RELATIONSHIPS BETWEEN NUTRIENTS AND VEGETATION IN PEATLANDS OF THE PRAIRIE PROVINCES

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ABSTRACT

The total mineral content of the surface 50-cm layer of peat and of the water from the top of the water table was analyzed from 313 sites in bogs, fens and swamps from the boreal zone of Alberta, Saskatchewan and Manitoba. Four trophic classes were indicated by the chemical analyses: very low (oliogotrophic), low (dystrophic), moderate (mesotrohpic) and high (macrotrohpic) nutrient levels. Specific broad vegetation classes were associated with each trophic class. The vegetation of oligotrohpic peatlands could be futher distinguished on the basis of water origin (ombrogenous and rheogenous). All swamps are in the mesotrohpic range. Indications are that further differences in vegetation are caused by moisture conditions as shown by the position of the water table.

La teneur minérale totale de la couche superficielle de tourbe de 50 cm, et de l'eau provenant de la partie supérieure de la nappe phréatique, a été analysée à 313 endroits de tourbières (bogs et fens) et de marécages des zones boréales de l'Alberta, de la Saskatchewan et du Manitoba. Les analyses chimiques ont révélé quatre classes trophiques : teneur très faible (oliogotrophe), faible (dystrophe), modérée (mésotrophe), et élevée (macrotrophe), en agents nutritifs. Des classes de végétation spéciales ont été associées à chaque classe trophique. La végétation de tourbières oligotrophes peut encore être divisée d'après l'origine de l'eau (ombrogènes et rhéogènes). Tous les bogs sont oligotrophes, mais les fens peuvent être de nature oligotrophes à macrotrophe. Tous les marécages se situent dans la classe mésotrophe. Certains indices laissent supposer que d'autres différences dans la végétation sont causés par l'humidité, comme le montre l'emplacement de la nappe phréatique.

INTRODUCTION

It has long been recognized that a close relationship exists between nutrient levels (trophic condition) and wetlands (Weber 1902 in Botch and Masing 1983). The initial classes (eutrophic = low mire; mesotrophic = transitional mire; oligotrophic = high mire) were later refined by subdividing these into narrower classes on the basis of the pH or the conductivity of the water (Du Rietz 1932, Sjörs 1950). Chemical analysis of the near-surface peat was successfully used to characterize broad peatland types (Pollett 1972, Stanek *et al.* 1977).

In general, however, the chemistry of wetlands was not fully applied to differentiate between various wetland types. Often the distinction between ombrotrophic and minerotrophic vegetation is based on the presence or absence of species believed to be exclusively minerotrophic (Gauthier 1980). The chemical analysis of groundwater and peat are relegated to a secondary, descriptive role. Basing the trophic classes on vegetation often results in a broad relationship to the chemical analyses, but with considerable overlap between the classes (Sjörs 1950). In geographically more restricted areas the mire classes are well differentiated by peat or water chemistry (Glaser *et al.* 1981, Wells 1981).

The basic premise of this study is that the nutrient status of the peatland has a profound influence on the vegetation of the peatlands, as determined by a number of floristic studies. We established nutrient classes, based on the amounts of some macronutrients present in the peat and water of the peatlands. The vegetation present in the nutrient classes was then described.

For the present study the data collected from a large number of peatlands in the Prairie provinces of Canada were used to establish broad nutrient and vegetation classes. In this paper the chemical properties of the nutrient classes and the distinctive species of the corresponding vegetation types are presented.

Some peatland types were not included in this analysis. Wetlands fed by groundwater discharge (spring fens) were excluded because of their unique chemistry and vegetation. Perennially frozen peatlands (palsas and peat plateaus) present a dry habitat on their raised surface and the vegetation resembles that of uplands. Peatlands that are chemically stratified in the upper 50 cm were excluded, because some vegetation may be rooted entirely in the upper, nutrient-poor stratum, while other plants are rooted in the lower, nutrient-rich peat, resulting in unusual, but characteristic assemblages of species for that particular nutrient stratification.

METHODS

During four field seasons (1981-1984) a total of 230 different peatlands were investigated in the Boreal portions of Alberta, Saskatchewan and Manitoba. The vegetation was described in detail at one or more stations if there was a diversity in the vegetation and landforms of the peatlands. A total of 309 stations were described. The peat was cored at each of these stations with a Macaulay peat sampler and sampled at 15 cm intervals. The peat from the top 50 cm of the section (typically four segments) was used for this study. Water was collected from shallow pits at the top of the water table. The measurement of pH was done immediately upon collection with Duotest pH indicator paper.

In the laboratory, the water was acidified with 0.18 N HCl as a stabilizer and preservative. It was then analyzed with an inductively coupled argon plasma atomic emission spectrophotometer. The elements included calcium (Ca), magnesium (Mg), potassium (K), aluminum (Al), sulphur (S), phosphorus (P), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), nickel (Ni), lead (Pb), titanium (Ti), and sodium (Na). The conductivity of the water was measured with a temperature-compensated conductivity meter and the results were corrected for pH according to Sjors (1950). The peat was ashed in an oven at 480°C, the ash treated with *aqua regia* (HNO_3 : HCl = 1:4.5), the residue was extracted with 1.5 N HCl and the filtrate was analyzed with the ICAP-AES for the same elements as the water.

The results of the vegetation sampling were subjected to TWINSPAN analysis. Preliminary characteristic species groupings for each peatland vegetation class were determined on the basis of those species which were dominant (i.e. had the greatest cover) and occurred in at least 50% of the sites in that grouping. In some cases, constant species with relatively low cover were used to further differentiate a class (e.g. *Sphagnum riparium* in the Oligotrophic Open Fen class). A minimum of 20% shrub or tree cover was set to separate shrubby and treed fens from open fens. The lower height limit for trees was 5 m. However, for the purposes of this classification, *Larix laricina* and *Picea mariana* were considered to be tree species regardless of size.

RESULTS

Peat Analyses

Nutrient classes were established on the basis of total calcium content of the surface 50 cm of the peat. Calcium was chosen because it is the most abundant inorganic constituent of the peat and because of its influence on the acidity and nutrient mobility in the soil. The following ranges were established to create the nutrient classes:

Oligotrophic:	<5000 mg kg^{-1}
Dystrophic:	5000 - 10000 mg kg^{-1}
Mesotrophic:	10000 - 30000 mg kg^{-1}
Macrotrophic:	>30000 mg kg^{-1}

Samples with visible marl ($CaCO_3$) were excluded from the analysis, as these would have given excessively high calcium readings.

Among the elements, Ca, Mg and S showed increased amounts according to the trophic classes (Table 1). All the other elements showed an irregular pattern, although the oligotrophic classes tended to have the lowest amounts of most nutrients. The macrotrophic class had the highest amounts only in Ca, Mg and S; all other elements occurred in as high or higher amounts in the other nutrient classes.

A similar pattern is evident when the peatland-nutrient-vegetation classes are examined (Table 2). Ca, Mg and S generally increase with trophic levels, but the broad vegetation classes (open, shrubby, or treed) introduce little or no variation.

The chemical composition of water from the top of the water table indicates that Ca and Mg increase with the trophic classes (Table 3). There is a general tendency for the values of S, Na and K to increase with the trophic classes. The trace elements do not display any consistent trend. The results by peatland-nutrient-vegetation classes show that there are similar levels of nutrients within each trophic class (Table 4). The results of the vegetation analysis are included in Table 5.

Table 1. Chemical composition of surface peat (50 cm) by nutrient classes (mg kg^{-1}). Standard error of the mean in brackets.

	Sites:Samples	pH	Ca	Mg	Fe	S	P	Na	K	Al	Ti	Pb	Cu	Mn	Zn	Ni
OLIGOTROPHIC (bog)	81 : 317	4.3 (.02)	2724 (93)	1006 (50)	1352 (92)	602 (17)	522 (16)	119 (4)	1276 (83)	1112 (43)	13.8 (.36)	9.6 (.54)	3.9 (.17)	146.4 (12.0)	21.8 (.81)	7.1 (.46)
OLIGOTROPHIC (fen)	13 : 62	4.6 (.04)	3298 (118)	918 (85)	1992 (251)	890 (56)	736 (38)	237 (33)	1606 (291)	1576 (147)	14.5 (0.88)	9.2 (1.02)	5.4 (.33)	153.5 (30.0)	32.4 (2.54)	7.2 (.46)
DYSTROPHIC (fen)	16 : 63	4.8 (.06)	6699 (392)	1803 (142)	3432 (463)	1147 (84)	812 (37)	202 (16)	1863 (269)	1486 (187)	33.6 (5.40)	5.4 (1.37)	7.1 (1.00)	368.5 (55.4)	37.9 (2.37)	7.7 (.77)
MESOTROPHIC (fen)	150 : 578	5.6 (.03)	18380 (409)	3480 (83)	4116 (310)	1920 (63)	861 (15)	177 (8)	1080 (60)	1316 (48)	18.1 (.51)	7.4 (.38)	5.6 (.18)	708.4 (57.7)	42.9 (1.30)	10.2 (.53)
MESOTROPHIC (conifer swamp)	33 : 141	5.3 (.08)	23120 (1470)	3539 (211)	2596 (308)	3046 (267)	816 (27)	128 (7)	1071 (115)	1597 (107)	18.6 (.82)	10.9 (.92)	6.2 (.72)	463.5 (74.0)	29.8 (2.09)	13.4 (1.63)
MACROTROPHIC (fen)	16 : 60	6.5 (.07)	44657 (3513)	3410 (208)	7677 (1212)	2757 (199)	801 (58)	122 (9)	644 (106)	1231 (95)	12.7 (1.09)	6.9 (.90)	5.5 (.44)	795.6 (219.6)	41.9 (4.30)	9.7 (1.54)

DISCUSSION

In general, the particular species assemblage listed in Table 5 achieves its greatest abundance (dominance) in that peatland vegetation class (exceptions are the open fen categories). All species may not be present at certain sites, but the listed grouping represents the majority situation when characterizing a particular peatland vegetation class. The characteristic species listed for each peatland vegetation class are not necessarily exclusive to that particular grouping. There is overlap at the extremes of most groupings. Also, the presence of a particular species does not automatically indicate a particular trophic level. Depth to water table and site history (fires, draining, flooding, etc.) are modifying factors.

For some of the uncommon peatland vegetation classes (i.e. oligotrophic shrubby and treed fens) the number of sites was too few and the vegetation too diverse to adequately characterize these groupings. Also, on the basis of the vegetation alone, there is not a clear separation between the mesotrophic and macrotrophic fen categories.

When vegetation analysis was done, no separation was made on the basis of whether a species occurred on a hummock or in a hollow. This tends to obscure the differences between certain classes. An additional problem is the uncertainty of the identification of some of the species encountered early in the growing season (particularly the graminoids).

Regional differences are evident when classifying peatland vegetation classes over such a broad area. In a particular habitat, a given species may be dominant in one area, but be replaced by another species, or even disappear altogether, in another. For example, *Fraxinus nigra* and *Thuja occidentalis* occur in swamps only in southeastern Manitoba where precipitation is higher and the growing season is slightly longer. *Kalmia polifolia* is a characteristic species of bogs in Saskatchewan and Manitoba, but it is rare in the Alberta sites. *Andromeda polifolia* and *Oxycoccus microcarpus* are characteristic and widespread species at sites in Alberta and Saskatchewan, but *Andromeda glaucophylla* and *Oxycoccus quadripetalus* are frequently encountered at sites in Manitoba. Also, the strings in patterned fens in Manitoba tend to have a greater diversity of shrub species than do those in Alberta and Saskatchewan.

Table 2. Macronutrient levels of surface peat (50 cm) of peatland-vegetation classes (mg kg^{-1}). Standard error of the mean in brackets.

	Sites:Samples	pH	Ca	Mg	Fe	S	K	P	Na
OLIGOTROPHIC TREED BOG	81 : 317	4.3 (.02)	2724 (93)	1006 (50)	1352 (92)	602 (17)	1276 (83)	522 (16)	119 (4)
OLIGOTROPHIC OPEN FEN	9 : 40	4.7 (.04)	3285 (304)	867 (119)	2001 (182)	872 (62)	1568 (372)	694 (48)	267 (49)
OLIGOTROPHIC TREED & SHRUBBY FEN	4 : 22	4.4	3323 (.06)	1011 (924)	1977 (100)	923 (636)	1674 (110)	690 (475)	183 (70)
DYSTROPHIC OPEN FEN	6 : 27	5.0 (.09)	6246 (482)	1803 (233)	2487 (350)	1512 (152)	1555 (364)	810 (65)	252 (30)
DYSTROPHIC SHRUBBY FEN	5 : 20	4.7 (.07)	7923 (764)	1540 (125)	5166 (1194)	962 (83)	1798 (519)	928 (68)	185 (24)
DYSTROPHIC TREED FEN	5 : 16	4.5 (.08)	5932 (841)	2130 (361)	4735 (1806)	764 (85)	2462 (574)	714 (53)	139 (14)
MESOTROPHIC OPEN FEN	49 : 184	6.0 (.05)	15687 (440)	2874 (114)	3942 (362)	2156 (117)	898 (110)	774 (26)	194 (19)
MESOTROPHIC SHRUBBY FEN	22 : 89	5.6 (.06)	17268 (793)	3743 (194)	2953 (398)	2193 (212)	1008 (114)	996 (39)	169 (14)
MESOTROPHIC TREED FEN	79 : 305	5.4 (.04)	20328 (672)	3636 (127)	4561 (532)	1763 (85)	1212 (86)	874 (21)	169 (9)
MESOTROPHIC THICKET SWAMP	9 : 37	5.6 (.09)	17215 (1356)	3617 (203)	2900 (526)	5772 (558)	935 (206)	1036 (88)	187 (20)
MESOTROPHIC HARDWOOD SWAMP	4 : 15	5.7 (.13)	16275 (4203)	4172 (482)	6332 (735)	4440 (1058)	1257 (264)	944 (117)	192 (22)
MESOTROPHIC CONIFER SWAMP	33 : 141	5.3 (.08)	23120 (1470)	3539 (211)	2596 (308)	3046 (267)	1071 (115)	816 (27)	128 (7)
MACROTROPHIC OPEN FEN	9 : 32	6.6 (.10)	49942 (5449)	4094 (327)	3858 (664)	2955 (251)	421 (77)	567 (46)	105 (9)
MACROTROPHIC SHRUBBY FEN	2 : 7	6.1 (.18)	29438 (6179)	3219 (373)	21126 (7082)	3491 (1139)	1198 (599)	703 (133)	173 (60)
MACROTROPHIC TREED FEN	5 : 21	6.5 (.14)	41675 (4867)	2430 (114)	9103 (1461)	2211 (173)	801 (189)	1192 (100)	131 (10)

In the area investigated the wetland vegetation appears to be sensitive chiefly to calcium, magnesium and sulfur. Of these three elements calcium is the most abundant, and a classification based on the abundance of calcium resulted in the distinction of trophic levels of ecological significance. The vegetation appears to be sensitive to relatively small changes at low Ca and Mg concentrations (oligotrophic and dystrophic). As the concentration of these elements increases, differences in vegetation are induced only by much greater changes in nutrient levels.

The relative abundance of elements in the peat and in the water table is similar. However, water samples were obtained only

Table 3. Chemical composition of water table by nutrient classes (mg L^{-1}). Standard error of the mean in brackets.

	Sites	Depth to Water Table (cm)	pH	Specific Conduct. (corr.) mS cm-1	Ca	Mg	Fe	S	P	Na	K	Al	Pb	Cu	Mn	Zn	Ni
OLIGOTROPHIC (bog)	71	37 (1.8)	4.5 (.02)	.062 (.003)	2.04 (.18)	0.87 (.12)	0.90 (.09)	1.21 (.12)	0.17 (.018)	2.59 (.28)	1.42 (.10)	0.46 (.04)	0.01 (.002)	0.02 (.003)	0.03 (.003)	0.02 (.002)	0.05 (.007)
OLIGOTROPHIC (fen)	17	12 (3.8)	4.7 (.03)	.048 (.005)	2.24 (.67)	0.72 (.25)	0.91 (.20)	1.11 (.14)	0.19 (.029)	4.15 (.72)	0.91 (.14)	0.74 (.12)	0.04 (.011)	0.04 (.009)	0.04 (.013)	0.02 (.003)	0.03 (.011)
DYSTROPHIC (fen)	16	11 (4.3)	4.9 (.06)	.058 (.009)	3.61 (.60)	1.68 (.38)	1.68 (.37)	0.79 (.25)	0.08 (.02)	3.62 (1.14)	1.64 (.24)	0.19 (.06)	0.02 (.006)	0.01 (.003)	0.07 (.016)	0.02 (.003)	0.28 (.086)
MESOTROPHIC (fen)	147	11 (1.2)	5.8 (.05)	.212 (.012)	24.98 (1.59)	10.16 (.69)	0.60 (.08)	1.68 (.29)	0.13 (.018)	4.75 (.36)	1.42 (.11)	0.30 (.03)	0.02 (.003)	0.02 (.002)	0.10 (.019)	0.02 (.004)	0.09 (.008)
MESOTROPHIC (conifer swamp)	29	29 (2.8)	5.8 (.17)	.243 (.029)	30.80 (4.68)	11.78 (1.81)	0.53 (.23)	3.38 (1.14)	0.20 (.046)	5.51 (.56)	2.22 (.11)	0.52 (.08)	0.02 (.005)	0.03 (.006)	0.28 (.1.85)	0.01 (.002)	0.01 (.002)
MACROTROPHIC (fen)	18	5 (1.6)	6.5 (.12)	.374 (.033)	53.60 (5.29)	14.20 (1.24)	0.41 (.20)	1.73 (.18)	0.12 (.020)	6.54 (.87)	0.97 (.20)	0.97 (.18)	0.06 (.011)	0.05 (.008)	0.01 (.003)	0.01 (.002)	0.06 (.025)

once from each site, disregarding any seasonal variations. Such variations, however, can result in considerable differences in the water quality (Glaser *et al.* 1981). As our water samples were taken between mid-June and mid-August, their average probably represents mid-summer conditions. The chemical properties of peat do not reflect any seasonal variations and are considered to be more reliable than the water analyses.

The main difference between vegetation classes within each trophic class appears to be the average level of water table below the surface. The water table is the closest to or above the surface in the open peatlands, somewhat lower in the shrubby peatlands and the deepest in the treed peatlands (Table 4). A similar trend was reported in the fens of northern Ontario (Sims *et al.* 1982) and in Saskatchewan (Jeglum 1971). In the mesotrophic and macrotrophic open fens the wettest sites contain *Scorpidium*, while somewhat drier sites have *Drepanocladus* (Table 4). However, as our water table data are based on single observations and are not seasonal averages, further detailed work is necessary to establish the relationship between broad vegetation types and the level of the water table.

The oligotrophic classes are chemically similar. However, when such readily mobilized elements as Na are examined, the oligotrophic fens are found to contain about twice the average amount in the oligotrophic bogs (Table 4). By definition, fen waters have percolated through upland terrain, usually mineral soil, whilst the bog waters have been derived from rain (ombrogenic). Fen waters can be enriched by such minerals that may be present in the mineral soil. Thus the distinction between ombrogenic (from the Greek *ombros* rain : originated by rain-water) and rheogenic (from the Greek *rheein* to flow : originated by moving water) has a significance in the chemistry of the wetlands, although this may not be manifested in the calcium content of the peat or water of fens.

Some nutrient classes are restricted to specific wetland classes or wetland forms (Zoltai and Pollett 1983). All bogs are oligotrophic. The swamps studied are all in the mesotrophic nutrient class. The fens, however, range from oligotrophic to macrotrophic, depending on the nutrient status of the land where the groundwater originates. The same wetland form, such as ribbed (string) fens occurs in all nutrient classes from oligotrophic to macrotrophic (Vitt *et al.* 1975, Slack *et al.* 1980). Thus the nutrient classes do not replace the existing wetland

Table 4. Macronutrient composition of water by peatland-vegetation classes (mg L^{-1}) Standard error of the mean in brackets.

	Sites	Depth to Water Table (cm)	pH	Specific Conduct. (corr.) mS cm^{-1}	Ca	Mg	Fe	S	K	P	Na
OLIGOTROPHIC TREED BOG	71	37 (1.8)	4.5 (.02)	.062 (.003)	2.04 (.18)	0.87 (.12)	0.90 (.09)	1.21 (.12)	1.42 (.10)	0.17 (.018)	2.59 (.28)
OLIGOTROPHIC OPEN FEN	13	8 (3.2)	4.7 (.05)	.045 (.006)	2.34 (.83)	0.78 (.32)	0.89 (.24)	1.14 (.18)	0.89 (.18)	0.21 (.034)	4.21 (.89)
OLIGOTROPHIC TREED & SHRUBBY FEN	4	26 (10.4)	4.7 (.00)	.056 (.001)	1.90 (1.20)	0.55 (.30)	0.99 (.40)	1.01 (.23)	0.99 (.20)	0.12 (.039)	3.95 (1.26)
DYSTROPHIC OPEN FEN	7	+2 (6.6)	5.0 (.12)	.075 (.017)	4.23 (1.22)	2.30 (.75)	0.92 (.26)	1.05 (.56)	1.81 (.39)	0.07 (.028)	4.71 (2.30)
DYSTROPHIC SHRUBBY FEN	5	17 (0.9)	4.9 (.06)	.048 (.010)	3.55 (.86)	1.26 (.39)	2.00 (.59)	0.53 (.14)	1.03 (.46)	0.08 (.045)	3.58 (1.85)
DYSTROPHIC TREED FEN	4	26 (5.0)	4.8 (.05)	.043 (.007)	2.59 (0.38)	1.12 (.20)	2.60 (1.20)	0.67 (.15)	1.71 (.43)	0.09 (.052)	1.78 (.29)
MESOTROPHIC OPEN FEN	49	+2 (1.4)	6.0 (.09)	.249 (.024)	27.71 (2.62)	11.11 (1.36)	0.52 (.14)	1.82 (.65)	1.03 (.17)	0.13 (.039)	4.71 (.56)
MESOTROPHIC SHRUBBY FEN	22	8 (1.9)	5.8 (.10)	.160 (.019)	18.82 (2.16)	8.91 (1.38)	0.57 (.20)	2.57 (.09)	1.65 (.38)	0.09 (.017)	4.27 (.63)
MESOTROPHIC TREED FEN	76	20 (1.3)	5.9 (.08)	.203 (.015)	25.00 (2.47)	9.90 (.93)	0.65 (.11)	1.33 (.27)	1.61 (.14)	0.15 (.022)	4.92 (.57)
MESOTROPHIC THICKET SWAMP	9	13 (5.0)	5.7 (.25)	.182 (.021)	20.02 (3.26)	9.28 (2.09)	0.71 (.38)	5.23 (1.37)	2.38 (.87)	0.41 (.200)	6.58 (1.11)
MESOTROPHIC HARDWOOD SWAMP	4	17 (6.1)	6.1 (.45)	.379 (.162)	59.80 (24.24)	18.87 (9.44)	1.57 (.78)	4.28 (.97)	1.11 (.61)	0.21 (.090)	5.14 (2.31)
MESOTROPHIC CONIFER SWAMP	32	32 (3)	5.7 (.15)	.192 (.020)	22.97 (3.23)	9.24 (1.36)	0.50 (.23)	2.78 (1.04)	2.22 (.11)	0.20 (.046)	5.51 (.56)
MACROTROPHIC OPEN FEN	9	+1 (2.1)	6.5 (.19)	.374 (.030)	54.18 (5.91)	16.70 (1.67)	0.04 (.02)	1.83 (.24)	0.80 (.32)	0.09 (.032)	5.56 (1.14)
MACROTROPHIC SHRUBBY FEN	2	8 (3.9)	6.2 (.25)	.277 (.133)	41.02 (23.68)	10.16 (1.43)	0.82 (.60)	1.31 (1.00)	1.02 (.60)	0.17 (.160)	4.19 (2.76)
MACROTROPHIC TREED FEN	7	9 (1.8)	6.4 (.17)	.402 (.070)	56.45 (10.40)	12.14 (1.88)	0.75 (.47)	1.72 (.28)	1.17 (.29)	0.16 (.025)	8.46 (1.34)

classification, but they can be used to further characterize the wetland classes.

The reliability of relating trophic levels to vegetation classes is variable. In the oligotrophic class, the vegetation is distinctive in both the bogs and fens. Similarly, the trophic levels and vegetation of treed fens and all treed swamps are distinctive. Open fens are problematical, as there is considerable overlap in the vegetation of the dystrophic and mesotrophic, and mesotrophic and macrotrophic nutrient classes. Perhaps more rigorous attention to microrelief, reflecting moisture conditions, would eliminate some of these problems.

Table 5. Characteristic plant species of peatland vegetation classes.

Peatland Class	Characteristic Plant Species[1]
OLIGOTROPHIC TREED BOG ("dry form")	*Picea mariana/Ledum groenlandicum Sphagnum fuscum--Pleurozium schreberi*
("wet form")	*Picea mariana/Ledum groenlandicum --Chamaedaphne calyculata/Sphagnum angustifolium--S. magellanicum*
OLIGOTROPHIC OPEN FEN	*Carex limosa--Scheuchzeria palustris /Sphagnum jensenii--S. majus-- S. riparium*
OLIGOTROPHIC SHRUBBY AND TREED FENS (too few sites to adequately characterize these classes)	
DYSTROPHIC OPEN FEN	*Carex lasiocarpa--C. chordorrhiza /Campylium stellatum*[2]
DYSTROPHIC SHRUBBY FEN	*Chamaedaphne calyculata--Andromeda polifolia/Sphagnum angustifolium-- S. magellanicum*
DYSTROPHIC TREED FEN	*Larix laricina--Picea mariana/ Chamaedaphne calyculata/Sphagnum angustifolium--S. magellanicum*
MESOTROPHIC OPEN FEN ("dry form")	*Carex aquatilis--C. diandra /Drepanocladus aduncus--D. revolvens*
("wet form")	*Carex chordorrhiza--C. lasiocarpa --C. limosa/Scorpidium scorpioides*
MESOTROPHIC SHRUBBY FEN	*Betula pumila/Carex lasiocarpa --C. aquatilis--C. diandra /Tomenthypnum nitens--Drepanocladus aduncus--Campylium stellatum*
MESOTROPHIC TREED FEN (Sphagnum cushion type)	*Larix laricina--Picea mariana/ Betula pumila--Ledum groenlandicum /Sphagnum warnstorfii--S. fuscum --S. angustifolium--S. magellanicum*
(Tomenthypnum/Sphagnum type)	*Larix laricina--Picea mariana/ Betula pumila/Tomenthypnum nitens --Sphagnum warnstorfii*
(Tomenthypnum type)	*Larix laricina/Betula pumila/ Carex lasiocarpa/Tomenthypnum nitens*
MESOTROPHIC THICKET SWAMP	tall *Salix* spp.[3]/*Carex aquatilis --Calamagrostis inexpansa/Drepanocladus aduncus--Climacium dendroides*
MESOTROPHIC HARDWOOD SWAMP ("birch type") (one site only)	*Betula papyrifera/Salix bebbiana/ Calamagrostis canadensis/Climacium dendroides*
("black ash type") (SE Manitoba only)	*Fraxinus nigra/Matteuccia struthiopteris/Plagiomnium ellipticum-- Climacium dendroides*
MESOTROPHIC CONIFER SWAMP ("black spruce type")	*Picea mariana*[4]/*Ledum groenlandicum /Pleurozium schreberi--Hylocomium splendens*
("tamarack type")	*Larix laricina*[4]*--Picea mariana /Ledum groenlandicum--Betula pumila /Carex leptalea--C. disperma*
MACROTROPHIC OPEN FEN[5]	*Carex chordorrhiza--C. limosa-- C. lasiocarpa/Scorpidium scorpioides*
MACROTROPHIC SHRUBBY FEN	*Betula pumila/Tomenthypnum nitens --Drepanocladus revolvens*
MACROTROPHIC TREED FEN	*Larix laricina--Picea mariana/ Betula pumila/Muhlenbergia glomerata/Tomenthypnum nitens*

[1] Species within a given stratum are listed in order of decreasing abundance.
[2] Differentiating species *Sphagnum subsecundum sensu stricto*.
[3] The most common species are: *Salix bebbiana, S. lucida, S. planifolia,* and *S. pyrifolia*.
[4] Sites in southeastern Manitoba may also have *Thuja occidentalis* in association with *Picea* and *Larix*.
[5] Differentiating species from Mesotrophic Open Fen are *Catoscopium nigritum* and *Cinclidium stygium*.

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PROCEEDINGS

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