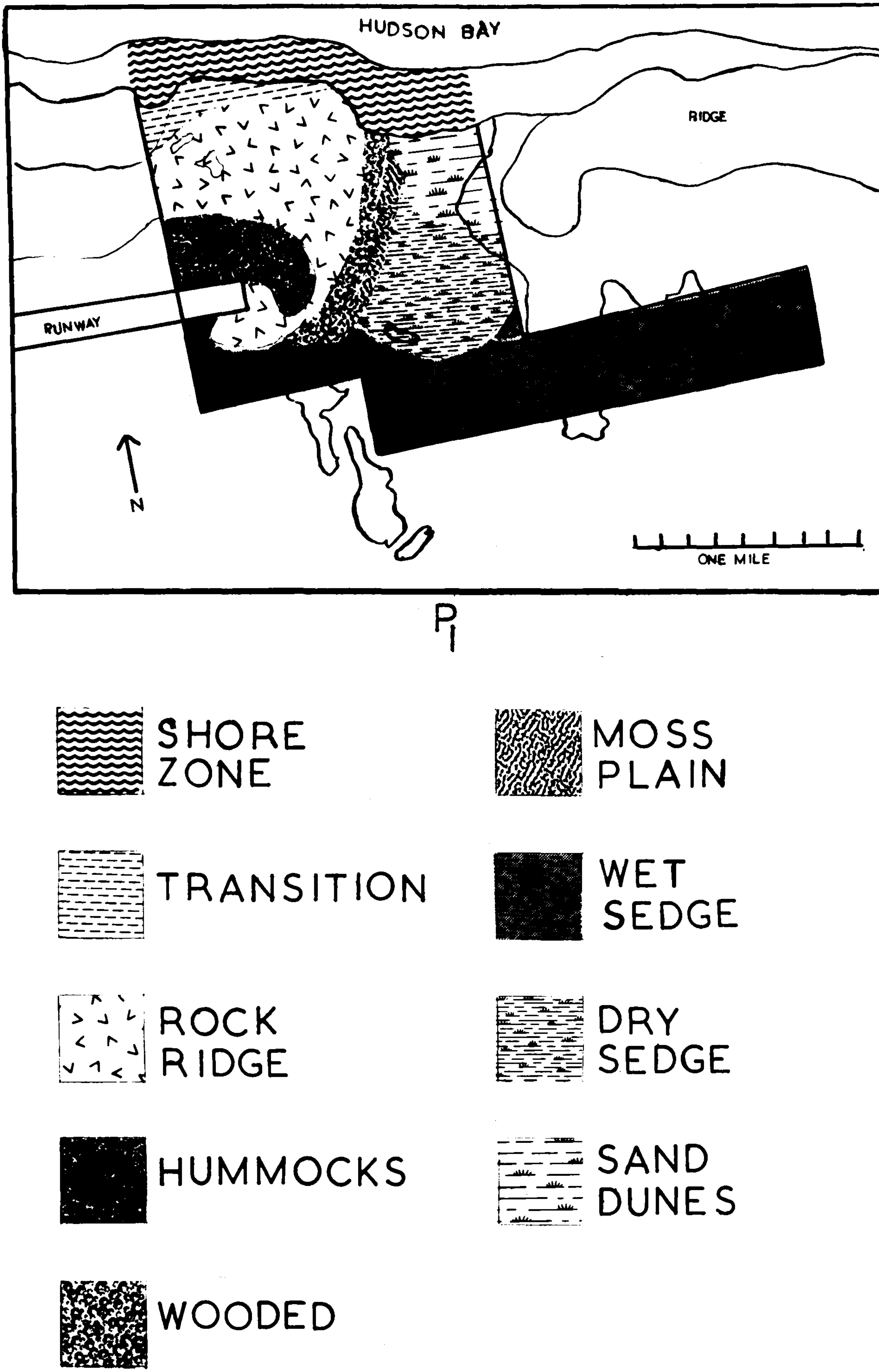

NUMBER OF SPECIES
120
110
100
90
80
70
60
50
40
30
20
10
0
S
E
MM
M
N
CH
HH
G
H
TH
LIFE-FORM

EXPLANATION OF PLATE V

Map of P_1 experimental area. It shows the extent and general field type description.

Scale - .5 miles to the inch.

PLATE V

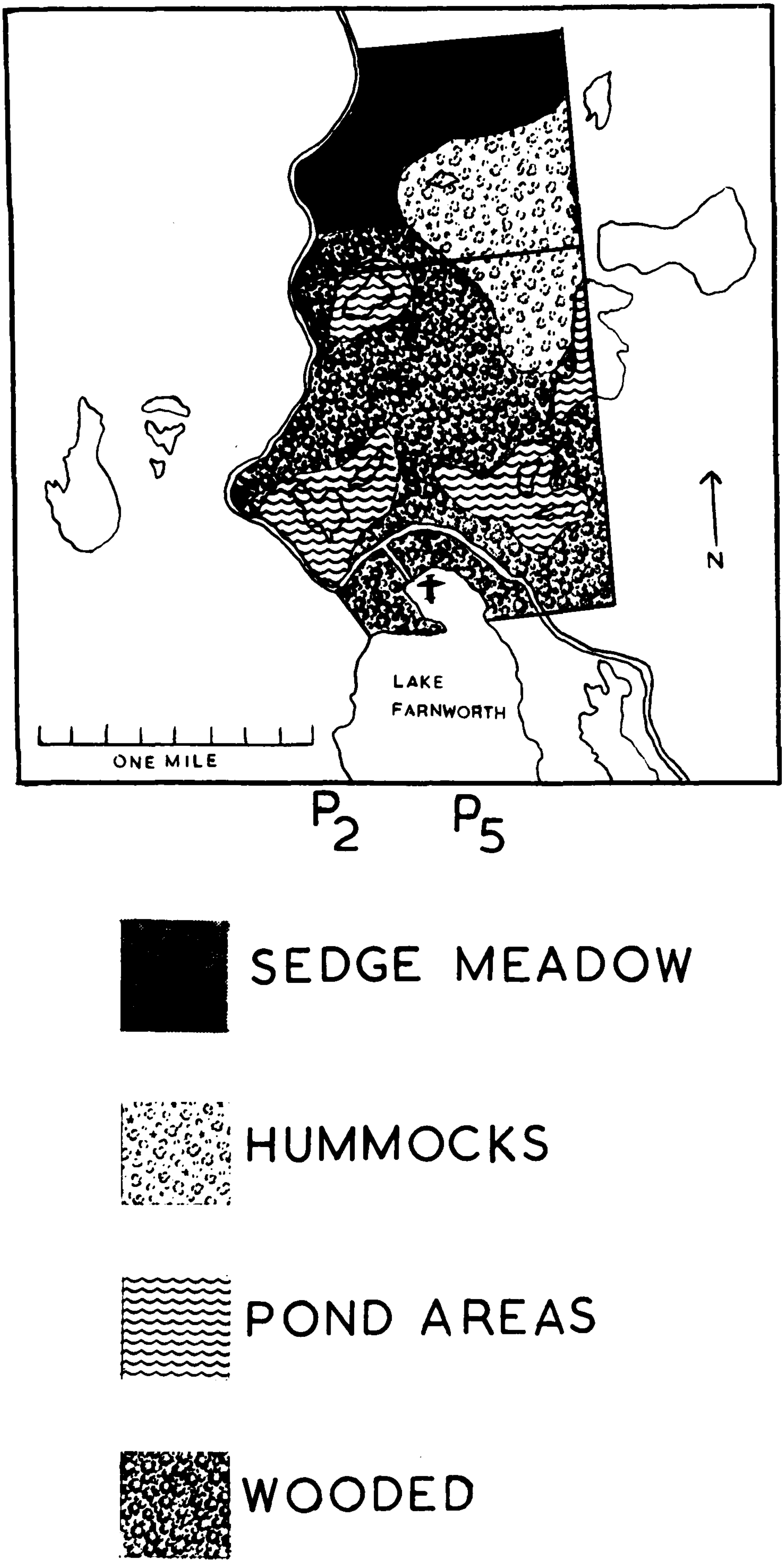

HUDSON BAY
RIDGE
RUNWAY
N
ONE MILE
P1
SHORE ZONE
MOSS PLAIN
TRANSITION
WET SEDGE
ROCK RIDGE
DRY SEDGE
HUMMOCKS
SAND DUNES
WOODED

EXPLANATION OF PLATE VI

Map of P_2 and P_5 experimental areas. P_5 is north of and adjacent to P_2 area. Extent and general field type description are shown.

Scale - .5 miles to the inch.

PLATE VI

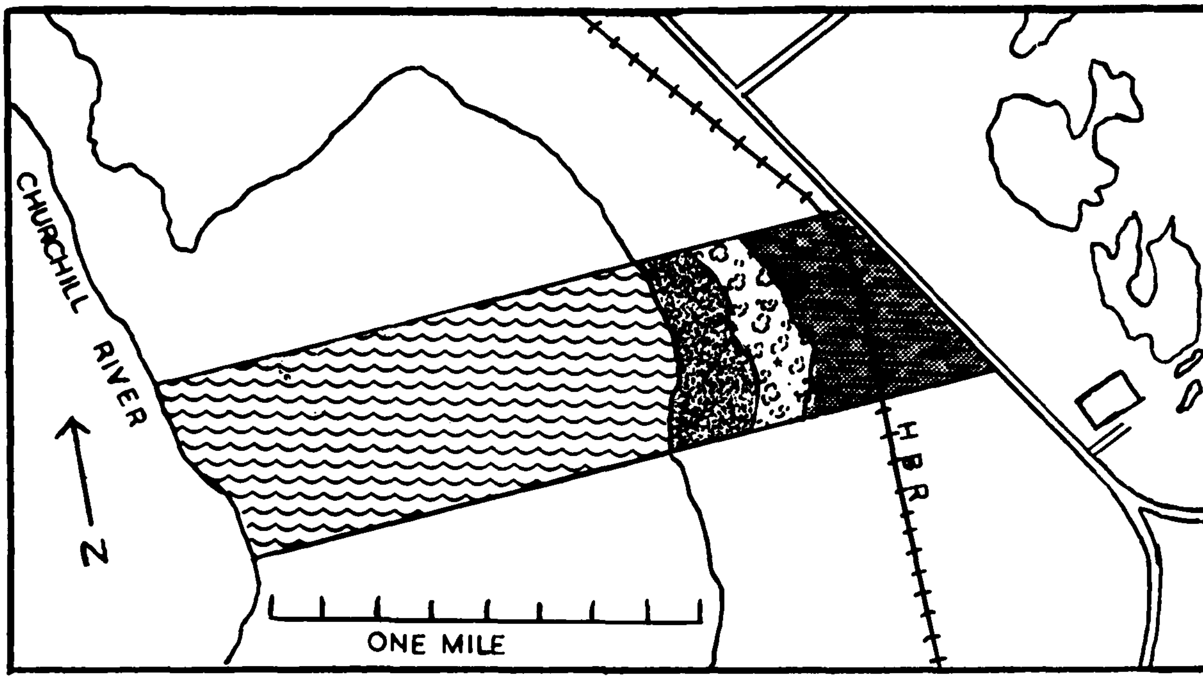

LAKE
FARNWORTH
ONE MILE
N
P2
P5
SEDGE MEADOW
HUMMOCKS
POND AREAS
WOODED

EXPLANATION OF PLATE VII

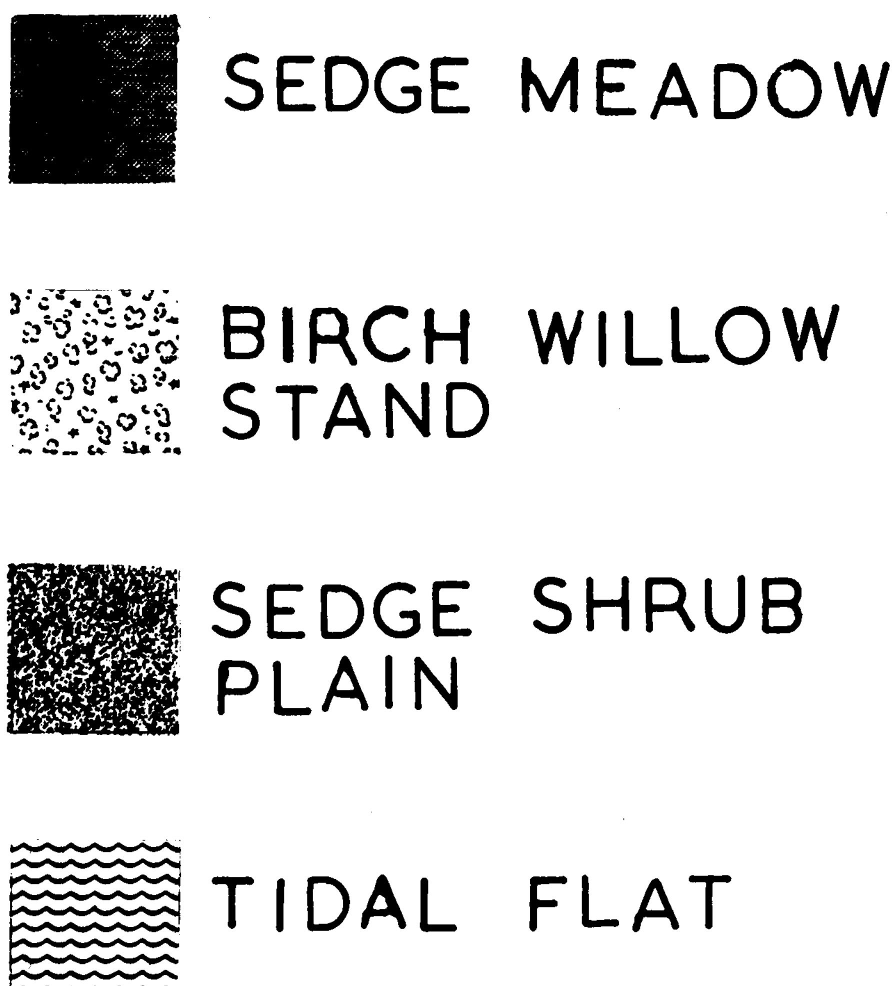
Map of P_3 experimental area. It shows the extent and general field type description.

Scale - .5 miles to the inch.

PLATE VII


CHURCHILL RIVER
N
ONE MILE
H B R

P_3

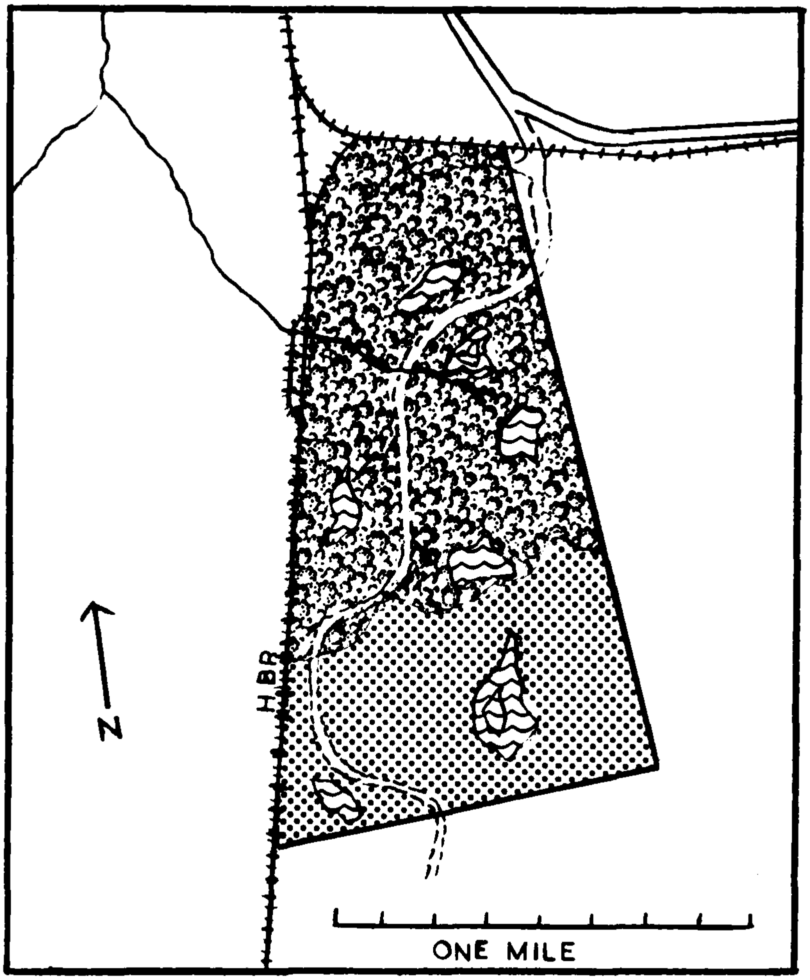

SEDGE MEADOW
BIRCH WILLOW STAND
SEDGE SHRUB PLAIN
TIDAL FLAT

EXPLANATION OF PLATE VIII

Map of P_4 experimental area. It shows the extent and general field type description. A winter tractor trail passes through the area.

Scale – .5 miles to the inch.

PLATE VIII



P_4