BASIS FOR REGIONAL WETLAND STUDIES

S.C. Zoltai

and

C. Tarnocai

Abstract

The great diversity of physiography and climate of Canada combine to develop distinctive but regionally different wetlands across the continent. Wetland surveys must not be restrictive in their scope; the needs of a wide variety of disciplines should be satisfied, and therefore the most successful study will be conducted by a multidisciplinary group. A most promising approach is the study of the development of wetlands within defined Wetland Regions. By examining the physical, chemical, and biotic characteristics of distinctive wetland types in given climatic regions and in a variety of landscape settings, a thorough understanding of wetland dynamics is obtained. This understanding will lead to a reliable indication of conditions in other similar wetlands and will serve as a tool to predict the consequences of man's interference with the natural system. The Wetland Regions of the western District of Mackenzie are delineated and discussed in terms of the problems presented for the construction of a chilled pipeline and roads.

- * -

Introduction

Wetlands are dynamic ecosystems, being influenced by the interactions of biotic and abiotic environmental factors. Wetland ecosystems are capable of changing their own environment through the accumulation or degradation of the materials in the wetlands. The peaty materials of many wetlands were deposited through long periods of time, with particular sets of environmental conditions operating at each segment of time. The depositional sequence of these materials is a testimony to the changing, dynamic conditions in the wetlands, showing reactions and adaptations induced by peat accumulation, climatic changes, and other external or internal changes.

The dynamic nature of wetlands requires that developmental trends and the factors governing these trends be understood in order to gain a meaningful knowledge of wetlands. Such understanding can

be obtained only by coordinated multidisciplinary studies, not by shortcuts looking for magic "indicator" factors.

The great diversity of climatic and physiographic conditions in Canada makes the study of wetland dynamics an enormous task. However, it is this great diversity that points a way to a rational study of wetlands. Initial investigations of wetland dynamics showed that large regions have distinctive trends in wetland development, resulting in well defined readily identifiable types of wetlands. These regions are apparently determined by the summary effects of physiography and climate on wetland dynamics. In this paper the concept of Wetland Regions is examined and illustrated by examples from Western Canada, and applied to terrain evaluation in subarctic and low arctic conditions.

Discussion

The basic requirement for regional wetland studies is an appreciation of the roles of the different components of the natural ecosystem which produced the wetlands through time and through changing climatic conditions. Figure 1 shows the complex interactions which influence not only the wetlands, but the surrounding areas as well. This diagram emphasizes the dynamic nature of wetlands, with different ecosystems developing under different conditions. If the developing wetland is in equilibrium with its environment as modified by the wetland itself, very few changes will occur. On the other hand, if the developing wetland alters its environment, or if the environment changes because of natural or artificial causes, certain changes will take place in the development of the wetland. It follows that surface conditions reflect the present status: the present status is a slice in time of what may be either a steady state or a transitional period. An understanding of wetland dynamics is therefore essential in a rational study and classification of wetlands. Such understanding is necessary to predict the kind and magnitude of response to artificially induced changes.

Initial regional studies showed that wetlands do not develop in a haphazard manner; instead, broad geographic regions have characteristic wetlands. These wetlands can be characterized within regions by their morphology and chemical and physical properties of their materials, as well as by the living and fossil vegetation. It was also found that the developmental trends of different wetlands are generally similar within Wetland Regions.

The classification developed by the Wetland Subcommittee (Zoltai et al. 1975) was followed in these regional studies. The most useful classes at this level of generalization were based on the landform

of wetlands, following an initial breakdown into broad physiognomic classes (bogs, fens, swamps, and marshes). Bogs are peat-covered areas having a high water table. The surface bog waters are strongly acid and the upper peat layers are extremely deficient in nutrients. Fens are also characterized by peat accumulation, but with far less acid reaction near the surface. Although drainage is very restricted, slow internal drainage does take place, resulting in higher levels of nutrients than in bogs. Swamps are wooded wetlands where standing or gently flowing waters occur seasonally or persist for long periods on the surface. Waters are circumneutral and usually do not lack oxygen or mineral nutrients. Marshes are grassy wet areas periodically inundated up to a depth of 2 m with standing or slowly moving water. There is usually little peat accumulation. The surface waters are usually circumneutral with relatively high oxygen and mineral nutrient levels.

The broad Wetland Regions of Canada were determined (Zoltai et al. 1975) and are reproduced here (Figure 2). These Regions were based on our often sketchy knowledge of wetland dynamics and characteristic wetland development across Canada. Work is presently under way to refine this map; a map of Wetland Regions of British Columbia was developed recently (Figure 3).

The peatland Regions of the western District of Mackenzie, N. W. T. were presented by Zoltai and Tarnocai (1975). The delineation of these Regions was also based on the developmental trends and prevalence of characteristic wetlands within the regions. This map was modified to include all wetlands in the area, resulting in a map of Wetland Regions of the District of Mackenzie (Figure 4). This map shows a marked zonation extending from east to west, with only minor influences by the physiography of the region. A more complex situation exists in British Columbia where the high and low rainfall areas, as well as high elevations, complicate the expected north-south gradient.

The study in the District of Mackenzie may be used to illustrate the approach to a regional wetland investigation (Zoltai and Tarnocai, 1975). In this study the basic team consisted of two peat landform specialists, one with special interest in plants, the other in soils. This team worked in close association with Pleistocence geologists and geomorphologists who provided input on mineral soil distribution and groundwater. During field work the external peatland forms were determined, measurements of the morphology were taken, and the present vegetation was described. Several cores were taken at each location, and the material was later analyzed for macrofossil, ice or water, chemical, and ash content.

The results of this study show that peat developed under non-permafrost conditions in all but the most northerly Wetland Region. Two dominant development paths were followed: one by the in-filling of lakes with organic debris until a sedge fen finally covered the lake, and another by the gradual buildup of peat in often shrubby fen conditions. In the first instance the water table was high initially and remained high, while in the second instance the water table rose as peat accumulation impeded the drainage. Permafrost developed in many wetlands only relatively recently following the development of a Sphagnum cap, although the rare occurrence of mixed peat at depth indicates that small frozen lenses may have existed in some peatlands prior to the general trend toward permafrost developments. In the northern Region, basal peat is mixed with mineral soil by cryoturbation, indicating that permafrost conditions obtained during their development. Many high centre polygons are relic features, as peat has ceased to accumulate in them for as much as 8000 years.

The regional characteristic of particular Wetland Regions in the District of Mackenzie may be summarized as follows:

Low Arctic Region (A1)	Wetlands dominated by lowland polygons. The low centre polygons are active, with peat developing in them, but the high centre polygons are mainly deteriorating. Shrubby or grassy fens may occur; all wetlands are underlain by permafrost at less than 50 cm. There are occasional tidal marshes.
High Subarctic Region (Sp)	Wetlands are characterized by polygonal peat plateaus, e.g. peat plateaus having ice wedge polygons. Other wetlands include peat plateaus with associated frozen or unfrozen bog pools. Unfrozen patterned fens with frozen ridges occur, as well as unfrozen seepage fens, often with shrubby swamps.
Mid-Subarctic Region (Spp)	Wetlands are dominated by peat plateaus and palsas, with associated unfrozen fens, shrubby swamps, bog pools, and some collapse scars. Patterned and unpatterned fens are frequent, some with small frozen peat plateaus.
Low Subarctic Region (S)	Wetlands are characterized by peat plateaus and palsas, with frequent collapse scars, and by unfrozen flat bogs, seepage fens, patterned fens, and horizontal fens, and spruce swamp.

The open, stunted black spruce forest, a "muskeg" occurring commonly on upland sites in the High and Mid-Subarctic Regions, is

not considered to be a wetland. In the District of Mackenzie these forests generally occur on frost-heaved, hummocky terrain, where thin peat (less than 30 cm) may accumulate in the interhummock troughs, but little on the drier hummocks. In our experience this amount of peat accumulation is not sufficient to block the drainage and initiate further peat accumulation. These lands are considered to be imperfectly to poorly drained mineral soils.

In any region the wetlands present particular problems for resource development. A knowledge of the potential problems, however, allows the development of special designs which may overcome any difficulties. In the western part of the District of Mackenzie the terrain presents certain problems which must be taken into account in planning road and chilled gas pipeline construction.

In general, the scraping or disturbance of the surface active layer must be avoided, as in mineral soil sites. Such disturbance will lead to a thickening of the active layer which may lead to thermal degradation. Similarly, the ponding of surface water must be avoided, as this will have the same effect as the disturbance of the active layer. Particular regional characteristics indicate the following considerations.

Low Arctic Regions	Most high centre polygons are eroding and are bare of vegetation; minor surface disturbance should cause little problem. Because of the prevalence of permafrost, only active layer and surface water drainage can take place; well placed culverts can prevent ponding.
High Subarctic Region	Complete insulating vegetation cover protects the permafrost; disruption of the vegetation mat will cause subsidence. However, if the water derived from thawing permafrost can be drained, the new peat surface will eventually insulate the surface; thus frozen peatlands present only moderate difficulties. Drainage across frozen fens by culverts is adequate. However, placing a pipeline having below freezing temperatures across unfrozen seepage fens will impede the flow of water, with subsequent upstream ponding and thermal erosion.
Mid-Subarctic Region	Placement of cold pipeline across fens presents the same problems as in the High Subarctic Region. Alternating frozen-unfrozen wetlands present particular danger with a cold pipeline: a frost bulb will develop around the pipe in a previously unfrozen

ground, with attendant heaving. Water from the unfrozen fen will flood into the pipeline ditch in adjacent areas. Frozen peatlands present only moderate problems to road builders, but unfrozen bog pools and fens will cause foundation problems.

Low Subarctic Region Frequent collapse scars indicate that permafrost conditions are unstable, hence a small disturbance may cause severe thermal erosion. Problems encountered in the Mid-Subarctic Region are also applicable to this Region.

The above examples, although presented only in summary form, indicate some of the specific applications of a regional wetland study. Other applications include characterizing the hydrological conditions in various wetlands. Information could also be extracted on the amount and kind of peat occurring in each Region, along with its chemical characteristics. Other uses, such as regional planning and development, drainage feasibility, agricultural or forestry use could greatly benefit from such studies.

The greatest value of the Wetland Region concept lies in its ecological foundation. Because of this firm background, similar wetlands in the same Region can be compared with one another, and experience gained in wetlands can by safely applied to similar wetlands in the same Region. On the other hand, knowledge obtained in another region will probably not be directly transferable between regions. The user, be it a biologist, engineer, planner, or any other resource user, must establish some experience within a region before he can claim a working knowledge of the wetlands, however great his experience may be in other Wetland Regions.

REFERENCES

Zoltai, S.C., F.C. Pollett, J.K. Jeglum, and G.D. Adams. 1975. Developing a wetland classification for Canada. Proc. 4th North Am. For. Soils Conf., Québec, 1973. pp. 497-511.

Zoltai, S.C. and Tarnocai, C. 1975. Perennially frozen peatlands in the Western Arctic and Subarctic of Canada. Can. J. Earth Sci. 12 : 28-43.

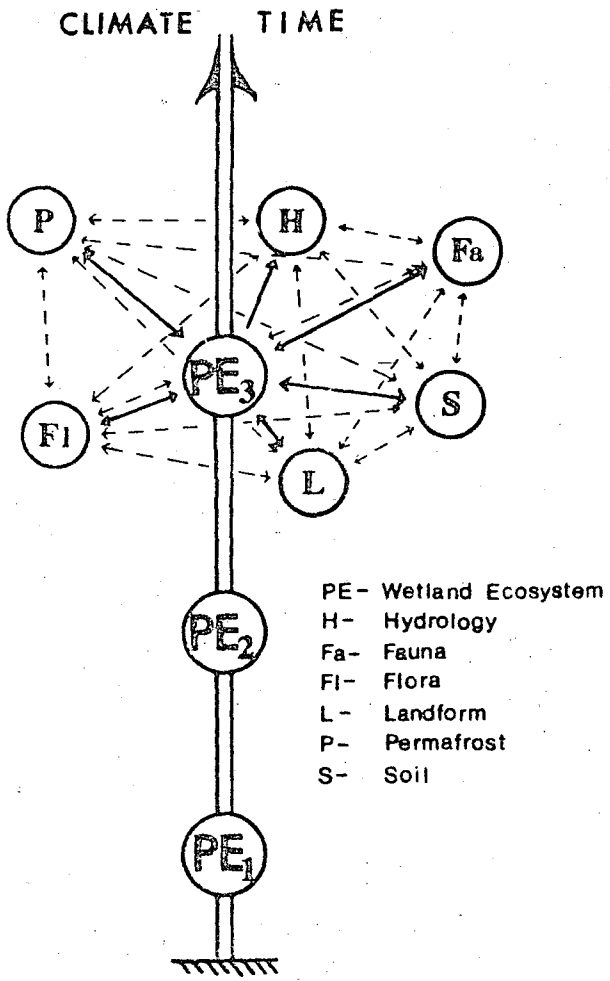

Figure 1.
Diagram of interactions between environmental parameters and wetland ecosystems through time and changing climate

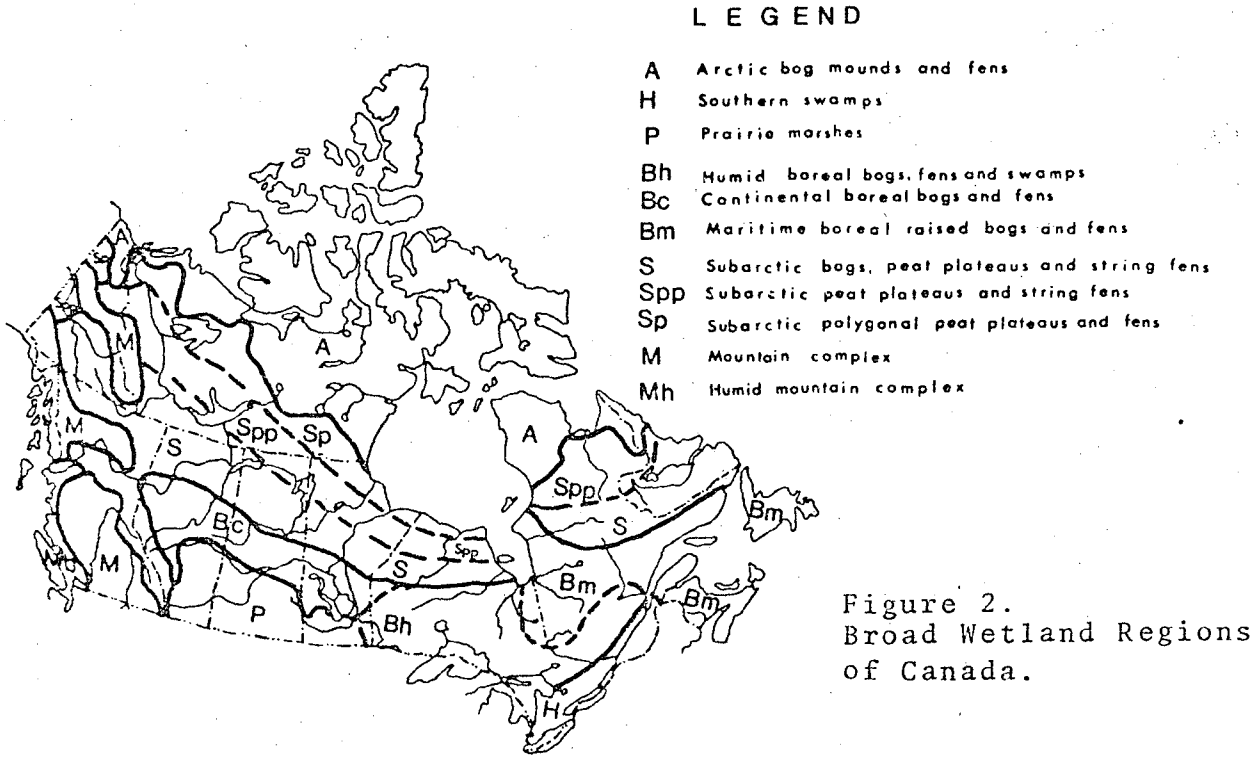

Figure 2.
Broad Wetland Regions of Canada.

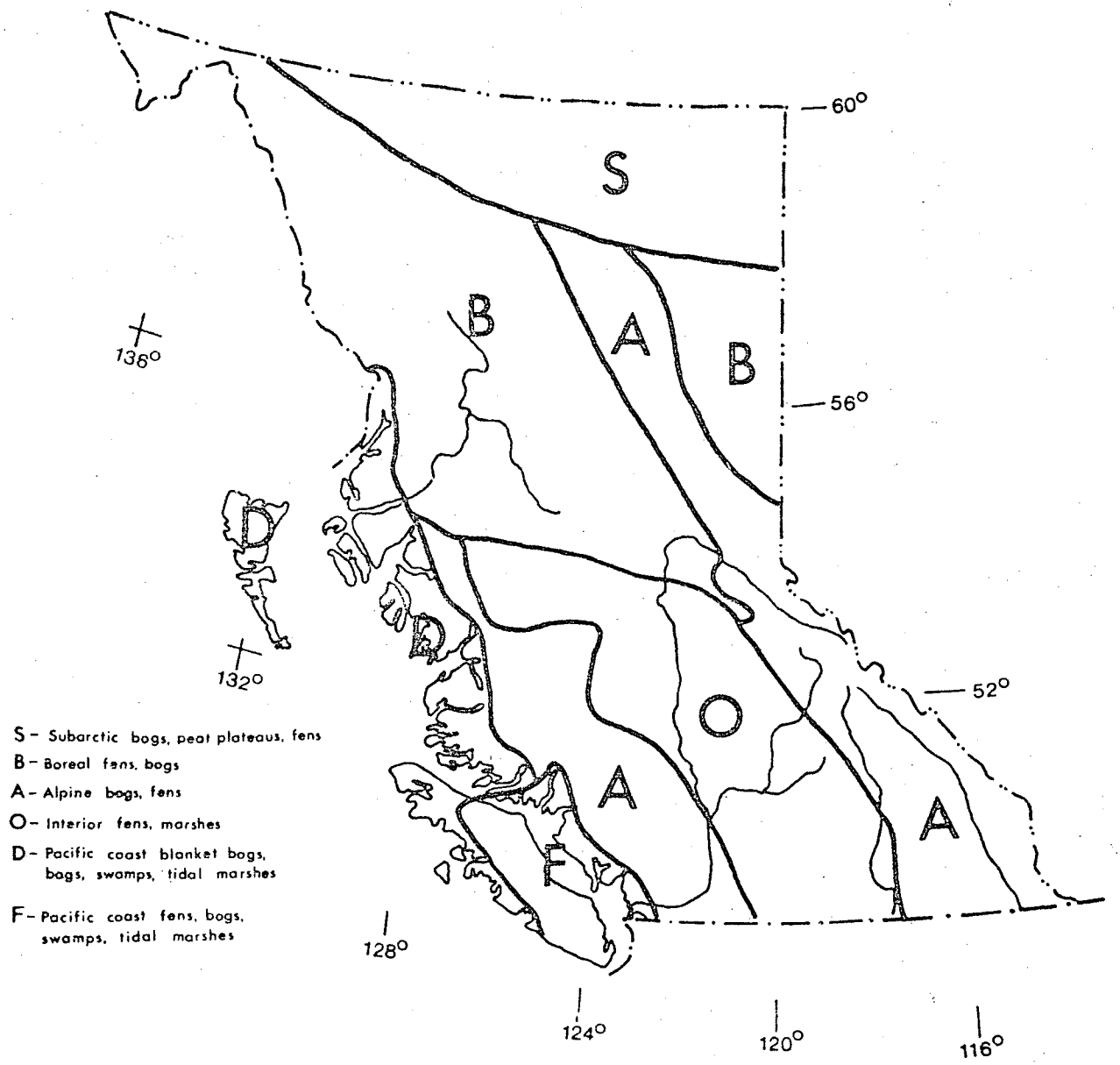

Figure 3. Wetland Regions of British Columbia

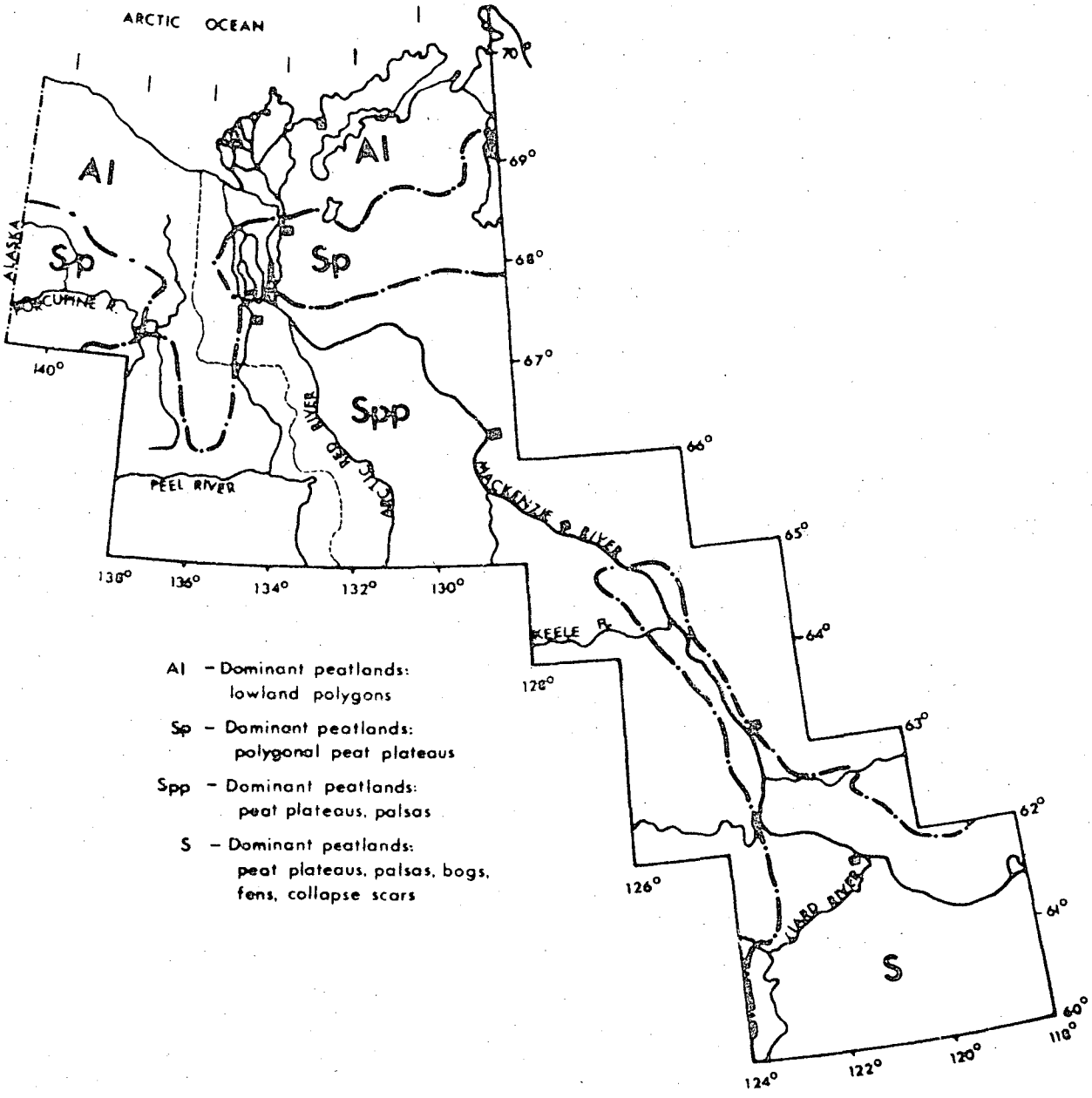

Figure 4. Wetland Regions of western District of Mackenzie, N.W.T.

National Research Council Canada
Conseil national de recherches Canada

ASSOCIATE COMMITTEE ON GEOTECHNICAL RESEARCH

PROCEEDINGS

OF THE

SIXTEENTH MUSKEG RESEARCH CONFERENCE

OCTOBER 7, 1975

PREPARED BY

G. P. WILLIAMS
AND
J. CURRAN

TECHNICAL MEMORANDUM NO. 116

OTTAWA

MARCH 1976