The use of plant material in the recognition of norther organic terrain characteristics

Radforth, N. W.

Publisher's version / Version de l'éditeur:

Technical Memorandum (National Research Council of Canada. Division of Building Research); no. DBR-TM-28, 1953-06-01

NATIONAL RESEARCH COUNCIL
CANADA
ASSOCIATE COMMITTEE ON SOIL AND SNOW MECHANICS

THE USE OF PLANT MATERIAL IN THE RECOGNITION OF NORTHERN ORGANIC TERRAIN CHARACTERISTICS

by

NORMAN W. RADFORTH

REPRINT FROM "TRANSACTIONS OF THE ROYAL SOCIETY OF CANADA"
VOLUME XLVII : SERIES III : JUNE, 1953
SECTION FIVE

TECHNICAL MEMORANDUM NO. 28

OTTAWA
MARCH 1954

TRANSACTIONS OF THE ROYAL SOCIETY OF CANADA

VOLUME XLVII : SERIES III : JUNE, 1953

SECTION FIVE

The Use of Plant Material in the Recognition of Northern Organic Terrain Characteristics

NORMAN W. RADFORTH

Presented by G. KROTKOV, F.R.S.C.

IN recent years emphasis has been placed on the importance of muskeg as a major land type in Canada. Aware of this, the writer and his associates have been concerned with a fundamental method of reference for muskeg. Adequate description of the medium proved difficult because definition must not only relate to material, but also to conditions or states to which the material and the environment contribute separately and in combination. The significance of this complexity has been indicated elsewhere when, for engineers, consideration was given to the principles on which a system for muskeg classification should be built (Radforth, 1952). There, the author proposed and utilized vegetal coverage classes and combinations of these to assist in demonstrating variation in the living component of the organic terrain.

Here, emphasis will be placed on the recognition of botanical relationships in connection with the defining of cover type and subsurface features within the organic terrain. If such relationships among plant components, living and fossilized, are manifest, two major needs will be satisfied. Relationship between characteristics of subsurface and surface organic terrain will be easier to predict and assess, with assurance that generalizations in the field will be more reliable. Also, it will be possible to assess, evaluate, and map conditions associated with terrain change over large areas, particularly for purposes of airphoto interpretation.

FORM DIFFERENTIATION IN VEGETAL COVERAGE

The northern organic terrain providing the greatest number of problems for the field worker falls within the taiga of the Churchill area of Hudson Bay. Between The Pas and the Churchill area in Manitoba for a distance of over five hundred miles, organic terrain is by far the predominating type. South from Churchill on Hudson

Bay, it extends for distances exceeding twenty miles with no interruption and even where finally broken regains characteristic continuity beyond the intrusion.

In these regions, an observer has little difficulty in recognizing a marked peculiarity in vegetal coverage, even though he lacks experience with northern muskeg. There are frequently abrupt character changes in the vegetation. This has the effect of marking out or delimiting discreet areas of vegetation with contrasting character. The observer finds it convenient to make use of these areas as descriptive references. However, when asked to explain the qualities by which detection of difference has been claimed, his reference terms are likely to be ill defined, often intangible, and inconsistent. This is particularly the case when the observer is not trained botanically.

Preliminary analysis of the basis leading to detection suggests vegetal form, not species distribution, to be the important agent. Sometimes, topographic and other physiographic factors are influential but usually in a secondary sense.

Following extensive ground and air survey over wide areas of northern muskeg, the writer has found it convenient to establish a classification system referring to relatively pure categories of vegetation (Radforth, 1952). Nine fundamental classes or coverage types are designated. Each is characterized on the basis of variation of three morphological factors—presence or absence of woodiness, range in stature and, where necessary, texture of the foliose material.

Combinations of these class types furnish the descriptive coverage formula for any given area of muskeg. Class components, each represented by a letter, are arranged in the formula in order of prominence. If present to a degree less than 25 per cent by inspection of the total coverage, the component is arbitrarily not significant.

It will be appreciated that class combinations are more significant as designators of coverage character than are the pure classes, the elementary constituents. For consideration in this account, coverage combinations have been mapped (Fig. 1). The combination formulae apply to areas sufficiently large to allow for comparisons with terrain character and change in terrain conditions. They are proving useful for geographical demarcation in the field, on maps, or for airphoto interpretation. Also, they are suggestive of natural relationship in the synoecological sense.

Of the nine coverage classes necessary to designate construction of the coverage, four (A, B, D, and E) contain essentially woody plants. The remaining classes (C, F, G, H, I) are non-woody. In the former group, all but the first-mentioned class contain plants less than fifteen feet high. In the latter group no plants exceed a height of five feet and this order of height is rare. Immediately south of the Churchill area, coverage formulae containing Class A (strictly arboreous) or Class B (dwarf tree or tall shrub) may be common (Fig. 2). In parts of the coastal area of Hudson Bay and generally to the north of the arboreous coverage, Classes F, E, H, and I are comparatively prominent (Fig. 1). With the exception of E (shrubs under two feet) all members

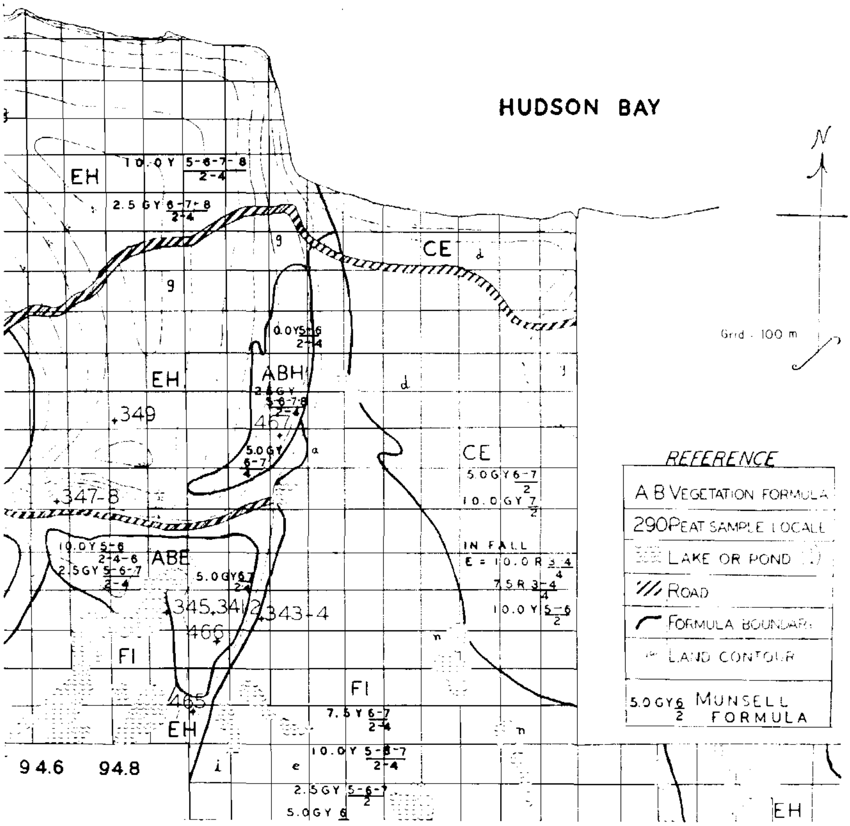

FIGURE 1. Muskeg coverage description map of a coastal area east of Churchill. The spatial relationship between three primary coverage types (E.H., F.I., and C.E.) and two secondary ones (A.B.H., A.B.E.) is expressed.

Topographic symbols (*a*, *d*, *e*, *g*, *i*, *n*) relate to the descriptions established in an earlier work (Radforth, 1952). Among them *d* (rock gravel plain), *g* (exposed boulder), *n* (pond or lake margin sloped) are characteristic of the coverage types with which they occur.

Colour ranges expressed by the Munsell formulae also assist in describing and assessing the coverage character.

of these classes are non-woody: F, eriophoraceous in growth habit; H, lichenaceous, mostly in mats; and I, moss-like, frequently in mats or in hummocks. Beyond the arboreous zone to the south, using the Hudson Bay Railway as a reference axis, treeless barrens are very extensive. Here, combinations of F, E, H, and I cover areas exceeding one hundred square miles, with only negligible interruption by woody plants over five feet in height. The common plants making up these cover zones are listed in Table I.

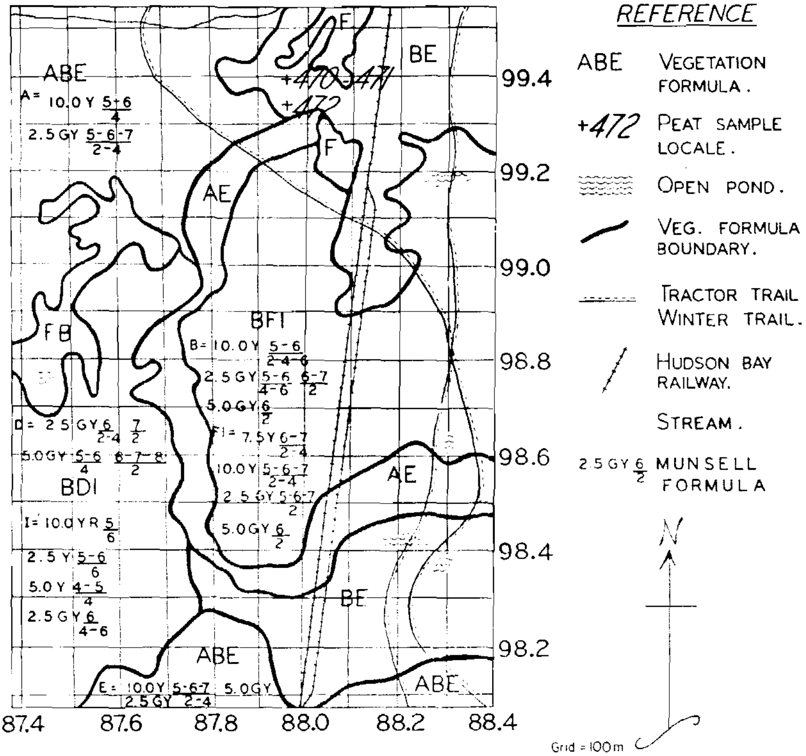

FIGURE 2. Coverage description map for typical muskeg immediately south of Churchill, Manitoba, where dwarf trees and tall shrubs are common (cf. Fig. 1).

The splendid work of Lewis and Dowding (1926) on floristics of more southern confined muskegs, leads one to the conclusion that, for terrain studies, the concept implied in the expression "ecotone" is highly significant. Sometimes borderlines between associations are sharp, sometimes they are ill defined. This also applies to the more northern muskegs. However, ill-defined ecotones are very common,

TABLE I

SPECIES PREDOMINANT IN VEGETAL COVERAGE CLASSES
(Cf. descriptions pages 54–6)

	Class								
	A	B	C	D	E	F	G	H	I
Larix laricina (DuRoi) Koch.	x	xx		x					
Picea glauca (Moench.) Voss.	xx	x		x					
Picea mariana (Mill.) B.S.P.	x	xx		x					
Betula glandulosa Michx.		x		xx	x				
Salix spp.	x	xx		x					
Andromeda polifolia L.					xx				
Arctostaphylos rubra (Fern.) Rhed. and Wils.					xx				
Arctostaphylos uva-ursi (L.) Spreng.					xx				
Dryas integrifolia M. Vahl.					xx				
Empetrum nigrum L.					xx				
Kalmia polifolia Wang.				x	xx				
Ledum decumbens (Ait.) Lodd.					xx				
Ledum groenlandicum Oeder				x	xx				
Rhododendron lapponicum (L.) Wahlenb.					xx				
Rubus arcticus L.					xx				
Rubus chamaemorus L.					xx				
Vaccinium uliginosum L.					xx				
Vaccinium Vitis-Idaea L.					xx				
Calamagrostis canadensis (Michx.) Beauv.			x						
Carex spp.						xx	x		
Eriophorum angustifolium Roth.						xx			
Eriophorum scheuchzeri Hoppe S. lat.						xx			
Juncus albescens (Lge.) Fern.						xx	x		
Epilobium spp.									
E.g. *E. angustifolium* L.							xx		
Pedicularis spp.									
E.g. *P. labradorica* L.							xx		
Petasites palmata (Ait.) Gray							xx		
Petasites sagittata Pursh.							xx		
Senecio spp.							xx		
E.g. *S. palustris* (L.) Hook.									
Hypnaceae spp.									xx
Sphagnaceae spp.									xx
Cladonia spp.									
E.g. *C. coccifera* (L.) Willd.								xx	
C. fimbriata (L.) Fr.								xx	
C. gracilis (L.) Willd.								xx	
C. rangiferina (L.) Web.								xx	

almost characteristic in the north. Often the gradient between associations is so gradual and extensive that it is hard to recognize a mictium. The dynamic nature of coverage development in the north is made increasingly difficult to understand from the floristic aspect because many species are often found which are common to different ecological circumstances. For these reasons the species represented in Table I are difficult to relate by the usual phytosociological methods unless the concept of "life form" is applied.

The evidence presented here seems to indicate that "communities" as interpreted on a morphological basis are clearly delimited. The relationships they seem to reflect (Figs. 1–3) are natural ones, presumably largely controlled by microclimatological, edaphic, and physiographic conditions.

That species can range into different morphological class zones is not unnatural. Seral development may be proceeding at different rates according to the degree of influence of ecological control. The latter may also be responsible for the localized difference in plant stature applicable to many species. A good example of this is *Ledum groenlandicum* Ceder which appears to have several stature ranges recognizable *en masse* by inspection in the field.

Presence of "form communities" discourages any tendency to regard muskeg coverage as advancing towards a stage when it might be referred to as a "continuum." Subseres, on a form basis, seem to maintain their identity. For those interested in the applied aspects of organic terrain interpretation, this is important. Apparently, discreet zonation of vegetative form may always be expected as a convenience in demonstrating organization and change in the muskeg surface features at all stages of development.

Though it is not within the scope of this account to deal with the use of colour as an interpretive agent in organic terrain studies, secondary reference should be made to its importance. Colour as a variant in terrain coverage character is frequently helpful in identification of class components and delimitation. It is also useful in the comparison of field characters with airphoto records, whether the latter are in colour or not.

The writer finds the best system of colour reference for field use to be the Munsell System (*Munsell Book of Color*) which expresses colour in terms of hue ("relation to red, yellow, green, blue and purple"), value ("lightness") and chroma ("departure from neutral"). Fractions symbolizing values for these components have been used in estimating colour range for different cover assemblages (Figs. 1–3). Seasonal advance must be kept in mind when applying them. However, for a given time, some shift in colour range is recognizable from one cover designation to another. It is these slight characteristic differences which provide useful collateral in large-scale field survey from the air.

Plant Remains as Aids in Organic Terrain Interpretation

Fossil plants rank high in significance in that they form the major portion of the mass of material in organic terrain. However, their utilization as reference material is limited, unless organized relationship among them is revealed. Technical field investigators and soil taxonomists tend to describe peaty organic deposits as collections of mosses, leaves, twigs, and roots of higher plants which suggest an unorganized heterogeneous mixture of constituents. Published contributions offsetting this attitude are few. Dachnowski-Stokes (1933) has presented the most encouraging account in this regard and his work demonstrates how peaty deposits may differ on the basis of the predominant constituent species. Others have revealed successional organization in peats based on microfossil determinations. However, the former kind of contribution, scarce at the outset, emphasizes constituent species, not constituent plant form units, and the latter utilizes materials which are largely extrinsic. One contributes to peat genesis on a floristic and ecological basis, the other to interglacial and postglacial history of forests and the distribution of tree species.

Neither type of study, though invaluable in its own sphere, lends itself adequately or directly to investigation of the physical attributes and organization on a form range (gross morphological) basis. Form, size, and spatial relationship of macroscopic constituent particles are as important for the applied studies on peats as for an adequate understanding of mineral soils. Also, microfossils to be useful must reveal organization relative to peaty accumulation. To accomplish this, fossil pollen and spore derivatives of intrinsic source must be emphasized in analyses.

Finally, an approach is required which will be appropriate to an adequate definition of muskeg. This the writer found necessary to define elsewhere as "the term designating organic terrain, the physical condition of which is governed by the structure of the peat it contains, and its related mineral sub-layer, considered in relation to topographic features and the surface vegetation with which the peat co-exists" (Radforth, 1952).

The use of macrofossils for interpretation depends upon the purpose to be served. Presence or absence of large members throughout depth in the organic deposit is important to engineers. Bearing potential and other characteristics will vary with this attribute. Whatever the special need, results depend upon the possibility of classifying the macrofossils as to their size, form, arrangement, and predominance. That variation in size and form does exist will be granted at the outset. How to treat this for classification purposes is not yet fully understood. Variation in arrangement and predominance, if present, may not be revealed on an organized and consistent pattern or series of patterns.

Fortunately, this problem, which is the chief concern of this paper in relation to macrofossils, is not unsurmountable. Its solution lies in the possibility that the record of seral or subseral advance for muskeg is preserved. Since most organic terrain is poorly drained and aerated even in its early history, it is a natural medium for fossilization. Even should seasonal drying, microclimatic change, or edaphic conditions interfere, some record persists. Also, even though certain plants or plant parts disintegrate before or during fossilization leaving no trace of their former presence, field survey indicates that a partial record still remains.

To seek evidence for organized pattern in macrofossil constitution by random selection of gross peat samples is undesirable. Yet this was the method used in all preliminary surveys. The most that the results indicated was confirmation that macroscopically the peats differed widely. Some samples consisted of large interlocking woody conglomerations. Others had a fine-textured matrix that seemed typical for the designation "black muck" used on occasion to define muskeg. The gradient between these two extremes was marked by numerous examples distinguishable on the basis of particle size, form, arrangement, and predominance.

When community development in surface coverage became discernible, search for variation of macrofossil constitution was made accordingly. Significant change in coverage formula was accompanied by evidence of change in macrofossil composition. Though random sampling of organic material was made, it was applied more vigorously wherever surface vegetation pattern changed. Thus, even before discreet surface communities were discerned, indirectly their locations were objectively marked by change in density of subsurface sampling.

As yet quantitative evidence demonstrating macrofossil sample variation with coverage formula is not available. However, descriptive data of a qualitative nature are at hand for several hundred samples. In Fig. 3, coverage formula HE is represented in terms of macrofossil constitution by a predominance of fine-textured, wood-fibrous matrix with associated non-fibrous amorphous matrix. This constitution is interrupted at intervals with discontinuous masses of coarser, mechanically resistant, woody lengths.

For coverage formula AE, the entire mass of peat macroscopically resembles the discontinuous member of HE, except for a foundation of coarse fibrous members varying in size from one-half to one inch in cross-section.

For coverage formula BE, the composition is similar to that for the foundation of AE, with the addition of occasional coarser components as in HE.

Examination of macroscopic content at locations 478 and 479 (Fig. 3), which lie in FI, shows a non-woody fine-textured fibre predominating. This kind of construction is often interrupted by amorphous organic muck and the combined type continues as a background matrix throughout FI, the common coverage for the terrain represented in Fig. 3. Open water occurs only in FI.

Though these descriptions are qualitative in nature they seem to satisfactorily establish the principle that coverage type can be correlated with subsurface macrofossil constitution.

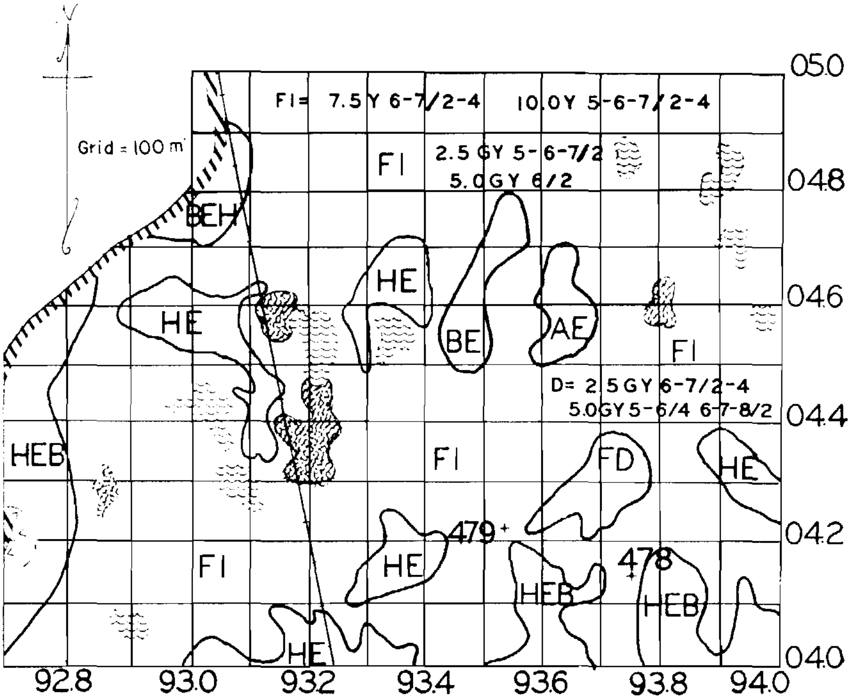

FIGURE 3. Coverage description map for a muskeg type area four miles south of Churchill. The primary coverage is non-woody, less than 2 ft. in height, in discontinuous mats in a mossy matrix.

The level of consistency of the interrelationships expressed is encouraging. This is fortunate, and useful in predicting local terrain conditions. However, there are difficulties, particularly with peat depths exceeding five or six feet. In deep peats, fine-textured, non-fibrous constitution is prevalent in the basal portion which might represent most of the depth of the peat. Also, thickness of fibrous mats and the construction of their components may differ. Spatial relationships between discontinuous secondary units in given types may vary. Similar significant differences occur in given field samples of mineral soils which otherwise compare more or less favourably on a broad basis.

Further evidence of subsurface organization to facilitate prediction of terrain conditions and change rests on the results of microfossil analyses. The writer demonstrated elsewhere (Radforth, 1952) that fossil pollens and spores served as useful indices for reflecting developmental organization in the peat. Seven histogram sets were used. The variants (fossil pollens and spores) were termed index units (Figs. 4, 5). Their frequency was recorded for every two inches of depth as proportions of total counts. Frequencies based on counts higher than 200 did not vary appreciably.

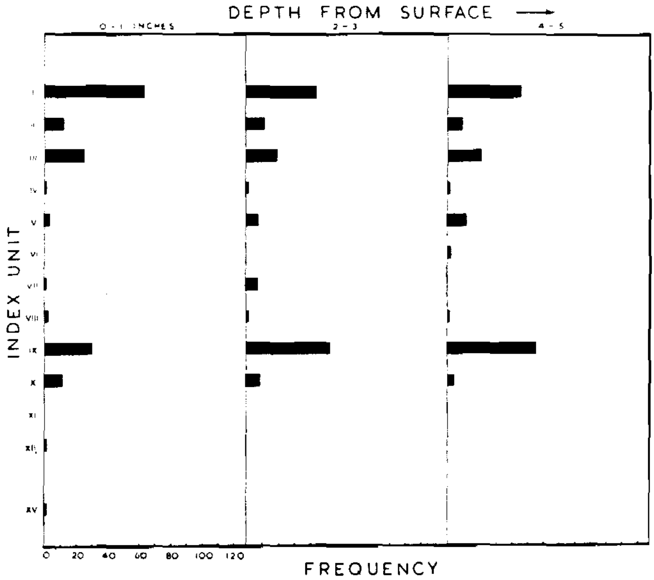

FIGURE 4. Histogram patterns expressing frequency relationships for peats high in Cyperaceous pollens (Index unit IX). The patterns do not change appreciably with depth.

A comparison of histogram results suggests several conclusions:

1. Stable peat constitution throughout depth may occur (Fig. 4).
2. Peats stable in constitution throughout depth may differ in constitution with each other.
3. Some peats, apparently not stable, may reflect a constitutional trend (Fig. 5).
4. Constitutional trends may differ from one example to another.

Intelligent appraisal of these derived observations depends upon a knowledge of the botanical equivalents of the index units, which was not to be found in previous accounts. The botanical designation for each index unit is given in Table II. The somewhat artificial order of listing has been deliberate. It facilitates quick reference in comparing histogram sets.

TABLE II
BOTANICAL DESIGNATION OF INDEX UNITS

Index unit	*Microfossil (pollen or spore)*
I	*Pinus* spp.
II	*Picea glauca*
III	*Picea mariana*
IV	*Alnus*
V	*Betula*
VI	Salicaceae
VII	Ericaceae
VIII	Herbaceous (coverage class G)
IX	Cyperaceae
X	Sphagnaceae
XI	Polytrichaceae
XII	Polypodiaceae
XIII	Equisetaceae
XIV	Lycopodiaceae
XV	Gramineae

Fig. 4, showing a set of histogram patterns which are primarily similar, also shows a high predominance of index unit IX (Cyperaceae) throughout its depth. Where Cyperaceae is relatively high, it is generally the case that there is little evidence for the establishment of a constitutional trend in the peat. When units IV (*Alnus*), V (*Betula*), VI (Salicaceae), VII (Ericaceae), and X (Sphagnaceae) all increase in relation to IX (Cyperaceae) there is also a general similarity of histogram pattern with depth and little suggestion of constitutional change, especially if Sphagnaceae and Ericaceae are unusually high.

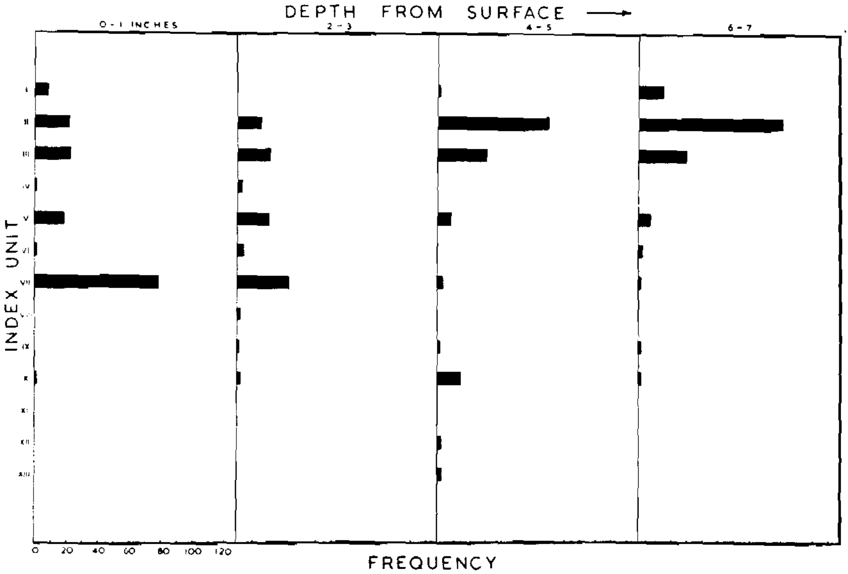

FIGURE 5. Histogram patterns in which relation predominance of index unit VII (Ericaceae) is gradually achieved with decreasing depth of peat. This type of series occurs with E.H. coverage (Fig. 1) and the peat is relatively well drained.

There are of course exceptions. In the case of Cyperaceous dominance, constitutional trends will be evident in the depth scale if topography is irregular even though the amplitude of contour change is only two to three feet. Such changes sometimes occur at intervals of from twenty to a hundred feet.

A similar situation may arise as an exception when Sphagnaceae and Ericaceae are prominent in the sequence of histograms. However, in this case the amplitude of contour change is greater, from two to five feet, often occurring at intervals from ten to fifty feet apart.

Where, in a given set of histograms, there is dissimilarity in the sequence, the constitutional trend revealed in the peat is reflected in the histogram set as a whole (Fig. 5). Here, Ericaceae has gradually moved into relative prominence at the expense of *Picea glauca*.

In Fig. 6, V (*Betula*) then VI (Salicaceae) increase in relative predominance and IX (Cyperaceae) remains steady. Unit VII (Ericaceae) is not prominent at any depth.

The sets of histograms shown in the text figures represent shallow peats. Sometimes top, uncompressed organic matter is several inches to a foot in depth over the more consolidated organic matter below.

Hence the muskeg as it appears in the field ranges from one to three feet in depth. In muskegs varying from three to six feet in depth, microfossil constitutional trends of a secondary nature may be in evidence. However, primary trends in deep peats showing Cyperaceous prominence at any depth maintain this characteristic at all depths (Fig. 4). When Sphagnaceae, Ericaceae, and Betulaceae show relative predominance over Cyperaceae in deep peats at a given depth, this characteristic is generally maintained at any depth. At the moment of writing, the principles outlined here for shallow peats apparently apply for deep peats with the qualification that, for the latter, secondary constitutional trends may become apparent. These represent a measure of botanical instability in muskeg community development. However, their effect is negligible for purposes of assessing organic terrain variation because they do not appreciably change primary microfossil constitutional stability or trend.

Microfossil studies, in signifying the kind of stability or the kind of trend prevalent in the peaty matrix, provide the most accurate and detailed accounts for organic terrain classification and interpretation. Without this detail, it would be unsafe to predict structural change

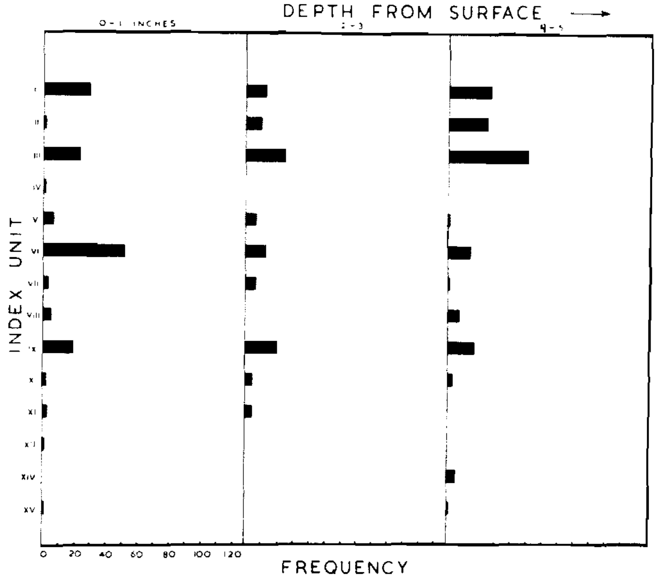

FIGURE 6. Histogram patterns showing change in frequency relationship of microfossil index units with depth. This analysis compares favourably with coverage formulae prominent in dense woody constituents, e.g., B.D.I., Fig. 2.

in the terrain. They are also essential to the establishment of a reliable basis of correlation between surface features and macroscopic subsurface constitution.

Correlation of Surface and Subsurface Vegetal Data for Special Cases

Though microfossil investigations are fundamental to organic terrain interpretation and to disclosure of organization in peaty material, their contribution is enhanced when considered along with other data. The importance of surface studies and macrofossil survey has already been mentioned. With these it is instructive to correlate any unusual topographic, edaphic, and climatological influence. Also, to assist in aerial interpretation programmes which may follow ground surveys, a knowledge of colour relations in the coverage is essential for best results.

Often a topographic peculiarity in the terrain suggests a problem of muskeg interpretation involving the general appraisal suggested. An example is a type of polygon formation arising frequently in muskeg where permafrost is prevalent. The polygons in Fig. 7 were photographed at an altitude of about 1000 feet when *en route* to Padlei about two hundred miles northwest of Churchill, Manitoba. The detailed study of this type of phenomenon was made about sixty miles to the south of Churchill where the features were typical and the data relatively easy to obtain.

The coverage is also typical for one class of polygon (Figs. 8, 9, 10). Each polygon is ditch-like and along with neighbouring polygons forms a network of depressions, often with abrupt walls except where wind action has uncovered the dead organic remains on the shoulders (Fig. 8). Segments of two depressions are shown in Figs. 8 and 9 with metre quadrat stakes in place. The polygon encloses a peaty plateau with hummocks frequenting the marginal zone (Fig. 10).

The coverage in the depressions contrasts markedly with that on the plateaus. Usually for the former the coverage class is FI and less frequently FD (Figs. 8, 9). For the plateaus the coverage is HE (Fig. 10). The macrofossil constitution throughout depth compares favourably with normal HE coverage (see page 60), except for the upper third (about one foot) of the peat in the depressions where it largely resembles that for FI elsewhere (see page 61). Occasionally where D class becomes influential, the coarse wood-fibrous element invades the peaty matrix.

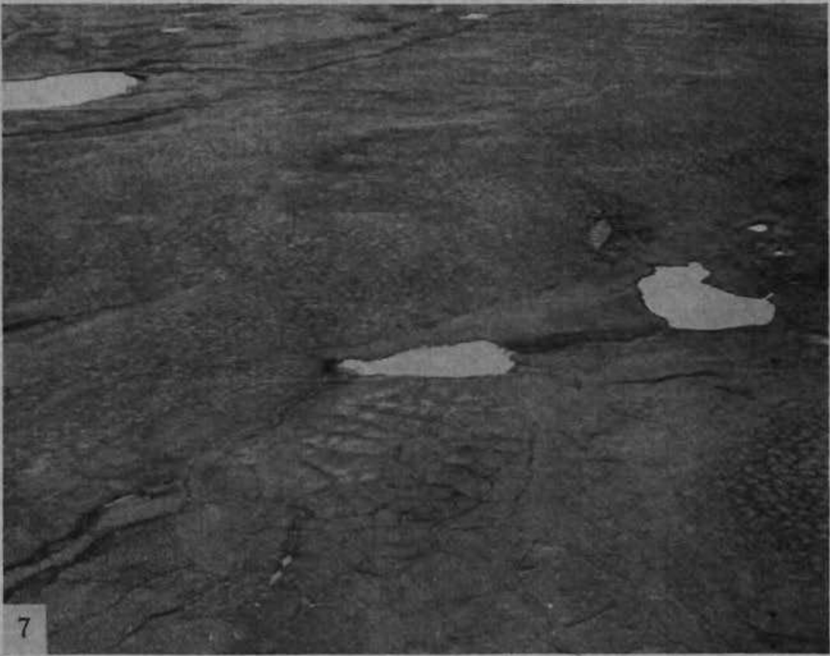

FIGURE 7. Aerial photograph taken at an altitude of about 1,000 feet *en route* to Padlei from Churchill, showing polygon formation in the foreground.

FIGURE 8. A polygon marginal depression showing some F.D. coverage and exposed eroded shoulders of dead organic material.

FIGURE 9. A polygon marginal depression showing F.I. coverage. Drainage here is poor as compared with that for F.D. coverage.

FIGURE 10. A type polygon enclosure demonstrating frequent hummocking which occurs with H.E. coverage in the polygon plateaus thirty miles south of Churchill.

Microfossil analysis in the plateaux shows a uniform constitution comparing favourably with that described on page 60 for HE. In the depressions a trend is exhibited in the upper portion in the direction of the constitution described for FI.

The second category of polygons is recognized at once by F and FI class coverage for the plateaux with macrofossil and microfossil constitutions typical for FI coverage. In the depressions the coverage class is DF in the Churchill area, changing to F or I towards Padlei (Fig. 7). For the DF coverage, in the depressions the macro-microfossil constitution exhibits trend; for the F or I class, no trend.

This kind of comparison facilitates conclusions concerning the constructional properties of polygon terrain and its associated physiographical character. The terrain shown in Fig. 10 with HE coverage has with its woody-fibrous constitution relatively good resistance to compressional force and is reasonably well drained. It has a high degree of irregularity topographically, as compared with the type with FI coverage. For the former type the terrain has resilience in contrast with the latter which tends to lose coherence and to dissociate structurally when disturbed.

Comparisons on the basis of coverage alone, though very helpful, are not adequate for predicting polygon terrain conditions. Neither is the combination of coverage and macrofossil constitution. Where class D is prominent in the depressions there is a reasonable mechanical stability to the terrain for the first type of polygon, but not for the second. Drainage is good in the first and poor in the latter. Differentiation between these two on the basis of plant material is only reliable through microfossil analysis. For the relatively stable, better-drained example with DF coverage, the macrofossil constitution will be similar to that for the unstable example. The microfossil histogram pattern would show a relatively high density of Ericaceae-Betulaceae for the approximate lower two thirds of the peat in the case of the former and a relatively high Cyperaceous density for the latter.

Summary and Conclusions

The occurrence of zonation in coverage vegetation provides a valuable aid in interpreting and assessing organic terrain character. In addition, the utilization of zone limits for mapping facilitates an appreciation of terrain change and frequency of change.

It is also significant that the zonation is not based on arbitrary factors and classification technique. The recognition and use of "form communities" rather than floristic communities does not affect this claim. The grouping of form types as they occur naturally provides a logical lead for subsurface exploration. It also suggests the means by which frequency and distribution of terrain differences may be assessed on an organized basis, from the ground or the air, particularly when vegetation colour range is an accessory interpretive agent.

In only two combinations of coverage classes (HE and FI) does macrofossil constitution seem to be predictable and consistent throughout the depth of the peat. Also, macrofossil constitution for extensive areas is difficult to characterize from small gross samples. This makes terrain interpretation difficult and uncertain unless microfossil constitution is considered.

Microfossils provide the ultimate source of reference and the most reliable source of plant materials in the investigation of northern organic terrain. They are indicators of organization for the vertical and horizontal axes in the organic matter. Through them, detection of constitutional change in peats can be accomplished and assessed. Indirectly they are aids in the study of drainage and other physiographic features.

Finally, and most significantly, microfossils are essential to an understanding of botanical and structural development anywhere in the muskeg. In this capacity, they support the use of vegetal coverage in the classification and prediction studies of terrain interpretation. This is subject to the condition that laboratory analyses of microfossil sequence corresponding to given coverage combinations are consulted fully.

Acknowledgments

The writer is indebted to Miss Jean Evel for her assistance in the preparation of this manuscript and to Edward J. Johnson who as a research technician has provided many of the technical data. Grateful acknowledgment is also extended to many students who have contributed to muskeg studies and to several colleagues, particularly Robert F. Legget, Director, Division of Building Research, National Research Council, to whom all credit must go for initiating inquiry into organic terrain constitution. The National Research Council through the Associate Committee on Soil and Snow Mechanics has provided financial aid along with the Defence Research Board,

through the Arctic Research Section. The latter has shown keen interest in delimitation of muskeg surface character in aerial interpretation studies presently being conducted by the writer.

REFERENCES

AUER, VAINO (1933). Peat bogs of southeastern Canada. Handbuch der Moorkunde, **7**: 141–223.

DACHNOWSKI-STOKES, A. P. (1933). Peat deposits in U.S.A. Handbuch der Moorkunde, **7**: 1–140.

LEWIS, F. J. and DOWDING, E. S. (1926). The vegetation and retrogressive changes of peat areas ("muskegs") in central Alberta. J. Ecol., **14** (2): 317–41.

Munsell Book of Color. Pocket ed., Baltimore: Munsell Color Co. Inc., 1929–42.

RADFORTH, N. W. (1952). Suggested classification of muskeg for the engineer. Engineering J., **35** (11): 1–12.

NATIONAL RESEARCH COUNCIL
ASSOCIATE COMMITTEE ON SOIL AND SNOW MECHANICS

LIST OF TECHNICAL MEMORANDA

No.	Date	Title
1	August, 1945	Proposed field soil testing device.*
2	September, 1945	Report classified "restricted"
3	November, 1945	Report classified "confidential"
4	October, 1945	Soil survey of the Vehicle Proving Establishment, Ottawa.*
5	November, 1946	Method of measuring the significant characteristics of a snow-cover. G.J. Klein.*
6	November, 1946	Report classified "confidential"
7	March, 1947	Report classified "restricted"
8	June, 1947	Report classified "confidential"
9	August, 1947	Proceedings of the 1947 Civilian Soil Mechanics Conference.*
10	October, 1947	Proceedings of the Conference on Snow and Ice, 1947.
11	March, 1949	Proceedings of the 1948 Civilian Soil Mechanics Conference.*
12	May, 1949	Index to Proceedings of Rotterdam Soil Mechanics Conference. (Soil Mechanics Bulletin No. 1).
13	June, 1949	Canadian papers: Rotterdam Soil Mechanics Conference.
14	December, 1949	Canadian papers presented at the Oslo meetings of the International Union of Geodesy and Geophysics.
15	April, 1950	Canadian survey of physical characteristics of snow-covers. G.J. Klein.
16	April, 1950	Progress report on organic terrain studies. N.W. Radforth.
17	August, 1950	Proceedings of the 1949 Civilian Soil Mechanics Conference.
18	November, 1950	Method of measuring the significant characteristics of a snow-cover. G.J. Klein, D.C. Pearce, L.W. Gold.
19	April, 1951	Proceedings of the 1950 Soil Mechanics Conference.
20	May, 1951	Snow studies in Germany. Major M.G. Bekker, Directorate of Vehicle Development, Department of National Defence.
21	August, 1951	The Canadian snow survey 1947-1950. D.C. Pearce, L.W. Gold.
22	October, 1951	Annual report of the Canadian Section of the International Society of Soil Mechanics and Foundation Engineering (June 1950 - June 1951).
23	May, 1952	Proceedings of the Fifth Canadian Soil Mechanics Conference, January 10 and 11, 1952.
24	May, 1952	A suggested classification of muskeg for the engineer. N.W. Radforth.
25	November, 1952	Soil mechanics papers presented at the Building Research Congress 1951.
26	December, 1952	Annual report of the Canadian Section of the International Society of Soil Mechanics and Foundation Engineering (June 1951 - June 1952).
27	May, 1953	Proceedings of the Sixth Canadian Soil Mechanics Conference, Winnipeg, December 15 and 16, 1952.

* Out of print