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MUSKEG
REVIEW OF RESEARCH
1. Terrain
2. Geophysics
3. Organic materials
4. Arctic regions
5. Bibliography
6. Military operations
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1. Robeson, William C.
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HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

EARTH SCIENCES DIVISION

Technical Report
ES-5

MUSKEG
REVIEW OF RESEARCH

William C. Robison
Regional Environments Branch

Arthur V. Dodd

Will F. Thompson
General Environments Branch

Project Reference:
7X83-01-008

July 1962
Organic terrain or "muskeg", which covers vast areas of the sub-arctic and adjacent regions, presents special problems in both road construction and off-road travel. Development of a year-round capability for Army operations in northern regions requires special consideration of these problems. In planning its program for dealing with them, the U.S. Army Transportation Corps requested the Quartermaster Corps, under its assigned cognizance for Applied Environmental Research, to review the present state of knowledge of muskeg and to suggest possible future approaches to studying it. This report, consisting of a selected bibliography and a review of research on organic terrain in various parts of the world, is one result of the study conducted by the Quartermaster Corps. It offers a guide to past and current investigations of the subject, both theoretical and applied, for the use of those embarking on research in this field or responsible for planning and directing such research.

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Brigadier General, USA
Commanding
QM Research & Engineering Command
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ABSTRACT

Muskeg is defined and its relation to other types of soft terrain is discussed. Terms such as mire, fen, moor, moss, peatland, bog, marsh, swamp, and others are set forth as an aid in understanding the literature in other parts of the world. Systems of classification of muskeg are discussed and the Radforth system is recommended for use in classifying muskeg according to its trafficability.

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1. Terminology

"Muskeg" is a convenient term for a type of terrain that offers serious problems of trafficability and construction, especially in subarctic regions. The word is commonly used in Canada and Alaska, but it is subject to various interpretations and therefore must be defined at the outset of this discussion. While the Indian meaning was simply "grassy bog", it has acquired a broader connotation in modern usage. MacFarlane (1956) gives a definition that is generally accepted in Canada and will be followed in this report:

"that terrain which is made up of a living organic mat of mosses, sedges and/or grasses (with or without tree growth) underlain by an extremely compressible mixture of partly disintegrated and decomposed organic material"

The distinctive character of muskeg is derived from the organic material, both living and dead, that it comprises. Therefore, the scientific study of muskeg has been conducted primarily by botanists. On the other hand, as a type of terrain it is also of great concern to engineers, geologists, and others who have an interest in surface and subsurface conditions. Muskeg, as a terrain type, should be distinguished from peat, which is its basic material but lacks the areal connotation of "muskeg".

Since the essential characteristic of muskeg is its constituent organic material, the term "organic terrain" has become widely used in Canada as more descriptive. It should be emphasized that muskeg or organic terrain is not the only type of terrain that causes a mobility problem in northern regions, but, as stated by Dr. W. J. Turnbull of the U.S. Army Corps of Engineers, "it constitutes one of our major trafficability problem areas."

Muskeg reaches its maximum development in subarctic regions, where the predominant vegetation is coniferous forest. For this reason it is sometimes thought of as coextensive with the "taiga" or northern coniferous ("boreal") forest. As defined here, however, muskegs are also found both north and south of the boreal forest region. In such situations they are less extensive and commonly occur as distinct bogs (sometimes called "confined muskegs") rather than as the "peat seas" which occupy as much as 80 percent of the area in parts of the Hudson Bay Lowland (Sjörs 1959). Likewise, the "blanket bogs" that cover large areas

in climatically maritime regions such as the Aleutian Islands and western Ireland are a type of peatland presenting the same engineering and trafficability problems as the muskeg of the boreal forest region. For this reason, and because they fall within the broader meaning of "muskeg" as defined above, they are included in this review, although the term "muskeg" is not popularly used in those treeless areas.

An understanding of the literature on muskeg—especially the writings of Europeans—requires recognition of terms that are used for similar types of terrain in other countries. Wet, peaty terrain may be called mire, fen, moor, moss, peatland, and bog in various English-speaking regions. While not entirely synonymous, all these terms are used in association with organic terrain.

Organic terrain, and often the vegetation growing on such terrain, is known in Sweden as myr (equivalent to the English "mire"), in Germany as Moor or Moos, in Poland as torfy, in Russia as boloto, and in England as bog (or, locally in northern England and southern Scotland, as moss). Swedish scientists writing in English frequently use the term mire as a general term for peaty terrain or vegetation, a practice followed by some English writers, but to many English-speaking people mire means simply "mud". The German word Moor should be avoided in English because an English "moor", in common speech, is an unenclosed wasteland, usually covered with heather, and may contain no peat whatever. Therefore the German Moor should be translated either as "bog" or "fen", depending on the particular type being discussed.

There is a similarity between the words "marsh", "swamp", "bog", "fen", and "muskeg" in that all represent wet terrain. In fact, all are sometimes used interchangeably in uncritical speech and writing. Even specialists in the study of terrain and vegetation are not entirely in agreement as to the differences between these terms (Welch 1935), but it is convenient to make a basic distinction between wetlands that have a substratum of peat (bog or muskeg) and those with a substratum of mineral soil (marsh and swamp). The latter, although undeniably a serious obstacle to cross-country movement in some places, are outside the scope of the present discussion. The word "fen" is used by many writers, especially in Great Britain, to denote a particular kind of bog in which peat is formed below the surface of water. Fens, marshes, and swamps have in common the fact that their water is telluric (i.e., comes from the ground); in a bog, on the other hand, the water may be derived partially or entirely from the atmosphere (Tansley 1939). Because of the local differences in usage, the British "fen" will be referred to here as "low bog", which is a subtype of muskeg.
2. **Classification of muskeg**

Many systems of classification have been proposed for the various types of muskeg, peat, and their associated vegetation. Ecologists have attempted classifications on the basis of chemical composition of the water, the plant communities, the associated terrain, and climate. These systems are discussed in detail in various references listed in the bibliography (Dachnowski-Stokes 1933, von Post 1937, Radforth 1952, and others). This section will identify the most common categories and their various designations, so that they will be recognizable regardless of the country in which they occur or the nationality of the author.

a. **Physiographic and climatic categories**

In most of the systems of classification that have been proposed and used, a basic distinction is apparent between two principal types of bog, referred to in German as Hochmoor and Niedermoor. These are often translated into English as "high moor" and "low moor", but because of the different connotation of "moor" in English the equivalents adopted here are "raised bog" and "low bog". The Hochmoor is not necessarily "high" in elevation; rather, the word refers to the fact that the bog is raised above the surrounding terrain and especially above the water table. The height to which it is raised above its surroundings depends on both the climate and the area covered by the bog (Gorham 1957) but rarely is it more than 6 feet. The Germans also recognize an intermediate type called "transitional" bog.

A comparison of the designations of the major types of bog used in different languages is given below (based on Spirhansl 1937, but modified):

<table>
<thead>
<tr>
<th>Language</th>
<th>I. Raised bog</th>
<th>II. Low bog</th>
<th>III. Transitional bog</th>
</tr>
</thead>
<tbody>
<tr>
<td>German</td>
<td>Hochmoor, Moos-,</td>
<td>Grünland-, Tal-,</td>
<td>Übergangsmoor, Flach-,</td>
</tr>
<tr>
<td></td>
<td>Heidemoor</td>
<td>Wiesen-</td>
<td>Mischmoor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Niedermoor</td>
<td></td>
</tr>
<tr>
<td>French</td>
<td>Tourbières de pente</td>
<td>Tourbières de vallées</td>
<td></td>
</tr>
<tr>
<td>Polish</td>
<td>Torfy wododziałowe</td>
<td>Torfy nizinne</td>
<td>Torfy przejściowe</td>
</tr>
<tr>
<td>Dutch</td>
<td>Hoogveen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swedish</td>
<td>Hvitmossor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian</td>
<td>Mochovoye boloto</td>
<td>Nizinnyoe boloto</td>
<td>Perechodnoye boloto</td>
</tr>
<tr>
<td>Czech</td>
<td>Vrchoviště</td>
<td>Slatiny</td>
<td>Rašeliniště přechodové</td>
</tr>
<tr>
<td>English</td>
<td>Moss, bog</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The types of bog listed above are also distinguished in various writings according to their source of nutrients, climatic affinities, and position relative to the water table. It is helpful to recognize that these systems of classification all roughly correspond to the major categories already mentioned:

<table>
<thead>
<tr>
<th>System</th>
<th>I. Raised bog</th>
<th>II. Low Bog</th>
<th>III. Transitional Bog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weber (1902)</td>
<td>Oligotrophic*</td>
<td>Eutrophic*</td>
<td>Mesotrophic</td>
</tr>
<tr>
<td>von Post (1937)</td>
<td>Ombrogenous</td>
<td>Topogenous</td>
<td>Soligenous</td>
</tr>
<tr>
<td>Spirhanzl (1938)</td>
<td>Supra-aquatic</td>
<td>Infra-aquatic</td>
<td></td>
</tr>
</tbody>
</table>

It should be noted here that all the terms used above (except the English) are current in the more or less continental regions of Europe, where precipitation is moderate and temperatures have a large annual variation. When the British began serious ecological study of their bogs, it became necessary to recognize an additional major category—the "blanket bog"—for bogs occupying extremely maritime sites having high precipitation. Thus in the British Isles the three major types recognized (e.g., by Tansley 1939) are "valley bog," "raised bog," and "blanket bog." These types correspond more or less to the categories recognized in Alaska by Dachnowski-Stokes (1941) as flat or "valley muskegs", "raised muskegs", and "slope muskegs". Blanket bogs are often well drained; other bogs and muskegs normally have a water table close to their surface.

b. Physiognomic classifications

For many years botanists have recognized that vegetation can be classified not only by its floristic elements but also according to its form and structure. On this basis they have divided the vegetation of the world into various "formations" or "formation-classes" such as evergreen forest and prairie. A recent restatement of these concepts has been made by Dansereau (1958), who recognized 15 structural categories based largely on earlier work by Schimper. In this system, muskegs fall either in the "needle-leaf evergreen forest" or the "meadow" type, depending upon whether or not trees are present. For a meaningful classification of muskeg, a system providing a greater degree of detail is obviously needed. The plant geographer Küchler (1949) devised a system for representing any type of vegetation by combinations of letters and has applied this system on a world-wide basis (see the Vegetation Map in Goode's World Atlas). Both this and Dansereau's system have the merit of being applicable throughout the world.

*Authorities differ in their use of these terms. Godwin (1941) considers both "eutrophic" and "oligotrophic" to be subdivisions of topogenous mires, or fens.
A method that similarly uses letter-symbols to represent the form, structure, and density of vegetation, but which is intended specifically for use in muskeg, was devised by the Canadian paleobotanist Radforth. This system assumes that the surface vegetation can indicate the subsurface conditions that determine trafficability of a given terrain, and various writings by Radforth state that this relationship has been established. The Radforth system of classification was first published in 1952 and has been summarized or reiterated in several subsequent publications by both Radforth (1955, 1956b, etc.), and MacFarlane (1958, 1959a). It has the advantage that non-technical personnel can use it, since its nine classes are identified by descriptive terms such as "woody, 5 to 15 feet high" (class B) rather than by botanical names. These basic coverage classes may be correlated with 16 types of topographic features ("contour types": hummock, mound, ridge, etc.) and with 16 subsurface categories based on the gross morphology of the underlying peat. It has been widely accepted in Canada by engineers and others who are concerned with the practical aspects of mobility over muskeg. For this reason, as well as its convenience and applicability to muskeg problems, it is recommended for classifying organic terrain according to its military significance.

3. *The status of research on muskeg in Eurasia and North America*

   a. *Eurasia*

   Although many Europeans have studied muskeg solely from the point of view of botany and ecological theory, most of the work has had some economic significance. In Ireland, Central Europe, and the USSR, the importance of peat as a source of fuel overshadows everything else. The possibility of reclaiming peat bogs for agriculture is also of great importance in those countries. Loss of forest land which has changed into muskeg, whether because of human disturbance or simply because of the natural trend of ecological succession, is of historic importance in the mountains of Great Britain and Ireland and is occurring today in Finland. Although many ecological studies of bogs have been made in the British Isles, study of peat as a resource has hardly begun there because (except in Ireland) the economy has long been dominated by coal. The Irish Peat Board (Bord na Mona) has planned investigations but few of their results are as yet to be found in the literature (see Barry 1954).

   Central Europeans tend to study peat either as a stratified geologic deposit or from a purely botanical point of view. There is extensive literature on pollen found in peat bogs, where it is preserved as a stratified record of the vegetation of the region since the origin of the bog. However, pollen studies are largely disregarded in the Bibliography in this report because most paleobotanists have paid little attention to the general characteristics of peat bogs.
Russian research on peat and muskeg has been very intensive. Although the chief interest in peat in the USSR has been as a source of power, problems of trafficability have not been ignored. The work of the Peat Institute at Moscow, where there are 400 full-time employees and about 1,000 students, was reported briefly by Radforth at the Fourth Muskeg Research Conference (National Research Council, Canada, 1958). The Russian literature on organic terrain and its constituent vegetation and peat was summarized by S. N. Tyuremmov (1949), whose work has been abstracted and parts of it translated into English for the US Army Quartermaster Corps.

The most searching analysis of muskegs has come from Finland and Sweden. Those countries have a variety of peat accumulations unmatched elsewhere in the Old World except perhaps in the USSR, and both are vitally concerned with the relation of peat accumulation to forestry and agriculture. Consideration of muskegs as complex ecological phenomena began in Finland with the works of Cajander, Huikari, Kivinen, and Auer, and was continued brilliantly by such Swedes as von Post, Osvald, Sjörs, and Du Rietz.

b. North America

In the New World, fuel and agricultural land are abundant and except in Newfoundland peat lands have been of little commercial significance especially in high latitudes. On the other hand, economic conditions here demand that the frontier economy of the North be a machine economy, and muskeg is a barrier to the passage of machines. Studies in Canada by Radforth, MacFarlane, and others have therefore emphasized the location of vehicular routes through regions predominantly muskeg. Although ecological aspects of muskeg have not been ignored in North America (see works by Cooper, Drury, Rigg, and others), primary attention has been given to the economic problem of traffic over muskeg.

In determining the best route over muskeg, the interests of industrial firms (such as oil companies) and of the military forces coincide, for both have a vital interest in the movement of heavy equipment over roadless terrain. In addition, seasonal limitations on movement present a serious problem to both. For these reasons, the possibilities for increasing mobility by photointerpretative selection of routes over muskeg are of more than academic interest to both industry and the military. Preliminary studies of photointerpretation in muskeg regions by Stoeckeler (1949), Frost (1950), and O'Neill (1952) have been supported by the US Department of Defense. In Canada, the Muskeg Research Institute at McMaster University, Hamilton, Ontario, is preparing a series of handbooks for use as guides to airphoto interpretation from various elevations. The first two of these (Radforth 1955 and 1958), treating
interpretation of organic terrain as seen from elevations of less than 1,000 feet and from 1,000 to 5,000 feet, respectively, have been published. A third handbook, extending the range of interpretation to 30,000 feet, is in preparation.

Significant applications of airphotos to the mapping and classifying of vegetation in regions where muskeg is common have been made at McGill University by Hare (1959) and Allington (1959). Despite these efforts, the study of organic terrain from airphotos cannot be said to be entirely on a firm footing.
Annotated bibliography on muskeg

Muskegs, under various names, have been studied since the last decades of the 19th century, and the volume of literature devoted to them has steadily expanded in the last 20 years. A representative number of these works, including those considered to be most significant, is given. To show the range of approaches to the study of muskeg, the bibliography includes studies by botanists, engineers, and soil scientists. To show the extent of its geographical distribution, the list includes several studies in the tropics and middle latitudes as well as in high latitudes.


A study of the vegetation of Novaya Zemlya, where bogs occur in the wettest sites, recognized as an "azonal type."


A study of muskeg in the Knob Lake area, based on photointerpretation and analysis of physiography. Classification consists of seven sub-types, the most common being string bog, sedge meadow, and spruce muskeg. Modes of origin are discussed. Good survey of the literature.


A review of agricultural aspects of peat and peatlands. Includes an extensive bibliography.


The American literature through 1925 was scant and is now mostly obsolete.


A detailed stratigraphic study, noting extensive paludification of formerly well-drained land. Discusses the regional dominance of sphagnum in maritime areas and of carex inland. Mentions effect of forest fires on peat bogs.
A discussion of peat bogs in Tierra del Fuego.

Classifies Finnish peat bogs; includes map showing percentage of total land area occupied by peat. Discusses various theories, especially with respect to "aapa bog" (string bog).

Describes the principal types of peat bogs in Ireland and their relation to rainfall, relief, and climatic trends. Includes rough map showing distribution of bogs.


Bog constitutes a very prominent element in the landscape of the forest zone of Russia, especially in northern Europe and in western Siberia. Berg distinguishes three principal types: (1) lowland (hypnum and herbaceous) bog, (2) transitional (forest bogs), and (3) sphagnum bogs.

Describes a "landslide" of blanket-bog peat from a hilltop into a valley, a phenomenon not uncommon in Ireland.

A slide similar to that described by Bishopp, which released a peat-dammed lake.
13. Cajander, Aimo Kaarlo. 1902-03. EIN BEITRAG ZUR ENTWICKLUNGS-
GESCHICHTE DER NORDFINNISCHEN MOORE. Fennia 20, No. 6.
A study of the development of peat bogs in northern Finland.

14. ———. 1904-05. BEITRÄGE ZUR KENNINSS DES ENTWICKLUNG DER
EUROPÄISCHEN MOORE. Fennia 22, No. 3.
Compares bogs in Lapland and Bavaria.

15. ———. 1913. STUDIEN ÜBER DIE MOORE FINNLANDS. Acta
Forestalia Pennica 2: 3-208.
Detailed classification, with extensive observations on factors
controlling paludification.

16. Cameron, Margaret. 1947. UTILIZATION OF PEAT. Natl Research
Council, Canada No.1623, Ottawa.
Describes commercial uses of peat as fuel and for many other
purposes.

17. Chouard, P. and H. Prat. 1929. NOTE SUR LES TOURBIÈRES DU MASSIF
DE NOUVELLE (HAUTES-PYRENEES). Bull Société Botan Francaise 76:
113-130.
Remarks on peat bogs in the Pyrenees Mountains.

Describes the physical geography of a muskeg-dominated area.

19. ———. 1954. THE PHYSIOGRAPHIC SUBDIVISIONS OF THE HUDSON
BAY LOWLANDS SOUTH OF 60 DEGREES NORTH. Dept Mines and Tech
Surveys, Geog Bull 6, Ottawa.
Distinguishes the following subdivisions: Dry Zone, Muskeg and
Small Lake Zone, Marine Clay Zone, Coastal Zone. Delimits
zones on a map and includes airphotos of each.

20. Cooper, William S. 1942. VEGETATION OF THE PRINCE WILLIAM SOUND
Muskeg of Southeastern Alaska is well described under the
heading "Carex bog". Mound formation, peat dams, and invasion
of forest are discussed.

Describes a method of crossing muskeg using a vehicle in which power is applied to a previously-laid cable rather than to wheels or tracks.


24. ———. 1933. PEAT DEPOSITS IN USA, THEIR CHARACTERISTIC PROFILES AND CLASSIFICATION. Handbuch der Moorkunde 7: 1-140.

Recognizes 10 series of peat profiles subdivided into 49 "types", each described in detail.


A brief summary of the various types of peat soils in the United States. Map shows "Regions in which the major groups of peat land occur."


Includes profiles showing stratigraphy and botanical composition of typical muskegs in several localities in Alaska.


Discusses muskeg both as a region and as a plant formation, and its relation to other northern regions and formations.


Attempts to define difference between bogs and swamps or marshes.
29. ———. 1958. A UNIVERSAL SYSTEM FOR RECORDING VEGETATION. 
Contract DA-22-079-eng-208, US Army Corps of Engineers, Vicksburg, 
Miss.

Vegetation of the world divided into 10 "formation-types" (in- 
cluding bog as "meadow") and 15 "regional climaxes". Appendix 
includes system for symbolic representation of all types of 
vegetation.

30. Daubenmire, R. F. 1953. NOTES ON THE VEGETATION OF FORESTED 
REGIONS OF THE FAR NORTHERN ROCKIES AND ALASKA. Northwest Sci 27: 
125-138.

Discusses the association of black spruce with muskeg, noting 
that the organic accumulation beneath such forest is often 
thin.

31. Drury, William H., Jr. 1956. BOG FLATS AND PHYSIOGRAPHIC PROCESSES 
IN THE UPPER KUSKOQUIF RIVER REGIONS, ALASKA. Contributions from 

An ecological study of changes from muskeg to spruce forest 
and back in a permafrost region with meandering rivers. In- 
cludes a useful glossary and a thorough survey of European and 
American literature.

32. Dryburgh, F. B. and E. R. McKillop. 1954. CONSTRUCTION AND MAIN-
TENANCE OF ROADS OVER PEAT. Tech Memo 29, NRCC, ACSSM, Ottawa.

A discussion of British experience in constructing low-cost 
roads to carry light traffic over peat in northern Scotland.

33. Du Rietz, G. E. 1949. HUVUDENHETER OCH HUVUDENGÄRNÄSER I SVENSK 
MRVEGETATION ("Main units and main limits in Swedish mire vege- 

34. ———. 1954. DIE MINERALBODENWASSERZEIGERGERENZE ALS GRUNDLAGE 
EINER NATÜRLICHEN ZWEIGLIEDERUNG DER NORD UND MITTELeuropäischen 
MOORE. Vegetatio 5-6: 571-585.

Makes distinction between bog and fen on the basis of presence 
in the latter of nutrient-bearing water from mineral ground.

Summarizes the character and importance of blanket bogs and other bogs in Ireland.


A discussion of mountain soils, including bogs, on a climatic basis. French translation of a Russian paper.


Photointerpretive study of Alaskan landforms, soils, and vegetation. Muskeg is discussed under "Vegetation," especially in Chapter 1. Contains numerous photographs.


A study of peat bogs in Switzerland.


Presents the official system of bog survey in the USSR.


Brief account of a discussion at the British Ecological Society points out "frequent misuse of the term 'blanket bog.'"


A British biologist summarizes the effects of climatic, topographic, geologic, and biotic factors on the development of bogs.


A map of vegetation types in Labrador-Ungava, with discussion and analysis. Distinguishes several types of muskeg.


Describes modern peat accumulations under swamp forest in the Orinoco and middle Magdalena Valleys.


A brief survey of the problems that muskeg presents to transportation in Canada, and progress toward their solution.


A summary of the Radforth system of classifying muskeg, and a brief description of muskeg vehicles used in Canada.


Optimistic view of potentialities of the Musk-Ox, a 20-ton-payload vehicle built for Imperial Oil for use over muskeg.


Describes surface patterns on King William Island and Adelaide Peninsula under the name "fingerprint bog." They resemble string bogs but have permafrost, ridges of mineral material (including sand and gravel), and transgress contours. Does not state clearly whether peat is present.

Describes the mechanism of frost action in certain New England bogs.


Brief notes on bogs, bog hummocks, bog vegetation, and their distribution.


Study of vegetation, pollen, and stratigraphy, used to throw light on the Norse occupation of Greenland and the climatic changes that brought it to an end.


Distinguishes three principal types: (1) marsh or fen (Niedermoor), (2) transition bog (Uebergangsmoor), and (3) Sphagnum bog (Hochmoor). Sphagnum bogs are by far the most common in Central Russia, occupying thousands of square kilometers. Discusses effects of culture and fire on bogs.

53. ———. 1930. ZUR KENNTNIS DER MOORE NORDOSTEUROPAS. Botanisches Zentralblatt, Beiheft, vol. 46.

Notes on reconnaissance studies of bogs in area draining northward to the White Sea.


Types of bogs in the West Siberian Lowland and their geographical zonation.


Results of the Kamchatka expedition of the (Soviet) Peat Institute in 1931.

Notes on the classification of peat soils in Finland.


A simple system of classifying vegetation without using botanical categories. Can be applied to muskegs as well as other types.


A discussion of bogs in the Polesie Basin of Poland, where wooded raised bogs are the rule. (Summarized by Gorham 1957).


This is source of estimate that Canada has 435,000 square miles of organic soils (11.8% of the entire country).


Includes remarks on relation of muskeg to road construction.


Discusses distribution of muskegs in Central Alberta, and their degeneration as a result of climatic changes and fire.


A list of 90 references, with special emphasis on road construction over muskeg.

A well-organized review of the methods used in various countries to overcome the peculiar problems of building roads across organic terrain. Includes a good definition of muskeg.


A pocket summary of the Radforth system of classification, with photographs of each category.


Summarizes history and current status of muskeg research in Canada.


Points out existence of many gaps in knowledge of engineering properties of peat.


Includes a good description of muskeg of the kind common in southeastern Alaska.


A study of chemical aspects of peat.


Photointerpretation keys and vegetation-type descriptions based on detailed studies in the vicinities of Ely, Park Rapids, International Falls, and Grand Rapids, Minnesota. (See also: Morris, 1954).

A study of muskegs in Australia.


Stresses value of photointerpretation in planning penetration of muskeg or permafrost areas.


A discussion of physical environment, biological environment, swamps and bogs, and transportation and communication in the boreal fringe area, based on detailed studies in the vicinities of Ely, Park Rapids, International Falls, and Grand Rapids, Minnesota. Vegetation is studied as basis for photointerpretation of terrain. (See also: Meyer, 1954).


Contains good descriptions. Discusses role of permafrost in mound formation.


Contains many references to peat soil as related to permafrost. Notes differential cooling of sphagnum areas relative to normal soils because of high conductivity of peat when frozen.


Includes papers on engineering properties of muskeg, access over muskeg in forestry practice, muskeg problems in Quebec highway construction, and pre-construction surveys of organic terrain.

Various papers on economic applications of muskeg research in Canada.


Papers on problems of movement over muskeg, both in summer and winter.


Includes sections on Muskeg Research in the USSR: Vehicles and Trafficability; Mechanical Properties of Peat; Drainage Problems.


Includes sections on Mechanical Properties and Road Construction; Vehicles and Trafficability; Forestry Drainage.


Includes sections on Highway Construction and Foundations; Classification and Exploration; Permafrost; and Northern Development.


Papers largely concerned with problems of road construction over organic terrain. Others treat nature, distribution, and photointerpretation of muskeg.


Specifications of the "Musk-ox" and its performance on muskeg.
83. O'Neill, Hugh et al. 1952. INTERPRETATION OF VEGETATION FROM 
AERIAL PHOTOGRAPHY. (Mimeo) Contract N6-onr-25504, Catholic Univ 
Am, Washington.
A study of airphoto interpretation of arctic and subarctic 
regions, with special emphasis on trafficability. Includes 
preliminary keys. Based on recent studies at Kaniapiskau River 
and Val David, Quebec; and Anchorage, Homer, and Unalakleet, 
Alaska.

84. Osborn, C. C. 1921. CLASSIFICATION AND FORMATION OF PEAT AND 
A good guide to traditional American terms and concepts. 
Little reference to European usage.

85. Osvald, Hugo. 1925. DIE HOCHMOORTYPEN EUROPAS. Veröffentlichen 
Geobotanische Institut Rübel, Zurich.
A study of raised bogs in Europe.

86. 1933. VEGETATION ON THE PACIFIC COAST BOGS OF NORTH 
Description and flora of bogs near Vancouver, British Columbia.

87. 1949. NOTES ON THE VEGETATION OF BRITISH AND IRISH 
Botanical study of British and Irish peat bogs ("mosses"). 
Good illustrations.

88. 1954. SLOPING MIRES IN NORTHWEST NORWAY. Bot. 
Tidskr. 51: 274-283.
A description of bogs in the Lofoten Islands.

89. 1955. THE VEGETATION OF TWO RAISED BOGS IN NORTH-
Discusses regional (climatic) differentiation of bogs in Maine.

90. Pearsall, William H. 1950. MOUNTAINS AND MOORLANDS. Collins, 
London.
A scholarly and highly readable account of the history and 
character of the blanket bogs which cover the mountains of 
Great Britain, and of related phenomena. Well illustrated.

Discusses form-evolution of bogs in the extreme north of Scotland, and their relation to salt spray as a source of nutrients.


Discusses the character, origin, and distribution of peat bogs both in the Indies and throughout the world.


Pollen analyses in the Gaspé and St. Lawrence Valley.


An attempt to relate pollen profiles to climatic changes.


Account of a traverse by light plane, with bog borings at regular intervals. Average depth of peat was found to decrease northward from the St. Lawrence Valley; no muskegs found in tundra region.


Reports extensive "high moor" on uplands of southeastern Australia and Tasmania.

Proposes a basic classification of muskeg according to 9 cover types, with full-page photographs of each. Includes classifications of topographic and subsurface features.


Emphasizes need for study of botanical relationships that have a bearing on cover type and subsurface features in organic terrain.


Discusses the relationships between permafrost, ice-formed terrain, and northern organic terrain and vegetation.


A photointerpretive study of muskeg using large-scale aerial photographs. Typical organic terrain features are shown as seen in both aerial and ground photographs. Stresses importance of properly assessing subsurface conditions, and includes classifications of summer subsurface ice conditions and subsurface terrain structure.


Discusses macroscopic variations in organic terrain and the relationship of peaty constituents to its resistance to compressional forces.

Shows air-form patterns as seen from 30,000 feet. Author states these can be correlated with "low altitude experience", particularly to indicate ease of access to undeveloped areas.


A review of the author's previous work on classification of muskeg and its recognition from the air, with suggestions for planning field operations.


A comparison of "peat-lands" in Great Britain and "muskeg" in Canada, with a review of Canadian research.


A continuation of photointerpretive studies explained in Handbook No. 1, with classification of form and tone categories. Photographs show various cover and terrain types at 5,000 feet, 1,000 feet, and ground level.


Reviews problems of vehicular access over muskeg during periods of thaw. Includes requirements for design of vehicles.


A good, brief discussion of operational difficulties on muskeg, slightly obscured by introduction of unfamiliar terms.
109. ________ and I. C. MacFarlane. 1957. CORRELATION OF PALAEO-
BOTANICAL AND ENGINEERING STUDIES OF MUSKEG (PEAT) IN CANADA. Proc

A review of earlier works, stressing need for linking studies
of the mechanical properties of muskeg to Radforth's system
of classification.

110. Ratcliffe, D. A. and D. Walker. 1958. THE SILVER FLOWE, GALLOWAY,

A description and history of a series of bogs ranging from
blanket bog to "high moor".

111. Rigg, George B. 1916. A SUMMARY OF BOG THEORIES. Plant World 19:
310-325.

A survey of literature on the exclusion from bogs of plants
other than those normal to them.

112. ________. 1917. FOREST SUCCESSION AND RATE OF GROWTH IN
SPHAGNUM BOGS. J Forestry 15: 726-739.

113. ________. 1925. SOME SPHAGNUM BOGS OF THE NORTH PACIFIC COAST
OF AMERICA. Ecol 6: 260-278.

Cites evidence of advance of bog into forest. Regional de-
scription not attempted.

114. ________. 1937. SOME RAISED BOGS OF SOUTHEASTERN ALASKA, WITH

115. ________. 1940a. COMPARISONS OF THE DEVELOPMENT OF SOME
SPHAGNUM BOGS OF THE ATLANTIC COAST, THE INTERIOR, AND THE PACIFIC

116. ________. 1940b. THE DEVELOPMENT OF SPHAGNUM BOGS IN NORTH
AMERICA. Botan Rev 6: 666-693.

A survey of the American literature.

117. ________. 1951. THE DEVELOPMENT OF SPHAGNUM BOGS IN NORTH

A continuation of the above.


Distinguishes the following vegetation zones in the Hudson Bay Lowlands of northern Manitoba: Transitional, moss muskeg, treeless bog, lowland complex. Zones on the Canadian Shield are tundra, forest tundra, open coniferous forest, and closed coniferous forest. Includes air photo of each type.


Classification of bogs in Tierra del Fuego by physiographic type, vegetation, character of peat, and acidity. Makes regional distinctions related to rainfall and vegetation.


A well written but overly optimistic view of measures being taken to overcome the muskeg problem in Canada.


A botanical study of a Japanese peat bog.


A classic description of lake-filling by bogs.


Uses "mire" as equivalent of German "Moor", or English "moss" (bog) and "fen" together.

The Hudson Bay Lowland is one of several areas in the world where an extensive "peat sea" is interrupted only by occasional lakes, rivers, and islands of mineral soil. Representative patterns are well illustrated and explained. Includes map showing extent of continuous bogs and fens.


Discusses several classifications of peat bogs, and gives a detailed table of peat types based mostly on vegetation.


Includes discussion of types of muskeg in Alaska. Illustrated by many photographs, including stereo-pairs.


A survey of the literature on tropical peat bogs.


A discussion of bog types at various altitudes and climates in Madagascar, including temperate types at high altitudes.


A popular account of occurrence and commercial use of peat in Canada, including methods of extracting and processing.


An extended discussion of peat accumulations and their vegetation in Great Britain and Ireland, with a well-defined terminology.

Describes the blanket-bog peat of the Aleutians and its relation to accumulation of volcanic ash.


Evaluation of standard mobility tests of a small-tracked vehicle in muskeg.


Concludes from second phase of the testing program that muskeg mechanics is properly a part of conventional soil mechanics.


A brief description of access problems in the north, followed by a comparison of costs of wheeled and tracked vehicles in several northern operations.


A review of the Radforth classification, followed by discussion of muskeg vehicle design.


A discussion of bog communities according to conventional ecological theory.


A geological description and explanation of massive accumulations of organic sediments in the Tanana drainage in Alaska.

A textbook on peat deposits, treating their formation, classification, composition, stratigraphy, terrain relationships, geographic distribution, and methods of prospecting. (English abstract in files of Earth Sciences Division, QM R&EC.)

141. von Post, Lennart. 1926. EINIGE AUFGABEN DER REGIONALEN MOORFORSCHUNG. Sveriges Geologiska Undersokning, Series 6, No. 337, Stockholm.

A regional study of peat bogs in Sweden.


A review of a Swedish bog inventory, suggested as basis for proposed studies in Ireland. Gives a classification covering the relation of bogs to topography and drainage. Not a discussion of Irish bogs.


A review of the chemistry of peat.


Depicts permafrost as "nature's aid" in road construction over muskeg. Gives practical guides for route location, construction, and maintenance in the North.


Includes description and mechanical properties of muskeg in the Fort Churchill area of Canada.


Includes original distinction between "oligotrophic" and "eutrophic" peats, now commonly used by European writers.

Discuss types of bog lakes and their physical, chemical, and biological conditions.


Description and illustrations of blanket bog on Kerguelen Island in the south Indian Ocean.


Comments on effect of muskeg on oil development of the North, by the President of Imperial Oil Ltd. States that Musk-Ox and Nodwell Transporter give capacity for traversing muskeg in summer.


Notes trend of succession toward muskeg in southwestern Alaska. Regards muskeg on slopes of less than a certain steepness as a "physiographic climax," maintaining itself and in some places invading forest.
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