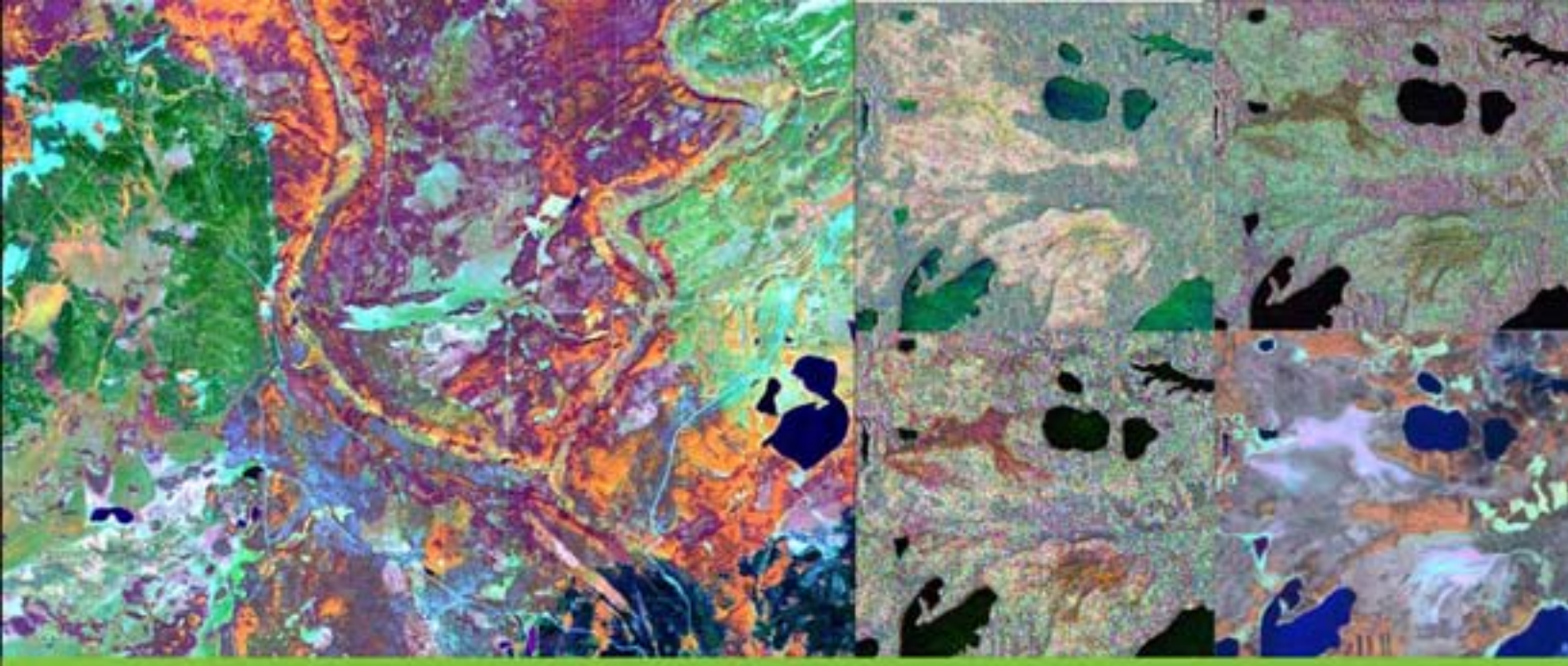

A FIELD GUIDE TO THE WETLANDS OF THE BOREAL PLAINS ECOZONE OF CANADA

Kevin B. Smith[1], Christopher E. Smith[1], Silvie F. Forest[1], and Alain J. Richard[1]

[1] Ducks Unlimited Canada, Western Boreal Office,
#100 17958 106th Avenue, Edmonton, Alberta

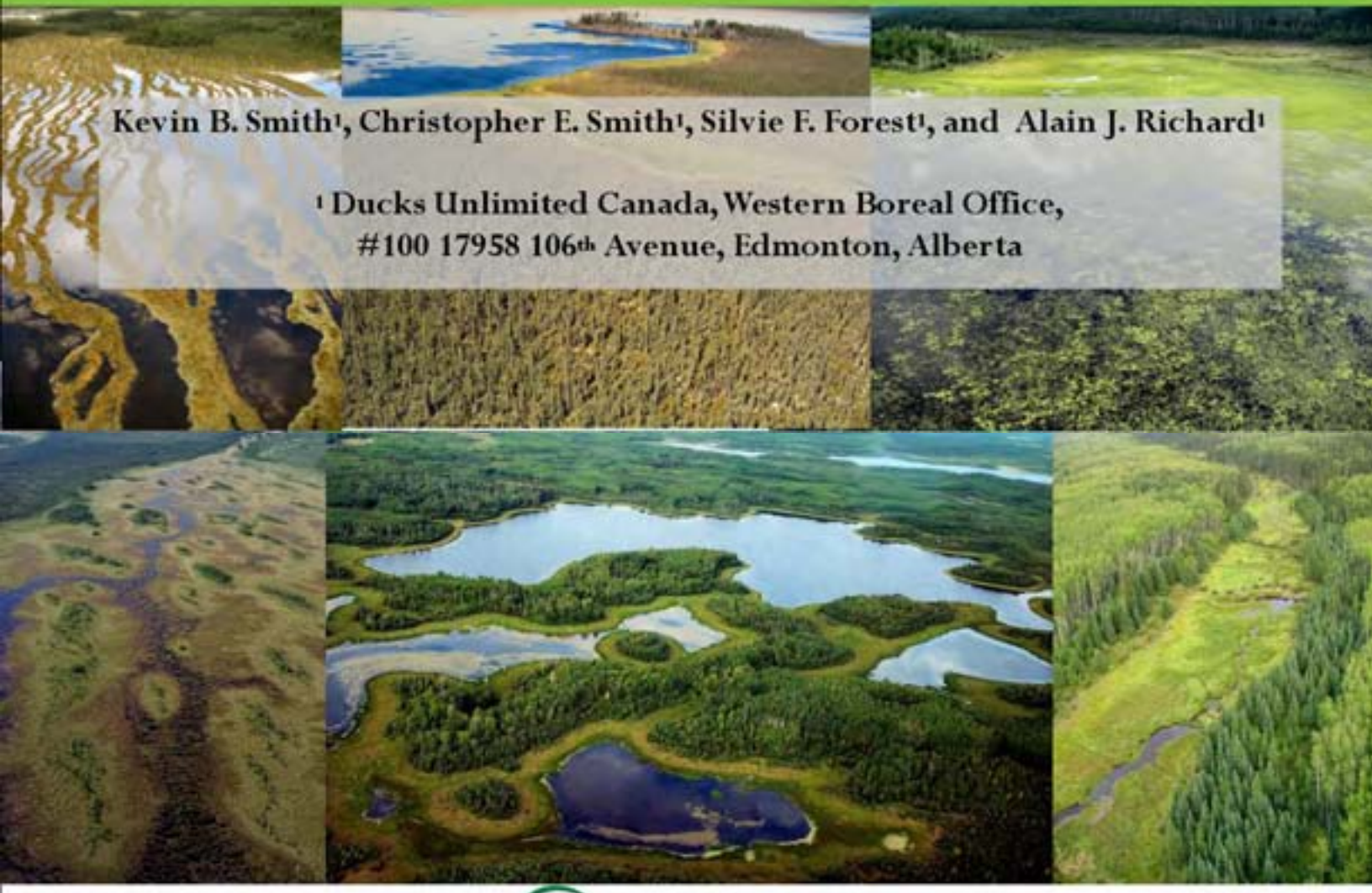

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Table of Contents

Index of Tables and Figures

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Introduction

This guide provides a field guide to a remote sensing-based wetland classification system that is applicable to the Boreal Plains ecozone of Canada. The Boreal Plains ecozone covers 740,632 square kilometers of the 2.6 million square kilometers of the Western Boreal Forest and extends across portions of British Columbia, Alberta, Saskatchewan and Manitoba (Figure 1). Forest cover is predominantly coniferous with black spruce being dominant overall, although white spruce, jack pine and tamarack are principle species. Hardwoods, particularly trembling aspen, white birch and balsam poplar are well represented and are often mixed with conifers (Ecological Stratification Working Group, 1995).

The largely crown-owned, resource-rich region is under increasing development pressures including agricultural expansion, forest management, oil and gas exploration and development, hydroelectric power generation, mining, and access development. Associated with this development is the potential for disruption of hydrology and loss of wetlands. Known impacts of these activities are fragmentation, loss of habitat and potential disruption of hydrology from roads, pipelines, well sites and seismic lines.

Figure 1. A map of the ecozones of Canada, with the Boreal Plains highlighted in yellow.

The classification is based on the Canadian Wetland Classification System (CWCS) (National Wetlands Working Group, 1988), and adapted for regional use via a satellite-based remote sensing classification system. The classification system presented here utilizes remotely-observable site characteristics at multiple scales to infer ecological processes and functions and ultimately determine wetland type.

The purpose of this field guide is to outline an approach that incorporates information at various observation levels (ground, aerial, and satellite) into a comprehensive wetland classification system that can be used for field identification as well as for mapping purposes. The general wetland classes determined in the field guide are applicable at a national scale (bog, fen, marsh, swamp, open/shallow water) but designed to be interchangeable at a regional scale with the more detailed wetland classes (to compensate for regional scale differences in vegetation/climate/wetland type/distribution) with the more detailed wetland classes.

The objectives of the classification system are to:

1.) Provide a regional classification system developed at the ecozone level (Boreal Plains), but compatible with the CWCS, and which can be input into national (Canadian) GIS databases.
2.) Build a classification system that is compatible with existing classification systems (e.g. Alberta Wetland Inventory), national (CWCS), continental (Cowardin et. al. 1979), and international (RAMSAR) (see Appendix E for a comparison).

3.) Use remote sensing platforms and existing datasets to reduce cost and logistic constraints of ground-based classification systems
4.) Link high resolution ground observations with ecosite level datasets and spectral responses of wetlands at a medium resolution (30 m pixel).
5.) Include all wetland types commonly found within the ecozone.
6.) Provide high accuracy, and detailed wetland information for wetland areas greater than 1 hectare (minimum mapping unit).
7.) Promote ecological understanding at a landscape level of wetland type (diversity), distribution, abundance, and connectivity.

Development of the Boreal Plains Wetland Classification System

The Boreal Plains Wetland Classification System was established to overcome the many challenges to mapping boreal wetland systems (e.g. extent, abundance, diversity of forms, complexity, and logistics). There were two main steps to the development of this classification system:

1. The development of a ***classification scheme*** (decision hierarchy) to differentiate the different types of wetlands
2. The development of a ***classification methodology*** that links the ecological determinants of wetland classes (soils, veg, hyrology) observed at the ground and stand levels to the spectral and spatial information provided by the satellite data

The primary assumption of this approach is that the vegetation in the landscape is a key factor in wetland identification. Other factors, such as hydrology and inferred nutrient status are used (and often important), but the basis of this classification is ultimately the vegetation present in the wetland (in relation to all of the environmental factors, including position on the landscape) and the resulting spectral signature which is recorded by the satellite. A particular type of wetland in this classification system may be generated from multiple environmental processes (climate, hydrology, geology,etc.), but only physically present, above-ground indicators of wetland features are available using this approach. For remote wetland areas in northern Canada, satellite-based imagery is often the sole data source available for classification. This classification system was developed with this data-limitation assumption, but where ancillary data on surficial geology, bedrock geology, digital elevation, etc. are available-they can be integrated into the classification system to improve the classification.

Step 1. Developing the Classification Scheme:

The first step in the classification system was to develop a classification scheme (decision hierarchy) to differentiate the different classes of wetlands. The classification scheme has a dual purpose: as an ecological field guide to define the observed wetland classes, and as a remote sensing-based guide for the classification. The underlying data model used to govern the decision tree is based on the major class level of the CWCS (Figure 2). The minor class level of the CWCS (which consists of primarily landform-based classes) is not remotely-sensible at a landscape level. Thus, a regional classification decision hierarchy was developed to separate the primary wetland classes found in the Boreal Plains Ecozone.

The primary challenge when developing the decision hierarchy was to match the soil, vegetation, and hydrology characteristics of wetland sites visited in the field with spectral or spatial cues from the remote sensing imagery data. Several regional wetland ecosite classification field guides were used to help differentiate wetland types in the field and compile the sampling datasets (Beckingham and Archibald 1996a, Beckingham et al. 1996b, Harris et al. 1996, Ontario Ministry of Natural Resources 1993). These field guides were referenced during six field sampling seasons from 2001-2006 at over five thousand field site locations across the Boreal Plains from Manitoba to Alberta (Figure 3), and used to develop and field test the decision hierarchy (see Appendix F). These field guides also provided detailed information on wetland vegetation, hydrology, nutrients, and other factors which aided in field identification.

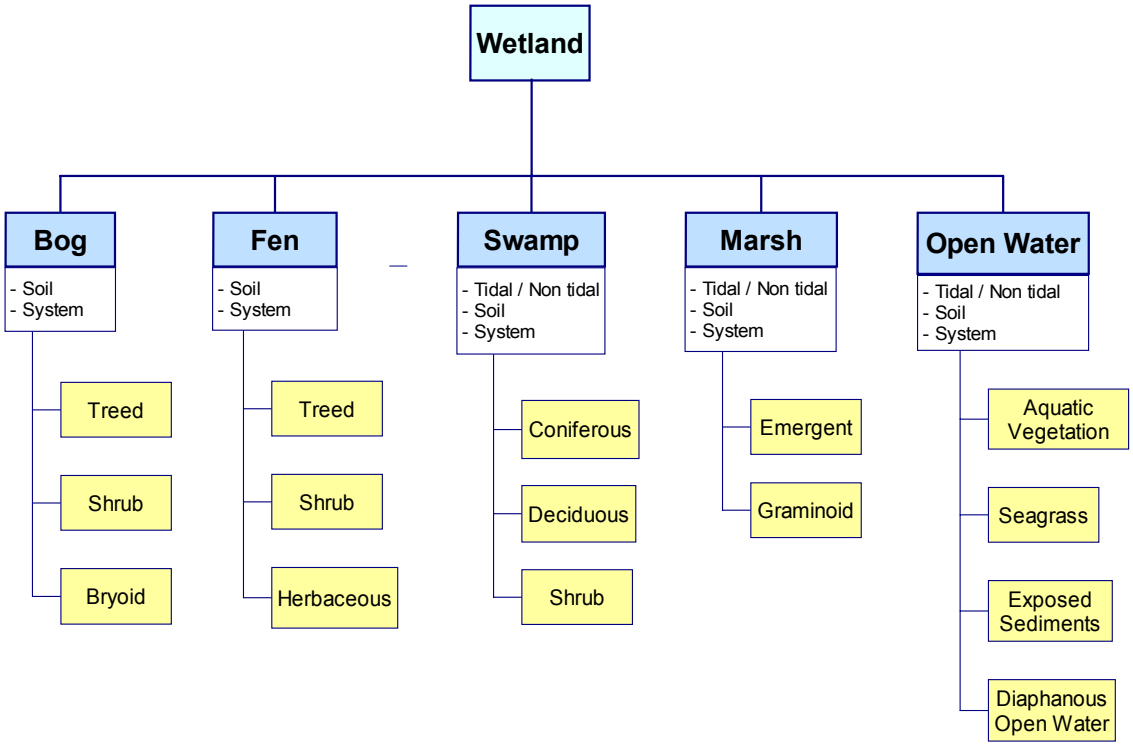


Figure 2. Canadian Wetland Classification System (major classes in blue, soil and wetland system modifiers in white and minor classes in yellow) modified for the Canadian Wetland Inventory.

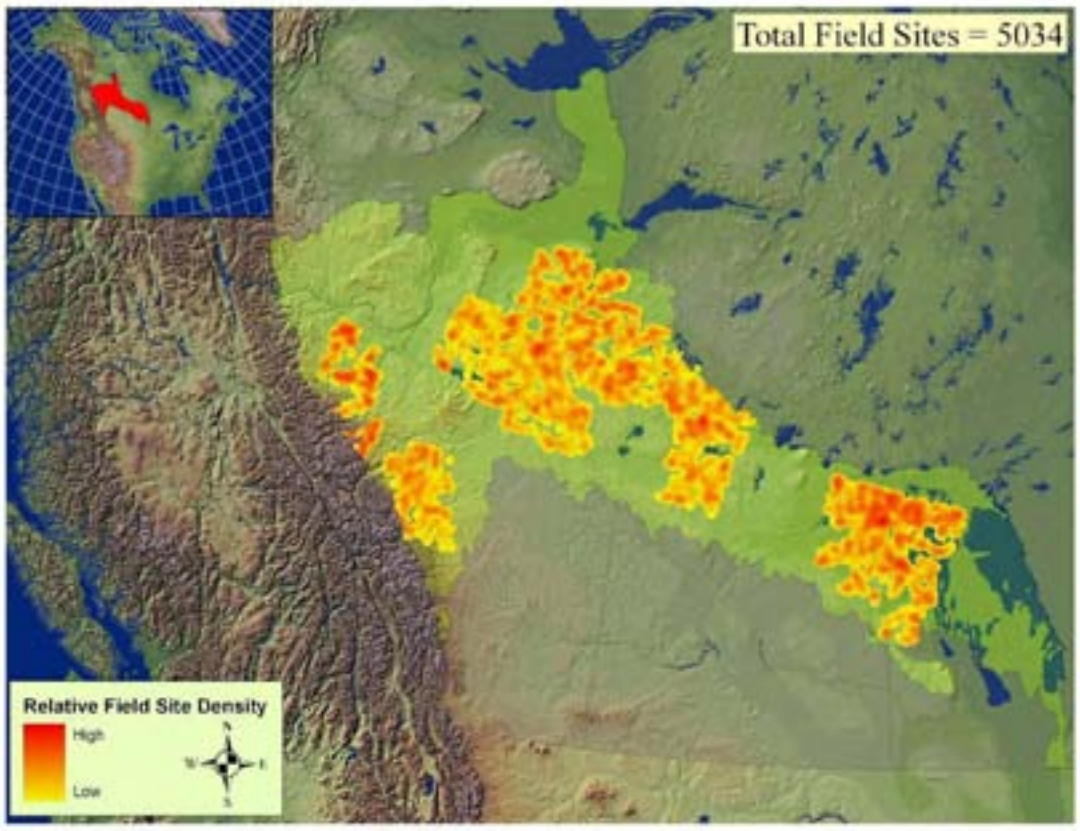


Figure 3. Relative field site location densities within the Boreal Plains ecozone.

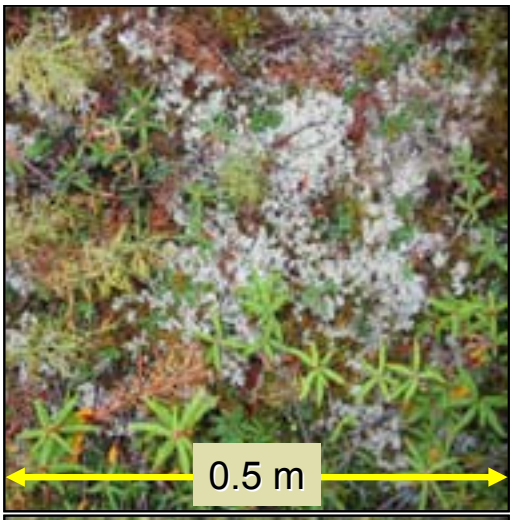
Step 2: Developing the classification methodology to link the ecological determinants of wetland class (observed at the ground and stand level) to the spectral and spatial information from the satellite data:

The next step in the development of the classification system was to link the ecological determinants of wetland classes (soils, vegetation, and hydrology) observed at the ground and stand level to the spectral and spatial information provided by the satellite data. This method allows for detailed wetland information to be collected fairly cost-effectively over large areas for use in the classification. Figure 4 highlights the relationship between scale and the types of information available at three different observation levels. Field site information at a high spatial scale (observation level 1) can be collected at a few sites, while critical vegetation, soil, and hydrology features are determined for a wider range of locations at a coarser scale (observation level 2), and then this level of information is translated to the landscape scale of the satellite imagery using classification techniques (observation level 3).

This classification system was tested using the data collected from "training" (i.e. ground-truthed) sites during the 2001-2006 field seasons, which was used to determine the spectral and spatial information needed to separate the wetland classes. Although minor variations exist, the field testing determined that the classification scheme accurately classifies 19 wetland classes in the Boreal Plains Ecozone. A detailed description of each wetland class is shown in Appendix C.

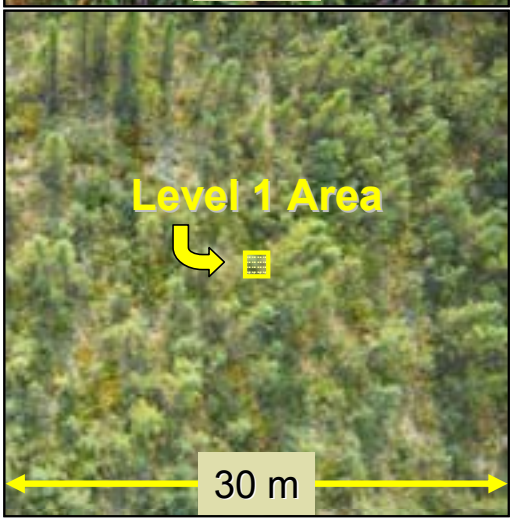
Observation Level 1

- Ground Level
- Site Information: Detailed
  - •Soil information, pH, vegetation parameters (species, biomass, density, height), nutrient availability, depth to water, permafrost presence/depth, more
- Remote Sampling Cost: High



Observation Level 2

- Stand/Pixel Level (Aerial)
- Site Information Level: High
  - • Terrain features: slope, aspect, drainage, position
  - • Vegetation features: vegetation species (macro), heights, canopy cover, cover percentage
- Remote Sampling Cost:Medium



Observation Level 3

- Regional Level (Satellite-based)
- Site information Level: Medium
  - •Landscape patterns, general vegetation features
- One hectare minimum mapping unit
- Remote Sampling Cost: Low

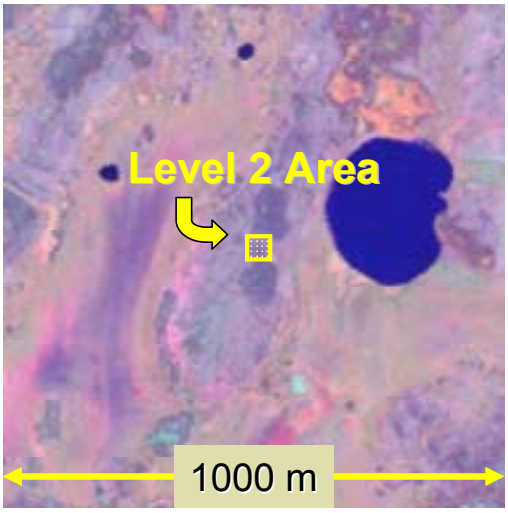


Figure 4. Relationship between scale, type of field site information available at various scales, and the cost of sampling at each level in remote areas.

A Field Guide to the Wetland Classes of the Boreal Plains Ecozone

Wetlands are defined in the CWCS (NWWG 1988) as "*land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment*". In many classifications (NWWG 1988, Halsey and Vitt 1997, Mackenzie and Moran 2004), wetlands are further divided based on soil properties into organic (or peatland) wetlands and mineral wetlands. Bogs, fens, and some classes of swamps occur in peatlands, while marshes, shallow/open water, and other classes of swamps occur in mineral soil wetlands.

The following sections provide a background to each of the wetland classes defined in this guide, the environmental factors that influence wetland processes (hydrology, soils, nutrients), and the vegetation communities common to each wetland type, which are a result of all of these intrinsic processes. In addition, each description contains a section on how these wetland processes can be inferred via orthogonal (directly overhead) field data collection (i.e. helicopter reconnaissance). This provides a linkage between detailed (and expensive) ground-based information and the larger spatial scale processes. Finally, a description for each class is given on how these inferred wetland processes translate to the spectral signatures of satellite imagery, allowing for regional extrapolation of wetland type.

While this field guide is intended to guide the field classification of wetlands using helicopter or aerial reconnaissance for a medium resolution (i.e. Landsat satellite – 30 meter pixel resolution) wetland classification, the field data generated could be applied to any scale remote sensing mapping effort. The purpose of this guide is to describe the inferred ecological/environmental conditions which govern each of the wetland types and detailed vegetation cover information. The data model used to govern the mapped classes is shown in Figure 5. A detailed description of each minor wetland class in this data model is included in Appendix C.

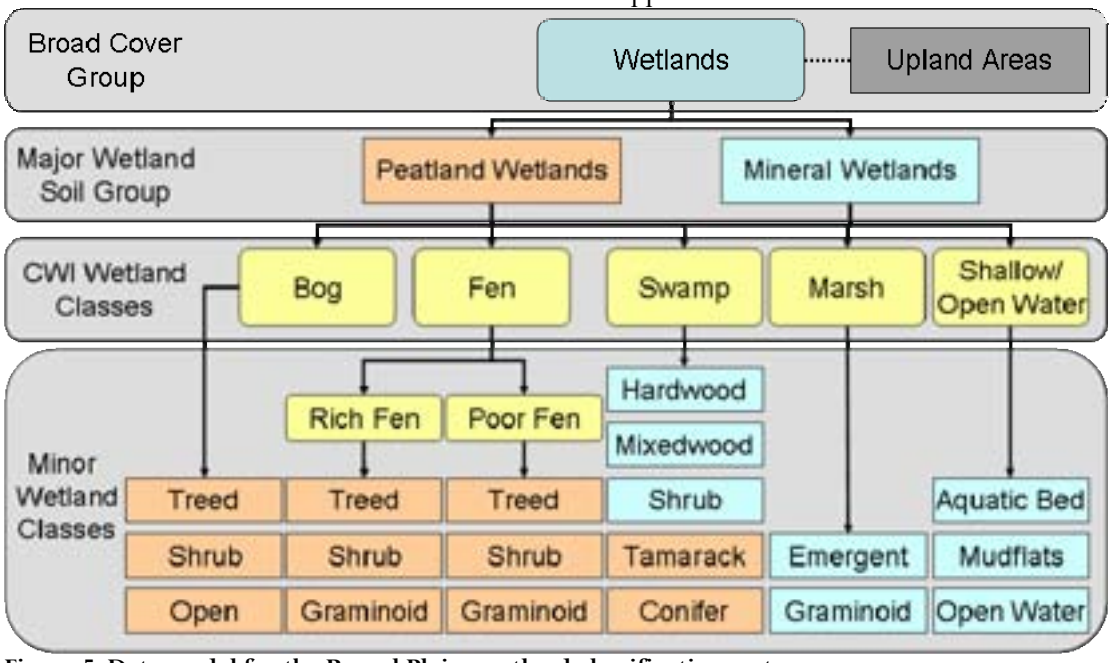


Figure 5. Data model for the Boreal Plains wetland classification system.

Environmental determinants of wetlands

The wetland vegetation communities that exist on the landscape are a result of the underlying factors including: geology, hydrology, nutrient availability, climate, position in the landscape etc. Of these factors, water table depth (hydrology), water flow (hydrodynamics), and nutrient availability are particularly important. Wetlands develop in response to these factors, and the resulting vegetation is comprised of species adapted in varying degrees to flooding frequency and duration, wave energy, and available dissolved minerals. Each wetland class has a set of environmental conditions which ultimately dictate the vegetation assemblages. These varying conditions and resulting vegetation indicator species can be used to distinguish between wetland classes. Figure 6 is a cross section of Boreal Plains wetlands showing the relationship between the various environmental determinants and the resulting vegetation communities. This field guide utilizes these differences in wetland conditions and vegetation to generate a descriptive key and a decision tree that enables the reader to classify a wetland to six major and nineteen minor wetland classes (as described in Figure 5).

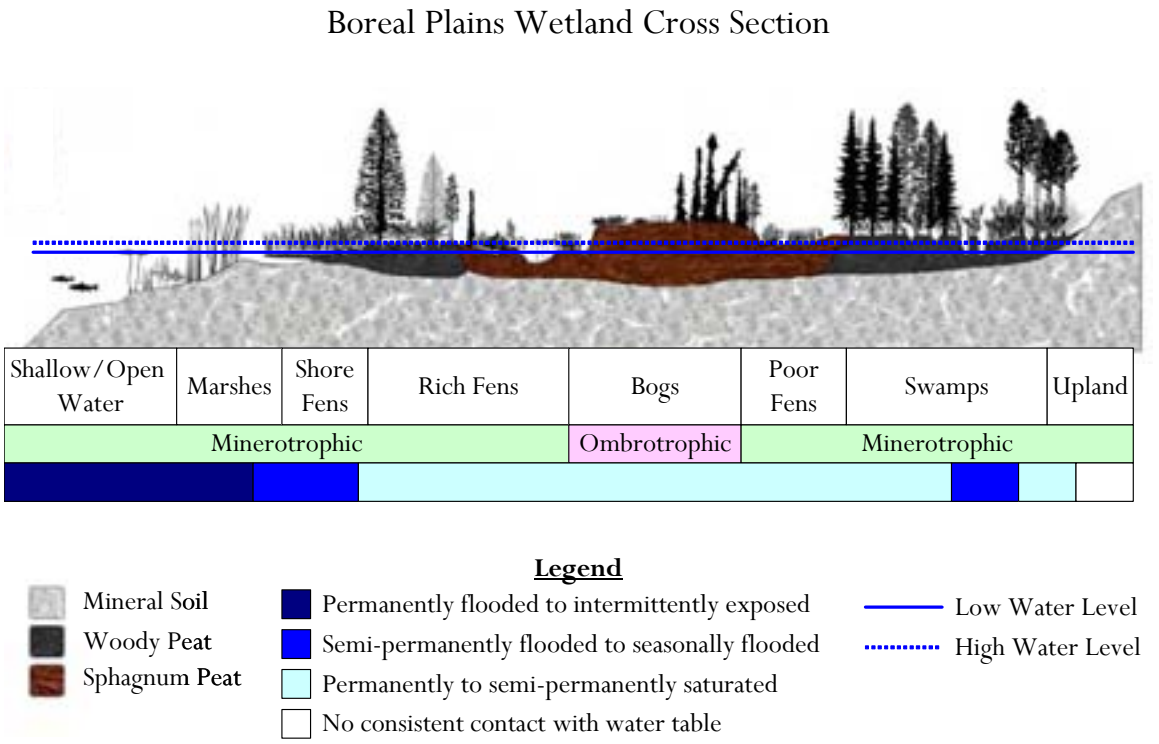


Figure 6. Landscape cross-section of Boreal Plains wetlands showing the relative positions of the major wetland types and the corresponding positions of water regime, soil regime, and nutrient status (adapted to the Boreal Plains and expanded from Harris et. al. 1996).

The field guide also provides a classification based on three factors: moisture regime, nutrient regime, and hydrodynamic regime. The relative combination of these factors is shown in edatopic grid format in Figure 7. For example, a field site with a very poor nutrient regime, hygric moisture regime, and a stagnant hydrodynamic regime would be a bog. The nutrient regime is shown on the x-axis, the moisture regime on the y-axis, and the hydrodynamic regime on the diagonal (2-d z-

axis). This edatopic grid shows the relative distribution of major wetland classes according to the relative combination of each of the three inferred environmental determinants.

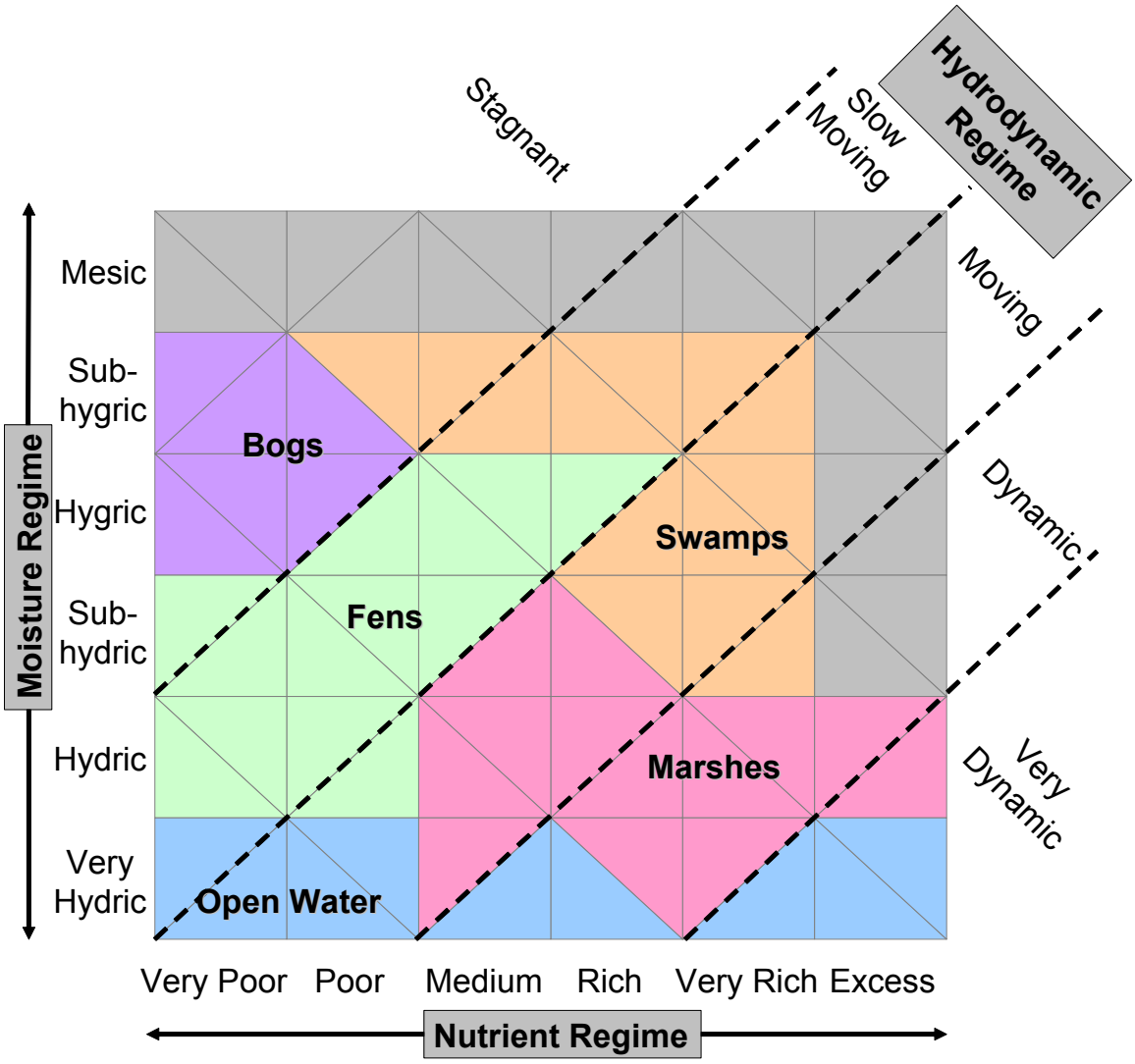


Figure 7. Edatopic grid showing the distribution of wetland classes in relation to inferred moisture, nutrient, and hydrodynamic regimes.

The following sections provide a description of each inferred environmental determinant (nutrient regime, moisture regime, and hydrodynamic regime), along with the features used in the field to determine the appropriate wetland class (e.g., wet vs. dry, rich vs. poor, stagnant vs. dynamic).

Soil Moisture Factor

A key determinant (and indicator) of wetland presence/function is the relative position of the wetland on the landscape as it relates to soil moisture and hydrologic input source. Factors such as landscape position (visible), slope gradient (visible), water table location (visible or inferred), drainage class (visible), and vegetation community cues can all be used to assign soil moisture regime codes to any given wetland. In areas where ground-level site information can be easily collected, features such as surficial geology (soil type, texture, strata, depth to impermeable layer, parent material) and hydrology (soil moisture readings, depth to/height of water table measurements, etc.) would typically be used to assign soil moisture classes (SCWG 1998), however, due to cost and logistical restraints these factors often cannot be determined across much of the more remote access areas of the Boreal Plains. Therefore, this classification uses several inferred factors that can be visually observed and collected via aerial reconnaissance to assign a specific field site location to a moisture regime code to a field site location.

This wetland classification system assigns relative moisture codes on a scale of 1 to 10 (adapted from Beckingham and Archibald 1996). These codes take into account both the relative drainage and the hydrologic input source to derive this relative scale of ten classes (Table 1). The inferred soil moisture code (and corresponding moisture class) presented here is a representation of the average amount of soil water available to vegetation for evapotranspiration. A diagram showing the relative position in the landscape where the moisture classes typically occur is shown in Figure 8.

Table 1. Relative soil moisture code derivation guide. Adapted and expanded from Beckingham and Archibald 1996.

General Moisture Class	Water Table Location	Hydrologic Input Source	Position On Landscape	Soil Moisture Regime	Soil Drainage Class[1]	Slope Gradient (degrees)	Moisture Code
Very Dry	No Contact	Precipitation	Ridge, crest	Extremely Xeric	Very Rapid	Very Steep (>70°)	1
	Well Below Surface	Precipitation	Ridge, crest, upper slopes	Xeric	Very Rapid to Rapid	Very Steep (>70°)	2
Dry	Below Surface	Precipitation	Upper Slopes	Subxeric	Rapid	Steep (31-70°)	3
	Below Surface	Precipitation	Upper to Mid Slopes	Submesic	Rapid to Well	Steep (31-70°)	4
Mesic/ Moist	At/Below Surface	Precipitation/ Groundwater	Mid to Lower Slopes	Mesic	Well to Moderately Well	Slight to Moderate (2-30°)	5
	At/Below Surface	Groundwater/ Precipitation	Domes, Lower Slopes to Flat	Subhygric	Moderately Well to Imperfect	Slight (2-9°)	6
Wet	At/Above Surface	Surface/ Groundwater Seepage	Lower Slopes to Flat	Hygric	Imperfect to Poor	Slight (2-9°)	7
	Above Surface	Surface/ Groundwater Seepage	Depressions	Subhydric	Poor to Very Poor	Slight (2-9°)	8
Very Wet	Above Surface	Permanent Water Table	Depressions	Hydric	Very Poor	Flat (<2°)	9
	Above Surface	Permanent Water Table	Basin	Extremely Hydric	Water	Flat (<2°)	10

[1]Adapted from Soil Survey Division Staff (1993)

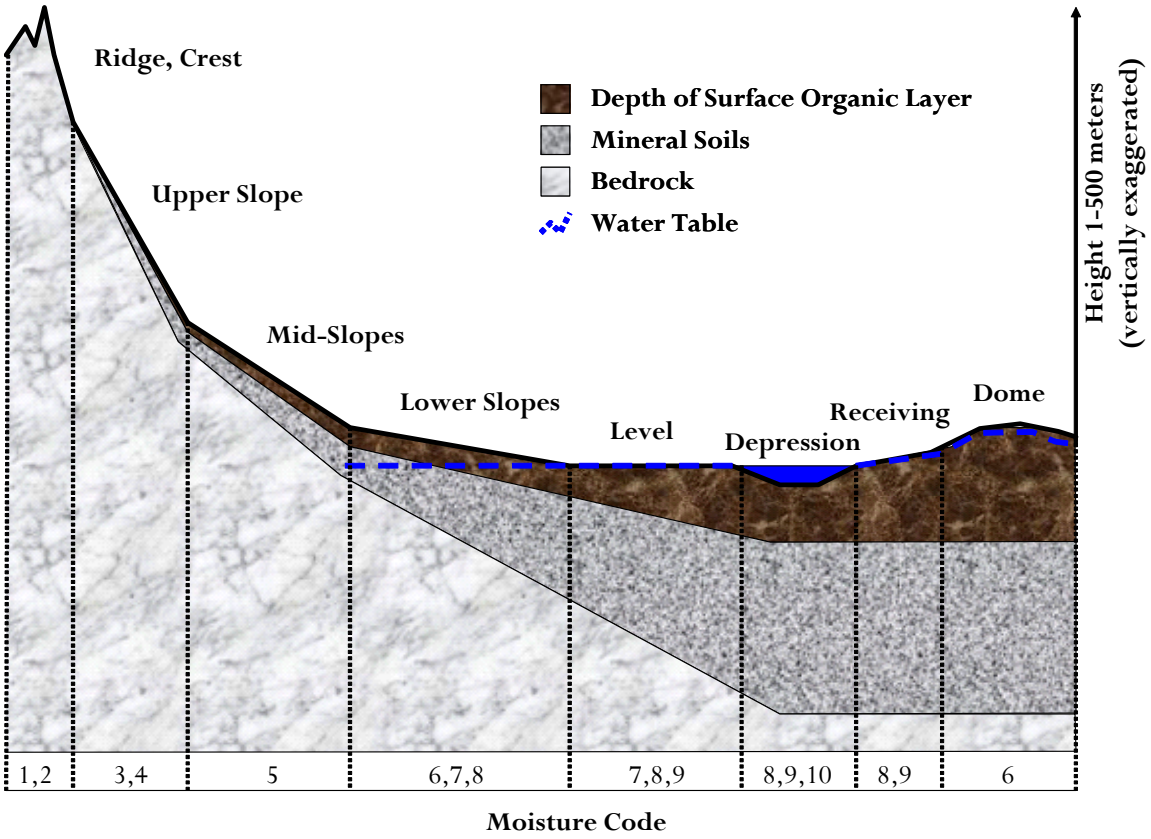


Figure 8. General relationship between landscape position and moisture code.

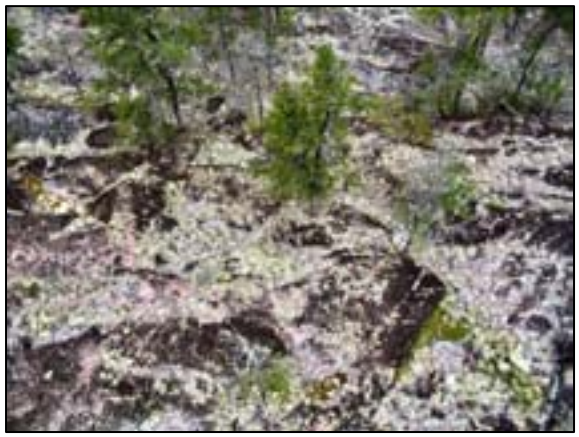
It should be noted that throughout this guide, when we mention groundwater we refer to water that has been in contact with minerals/nutrients and includes shallow subsurface water, but rarely includes groundwater from deepwater aquifers. Deepwater aquifers are present in the Boreal Plains, but their connection to wetlands and discharge/recharge functions are not well understood and beyond the scope of this field guide.

Description of moisture classes:

The following description of each moisture class (and associated moisture code for tracking purposes) is intended to aid in field determination. A list of common satellite imagery derived earthcover classes (per Ducks Unlimited Western Boreal Program's earth cover classification system) is also provided. The examples for the very dry regimes are from the Montane Cordillera (Extremely Xeric) and the Boreal Shield (Xeric), because these classes rarely occur in the Boreal Plains.

Very Dry Regimes:

Moisture Code 1: **Extremely Xeric**
Terrain with very steep slopes (>70%) or crests/ridges/high points of landscape with an impermeable substrate or water is in solid form (ice). This class consists of rock areas where surface runoff is immediate with little or no soil development and no contact with the water table at any time. The primary hydrologic input is through precipitation, which is very rapidly drained. Soils are primarily very coarse mineral soils, with little or no organic soil present. No vegetation is present in this class due to the constant water deficit and lack of soil development. This class includes upland areas such as rock faces of mountain crests, exposed granite shield, or glaciers. Common earth cover classes would include rock and/or ice. No wetlands exist in this moisture regime, and this class rarely occurs in the Boreal Plains.



Moisture Code 2: **Xeric**
Terrain with very steep slopes and/or very rapidly permeable soil types. This immediate drainage creates an extreme water deficit, which in turn limits vegetation growth. Precipitation is the only hydrologic input for this moisture class, and soil moisture is removed very rapidly. The resulting water table is well below surface with no visible influence on land surface. This class occurs in upland areas on ridge tops and topographic highs of the terrain. Soils are mainly coarse mineral soils, with little or no organic soil present. Common earth cover classes include rock, gravel, non-vegetated soil, sparse vegetation, and dwarf shrub classes. No wetlands exist in this moisture regime.

Dry Moisture Regimes:

Moisture Code 3: **Subxeric**

Terrain with steep (31-70% slopes) and/or rapidly drained soils. Positions on the landscape where this class exists include most of the upper slopes of the terrain. The only source of hydrologic input is precipitation, which is rapidly drained via permeable soil types, leading to an overall water deficit for this class. The soil is moist only for short periods after precipitation events or snowmelt. Shallow surface organic layers are usually present over moderately coarse mineral soils. Treed vegetation is supported, although it may be limited by water deficit or soil/nutrient conditions. Common earth cover classes include dwarf shrub, dry herbaceous/forb, woodland/open/deciduous, woodland/open/conifers (especially pine). No wetlands exist in this moisture regime.

Moisture Code 4: **Submesic**

This class represents most upland areas with moderate to high slopes (31-70%) in rapidly to well-drained permeable soils. A distinct water deficit is present in terrain areas with this moisture class. Precipitation is the major hydrologic input source. Water is available for short periods after rainfall or snowmelt but is readily drained due to slope and soil permeability. Surface organic layers are present in moderately shallow depths (<10cm), underlain by moderately coarse mineral soils. This class commonly supports treed vegetation, unless otherwise limited. Common earth cover classes include conifer, mixed or deciduous forest classes or low to tall shrubs. No wetlands exist in this moisture regime.

Mesic/Moist Regimes:

Moisture Code 5: **Mesic**

This class represents upland areas with midslope rolling to flat topographic positions (2-30% slopes) in well to moderately well-drained slopes. Precipitation is the major hydrologic input source, but groundwater seepage may also contribute in some areas. Soil water is available throughout the year and is removed somewhat slowly compared to precipitation inputs. The resulting water table is often near the surface, but little or no standing water exists. Surface organic layers are usually present with moderate (10-15cm) depths, underlain by a variety of medium to fine grained mineral soils. This class supports a wide variety of vegetation due to abundant moisture, soil mineral availability, and soil drainage. Common earth cover classes include most closed/open/mixed deciduous and/or conifer forest types. No wetland classes are present in this moisture regime class.

Moisture Code 6: **Subhygric**

This class marks the beginning of the wetland-associated moisture regimes and occurs in lower slopes, peatlands, and receiving areas of the landscape (slopes 0-9%). Precipitation is the primary hydrologic input source for the peatland areas (bogs), while precipitation and groundwater are the primary hydrologic input sources for many of the lower slope and receiving areas. Drainage is moderately well to imperfect and no water deficit occurs. The soil is either saturated in the rooting zone or at the surface for most or all of the growing season. The surface organic layer ranges from moderately deep to deep (10-40cm+), but this depth is widely variable. Common earth cover classes include open/closed deciduous and conifer forests, and tall/low shrubs. Wetland classes include some bogs, drier conifer swamps, and some poor fens.

Wet Regimes:

Moisture Code 7: **Hygric**

This class represents lower slopes to receiving areas to level areas of the landscape with little or no slope gradient (0-9%). The primary hydrologic input is surface or groundwater. The water table is at or above the surface for most of the year, and thus no water deficit exists. Drainage is imperfect to poor. The surface organic layer is deep and typically greater than 40 cm. This moisture regime supports tall shrubs and trees adapted to prolonged periods of inundation. Common earth cover types include closed/open/woodland conifer, closed/open deciduous, tall/low shrub. Wetland types include bogs, wetter fens, and swamps.

Moisture Code 8: **Subhydric**

This class represents depressions and level receiving areas of the landscape with little or no slope present (0-9%). The primary hydrologic inputs are surface and/or groundwater. The water table is at or above the surface for most of the year (near-permanent water table visible). Drainage is poor to very poor. Soils are organic or gleyed mineral, typically with very deep surface organic layers (>40cm). This moisture regime supports only sparse, stunted trees adapted to prolonged inundation, tall and low shrubs, and graminoid/forb/bryophytes. Common earth cover classes include woodland conifer, tall shrub, and wet graminoid/forb classes. Wetland classes include wetter fens and swamps.

Very Wet Moisture Regimes:

Moisture Code 9: **Hydric**

This class occurs in flat terrain that is inundated, very poorly drained, with submerged and/or floating aquatic vegetation usually present. This class has a semi-permanent to permanent water table that is at or above the surface throughout the year. Soils include deep (>40cm) organic or gleyed mineral soils. This class occurs in depressions and level receiving areas in the landscape. Common earth cover classes include aquatic bed and open water. Wetland classes include the marsh major class, and open water classes.

Moisture Code 10: **Very Hydric**

Deep open water areas that support only aquatic vegetation and are permanently flooded throughout the year (permanent water table). Hydrologic inputs are groundwater, precipitation, inflow (creek, river, stream), surface runoff, or over-bank flooding. Little or no soil development occurs due to water depth and duration of anaerobic conditions (but sedimentary peat may be present). This class supports only submerged and/or floating-leaved aquatic vegetation. Earth cover classes would include aquatic bed, clear or turbid water. The major wetland class is shallow open water with the minor wetland classes of aquatic bed and open water.

Nutrient Availability Factor:

Nutrient availability in wetlands is often assessed with ground-based measurements of soil and water chemistry which include pH, concentrations of dissolved nutrients, and inherent soil characteristics (i.e. color, texture, structure, C:N ratio – see Table 2). The degree of contact with nutrient-rich ground or surface water determines the total amount of nutrients available to the vegetation. This field guide utilizes several inferred factors that can be collected via helicopter or aircraft reconnaissance to assign a specific nutrient regime code to an overall field site location. Factors such as soil type, water color (Table 3, Figure 9), hydrology, vegetation species richness, vegetation indicator species and other factors can all be observed in the field and used in this classification.

In both peatland and mineral-soil wetlands, there is a link between water chemistry (available nutrients, pH), moisture regime, and plant species assemblages. Plants, like other organisms, have a habitat niche, or a certain set of conditions, under which they thrive (live and reproduce). Some species are generalists and can thrive in a wide-range of environmental conditions (e.g., environmental variables such as moisture gradients, nutrient availability, pH, alkalinity), while others, the specialists, need a very specific set of conditions. Plant species that respond to a narrow set of environmental variables (i.e., they do not grow outside these conditions) can be used as indicators of specific ecosystems. For example, observing a high percent cover of *Sphagnum fuscum* would indicate low pH, relatively dry and nutrient poor environment on the peatland scale from rich fen to bog. Further, because this species does well in poor conditions and a water table that is below the surface, it can be used to predict that there is no or very little mineral water input into the system, and thus the overall nutrient status of the site is poor.

This relationship of plant species and water chemistry has originally been identified by Sjörs (1952) in Swedish mires but has been adapted to North American wetlands (e.g., see NWWG 1988). Specifically in Alberta, studies by Vitt and Chee (1990) and Chee and Vitt (1989), and other similar studies showed relationships between plant assemblages and water chemistry. Such vegetation-water chemistry and moisture regime knowledge has been used extensively in the development of wetland, forest, or ecosite classification systems (e.g., see Harris et al. 1996; Archibald and Beckingham 1996; Jeglum 1971, 1973, and 1991). Often statistical programs such a TWINSPAN analysis in combination with an ordination analysis is used to correlate species presence with environmental data. These empirically-derived studies provide the basis for this guide/classification, which was then tested in the field.

In general, Vitt (1994) categorized Alberta fens into three broad categories: Poor fens (pH 4.5-5.5), poor in base cations, no or little alkalinity; moderate-rich fens (pH 5.5-7.0), low to moderate alkalinity and concentration of cations; extreme-rich fens (pH above 7.0), high concentrations of base cations and high alkalinity, and possibly marl deposits. To make the distinctions between moderate-rich fens and extreme rich fens is very difficult in a remote sensing application, and these two fen types are grouped together as rich fens in our classification. However, this classification distinguishes poor and rich fen types based largely on nutrient status and species assemblages (see the Boreal Plains Wetland Key. Swamps, including conifer swamps, are not separated in this classification by nutrient status, even though they range from poor to very rich. This was done

because in many cases, separation via remote sensing was difficult to impossible based on the spectral signatures alone.

Table 2. Ground-level determinants of nutrient regime code (adapted and expanded from Mackenzie and Moran 2004).

		Nutrient Regime Code					
Feature	**Specific Variable**	**1 Very Poor**	**2 Poor**	**3 Medium**	**4 Rich**	**5 Very Rich**	**6 Hyper**
Dissolved Nutrients	Available Nutrients	Very Low	Low	Average	Plentiful	Abundant	Excess
Water	Water pH	< 5.0	4.5 – 6.0	5.0 – 6.5	6.0 – 7.4	6.5 – 8.0	> 8.0
	Water Color	Deep Brown - Yellow		Green-Brown -Clear	Green-Brown - Turbid		Blue/ Green,Clear
	Ground water flow	Stagnant		seasonal seepage	Continuous Seepage		
	Surface Tier Saturation	Always saturated		Seasonal exposure of substrate	Diurnal exposure		
Soil	vonPost of surface tier	1-3	3-6	4-7	7-10	8-10	N/A
	SurfaceTier Material	Organic			Mineral		Marl
	Surface Peat Color	Pale		Dark			
	C:N Ratio	High		Medium	Low		
Plants	Relative Productivity	Very Low	Low	Medium	High	High	Low
	Species Richness	Very Low	Low	Medium	High	High	Low

Table 3. General characteristics of water with different trophic status (adapted from Mackenzie and Moran, 2004) (also shown in Figure 9).

	Characteristic				
Nutrient Status	**Water Color**	**Water Clarity**	**pH**	**Nitrogen and Mineral Availability**	**Nutrient Code**
Dystrophic	Yellow-Deep Brown	Stained	< 4.5	Very Low	1
Oligotrophic (Ca – Poor)	Greenish-brownish	Clear	4.5-7	Low	2-3
Oligotrophic (Ca – Rich)	Blue-Greenish	Very Clear	>7	Medium	3-4
Eutrophic	Greenish-Brownish	Turbid	>7	High-Very High	5

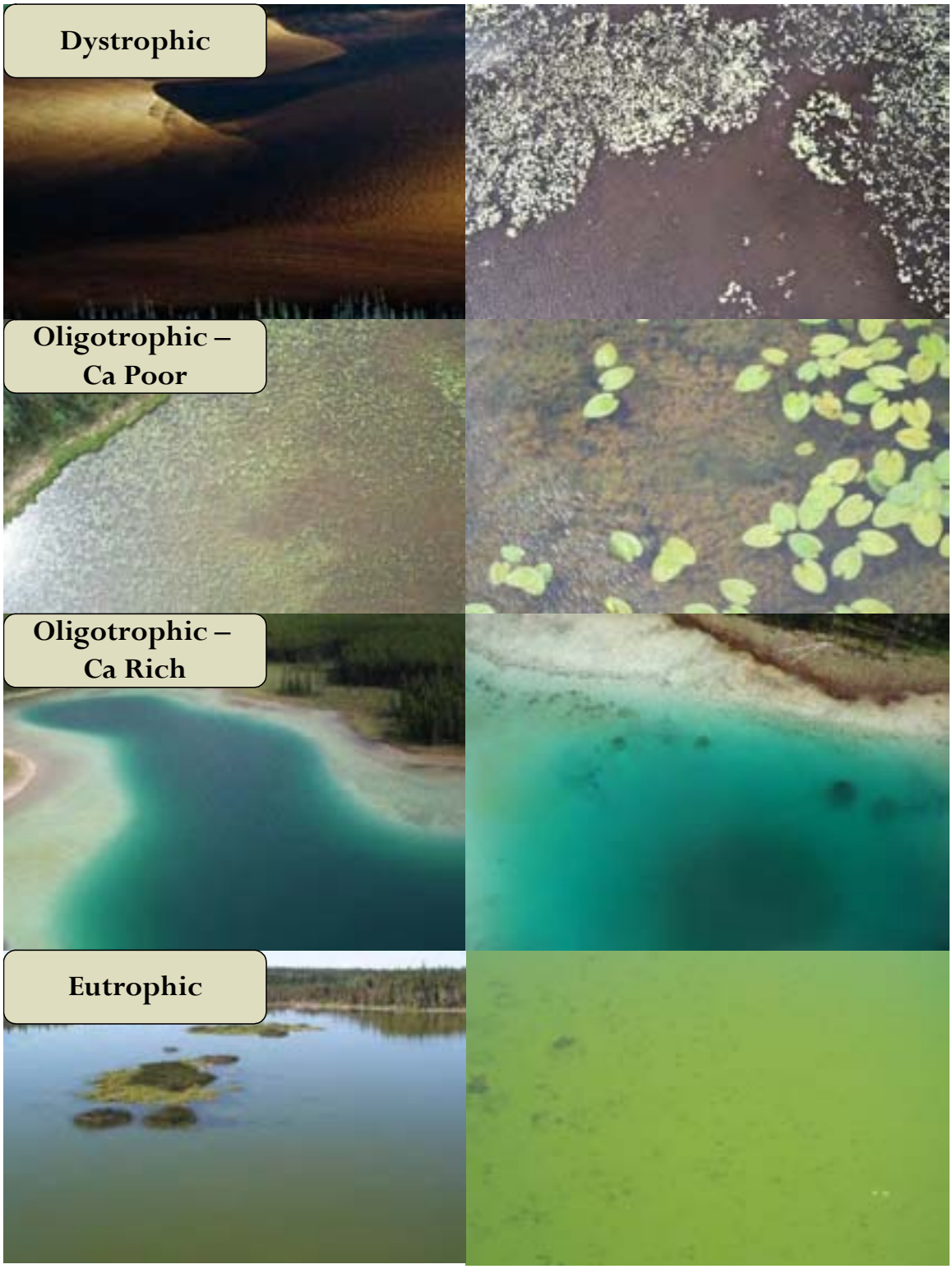


Figure 9. Field photos of water bodies and the association between water color and nutrient regime.

Description of Nutrient Regime Classes

Nutrient Code 1 -***Very Poor***: Areas with very low available nutrients to plants, typically due to low base cation availability as a result of highly acidic (pH < 5.) conditions. Wetlands with these conditions are peatland organic soil wetland types (bogs, poor fens). The von Post of the surface organic layer is typically fibric (1-3). These areas typically have little or no contact with mineral-rich water, but the surface is typically saturated due to ombrogenous inputs. Vegetation growing in these conditions are either species adapted specifically to the conditions or generalist species that can grow over a wide range of environmental conditions. The relative number of vegetative species is very low, with a dominance of *Sphagnum* mosses and ericaceous shrubs. Trees, if present (trees are limited by hydric conditions as well as nutrients), are typically < 2 m tall, and are primarily stunted Black Spruce (*Picea mariana*).

Nutrient Code 2 – ***Poor***: Areas with low available nutrients, and fairly high acidic conditions (pH 4.5 – 6.0). Wetlands with these conditions are peatland organic soil wetland types (bogs, fens, and poorer conifer swamps). The von Post of the surface organic layer is typically fibric to mesic (3-6). These areas have some contact with mineral-rich water. A slightly wider range of species can be found in poor nutrient regime areas compared to very poor nutrient regime areas, including most of the dominant species found in Nutrient Code 1. Some minerotrophic species begin to occur, including bog birch (*Betula* spp.), Tamarack (*Larix laricina*), and horsetail (*Equisetum fluviatile*). Trees are more common to this nutrient regime (*Picea mariana*, *Larix laricina*), but heights are generally < 10 m.

Nutrient Code 3 – ***Medium***: Areas with fairly high available nutrients to plants, typically with slightly acidic conditions (pH 5.0 -6.5). Contact with mineral-rich water is more common to this nutrient regime compared to the poor nutrient regimes (nutrient codes 1 and 2). The dominant soil type is organic, although some mineral wetlands fall into this class. The von Post scale of decomposition (Appendix D) of the surface organic layer, if present, is mesic (4-7). Wetlands with these conditions are fens, swamps, and some poorer marshes (sedge meadow marshes typically on deposited peat soils). A wider range of minerotrophic species exists in this nutrient regime, including *Caltha palustris* (Marsh marigold), *Petasites frigidus* (Arrow-leafed Coltsfoot), and *Calamagrostis canadensis* (Bluejoint grass). Trees, if present, are Black Spruce and Tamarack, and can be taller than 10 meters.

Nutrient Code 4 – ***Rich***: Areas with high available nutrients to plants, typically due to the more neutral pH ranges (6.0 -7.4). Contact with mineral-rich water is prevalent to plants in this nutrient regime. The dominant soil type is mineral, although some richer organic soil wetlands fall into this class. The von Post of the surface organic layer, if present is humic (7-10). Wetlands with these conditions are rich fens, all swamp classes, and marshes. The number of plant species in these types of wetlands is high, particularly for the herbs, forbs, and mosses. Mosses, if present, are typically brown mosses and some *Sphagnum*. Minerotrophic species that exist in this nutrient regime include: *Juniperus communis* (Common Juniper), *Potentilla fruticosa* (Shrubby Cinquefoil), and *Parnassia palustris* (Grass of Parnassis) in fens; and *Salix* spp. (Willows), *Cornus stolonifera* (Red-Osier Dogwood), and *Rhamnus alnifolia* (Alder-leaved Buckthorn) in swamps. Trees, if present, include all common wetland conifers and deciduous trees, and range in heights to well above 10 m.

Nutrient Code 5 – ***Very Rich***: Areas with very high available nutrients to plants and with alkaline conditions (pH 6.5 – 8.0). Mineral-rich water is in constant contact with the rooting zone of plants in this nutrient regime. The dominant soil type is mineral, with marl soils in the more alkaline (near pH of 8.0) in this range. The von Post of the surface layer of organic soils, if present, are predominantly humic (8 -10). Wetlands with these conditions are richer swamps, and marshes. The diversity of plant species that grow in this nutrient regime is very wide, including some species that exist in more upland areas as well, such as *Rosa acicularis* (Wild Rose), *Rubus ideaeus* (Raspberry), and *Ribes* spp. (Currents). Trees, if present, are typically deciduous (*Betula papyrifera* in palustrine wetlands, *Populus tremuloides* in riverine wetlands), although some conifers, including White Spruce, can occur in riverine swamps.

Nutrient Code 6 – ***Hyper***: Areas with hypersaline conditions due to excess mineral-rich inputs, and pH ranges are typically high (> 8.0). The high salinities found in this nutrient regime limit plant growth, and therefore this nutrient regime is found in marsh and shallow/open water wetlands only. In highly alkaline water environments, calcium carbonate ($CaCO_3$) commonly precipitates out of the water column, forming a marl substrate. Mineral and organic soils are not typically present in this class. This class is fairly rare in the Boreal Plains, occurring as marl pools or salt ponds with associated fringe marsh classes.

Hydrodynamic Factor

The lateral and vertical movement of water through wetland systems (i.e. hydrodynamics) is another important factor in the determination of wetland type. Movement of water can be groundwater or surface water, and for the purposes of this field guide groundwater movement is inferred from the position in the landscape, vegetation, and visible hydrologic features (Table 4). Hydrodynamic energy influences decomposition of organic material (by providing a mechanism for aeration), limits growth or establishment of vegetation, and stresses the vegetation due to physical damage (in higher wave energy environment areas). The hydrodynamic regime can be fairly static such as the percolation/capillary action of precipitation-driven hydrodynamics in bogs to the hydrodynamically variable marshes on exposed shores of water bodies with regular drawdowns.

Table 4. Inferred hydrodynamic factor classes for wetlands.

Class	Movement of Water	Associated Wetland Classes
1	**Stagnant** – Stable, non-flowing areas with no vertical hydroperiod change. Movement of soil water is stagnant to very gradual, with no movement at the surface, despite constant saturation.	**Bogs, Poor Fens, Swamps**
2	**Slow Moving** – Gradual flow through with minor vertical hydroperiod change.	**Poor to richer Fens, Swamps, Open Water**
3	**Moving** – Vertical hydroperiod change common, lateral water movement.	**Rich Fens, Swamps, Marshes, Open Water**
4	**Dynamic** – Strong Vertical/Lateral movement of water.	**Swamps, Marshes, Open Water**
5	**Very Dynamic** – High water displacement areas.	**Marshes, Open Water**

Vegetation Indicators

Wetland vegetation communities are influenced by various environmental determinants, including climate (precipitation, temperature, permafrost), hydrology (source, flow), substrate (soils, parent material), and chemistry (nutrient availability). The ability of vegetation to grow (or not grow) in response to these factors is commonly used to classify wetlands. Since vegetation is often regionally adapted to variations in these determinants, vegetation indicators for classification will differ depending on location. Some of the indicator species, such as *Carex spp.* (sedges) and *Sphagnum spp.* (mosses) require a specimen and often the use of a microscope to accurately distinguish the species. For this field guide, only species that are readily identifiable from an orthogonal view are included. For additional reference, a list of detailed species indicators is listed in Appendix A.

Treed Vegetation

Conifers:

Several softwood tree species can be used as wetland indicators in the Boreal Plains (Table 5). *Larix laricina* (Tamarack) is a tree that is common to treed swamp and fen wetlands throughout the Boreal Plains, and is associated with wet, nutrient-rich soils. Depending on the nutrient availability and hydrology, Tamarack ranges from 1-2 meter thin-foliaged, shrub-like stunted trees in poorer fens to 25 – 30 meter dense-foliaged trees in richer swamps. The presence of Tamarack is thus a good wetland indicator and is one of the important indicators that separate fens from bogs. *Picea mariana* (Black Spruce) is ubiquitous throughout the region and can be found in all of the treed wetland types and many upland areas. For this reason it is a less reliable wetland indicator, although the growth forms of Black Spruce can be used to assist in wetland identification. The upland form closely resembles *Picea glauca* (White Spruce), but the lowland form is unique as the upper portion of the tree forms a dense, pyramidal cone of limbs and needles. *Picea mariana* is the only tree species in bogs, typically occurring in this lowland form. Black Spruce in upland areas typically occurs mixed with Jack/Lodgepole Pine and White Spruce. In the Boreal Plains ecozone, Black Spruce only occurs as a pure closed stand in conifer swamps. Other conifers that are found in transitional zones of uplands to wetlands in the Boreal Plains include *Abies balsamea* (Balsam Fir), and *Thuja occidentalis* (Eastern White Cedar) in the easternmost extent of the Boreal Plains. However these species typically do not occur in densities high enough to be used as wetland indicators. The only other conifer trees common to the Boreal Plains are the pines, including *Pinus contorta* (Lodgepole Pine) and *Pinus banksiana* (Jack Pine), but they are almost always associated with upland environments. Pines occur extremely rarely in wetlands in the Boreal Plains.

Table 5. Coniferous trees associated with major wetland classes in the Boreal Plains.

Wetland Class	Primary Conifer Species Present
Bog	*Picea mariana* (Lowland Form)
Rich/Poor Fen	*Larix laricina*, *Picea mariana* (Lowland Form)
Swamp (Conifer[1], Mixedwood[2], Tamarack[3])	*Picea mariana*[1,2], *Larix laricina*[2,3], *Thuja occidentalis*[1,2]
Marsh/Open Water	None

Deciduous:

Only a few hardwood tree species exist in wetlands in the Boreal Plains Ecozone (Table 6). *Betula papyrifera* (Paper Birch) and *Betula neoalaskana* (Alaska Birch) are the most common deciduous tree species in the wetlands of the Boreal Plains. Birch is common to sloped seepage/drainage areas, where it forms hardwood or mixedwood swamps. These species also occur in mixed deciduous upland areas, but throughout most of the Boreal Plains it is the only deciduous hardwood species in non-floodplain wetlands. *Populus balsamifera* (Balsam Poplar), which is often an upland species, can occur in wetlands, particularly in riverine, floodplain-influenced swamp wetlands. In the easternmost portion of the Boreal Plains, *Acer negundo* (Manitoba Maple), *Fraxinus pennsylvanica* (Green Ash) and *Ulmus americana* (American Elm) can occur in wetlands or upland/wetland transitional areas, but they typically do not occur in densities high enough to be used as wetland indicators. Other deciduous trees that occur in the Boreal Plains (*Populus tremuloides* (Aspen), *Quercus macrocarpa* (Burr Oak)) are common to upland environments only and thus are primarily upland indicators.

Table 6. Deciduous vegetation associated with major wetland types in the Boreal Plains.

Wetland Class	Primary Deciduous Species Present
Bog	None

Rich/Poor Fen	None
Swamp (Hardwood, Mixedwood)	*Betula* spp., *Populus balsamifera*
Marsh/Open Water	None

Shrub Vegetation:

Vegetation height and species can be used in the field to help classify wetlands. In sparse-canopied forested and non-forested areas, shrubby vegetation is often the most identifiable portion of the vegetation. Shrub-dominated wetlands have conditions that are not conducive to supporting tree growth because of saturation/inundation or nutrient availability. Both species and vegetation height can be used in the field to help identify wetlands. A wide variety of shrubs occur in the Boreal Plains, but only the general indicator species for the major wetland types will be discussed here. Shrub vegetation with average heights of over 2 meters (e.g. *Salix* spp., *Alnus* spp.) are classified as tall shrubs and are associated with swamp wetland types. Wetlands that have shrub vegetation with shorter shrub heights (< 2 m) are bogs and fens. A list of common and indicator species is included in Table 7, while a list of indicator species for shrubs of the Boreal Plains is included in Appendix A.

Table 7. Shrub vegetation associated with major wetland types in the Boreal Plains.

Wetland Class	Primary Shrub Species Present
Bog	*Ledum groenlandicum*, *Vaccinium* spp., *Kalmia* spp.
Poor Fen	*Betula glandulosa*, *Betula pumila, Ledum groenlandicum*,
Rich Fen	*Myrica gale*, *Potentilla fruticosa*, *Betula* (Shrub forms)
Conifer Swamp	*Ledum groenlandicum*, *Alnus* spp.,
Tamarack Swamp	*Betula glandulosa*, *Betula pumila*, *Alnus* spp.
Hardwood, Mixedwood Swamp	*Salix* spp., *Alnus* spp.
Thicket Swamp	*Salix* spp., *Alnus* spp.
Marsh/Open Water	None

Boreal Plains Wetland Key

(Mapped wetland classes in Bold**, general classes in** *Italics***)**

(*See Appendix A for vegetation indicators listed in key*)

1a) Terrain/Imagery has one or more of the following conditions:

i) Recently burned, with little or no regenerating vegetation……**Burned Areas**
ii) Anthropogenic-influenced areas (agriculture, roads, towns, recent forestry cutblocks, oil/gas seismic lines and/or well pads, gravel/mining pits)……**Anthropogenic**
iii) Obscured by clouds/shadows/haze……**Cloud, Cloud Shadow**
iv) Scan lines or sensor defects ……**Imagery No Data**

1b) Terrain/ Imagery does not have above conditions……***Upland/Lowland Cover*** **(2)**

2a) Terrain contains cover not affected by ground or surface water, or if affected, only for short periods (moisture codes 1- 5). Dominance of upland indicators……***Upland***

i) *Conifer-treed forests*……**Conifer Upland**
ii) *Deciduous-treed forests*……**Deciduous Upland**
iii) *Mixedwood forests*……**Mixedwood Upland**
Upland other (Shrub, Herb, Rock, Snow, etc.)……**Upland Other**

2b) Water table at, near, or above the land surface (moisture codes 6-10) and some wetland indicators present……***Wetland*** **(3)**

3a) Wetland areas with an overall accumulation of peat (*Sphagnum* or woody) > 40 cm; mesic to hydric moisture conditions (moisture codes 6-8); stagnant to moving hydrodynamic systems (hydrodynamic regimes 1-2); trees, if present, are predominantly *Picea mariana* or *Larix laricina*, shrub layer variable, but typically less than 2 m tall and ericaceous shrubs typically present……***Peatland Wetlands*** **(4)**

3b) Wetland areas with predominantly mineral soils, with little or no peat accumulation, although some organic material may be present; highly variable moisture conditions (moisture codes 7-10); moving to very dynamic systems (hydrodynamic factors 3,4,5) trees, if present, typically in higher percentage cover and heights over 10 m; shrub layer typically more than 2 m tall and predominantly willows and alders (little or no ericaceous shrubs)……***Mineral Wetlands*** **(8)**

4a) Peatland wetlands with poor to medium nutrient regimes, mesic to hygric moisture conditions (moisture codes 6-8), relatively species-poor vegetation communities with a dominance of *Sphagnum* mosses and ericaceous shrubs (*Ledum groenlandicum*, *Kalmia* spp., etc.); lichens commonly present ……**(5)**

4b) Peatland wetlands with medium to rich nutrient regimes, hygric to hydric moisture conditions (7-10), species-rich vegetation communities, abundant fen and/or swamp indicators (See Appendix A)……**(7)**

5a) Peatland wetlands with predominantly fibric or woody-based peat accumulation; *Picea mariana* dominant tree layer with heights > 10 meters, canopy closure > 60%; hummocky terrain with pools of water may exist, rooting zone in contact with mineral-rich water; ground cover a mixture of feather mosses and some S*phagnum*
.....**Conifer (Black Spruce) Swamps**

5b) Peatland wetlands with a predominantly *Sphagnum* peat accumulation, tree heights < 10 m, canopy closures < 60%.....**(6)**

6a) Peatland wetlands with raised surface relative to surrounding terrain; hydrologic input is precipitation (no contact with surface or groundwater inputs); mesic moisture regimes (moisture code 6); very poor to poor nutrient regimes; tree layer, if present is <10m in height and <60% canopy cover, and dominated by the lowland form of *Picea mariana*; shrub layer is ericaceous; no fen or swamp indicators, *Sphagnum* moss dominant.....***Bogs***
i) Trees > 25% cover .....**Treed Bog**
ii) Shrubs > 25% cover .....**Shrubby Bog**
iii) Bryophytes/Herbaceous/Forb >25% cover.....**Open Bog**

6b) Peatland wetlands with some mineral-rich water inputs, mesic to hygric moisture regimes (moisture code 6-8), more species-rich vegetation assemblages than in 6a, trees, if present, contain both *Picea mariana* (lowland form) and *Larix laricina* at <60% cover and <10 m in height; shrub layer contains a mixture of ericaceous shrubs, dwarf willows, and shrub birch (*Betula pumila, Betula glandulosa*) typically at heights of < 2 m, graminoid layer typically has a large component of litter.....***Poor Fens***
i) Trees > 25% cover .....**Treed Poor Fen**
ii) Shrubs > 25% cover .....**Shrubby Poor Fen**
iii) Bryophytes/Herbaceous/Forb >25% cover .....**Graminoid Poor Fen**

7a) Peatland wetlands with *Larix laricina* trees > 10 meters tall, canopies > 60% cover, hummocky terrain with pools of water, swamp indicators.....**Tamarack Swamp**

7b) Peatland wetlands with trees in lowland forms (*Picea mariana* or *Larix laricina*) < 10 m, canopy covers < 60%, shrub layer containing shrub birch (*Betula pumila, Betula glandulosa*), minerotrophic indicators present, hygric to hydric moisture regime (moisture codes 7-9), hydrologic inputs primarily surface and groundwater, medium to rich nutrient regimes.....***Rich Fens***
i) Trees > 25% cover.....**Treed Rich Fen**
ii) Shrubs > 25% cover .....**Shrubby Rich Fen**
iii) Bryophytes/Herbaceous/Forb >25% cover.....**Graminoid Rich Fen**

8a) Wetlands with > 25% emergent herbaceous or woody vegetation.....**(9)**

8b) Wetlands with <25% herbaceous or woody vegetation, persistent water table well above surface, flooded conditions. Moisture regimes 9 to 10. Submerged or floating leaved vegetation may be present.....***Shallow/Open Water***
i) Floating or submerged aquatic vegetation > 25% .....**Aquatic Bed**
ii) Exposed mud, sand, gravel, or rock substrate > 25% cover.....**Mudflats**

iii) No vegetation present, permanent to semi-permanent water table……**Shallow/Open Water**

9a) Wetlands with periodic or persistent flooding or slow moving surface water (moisture regimes 8 - 10), nutrient regimes rich to very rich, and dominated with herbaceous or forb vegetation (emergents, graminoids (sedges, rushes, some grasses))……***Marshes***

i) Vegetation composed of > 25% emergent species…… **Emergent Marsh**

ii) Vegetation composed of > 25% graminoid/forb species……**Meadow Marsh**

9b) Wetlands with woody vegetation >1m, standing water and nutrient-rich water (moisture regimes 6,7,8,9) with a hummocky microtopography, swamp indicators……***Swamps*** **(10)**

10a) Wetlands with trees < 25% cover, shrubs > 25% cover, shrub vegetation primarily tall form (*Salix* spp*., Alnus rugosa, Cornus stolonifera*) >2 m, with species-rich herbaceous/forb understory……**Shrub Swamp (Swamp Thicket)**

10b) Wetlands with trees >25% cover……**(11)**

11a) Hardwood dominated (primarily *Betula papyrifera* in upland transitional environments or *Populus balsamifera* in floodplain environments) wetlands with trees > 10 m and canopy closures > 60%, moisture regimes 7-9, nutrient regimes rich to very rich ……**Hardwood Swamp**

11b) Wetlands with hardwood (*Betula papyrifera*) and/or conifer (*Larix laricina*, *Picea mariana*) present with no dominance of either (<80% single tree type in canopy), trees ≥ 10m and canopy closures > 60%, nutrient regimes rich to very rich, moisture regimes 7-9, swamp indicators present……**Mixedwood Swamp**

Organic /Peatland Wetlands:

Organic or peatland wetland types are defined as wetlands with an overall accumulation of *weakly* decomposed peat greater than 40 cm (NWWG 1988). Decomposition rates are measured on the von Post decomposition scale (see appendix D) where weakly decomposed peat has a von Post value of <5 (SCWG 1998). The interaction of environmental factors such as climate, soils, hydrology, and vegetation in peatlands result in low decomposition rates in relation to plant production, which leads to an accumulation of peat. It is important to note that different types of peat can form in wetlands. Peat in bogs and fens is primarily decomposed *Sphagnum* and other mosses and sedges, while the peat in swamps contains more decomposed woody material (silvic peat). Figure 10 shows a typical Boreal Plains wetland complex of bogs and fens in Northwestern Alberta. The influence of permafrost features on peatland wetlands is included in Appendix B for reference.

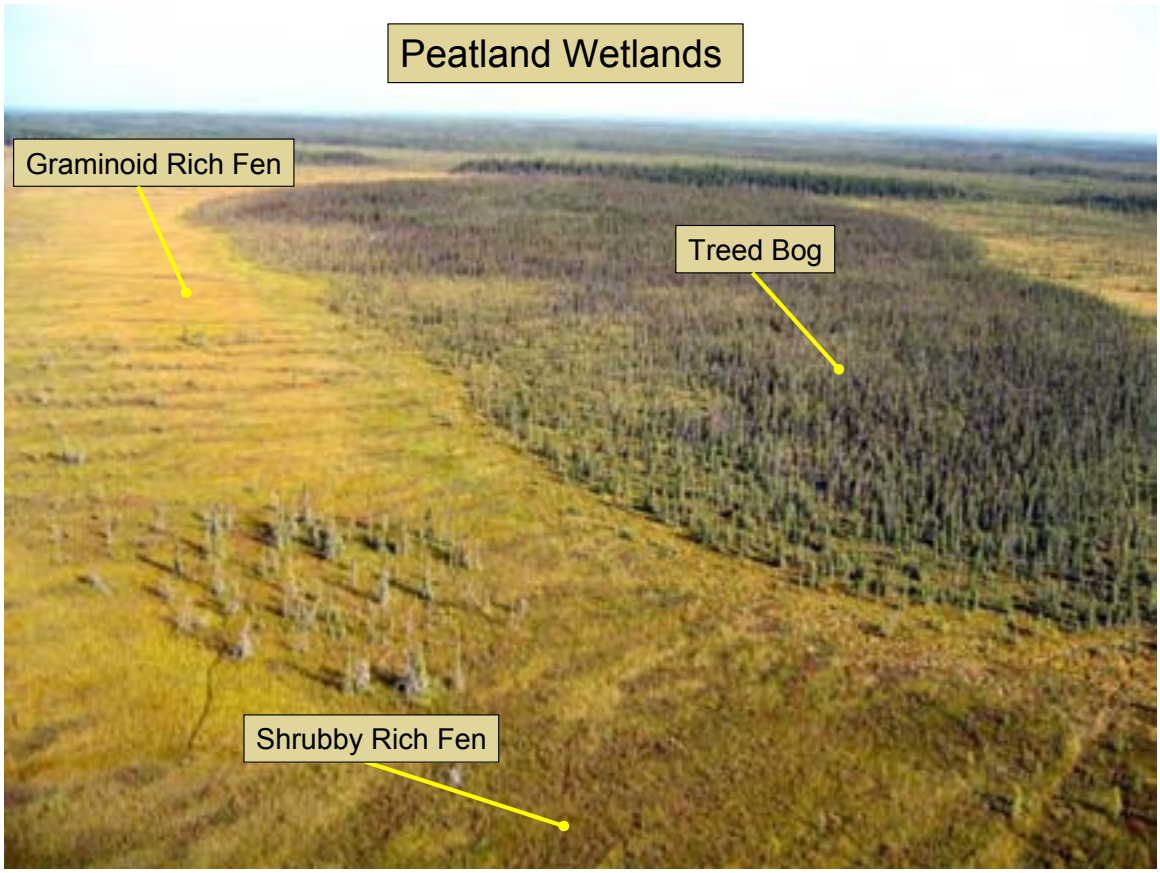


Figure 10. Aerial view of a peatland wetland complex containing bogs and fens. Note the raised surface of the bog and the water flow patterns in the fens. Bogs typically occur as islands in larger fen complexes in the Boreal Plains ecozone as shown above.

Peatland Wetland Types:

Bogs – Bog wetlands are part of the peatland wetland group that is characterized by overall accumulation of peat (primarily weakly decomposed *Sphagnum* mosses). This accumulation of peat in bogs creates a raised surface relative to the surrounding terrain. The bog surface is relatively unaffected by surface runoff or groundwater inputs. Precipitation is the primary hydrologic and nutrient driver in these wetlands (ombrogenous wetlands). The resulting water table is consistently at or slightly below the surface of the bog, but overall is also raised in comparison to the surrounding terrain due to capillary action of water in the organic substrate. The anoxic, cool environment promotes development of acidic organic soils and the accumulation of peat in a raised fashion isolates the rooting zone of plants from mineral-rich water. Few species can exist in such environments, and the resulting vegetation is consequently species-poor. Bogs occur in a wide variety of landforms as a result of slightly different hydrologic processes, presence of permafrost, climate, or other environmental factors that promote peat accumulation. They are common to areas with a cool, wet climate where summer evapotranspiration rates are low to maintain saturated conditions in the peat.

Hydrology/Moisture Regime – The hydrology of bogs is driven by precipitation inputs, and the raised surface of bogs prevents contact with mineral-rich water. Bogs on the Boreal Plains are not domed compared to oceanic bogs but still raised in comparison to the surrounding terrain. Despite the overall convex surface of the bog, capillary action of *Sphagnum* moss and other substrates maintains the water table at or below the surface.

Soils – Bogs have organic soils high in fibric peat with two distinct layers: the biotic surface layer with living *Sphagnum* and the aerobic rooting zone of plants, and the abiotic, anaerobic decomposed peat layer that is continually waterlogged or overlaying permafrost. The peat accumulation process isolates the bogs from mineral soils, which may underlay the deeper organic layers of bogs. The soil types typically found in bogs include soils from the Cryosolic Order (Great Group Organic Cryosols, in permafrost areas) and the Organic Order (Great Groups Fibrisols and Mesisols) (NWWG 1988, SCWG 1998).

Nutrient Regime – Bogs are isolated from mineral-rich water and groundwater and receive inputs from precipitation only, and are thus considered ombrotrophic. The resulting nutrient regimes of bogs are very poor to poor. Bogs have low pH values (typically ranging from <4.0 to 5.0), and are low in dissolved minerals and cation exchange capacity (CEC).

Vegetation and Indicator Species – Bogs may be treed, shrubby, or open depending on the interaction of soils, hydrology and nutrient availability. Bogs are dominated by oligotrophic *Sphagnum* mosses (primarily *S. fuscum*, *S. angustifolium*, *S. capillifolium*, and/or *S. magellanicum*), feather mosses (*Pleurozium shreberi*, *Hylocomium splendens*), and ericaceous shrubs (dominated by *Ledum groenlandicum*, but *Kalmia polifolia*, *Vaccinium vitis-idaea*, and *Oxycoccus microcarpus* are also common). Tree cover in bogs is almost exclusively *Picea mariana*, but in some cases after burns *Betula papyrifera* or *Pinus contorta/banksiana* may be present. In drier permafrost areas, lichen (*Cladina* spp. and/or *Cladonia* spp.) and dwarf ericaceous shrubs dominate the surface. Other common herbs/forbs include *Drosera rotundifolia*, *Rubus chamaemorus*, *Smilacina trifolia*, *Eriophorum* spp., and *Carex* spp. Bogs in general are relatively species-poor compared to other wetland types

(Figure 11). Most of the vegetation in bogs contains plants that are adapted to wide ranges of moisture and nutrient conditions (*Picea mariana*, *Ledum spp.*) and thus do not lend themselves as indicator species to separate bogs from other wetland types. Rather it is the lack of plants found in richer nutrient sites (particularly *Larix laricina* and *Betula glandulosa/pumila*) that distinguish bog vegetation.

Figure 11. Typical Open Bog Vegetation of the Boreal Plains. This area shows a bog in western Alberta, which is dominated by cottongrass (*Eriophorum angustifolium*), *Sphagnum* spp., bog laurel (*Kalmia* spp.), and sundew (*Drosera anglica*). Note the stunted black spruce in the lower parts of the bog in the background.

Field-observable characteristics –

Hydrologic cues – Continental bogs generally have no visible standing water (unlike oceanic bogs), and typically have a continuous moss surface with a saturated appearance. Some peat plateau type bogs will have collapse scars with depressions that extend into the water table. No water flow-related features should be present in bogs (flarks, patterning, channeling, etc.). The moisture regime in bogs is typically mesic, with the moisture class designation typically in the moderate range (saturated, precipitation primary input). Circular larger pools of water surrounded entirely by bogs are fairly common in the Boreal Plains, and pools with sizes larger than a hectare belong to the shallow/open water major class of wetlands.

Vegetation cues – In the Boreal Plains, treed bogs are composed primarily of *Picea mariana*. This lack of other treed types, particularly *Larix laricina* which is more common to fens, is a good

indicator of bogs. Black Spruce typically occurs in lowland form (branches close to the narrow bole and a bulbous, dense crown) in bogs as opposed to the much larger and more vigorous upland form which closely resembles *Picea glauca*. The black spruce are typically stunted due to oligotrophic conditions, with heights variable but always less than 10 meters and in open canopy form (canopy cover < 60%). Tree heights, although variable, are fairly uniform at the height maximum, which creates a "smoother" surface than upland spruce areas. Bogs that are not disturbed (e.g. fire) will have an abundance of arboreal lichen (*Bryoria* spp.), while recently burned bogs will have slightly higher vigor and may contain non-typical bog vegetation (e.g. *Betula papyrifera*, *Pinus contorta/banksiana*, *Betula glandulosa*). The shrub layer in bogs contains primarily ericaceous shrubs, dominated by *Ledum groenlandicum*. Many of the dwarf shrubs are difficult to discern in treed bogs, but the general appearance of ericaceous shrubs (height, color, texture) is quite different from other common shrubs (*Salix spp.*, *Betula spp.*). Bryophytes and lichens (*Sphagnum spp.* and *Cladina/Cladonia spp.*) are dominant in bogs that do not have a high tree or shrub canopy cover. Herbaceous and forb layers do not typically contribute large percentages to the overall cover, even in open bogs due to the dominance of bryophytes and shrubs.

Inferred soil/nutrient cues – The overall condition of the vegetation (height, vigor), presence of oligotrophic species and lack of minerotrophic indicators infer a poorer nutrient regime. The range of very poor (moss and dwarf ericaceous shrub) to poor (taller treed bog margins with a wider range of understory species) is based on the vegetation response to the soils, hydrology, and nutrient availability. The presence of *Sphagnum* moss (high percent cover) suggests fibric peat-dominated organic soils.

Landscape positional cues – Bogs are typically located on low-relief landscapes, but are raised above wetter areas where marshes, fens, and swamps develop. Bogs are associated with areas of permafrost, including landscape features in peatlands like collapse scars, peat plateaus, and basin bogs (for a complete description of Bog landforms, consult NWWG 1988).

Bog Minor Classes: Treed Bog, Shrubby Bog, Open Bog

In summary the main characteristics of bogs:

Wetland Group: Peatland	Nutrient Regime: Very Poor to Poor
Water Table: At or slightly below surface	Hydrologic Regime: Moderate to Imperfect
Hydrologic/Nutrient Input: Precipitation	Moisture Regime: Subhygric to Hygric

Fens – Fen wetlands (Figure 12) are the second group of wetlands under the peatland wetland group. These wetlands also have a high accumulation of peat, but unlike bogs, the surface of fens is level with the surrounding terrain (not raised) and fens receive mineral-rich water inputs. This contact with surface and/or groundwater provides more dissolved nutrients to fen wetlands (minerogenous). The water table in fens can fluctuate and surface runoff (in addition to potential groundwater inputs) from surrounding terrain can contribute to the hydrologic flow in fens. The varying amounts of peat accumulation, hydrologic inputs, and nutrient availability lead to a wide range of environmental gradients where fens may occur. For this classification, this range is separated into two classes: rich fens and poor fens (see e.g. Vitt 1994 for on-ground detailed fen classification based on nutrient richness). Fen areas with less contact to mineral-rich water are poor fens (transitional to bogs), while fen areas with higher nutrient availability are known as rich fens. Poor fens typically are dominated by *Sphagnum* mosses, ericaceous shrubs, and Black Spruce like bogs, but contain other fen indicators such as tamarack (*Larix laricina*) or bog birch (*Betula glandulosa*, *Betula pumila*).

Figure 12. Patterned Rich Fen with flarks perpendicular to the flow of water through the fen.

Vegetation and Indicator Species – All fens have some minerotrophic indicators (species that only grow in richer nutrient environments), and the vegetation in fens is closely related to the depth of the water table and the amount of dissolved minerals in the water. Trees, if present, are primarily *Larix laricina* and *Picea mariana*, and all treed fens have at least > 5% tree species of tamarack. Heights are similar to bogs, with all tree heights < 10 m. The canopy closure of treed fens is nearly always open (< 60% canopy closure). The shrub layer of fens is more species-rich than bogs, and contains large percentages of *Betula glandulosa/pumila* and *Salix spp.* Shrub heights in fens are typically low (< 2 m), which distinguishes shrubby fens from thicket swamps (along with differences in species composition). Rich fens have a larger portion of brown mosses with some *Sphagnum* mosses, while poorer fens lack brown mosses and are dominated by *Sphagnum* mosses.

The herb layer in fens is dominated by sedges, particularly narrow-leafed sedges such as *Carex lasiocarpa* or *Carex limosa*.

Hydrology/Moisture Regime – Hydrology plays a large role in influencing wetland processes in fen wetlands. Precipitation, surface and sometimes groundwater contribute to hydrologic inputs. Movement of water, although slow compared to drainage channels, is a characteristic of fens at both the surface and subsurface levels, and leads to fen wetland forms such as patterned fens (Figure 12). The water table in fens fluctuates, with the water table at or near the surface. Fens with a consistently high water table are typically non-treed. Poor fens have similar hydrology to bogs, but the rooting zone has some contact with mineral rich water, while rich fens have continual contact with mineral rich water. Further, the water in rich fens may simply come from a richer source (i.e. more overland / surface flow that carries more nutrients and/or is influenced by hydrogeochemistry).

Soils – Peatland organic soils are derived from decomposing sedges, mosses (brown and *Sphagnum*), and some woody material. The soil types typically found in bogs include soils from the Cryosolic Order (Great Group Organic Cryosols, in permafrost areas) and the Organic Order (Great Groups Humisols and Mesisols) (NWWG 1988, SCWG 1998).

Nutrient Regime – Depending on the hydrologic inputs (and contact with dissolved minerals), the nutrient regime of fens ranges from poor (isolated from mineral-rich water) to rich (surface water contact).

Field-observable characteristics

Hydrologic cues – Water and water-related surface features are major characteristics of fen wetlands. Standing water is present in many fens, and the surface is at least saturated, with the water table at or near the surface throughout the year. Water flow-related features such as flarks are common in fens (Figure 13). The moisture regime of fens ranges from mesic (poor fens) to hydric (rich fens), with moisture codes ranging from 6-8.

Vegetation cues – Although *Picea mariana* may be present in varying percentages (higher percentage in poor fens), the presence of *Larix laricina* in open canopied areas with heights < 10 m is indicative of treed fens. Tamarack occurs in swamps but always at heights > 10 m and closed canopies (> 60%). The fen form of the tamarack is often stunted like spruce in bogs due to the continually high water table. Shrubs in fens are always at or below 2 meters in height, and are composed of a wider range of species than typically found in bogs (e.g., *Betula glandulosa/pumila*, *Salix spp.*, *Myrica gale*, *Chamaedaphne calyculata*, *Potentilla fruticosa*). Poorer fens typically have a mix of ericaceous shrubs as well. The presence of *Betula glandulosa/pumila* in both rich and poor fen is a good indicator in the shrub layer of fens, as these shrub birches are minerotrophic species. Graminoids in fens are typically narrow-leafed sedges (*Carex* spp.) with a high litter component compared to sedges growing in marsh conditions. Forbs like *Menyanthes trifoliata* are also good indicators of rich fens.

Inferred soil/nutrient cues – The presence of *Sphagnum* and brown mosses (in rich fens) are indicative of peatland soils. The nutrient regimes in fens range from poor (*Sphagnum/Betula glandulosa/Picea mariana/Larix laricina* dominated fens) to rich (brown moss/*Betula glandulosa/Salix spp./Myrica*

gale/Menyanthes trifoliata dominated fens). In this case the type and number of minerotrophic vegetation species determines the relative richness.

Landscape positional cues – Fens occur where significant groundwater seepage or surface water runoff is generated in peat accumulating areas. Fens form major drainage areas of the landscape throughout the Boreal Plains. They also are common as shore fens or floating mats adjacent to water bodies.

Fen Minor Classes: Treed Rich Fen, Shrubby Rich Fen, Graminoid Rich Fen, Treed Poor Fen, Shrubby Poor Fen, Graminoid Poor Fen

In summary the main characteristics of fens:

Wetland Group: Peatland
Nutrient Regime: Poor to Rich
Water Table: At or above the surface
Hydrodynamic Regime: Stagnant to Moving
Moisture Regime: Hygric to Hydric
Hydrologic/Nutrient Input: Precipitation, Groundwater, Surface Flow

Figure 13. Patterned peatland area in Saskatchewan with flarks (water bodies with long axis perpendicular to the waterflow).

Mineral Wetlands

Mineral wetlands occur in areas on the landscape where there is an overall excess of water, but little (< 40 cm) or no organic matter or peat has formed. Factors such as position in the landscape, geology and soils, hydrology, and climate all influence the formation of mineral type wetlands. These can occur as wet areas in mineral soil drainages and seepages, floodplains with sedimentary mineral soils, shallow water areas of palustrine, lacustrine, or riverine systems, and many other areas in the landscape where water collects on mineral soil areas. Peat that does occur in shallow deposits is typically woody peat (silvic or sedimentary peat).

Swamps –

Figure 14. An example of a hardwood swamp dominated by *Betula* spp.

General Description - Swamps belong to both mineral and peatland wetland types, and can occur in widely different landscape settings from mineral soil floodplains to peatland soil conifer swamps. For this reason (and in part due to the connotation that the name swamp brings), swamps have traditionally been harder to identify than other wetland types and are often confused or grouped with other wetland classes. Swamps are distinguished from other wetland types in that they are wooded (treed or shrub) wetlands that are in contact with minerotrophic water in either mineral or peatland soils. An important distinction is that the woody vegetation dominates swamp areas (often

in percentages greater than 30% and up to 100% of the canopy) as a result of greater contact with nutrients, aerated soils, and high water availability. The majority of swamps have closed canopies (greater than 50%). This abundance of woody material in swamps provides another important distinction in that the peat is primarily composed of decomposing wooded material (shrub and tree) rather than the *Sphagnum* or sedge-dominated peat types that comprise the organic layer in poor fens and bogs. Further, peat soils in swamps are fairly well decomposed compared to peat in peatlands, which is caused by fluctuating water tables that allow for oxygen and decomposition.

Vegetation – Woody vegetation (shrubs >2m, and trees > 10 m) dominate the cover of swamps. Treed vegetation can be conifer (*Picea mariana* or *Larix Laricina*), deciduous (*Betula* sp.), or mixed. Shrub vegetation, when present, is in tall form, and is predominantly willows (*Salix* spp.) and alders (*Alnus rugosa*).

Hydrology/Moisture Regime – Water regime (fluctuating water table) and availability play a significant role in swamps. Swamps in general are not as inundated seasonally as marshes, periodically/continually as fens, or as permanently saturated as bogs. The water table in swamps fluctuates seasonally, or in some systems bi-yearly, but pools of water are often visible in the hummocky ground surface. Thus for most of the growing season, the majority of the soil layer is aerated, but water availability is still high in the continually saturated lower portions of the rooting zone. Treed swamps (such as hardwood or mixedwood swamps) in mineral soils are often drier, while swamps that grade into treed fens (tamarack swamps) are wetter. Shrub swamps are almost always wetter than most of the treed swamps, except in some riparian floodplain associated areas on mineral soils. Moisture regimes for swamps range from hygric to hydric (codes 7-9 in Table 1). Flow through swamps is fairly dynamic with good lateral flow through the ground water layer, and fluctuations of this water table allow for aeration of the rooting zone during the growing season.

Soils – Swamps exist in both peat and mineral soils. Swamps are sometimes termed peatlands but do not fit the definition of having a peat accumulation of *weakly* decomposed peat (Of or Om, von Post <5) of sedge or *Sphagnum* peat (see Appendix D von Post scale). Rather, the substrate is silvic peat and well decomposed. Decomposition is driven by the fluctuating water levels which are absent in *Sphagnum*-derived peatlands. Some swamps soils may be termed peatyphase soils (e.g. Racey et al., 1996) but do not have the weakly decomposed peat of peatlands (see Soil Classification Working Group 1998 for definition and detail of organic order).

Swamp soils are typically composed of gleysols with mottling in the upper horizons (signs of temporarily flooded soils) and gleying in the lower horizons (sign of permanently saturated soils) (Soil Classification Working Group 1998). Mottling occurs in a soil that has been inundated with water intermittently (the mottles are iron and manganese oxides) (Soil Classification Working Group, 1998). Gleization occurs during the chemical reduction of iron, thus changing the soil colours (Soil Classification Working Group. 1998). Soils with low chromas (see a Munsell colour chart) are indicative of hydric conditions.

Nutrient Regime – The nutrient regime in swamp wetlands ranges from poor to rich, depending on the amount of contact with dissolved mineral water. Conifer swamps tend to be poor to medium in nutrient regime, while most other swamps range from medium to rich.

Field-observable characteristics – Swamps are a common wetland type throughout the Boreal Plains.

Hydrologic cues – The most common water feature found in swamps, particularly treed swamps, are the small pools of water found in the hummocky understory of swamps. Water flow in swamps may be above the surface during flooding events, but typically the flow is subsurface internal flow. Moisture codes for swamps would range from 4 in some conifer swamps to 6 in some shrub swamps, with the bulk of the swamps somewhere in between. Hydrodynamic regimes in swamps range from 2 to 4.

Vegetation cues – Vegetation is an important cue in determining swamp wetlands in the field. Deciduous tree species common to swamps are limited to *Betula papyrifera*, *Betula neoalaskana*, and *Populus balsamifera* throughout most of the Boreal Plains, with *Acer negundo*, *Fraxinus pennsylvanica*, and *Ulmus americana* occurring only in the far eastern portion of the Boreal Plains in non-canopy dominant site distributions. *Populus balsamifera*, while it commonly occurs in upland areas, is typically only found in hardwood swamps located in floodplains along riverine systems. *Betula papyrifera* is the major deciduous species in many of the hardwood and mixedwood swamps of the Boreal Plains (and is rarely dominant in upland deciduous forest canopies). Conifer species in swamps are primarily *Picea mariana* and *Larix laricina*, with *Thuja occidentalis* and *Abies balsamea* occurring in the far eastern portions of the Boreal Plains in conifer swamps. While *Picea mariana* and *Larix laricina* are common to other wetland types, they typically occur in swamps in their high vigor form, and the tree heights are typically taller (greater than 10 m). Shrub species in swamps are differentiated by height (greater than 2 meters, on average) and species (tall shrub species/forms of *Alnus* spp. and *Salix* spp. vs. *Betula* spp. shrubs in fens). Understory species are variable depending on swamp type but include a variety of forbs and graminoids.

Inferred soil/nutrient cues – The inferred nutrient regimes in swamps are tied closely to the vegetation and inferred hydrology. In wetter systems on mineral soils (such as swamp thickets) the nutrient regime is rich, while conifer swamps that grade into bogs in organic soils have poorer nutrient availability. The condition of the vegetation (height, density) and the number of minerotrophic species or swamp indicators relates to the richness of the swamp wetland.

Landscape positional cues – Swamps occur in several different positions in the landscape, from peatland transitional areas (conifer swamps) to marsh transitional areas (thicket swamps) and along riverine systems or lake shores.

Swamp Minor Classes: Conifer Swamp, Tamarack Swamp, Mixedwood Swamp, Shrub (Thicket) Swamp, and Hardwood Swamp

In summary the main characteristics of swamps:

Wetland Group: Peatland (Conifer, Tamarack), Mineral (Hardwood, Mixedwood, Shrub)
Nutrient Regime: Poor to Very Rich Water Table: Above, At, or Below the surface
Hydrodynamic Regime: Stagnant to Moving Moisture Regime: Hygric to Hydric
Hydrologic/Nutrient Input: Precipitation, Groundwater, Surface Flow

Marshes

Figure 15. A typical Boreal Plains emergent basin marsh with a mix of emergents (*Typha* spp.) and sedges (*Carex* spp.).

General Description – Marsh wetlands are mineral wetlands that experience temporally variable inundation patterns (periodical to seasonal to annual), where the substrate is alternately exposed or flooded depending on the hydrodynamics of the wetland system. Emergent macrophytes, adapted to highly variable hydroperiods, are the dominant vegetation type in marshes. Hydrologic inputs to marshes come from a multitude of sources (inflow, surface runoff, groundwater discharge or seepage, precipitation, or flooding), and determine the variability of the water table (from flooding to drawdown). This diversity of dissolved mineral inputs and aeration give rise to high productivity and decomposition of vegetative material. Marshes are typically associated with shallow/open water classes or other lacustrine or riverine systems in topographic depressions or low-lying areas. In many areas in the Boreal Plains, marshes typically occur as smaller (10-100+ meters wide) rings of vegetation around basins, but they can also occur as large expanses, particularly in the nutrient-rich inland deltas or alluvial fans of major river systems (e.g., Peace/Athabasca Delta, Saskatchewan Delta).

Vegetation – Marsh vegetation communities are often dynamic in response to the frequent or seasonal changes in hydroperiod that typify marsh wetland hydrology. Emergent aquatic macrophytes, such as reeds, sedges, and grasses, broad-leaved emergents, floating-leaved and

submerged aquatic vegetation, algae, and other herbaceous and forb species comprise the major types of vegetation in marshes. Above surface vegetation cover is greater than 25%. Vegetation zonation in marshes is closely related to hydrology (water depth and inundation frequency), water chemistry, or in some cases, disturbance such as beaver dams. Deeper emergent marshes grade into the shallow/open water classes, while the meadow marsh grades into other wetland or upland classes.

Hydrology/Moisture Regime – Hydrologic inputs to marshes come from a multitude of sources: groundwater discharge, surface runoff, stream inflow, precipitation, and storm surges/wave action. Permanence of standing water is an important component of marsh wetland hydrology, and is related to climate, soils, and hydrologic input. The water table is highly variable and is typically at or above the surface, but may be below the surface during drawdowns, droughts, or disturbance. The moisture code for marsh sites ranges from 8 to 10.

Soils – Given the diversity of marsh wetland types, a similar diversity of soil substrates in marshes is also common. Mineral soils are commonly found in marsh wetlands and organic soils are only present as sedimentary peat (surficial layers of humic or limnic peat). Mixtures of both mineral and organic soils can be common in marshes. Soil types range from mineral Gleysols (Humic and Rego) to organic Humisols and Mesisols (Soil Classification Working Group 1998).

Nutrient Regime – The presence of mineral soils, along with the dynamic hydroperiod (periodic aeration of soils) and multitude of hydrologic inputs, leads to mineratrophic (and commonly eutrophic) conditions in marsh wetlands. Marshes are circum-neutral (around pH of 7) to alkaline which promotes high levels of dissolved minerals. This high nutrient availability leads in turn to high productivity of marsh vegetation as well as high decomposition rates throughout the year. The nutrient regime codes found in marshes range from rich to very rich (4 to 5). Some marshes may be saline, with extremely high nutrient availability, but the high salinities are toxic to typical marsh vegetation not adapted to those conditions.

Field-observable characteristics –

Hydrologic cues – Marshes are often found in association with shallow/open water wetlands or have standing water present for prolonged periods. The permanence of marsh wetlands is directly associated with a hydroperiod because prolonged periods of drawdown will support different vegetation communities.

Vegetation cues – Emergent macrophytic vegetation is dominant in marshes, and is the primary vegetation type present (25-100% cover). Depth of water, soil substrate material, hydrodynamics, disturbance and duration of inundation play a role in the vegetation type present in marshes. Vegetation types often create distinct zones of marsh vegetation with distinct spectral signatures. These zones range from deeper water marshes, such as *Scirpus* beds on mineral substrates with high water cover percentages to mixed emergent marshes in the shallow littoral zone to *Carex* spp. meadows that transition to swamps and fens.

Inferred soil/nutrient cues – The nutrient regimes most common in marshes are rich to very rich due to the high nutrient availability of marshes as a result of hydrologic inputs, pH, and frequent soil aeration. Marshes adjacent to peatlands with deposited organic material tend towards the rich

nutrient regime, while eutrophic mineral soil marsh complexes tend towards the very rich nutrient regime.

Landscape positional cues – Marshes occur in any areas of the landscape where periods of inundation occur for a sufficient period to promote emergent macrophytic vegetation. A large degree of temporal variation in inundation and vegetation cover is common in marsh wetlands. Disturbances such as changes in flooding regime or beaver dams often support marsh wetland types.

Marsh Minor Classes: Emergent Marsh, Graminoid Marsh

In summary the main characteristics of marshes:

Wetland Group: Mineral Nutrient Regime: Rich to Hyper
Water Table: Inundated, above the surface Moisture Regime: Hydric to Very Hydric
Hydrodynamic Regime: Moving to Very Dynamic
Hydrologic/Nutrient Input: Precipitation, Groundwater, Surface Flow

Shallow/Open Water

Figure 16. Floating-leaved vegetation (Aquatic Bed, *Nuphar* spp.) in a shallow boreal lake.

General Description – The major classification level wetland class shallow/open water encompasses all portions of the landscape that are perennially flooded and transitional between the emergent marsh in the littoral zone to the profundal/benthic zone of permanent deep water bodies. The NWCS classifies shallow water wetlands as "*…wetlands [that] have standing or flowing water less than 2 meters deep in mid-summer*". However, accurate satellite remote sensing of water depth in many of the conditions that exist in the Boreal Plains is nearly impossible to establish. Turbidity, algal blooms, dark organic substrates, stained water, and other natural features of shallow and deep water bodies do not permit spectral separation of water bodies by water depth (shallow vs. deep). For this reason, no distinction in this classification is given between deep, permanent water bodies (lakes) and shallow water bodies (ponds, pools, oxbows, sloughs, reaches, channels, flarks, etc.). Shallow water basins may be vegetated with floating or submerged vegetation or exposed mudflats during drawdown periods.

Vegetation – Floating leaved and submerged aquatic vegetation that are adapted to constant inundation are the only vegetation types represented in this wetland class in the Boreal Plains. Algae, while added as a potential class, is often an ephemeral event in shallow water bodies, and therefore not frequently mapped. Presence of algae is largely dependent on environmental

conditions at the time of imagery. The other vegetation component that is not present in the landlocked Boreal Plains, but common in the coastal ecozones is eelgrass and other tidally influenced vegetation.

Hydrology/Moisture Regime – The shallow/open water wetland class has a semi-permanent to permanent water table, and the corresponding moisture regime for these wetlands is hydric (Moisture codes 9, 10 in Table 1). The hydrodynamic regime for these types of wetlands ranges from dynamic in sheltered areas to very dynamic in more exposed areas to wave action.

Soil - The permanent flooding conditions found in this wetland class promote anaerobic conditions which do not support soil profile development. For this reason, shallow/open water soil substrates are classified as non-soil if they are flooded at depths greater than 60 cm (Soil Classification Working Group 1998). The soil substrates range widely in shallow/open water bodies and include rock, gravel, sand, silt, sedimentary peat, clay, marl, or a mix of both mineral and organic components.

Nutrient Regime – A multitude of wide-ranging factors influence the nutrient regime of shallow/open water wetlands including substrate type, water chemistry (acidity, salinity, dissolved nutrients), turbidity, water depth, hydrodynamics, source of hydrologic inputs, and landscape position. The nutrient regime of shallow water can range from dystrophic in peatland areas to oligotrophic to eutrophic in areas with significant nutrient inputs, and the resulting nutrient code ranges from 1 to 6.

Field-observable characteristics – This class is readily determined in the field due to the constant inundation of water and presence of floating-leaved or submerged aquatic vegetation, if present.

Hydrologic cues – The semi-permanent to permanent water table present in shallow/open water wetland is the primary cue for identification of these wetlands.

Vegetation cues – Floating-leaved and/or submerged aquatic vegetation along with algae are the only types of vegetation found in shallow/open water.

Inferred soil/nutrient cues – Soils are commonly not visible in these wetland types due to water depth, and given that most of the substrates are classified as non-soil, this is a non-factor in determining the wetland class in this case. Nutrient levels of this class can range from poor to extremely rich, depending on the situation.

Landscape positional cues – These wetlands are generally located in the lowest parts of the water catchments as rivers, lakes, pools, oxbows, or reaches.

Shallow/Open Water Minor Classes: Aquatic Bed, Mudflats (Exposed Sediments), Shallow/Open Water

In summary the main characteristics of shallow/open water wetlands:

Wetland Group: Mineral Nutrient Regime: Poor to Hyper
Water Table: Inundated Hydrodynamic Regime: Moving to Very Dynamic
Moisture Regime: Very Hydric
Hydrologic/Nutrient Input: Precipitation, Groundwater, Surface Flow

References

Beckingham, J.D., and J.H. Archibald. 1996a. Field Guide to ecosites of northern Alberta. Nat. Resour. Can., Can. For. Serv., Northwest Reg., North. For. Cent., Edmonton, Alberta. Spec. Rep. 5.

Beckingham, J.D., D.G. Nielsen, and V.A. Futoransky. 1996b. Field guide to ecosites of the mid-boreal ecoregions of Saskatchewan. Nat. Resour. Can., Can. For. Serv., Northwest Reg., North. For. Cent., Edmonton, Alberta. Spec. Rep. 6.

Beilman, D.W. and S.D. Robinson. 2003. Peatland permafrost thaw and landform type across a climatic gradient. Proceedings of the 8th International Conference on Permafrost, Zurich, Balkema Publishers, Vol. 1, pp. 61-65.

Brown, R.J.E. 1967. Permafrost in Canada. Geological Survey of Canada, Map 1246A.

Chee, W. and Vitt, D.H. 1989. The vegetation, surface water and peat chemistry of moderate-rich fens in central Alberta, Canada. Wetlands. 9:227-261.

Congalton, R. G. 1991. A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment 37:35-46.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Fish and Wildlife Service, United States Department of the Interior. Report No. FWS/OBS-79/31. 103 pp.

Halsey, L.A., and D.H.Vitt. 1997. Alberta Wetland Inventory Standards. In Alberta Vegetation Inventory Standards. Resource Data Division, Alberta Environmental Protection.

Harris, A.G., S.C. McMurray, P.W.C. Uhlig, J.K. Jeglum, R.F. Forster, and G.D. Racey. 1996. Field guide to wetland ecosystem classification for northwestern Ontario. Ont. Min. Natur. Resour., Northwest Sci. & Technol. Thunder Bay, Ont. Field Guide FG-01. 74pp + Append.

Jeglum, J.K. 1991. Definition of trophic classes in wooded peatlands by means of vegetation types and plant indicators. Ann. Bot. Fenn. 28: 175–192.

Jeglum, J.K. 1973. Boreal forest wetlands near central Saskatchewan. II. Relationships of vegetational variations to major environmental gradients. The Musk-ox 12:32-48.

Jeglum, J.K. 1971. Plant indicators of pH and water levels in peatlands at Candle Lake, Saskatchewan. Can. J. Bot. 49: 1661-1676.

Johnson, D., L. Kershaw, A. MacKinnon, and J. Pojar. 1995. Plants of the western boreal forest and aspen parkland. Lone Pine Publishing, Edmonton, Alberta. 392 pp.

Locky, D.A., S.E. Bayley, and D.H. Vitt. The vegetational ecology of Black Spruce swamps, fens, and bogs in Southern Boreal Manitoba, Canada. Wetlands, Vol. 25, No. 3, September 2005, pp. 564-582.

Mackenzie, W.H. and J.R. Moran. 2004. Wetlands of British Columbia: a guide to identification. Res. BR., B.C. Min. For., Victoria, D.C. Land Manage. Handb. No. 52.

National Wetlands Working Group. 1988. Wetlands of Canada. Ecological Land Classifcation Series, No. 24. Sustainable Development Branch, Environment Canada, Ottawa, Ontario, and Polyscience Publications Inc., Montreal, Quebec. 452 p.

Ontario Ministry of Natural Resources. 1993. Ontario Wetland Evaluation System: Northern Manual. First Edition. Ont. Min. Natur. Resour., Northest Sci. & Technol. Timmins, Ont. Technical Manual TM-001. 182 pp.

Racey, G.D., A.G. Harris, J.K. Jeglum, R.F. Foster, and G.M. Wickware. 1996. Terrestrial and Wetland Ecosites of Northwestern Ontario. Ont. Min. Natur. Resour., Northwest Sci. & Technol. Field Guide FG – 02. 94 pp. + Append.

Sjörs, H. 1952. On the Relation between Vegetation and Electrolytes in North Swedish Mire Waters. Oikos. 2:241-258.

Soil Classification Working Group. 1998. The Canadian System of Soil Classification, 3rd ed. Agriculture and Agri-Food Canada Publication 1646, 187 pp.

Soil Survey Division Staff. 1993. Soil Survey Manual. Agricultural Handbook No. 18 Revised. U.S. Department of Agriculture, Washington, D.C.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Fish. Wildl. Serv., Resour. Publ. 92. 57 pp.

Vitt, D.H. 1994. An overview of factors that influence the development of Canadian peatlands. Mem. Entm. Soc. Can. 169:7-20.

Vitt, D.H and W.L. Chee. 1990. The Relationship of Vegetation to Surface Water Chemistry and Peat Chemistry in Fens of Alberta, Canada. Vegetatio. 89: 87–106.

Vitt, D. H., L.A. Halsey, S.C. Zoltai. 1994. The bog landforms of continental western Canada in relations to climate and permafrost patterns. Arctic and Alpine Research 26 (1):1-13.

Vitt, D.H., Halsey, L.A., Thormann, M.N. and Martin, T. (1996) Peatland Inventory of Alberta. Phase 1: Overview of peatland resources in the natural regions and subregions of the province. Stephen C. Zoltai Peatland Resource Center, Devonian Botanic Garden, University of Alberta, Edmonton, Alberta.

Warner, B.G. and C.D.A. Rubec. (Eds.). 1997. The Canadian Wetland Classification System, Second Edition. National Wetlands Working Group. Wetlands Research Centre, University of Waterloo. Waterloo, Ontario. 68pp.

Zoltai S.C. 1971. Southern limits permafrost features in peat landforms, Manitoba and Saskatchewan. The Geological Association of Canada. Special Paper Number 9: 305-310.

Zoltai, S.C. 1993. Cyclic development of permafrost in the peatlands of Northwestern Alberta, Canada. Artic and Alpine Research 25(3): 240-246.

Glossary

Sources for this glossary include: MacKenzie and Moran 2004; Beckingham and Archibald 199; Harris et.al. 1996; National Wetlands Working Group 1988.

Aerobic - Occurring in the presence of free oxygen, either as a gas in the atmosphere or dissolved in water.
Alkaline – Water or soil with a pH greater than 7.4. Relatively high concentration of available base cations.

Anaerobic – Occurring in conditions devoid of oxygen

Annual flood – Flooding occurs at least once a year

Brown moss – A guild of peatland mosses that usually indicate mineral rich site conditions. Includes *Campylium stellatum* (starry campylium), *Scorpodium scorpoides* (scorpion tail moss), *Drepanocladus* spp., and *Tomenthypnum nitens* (fuzzy brown moss).

Bryophyte - A plant of the Bryophyta, a division of photosynthetic, chiefly terrestrial, nonvascular plants, including the mosses, liverworts, and hornworts.

Canopy – cover of branches and leaves formed collectively by the crowns of trees, shrubs, or other plants.

Capillary action – Particles in soil attract moisture, and surface tension is strong enough to cause moisture to rise up through the soil above the water table.

Dominant – Species which contributes the greatest vegetation cover to the overall community.

Drawdown – Decrease in water level of wetlands, lakes, or streams exposing substrate that is normally submerged.

Dwarf Shrubs – Plants with woody stems that are generally less than 15 cm in height at maturity. *Andromeda polifolia*, *Arctostaphylos uva-ursi*, *Empetrum nigrum*, *Gaultheria hispidula*, *Kalmia microphylla*, *Linnnaea borealis*, *Oxycoccus macrocarpus*, *Rubus chamaemorus*, *Rubus arcticus*, *Vaccinium caespitosum*, and *Vaccinium vitis-idaea* are the most common wetland dwarf shrub species.

Ecozone - An area of the earth's surface that represents a large ecological zone and has characteristic landforms and climate.

Emergents – Upright plants rooted in water or exposed to seasonal flooding, emerging above the water surface. Does not include some submergents that normally lie entirely under water but have flowering parts that break the surface. Includes mostly sedges, rushes, bulrushes, and other grass-like forbs.

Ericaceous shrubs – shrubs belonging to the Ericaceae (Heather) family. *Andromeda*, *Chamaedaphne*, *Gaultheria*, *Kalmia*, *Ledum*, *Oxycoccus*, and *Vaccinium* are the most common wetland genera.

Eutrophic – Very rich nutritional status, abundant supply of nutrients.

Feathermosses – Upland moss species with a feather-like form including Hylocomium splendens (stair-step moss), Pleurozium schreberi (big red stem moss), and Ptilium crista-castrensis (knight's plume moss).

Fibric – Poorly decomposed peat with large amounts of well-preserved fiber readily identifiable as to botanical origin.

Flark – Elongated wet depressions separated by raised ribs (strings) in patterned peatlands. The long axis is always perpendicular to the direction of waterflow.

Floating mat – Mat of peat held together by roots and rhizomes underlain by water or fluid, loose peat (National Wetlands Working Group 1988).

Floating-leaved plants – rooted or free-floating plants with leaves normally floating on the water surface.

Flooding – surface inundation by moderate to fast moving water. Usually associated with sedimentation and erosion (see also inundation).

Fluvial – Sites occurring along flowing watercourses, the watercourse itself, and the surrounding (riparian) terrain and vegetation.

Forb – And non-graminoid herb species.

Forested – Sites with > 5 % canopy cover of tree species > 10 m tall (see also Treed).

Frequent flooding – Flood return interval of 2-5 years.

Gleyed – A soil condition resulting from prolonged soil saturation, which is manifested by the presence of bluish or greenish colors throughout the soil mass or in mottles if occasionally exposed to oxygen (usually orange spots or streaks).

Graminoid – Plants with a grass-like growth form including rushes (Juncaceae), grasses (Poaceae), and sedges (Cyperaceae).

Groundwater – Water passing through or standing in soil and underlying strata. Free to move by gravity (National Wetlands Working Group 1988).

Hardwood – Deciduous broadleaved trees which are angiosperms.

Herb- Non-woody vascular plants. Includes forbs and graminoids.

Hollow – A wet depression or pool.

Humic – Highly decomposed organic material. Small amounts of fiber can be identified as to the botanical origin (National Wetlands Working Group 1988).

Hummock – A mound composed of organic material, often composed of *Sphagnum* peat (see also Mound).

Humus – Dead and decaying organic material at the soil surface.

Hydric – 1. A site where water is removed so slowly that the watertable is at or above the soil surface all year. 2. A Gleysol or Organic soil.

Hydrophytic plant – Any plant adapted for growing on permanently saturated soils deficient in oxygen.

Hygric – Water removed slowly enough to keep soil wet for most of the growing season; permanent seepage and mottling usually below 30 cm in depth.

Hypereutrophic – Sites with very high salinity or alkalinity.

Indicator Species – Plant species that reveal specific site conditions or environmental traits.

Inundation – Surface flooding by standing or slow-moving water.

Lacustrine – The environment (including wetlands) surrounding a lake.

Lagg – Depressed margin of a bog or fen; generally wetter than surrounding area, often contains open water.

Lawn – Relatively flat expanse of wetland moss usually raised above water level. Contrast with Hummock or Hollow.

Lichen – Fungi and certain species of algae that live in a symbiotic relationship whereby fungus provides structural support, nutrients absorbed from the substrate, and a relatively stable environment. The algae in turn provide carbohydrates through the process of photosynthesis. Reindeer lichens are most common to wetland (particularly peatland wetlands), including *Cladina* spp.

Loonshit – colloquial term for sedimentary peat.

Marl – Sediments composed of shells of aquatic animals and $CaCO_3$ precipitated in water.

Mesic – 1. (*Soils*) Organic material in an intermediate stage of decomposition where some fibers can be identified as to botanical origin. 2. (*Moisture*) Medium soil moisture regime where a site has neither excess soil moisture nor a moisture deficit.

Microtopography – small-scale (i.e. < 2m) variations in soils surface elevation (e.g., hummocks and hollows).

Minerotrophic – Nourished by mineral water. Refers to wetlands that receive nutrients from flowing or percolating mineral groundwater (National Wetland Working Group 1988)

Minerotrophic indicator species – Plant species requiring relatively high concentrations of nutrients associated with mineral groundwater.

Moderately acidic – Having a soil pH value of 4.5 -5.5.

Moist – No water deficit occurs.

Mound – Mounds composed of mineral materials (see also Hummock).

Neutral pH – Having a soil pH value of 6.5 -7.4. Available base cation concentration is high enough to buffer acidic conditions.

Occasional flooding – Flood interval greater than 5 years.

Oligotrophic – Relatively poor in nutrients.

Ombrotrophic – Nourished by rain. Peatlands entirely dependent on nutrients deposited by precipitation or aerial deposition (National Wetlands Working Group 1988).

Paludification – Succession or conversion of upland or mineral wetland habitats to peatland through accumulation of peat.

Palustrine – Basins, depressions, slopes, and small water bodies with a continually high watertable and poor-drainage wetland landscape units.

Patterned peatland – Peatlands marked by distinct patterns of vegetation in alternating raised ridges and depressions (flark) forms. Sites are slightly sloping and ridges form perpendicular to the direction of waterflow.

Peat – Partly decomposed plant material deposited under saturated soil conditions.

Peatland – A generic term including all types of peat-covered terrain. Many peatlands are a complex of swamps, bogs, and fens, sometimes called a "mire compex" (National Wetland Working Group 1988).

Permafrost – Areas with perennially frozen soil strata, occurring wherever the average mean annual temperature remains below 0°C (32°F) for several years.

Rarely flooded – Flooding occurs only during extreme events.

Riparian – The area at the interface between upland and water/wetland areas adjacent to or along the band of a river, lake, or wetland.

Saline – The presence of soluble salts in the soil parent material at concentrations that affect plant growth.

Saturated – A soil condition in which all voids (pore spaces) between soil particles are filled with water.

Sedimentary peat – Peat formed beneath a body of standing water composed of aquatic plant debris modified by aquatic animals. Material is loosely consolidated, slightly sticky, dark brown to black, and usually well decomposed (humic). Synonyms: aquatic peat, loonshit, allochthonous peat, detrital peat, gyttja (National Wetlands Working Group 1988).

Seepage – Groundwater discharge having less flow than a spring.

Shrub – Perennial plants usually with more than one low-branching woddy stem and <10m tall.

Slightly Acidic – Having a soil pH value of 5.5 to 6.5.

Stand – A plant community that is relatively uniform in composition, structure, and habitat conditions.

Subhydric – Water removed slowly enough from soil to keep the water table at or near the surface for most of the year; organic and gleyed mineral soils; permanent seepage less than 30 cm below the surface.

Subhygric - Water removed from soil slowly enough to keep soil wet for a significant part of the growing season; some temporary seepage and possibly mottling below 20 cm.

Submesic – Upland dry soil moisture regime where water is removed from soil readily in relation to supply.

Submergents – Plants that normally lie entirely beneath water. Some species have flowering parts that break the water surface.

Subxeric – Water removed rapidly in relation to supply; soil is moist for short periods after precipitation. Upland dry soil moisture regime.

Succession – Replacement of one community by another; often progresses to a relatively stable terminal community called the climax.

Treed – Sites with >5% canopy cover of tree species (see also Forested).

Tussock – A thick tuft of sedge or other vegetation forming a small mound of solid ground in a wetland (National Wetlands Working Group 1988).

Upland – Terrain dominated by non-hydrophytic vegetation where soils have high soil oxygen and are not saturated with water for any extended length of time.

Very acidic – Having a soil pH value less than 4.5. Low concentration of available base cations.

Very wet – Groundwater table at or above the ground surface throughout most of the growing season.

Water track – Path of concentrated water flow in a peatland.

Watertable – The upper zone of saturation within the soil profile.

Wetland – Sites dominated by hydrophytic vegetation where soils are water-saturated for a sufficient length of time such that excess water and resulting low soil oxygen levels are principal determinants of vegetation and soil development (MacKenzie and Moran 2004).

Wetland Complex – Contiguous wetland area consisting of several kinds of wetlands, potentially including shallow/open water, marsh, swamp, bog, and fen.

Xeric – Upland dry soil moisture regime where a site has an extreme water deficit (water is removed very rapidly in relation to supply). Soils is moist for brief periods after precipitation only.

Appendix A. VEGETATION MODIFIER CLASSES AND INDICATOR SPECIES:

The following is a description of the cutoffs to assemble the vegetation modifier (e.g. Treed Bog vs. Shrubby Bog) for each wetland class (National Wetland working Group 1997).

Treed (>25% Tree cover)

- Coniferous Treed:
- Hardwood Treed:
- Mixedwood:

Shrub (<25% Tree cover, >25% Shrub cover)

- Classified by heights into low (<2 m), and tall (>2 m)

Graminoid (<25% Tree cover, <25% Shrub cover, >25% Graminoid)

Forb (<25% non-graminoid herbaceous cover)

Moss (>25% Moss cover)

- Most common types are *Sphagnum*, Feather, and Brown Mosses

Lichen (>25% Lichen (*Cladina* or *Cladonia* spp.))

Aquatic (>25% Floating, Submerged, or Emergent Vegetation Cover)

Dominated by aquatic macrophytes in saturated to standing water to permanent water body areas of the landscape.

Non-Vegetated (<5% vegetation cover)

Common Plant Species for Wetland Types:

The following is a list of all of the plant species commonly encountered in each wetland type for the Boreal Plains ecozone, based on the species encountered in the field data, as well as the ecosite information available by province for the region (Harris et. al 1996, Beckingham and Archibald 1996a, Beckingham et al. 1996b). The species listed below are the ones that can be identified from an orthogonal viewpoint by an experienced botanist/field biologist, and therefore do not reflect a comprehensive list of every possible plant species encountered within a wetland class.

Bog Vegetation:

Tree layer (2-10m): *Picea mariana* (Black Spruce), *Larix laricina* (Tamarack) (<5% total cover)

Shrub layer (<2 m): *Andromeda polifolia* (Bog Rosemary), *Chamaedaphne calyculata* (Leatherleaf), *Gaultheria hispidul*a (Creeping Snowberry), *Kalmia polifolia* (Bog Laurel), *Ledum groenlandicum* (Labrador Tea), *Oxycoccus macrocarpu*s (Small Bog Cranberry), *Vaccinium vitis-idaea* (Bog Cranberry).

Forb Layer: *Drosera spp.* (Sundews), *Maianthemum trifolium* (Three-leaved Solomon's Seal), *Rubus chamaemorus* (Cloudberry), *Sarracena purpurea* (Pitcher Plant).

Graminoid Layer: *Eriophorum* spp. (Cottongrass), *Carex spp.* (Sedges),

Moss Layer: *Sphagnum fuscum*, *Sphagnum magellanicum*, *Pleurozium schreberi*, *Sphagnum angustifolium*.

Lichen Layer: *Cladina spp.*, *Cladonia spp.*

Fen Vegetation:

Poor Fens:

Tree Layer (2-10 m): *Larix laricina* (Tamarack), *Picea mariana* (Black Spruce)

Shrub Layer (<2 m): *Chamaedaphne calyculata* (Leatherleaf), *Betula pumila* (dwarf birch), *Betula glandulosa* (Bog Birch), *Kalmia polifolia* (Bog Laurel), *Ledum groenlandicum* (Labrador Tea), *Oxycoccus macrocarpu*s (Small Bog Cranberry), *Vaccinium vitis-idaea* (Bog Cranberry), *Salix* spp. (Willows)

Forb Layer: *Drosera* spp. (Sundews), *Equisitem fluviatile* (Water Horsetail), *Maianthemum trifolium* (Three-leaved Solomon's Seal), *Menyanthes trifoliata* (buckbean), *Sarracenia purpurea* (Pitcher Plant), *Scheuchzeria palustris* (Pod Grass).

Graminoid Layer: *Carex* spp. (Sedges)

Moss Layer: *Sphagnum capillifolium*, *Sphagnum fuscum*, *Sphagnum magellanicum*, *Pleurozium schreberi*, *Sphagnum angustifolium*.

Rich Fens:

Tree Layer (2-10 m): *Larix laricina* (Tamarack), *Picea mariana* (Black Spruce)

Shrub Layer (<2 m): *Andromeda polifolia* (Bog Rosemary), *Chamaedaphne calyculata* (Leatherleaf), *Juniperus communis* (Common Juniper), *Juniperus horizontalis* (Creeping Juniper), *Lonicera villosa* (Fly Honeysuckle), *Myrica gale* (Sweet Gale), *Potentilla fruticosa* (Shrubby Cinquefoil), *Rhamnus alnifolia* (Alder-leafed Buckthorn), *Ledum groenlandicum* (Labrador Tea), *Salix* spp. (Willows).

Forb Layer: *Drosera spp.* (Sundews), *Equisitem fluviatile* (Water Horsetail), Galium spp. (Bedstraws), *Maianthemum trifolium* (Three-leaved Solomon's Seal), *Menyanthes trifoliata* (buckbean), Parnassia palustris (Grass of Parnassus), Potentilla palustris (Marsh Five-Finger), *Sarracena purpurea* (Pitcher Plant), *Scheuchzeria palustris* (Pod Grass), Tofeldia glutinosa (Sticky False Asphodel).

Graminoid Layer: *Calamagrostis canadensis* (Bluejoint), Carex spp. (Sedges)

Moss Layer: *Sphagnum capillifolium*, *Sphagnum magellanicum*, *Pleurozium schreberi*, *Sphagnum angustifolium*. Brown mosses: Tomenthypnum nitens (fuzzy brown moss), Campyllium stellatum (Starry Campylium), *Scorpidium scorpioides* (scorpion tail moss), *Drepanocladus* spp.

Marsh Vegetation:

- **Free Floating or Floating-leaved** (macrophytes with leaves floating on the water surface) {Pond-Lilies: *Nuphar variegatum* (Yellow Pond Lily), *Nymphaea tetragona* (White Water-Lily); Duckweeds: *Lemna minor* (Common Duckweed), *Lemna trisulca* (Ivy-leaved Duckweed), *Spirodela polyrhiza* (Larger Duckweed); Pondweeds: *Potamogeton natans* (Floating Leafed Pondweed), *Potamogeton gramineus* (Various Leaved-Pondweed); Smartweeds: *Polygonum amphibium* (Water Smartweed); Bur-Reeds: *Sparganium angustifolium* (Narrow-Leafed Bur-Reed); Water Shields: *Brasenia schreberi* (Water Shield)}

-**Submerged** (macrophytes with leaves completely submerged under the water) {Pondweeds: *Potamogeton richardsonii* (Richardson Pondweed), *Potamogeton zosteriformis* (Flat-Stemmed Pondweed), *Potamogeton praelongus* (Whitestem Pondweed), *Potamogeton pectinatus* (Sago Pondweed), *Potamogeton friesii* (Fries' Pondweed), *Potamogeton vaginatus* (Large-Sheath Pondweed), *Potamogeton filiformis* (Thread-Leaved Pondweed), *Potamogeton pusillus* (Small-leaf Pondweed); Water Milfoils: *Myriophyllum spicatum var. exalbescens* (Spiked Water Milfoil); Hornworts: *Ceratophyllum demersum* (Hornwort or Coontail); Buttercups: *Ranunculus aquatilus var. capillaceus* (Large-Leafed White Water-Crowfoot), *Ranunculus circinatus* (Firm White Water-Crowfoot); Mare's Tails: *Hippurus vulgaris*; Water Plantains: *Alisma gramineum* (Narrow-Leaved Water Plantain); Bladderworts: *Utricularia vulgaris* (Common Bladderwort); Waterweeds: Elodea Canadensis (Canadian Waterweed) }

- **Emergent** (macrophytes with leaves and stems above the water surface) {Bur-Reed: *Sparganium eurycarpum* (Giant Bur-Reed); Cattails: *Typha latifolia* (Common Cattail); Sweet Flags: *Acorus calamus* (Sweet-Flag); Bulrushes: *Scirpus acutus* (Hard-Stemmed Bulrush), *Scirpus validus* (Soft-Stemmed Bulrush); Rushes: *Juncus* spp.; Arrowheads: *Sagittaria cuneata* (Arum-Leaved Arrowhead); Arums: *Calla palustris* (Water Arum); Water Plantains: *Alisma plantago-aquatica* (Broad-Leaved Water-Plantain), Buckbean: *Menyanthes trifoliata* (Buckbean), Cinquefoils: *Potentilla palustris*, Scheuchzeria: *Scheuchzeria palustris* (Scheuchzeria)}.

Swamp Vegetation:

Hardwood Swamps

- Trees (> 10m) *Populus balsamifera* (Balsam Poplar), *Betula papyrifera* (Paper Birch);
- Shrubs (0-10m) *Salix* spp., *Alnus* spp., *Cornus stolonifera* (Red Osier Dogwood), *Rhamnus alnifolia* (Alder-leafed Buckthorn)
- Forbs – *Corylus cornuta* (Beaked Hazel), *Equisitem fluviatile* (Water Horsetail), *Galium* spp. (Bedstraws) *Rubus* spp., *Ribes* spp., *Salix* spp. *Cornus stolonifera* (Red Osier Dogwood)

- Graminoids: *Calamagrostis canadensis* (Bluejoint), *Carex* spp. (Sedges), *Typha latifolia* (Common Cattail)

Mixedwood Swamps

- Trees *Populus balsamifera* (Balsam Poplar), *Betula papyrifera* (Paper Birch), *Picea mariana* (Black Spruce), *Larix laricina* (Tamarack), *Thuja occidentalis* (Eastern White Cedar), *Abies balsamea* (Balsam Fir)
- Shrubs: *Salix* spp., *Alnus* spp., *Cornus stolonifera* (Red Osier Dogwood), *Rhamnus alnifolia* (Alder-leafed Buckthorn)
- Forbs: *Equisitem fluviatile* (Water Horsetail), *Galium* spp. (Bedstraws)
-Graminoids *Calamagrostis canadensis* (Bluejoint), *Carex* spp. (Sedges), *Typha latifolia* (Common Cattail)

Tamarack Swamps

- Trees - *Larix laricina* (Tamarack).
- Shrubs *Andromeda polifolia* (Bog Rosemary), *Betula papyrifera* (Paper Birch) *Chamaedaphne calyculata* (Leatherleaf), *Lonicera villosa* (Fly Honeysuckle), *Myrica gale* (Sweet Gale), *Potentilla fruticosa* (Shrubby Cinquefoil), *Rhamnus alnifolia* (Alder-leafed Buckthorn), *Ledum groenlandicum* (Labrador Tea), *Salix* spp. (Willows).
- Forbs – *Caltha palustris* (Marsh Marigold)
-Graminoids – *Calamagrostis canadensis* (Bluejoint), *Carex* spp. (Sedges), *Typha latifolia* (Common Cattail)

Conifer Swamps

- Trees: *Picea mariana* (Black Spruce), *Thuja occidentalis* (Eastern White Cedar), *Abies balsamea* (Balsam Fir)
- Shrubs: *Chamaedaphne calyculata* (Leatherleaf), *Betula pumila* (dwarf birch), *Betula glandulosa* (Bog Birch), *Gaultheria hispidul*a (Creeping Snowberry), *Kalmia polifolia* (Bog Laurel), *Ledum groenlandicum* (Labrador Tea), *Lonicera villosa* (Fly Honeysuckle) *Oxycoccus microcarpu*s (Small Bog Cranberry), *Vaccinium myrtilloides* (Common Blueberry), *Salix* spp. (Willows)
- Forbs: *Caltha palustris* (Marsh Marigold), *Cornus canadensis* (Bunchberry), *Equisitem fluviatile* (Water Horsetail), *Galium* spp. (Bedstraws)
-Graminoids: *Calamagrostis canadensis* (Bluejoint), *Carex* spp. (Sedges), *Typha latifolia* (Common Cattail)

Shrub Swamps (Swamp Thickets)

- Trees: (None)
- Shrubs (>2 m): *Alnus* spp. (Alders), *Salix* spp. (Willows), *Cornus stolonifera* (Red Osier Dogwood), *Rubus idaeus* (Red raspberry).
- Herbs: *Caltha palustris* (Marsh Marigold), *Equisitem fluviatile* (Water Horsetail), *Galium* spp. (Bedstraws), *Potentilla palustris* (Marsh Five-Finger),
-Graminoids: *Calamagrostis canadensis* (Bluejoint), *Carex* spp. (Sedges), *Typha latifolia* (Common Cattail)

Shallow/Open Water Species:

Free Floating or Floating-leaved (macrophytes with leaves floating on the water surface) {Pond-Lilies: *Nuphar variegatum* (Yellow Pond Lily), *Nymphaea tetragona* (White Water-Lily); Duckweeds: *Lemna minor* (Common Duckweed), *Lemna trisulca* (Ivy-leaved Duckweed), *Spirodela polyrhiza* (Larger Duckweed); Pondweeds: *Potamogeton natans* (Floating Leafed Pondweed), *Potamogeton gramineus* (Various Leaved-Pondweed); Smartweeds: *Polygonum amphibium* (Water Smartweed); Bur-Reeds: *Sparganium angustifolium* (Narrow-Leafed Bur-Reed); Water Shields: *Brasenia schreberi* (Water Shield)}

-**Submerged** (macrophytes with leaves completely submerged under the water) {Pondweeds: *Potamogeton richardsonii* (Richardson Pondweed), *Potamogeton zosteriformis* (Flat-Stemmed Pondweed), *Potamogeton praelongus* (Whitestem Pondweed), *Potamogeton pectinatus* (Sago Pondweed), *Potamogeton friesii* (Fries' Pondweed), *Potamogeton vaginatus* (Large-Sheath Pondweed), *Potamogeton filiformis* (Thread-Leaved Pondweed), *Potamogeton pusillus* (Small-leaf Pondweed); Water Milfoils: *Myriophyllum spicatum var. exalbescens* (Spiked Water Milfoil); Hornworts: *Ceratophyllum demersum* (Hornwort or Coontail); Buttercups: *Ranunculus aquatilus var. capillaceus* (Large-Leafed White Water-Crowfoot), *Ranunculus circinatus* (Firm White Water-Crowfoot); Mare's Tails: *Hippurus vulgaris*; Water Plantains: *Alisma gramineum* (Narrow-Leaved Water Plantain); Bladderworts: *Utricularia vulgaris* (Common Bladderwort); Waterweeds: Elodea Canadensis (Canadian Waterweed) }

Appendix B. Permafrost influence on peatland wetlands

Most of Canada's north is underlain by permafrost while discontinuous, sporadic pockets or smaller lenses typically exist farther south into the lower boreal forest. In the lower boreal (including the Boreal Plains), permafrost occurs mostly in peatlands and underlies small areas that cover less than 10% of the total land area to larger regions where permafrost exists in up to 50% of the total land area. Overall, more than 50% of the ground surface of Canada is underlain by permafrost (Figure 16). The southern limit of discontinuous permafrost is at the 0 ° C to -1.1° C isotherm (Brown, 1967).

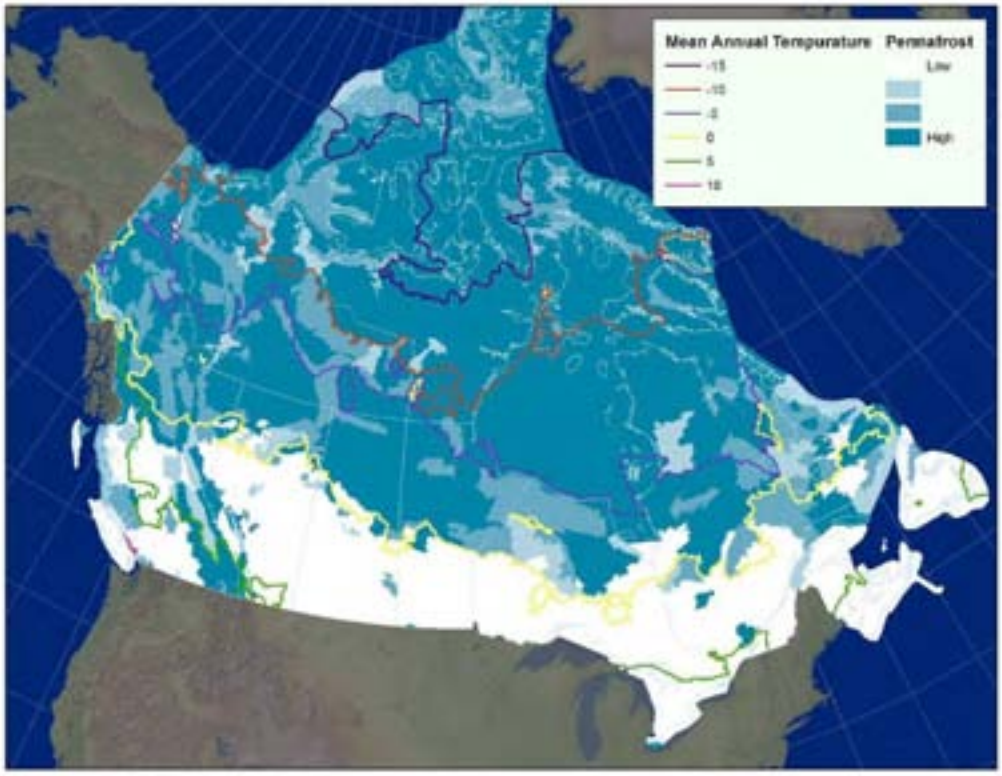


Figure 16. Permafrost zones of Canada.

South of the 60th parallel, discontinuous permafrost is confined to peatlands, predominantly ombrogenous systems (Vitt et. al. 1994). Permafrost stores groundwater as ice and it therefore influences ground and surface waters: therefore the disturbance of surface vegetation cover can initiate permafrost melting and change local hydrology. Natural disturbances are often fires while anthropogenic disturbance includes infrastructure development for oil and gas (well pads, pipelines and seismic lines, roads). Most of the discontinuous permafrost in the Boreal Plains is actively melting (Beilman and Robinson 2003).

Permafrost and permafrost remnants in peatlands often create visibly observable surface expressions that can complicate wetland classification (e.g., collapse scars in bogs that can have fen-like vegetation or species that prefer wetter, but yet nutrient-poor environments): however, understanding the surface expressions and their associated ecology should allow for easier decision making in the field. Permafrost surface expressions on the Boreal Plains appear in three distinct

forms: internal lawns, collapse scars, and peat plateaus.The spatial extent of most permafrost features in the Boreal Plains are typically on the scale of 300 meters or smaller (10 TM imagery pixels or smaller), but they influence the tone and texture of the peatland wetlands, and are readily recognized in the field (Figure 17).

Boreal Plains Peatland Permafrost Features – Ground Level

Peat Mounds

• Dense canopy of Picea mariana (Black Spruce)

• Uniform height compared to upland

• Raised surface with surrounding water track

•Silvic peat, feathermosses

Collapse Scars

• Leaning, often dead trees

• Understory sedges,shrubs

• Typically sunken 1 m below surface

•pH very similar to surrounding matrix, *Sphagnum* mosses

Internal Lawns

• Meadows of sedges and mosses forming "lawns"

• Typically sunken 1 m below peatland surface

• Trees, if present are partially buried or on the ground

Figure 17. Common permafrost features of peatland wetlands in the Boreal Plains. Photos courtesy Silvie Forest.

Intact Permafrost Features: Peat mounds/plateaus/pingos:

In peatlands underlain with permafrost, frost expansion can sometimes raise a portion of the permafrost area above the surrounding landscape, creating peat plateaus. Peat plateaus are approximately raised 1 m above the surrounding area and generally have a moat-like water track encircling the raised portion where the permafrost is actively melting. These sites are typically vegetated by black spruce (*Picea mariana*), feather mosses, lichens, and some ericaceous shrubs (pers. obs. S. Forest). *Betula papyrifera* may also be present in these areas due to the drier peat conditions (Zoltai 1971). Because these sites are raised above the water table, better growing conditions promote upland-type vegetation, tree height and density. Further north (e.g. Taiga Plains), peat plateaus can be more open and densely covered by *Cladina* species (reindeer lichen) (Vitt et al. 1994).

Most permafrost sites in the Boreal Plains are actively melting which causes collapse at the margins which creates a moat-like outer water track and also leaning trees. Peat plateaus are easily recognized by these features in combination with the tall black spruce and high tree density. Peat plateaus can be found as large ombrotrophic bog islands in fens (Figure 10), in peatlands associated with riverine systems, and at the margins of or in better drained portions of fens (Zoltai 1971). The occurrence of peat plateaus is highest in northern central portion of Alberta and north eastern Manitoba, and occasional to rare throughout the rest of the Boreal Plains (Vitt et al. 1994).

Melting Permafrost Features: Collapse Scars and Internal Lawns:

Permafrost underlain peatlands can be subject to melting, as indicated by the formation of two landforms are common to the boreal forest of western Canada: collapse scars and internal lawns (Zoltai 1971; Vitt et al. 1994). Collapse scars are typically 1 m lower than the surrounding permafrost matrix. These scars are generally wet and dominated by *Sphagnum riparium* and *S. angustifolium* (Zoltai 1993; pers. obs. S. Forest). The pH of collapse scars is the same or very similar to the pH of the surrounding peatland (S. Forest, unpublished data). Collapse scars are not vegetated by trees, but leaning trees at the margins are common. The leaning trees are caused by the collapse of the margins as the permafrost is melting. Collapse scars are found within a permafrost matrix whereas internal lawns are permafrost remnants in peatlands that are no longer underlain by permafrost.

Internal lawns are often dominated by wet species of *Sphagnum* and *Carex* (sedge) (Vitt et al., 1994) but later successional stages may be dominated by ombrotrophic species of *Sphagnum* and *Eriophorum* (pers. obs. S. Forest). These internal lawns can be as dry as the surrounding matrix. Often internal lawns are surrounded by partially buried, leaning trees, dead or alive. Older internal lawns still show similar patterns but leaning trees maybe less obvious.

Permafrost features and observation scale considerations

Although permafrost features exist at smaller spatial scales (generally less than 10 TM imagery pixels), they contribute to the overall tone, texture, and signature of peatland wetlands. Further, these features are readily recognizable from an orthogonal viewpoint. Melting of permafrost

renders the once homogeneous peat plateau into a more heterogeneous mixture of dead trees, internal lawns, and collapse scars (Figures 17,18). These features often become more prevalent at smaller scales, and knowledge of the underlying permafrost processes and their expression on the landscape will aid in the identification of the peatland wetland type. This is important because many of the features of collapse scars/internal lawns more resemble fens (but have similar chemistry to bogs) just as many peat plateaus can have some upland indicators present due to the drier conditions. Thus, while some peatland areas might have smaller scale internal lawns that more closely resemble fens, the larger wetland complex is still a bog, and should be mapped as such.

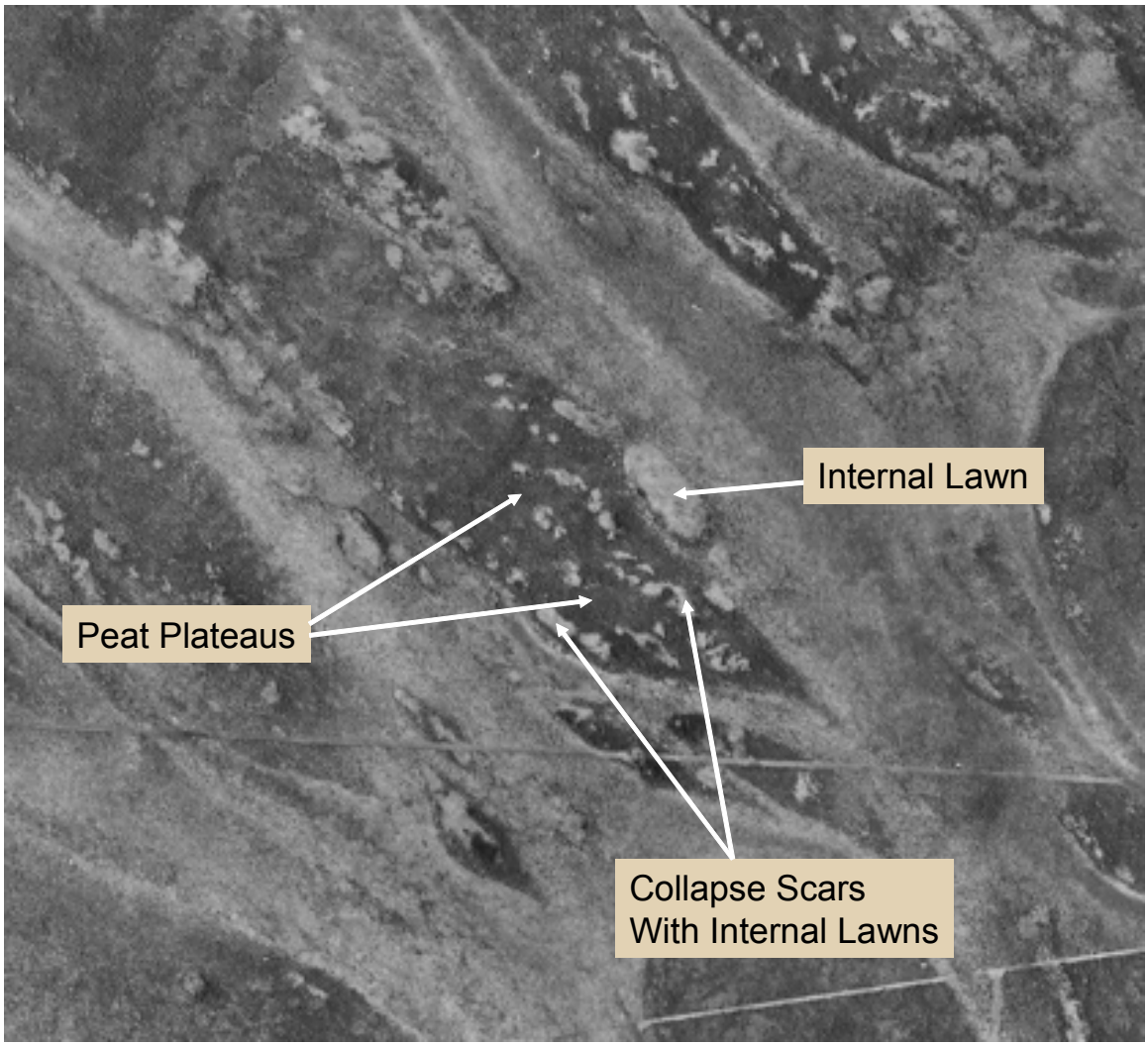
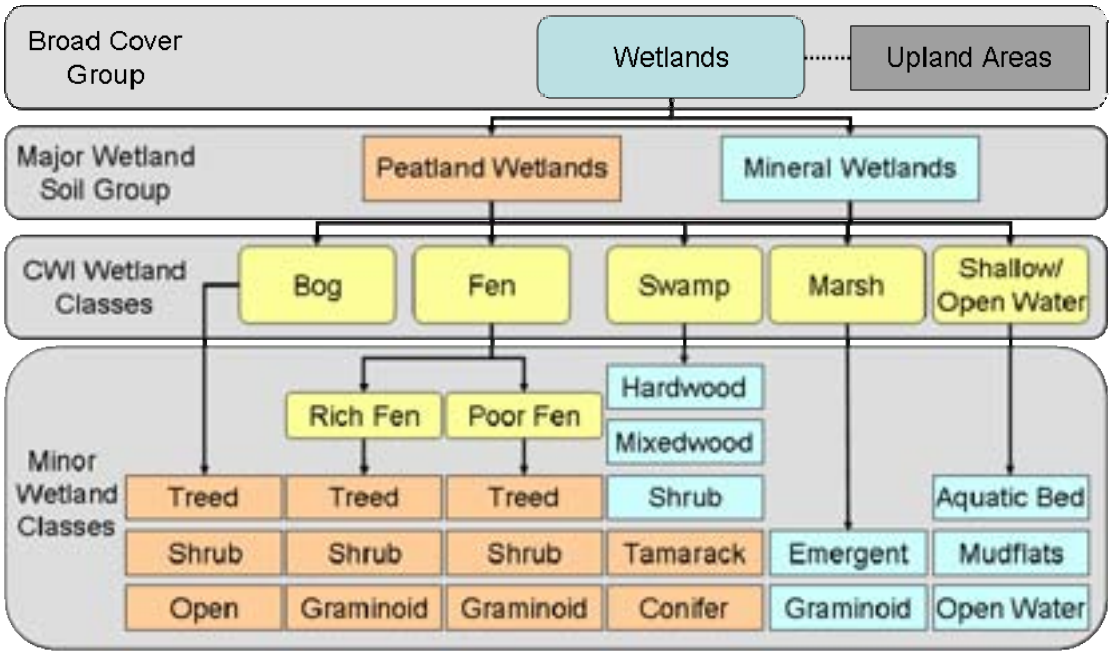


Figure 18. A portion of an aerial photograph (Original Scale = 1:40000) showing permafrost features in a peatland complex in Alberta. The smooth darker areas of the raised bog surface are the peat plateaus, while the lighter, more open areas are the collapse scars (surrounded by permafrost) with internal lawns (no permafrost).

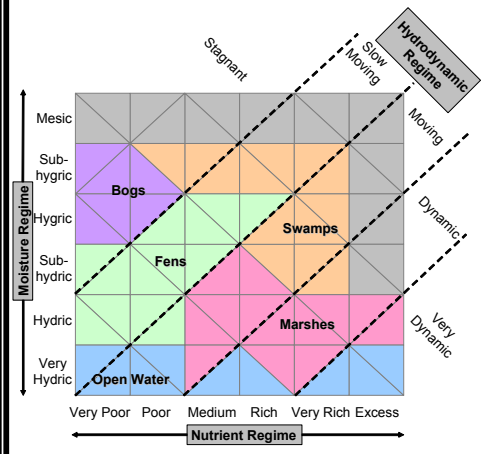
Appendix C. – Western Boreal Plains Wetland Types



Shallow/Open WaterClasses

SHALLOW/OPEN WATER

Shallow/Open Water



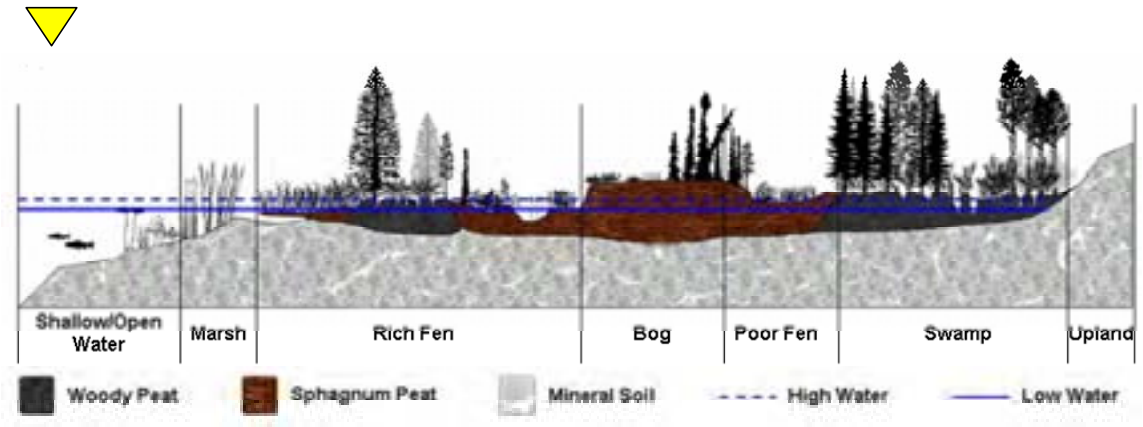
<u>Shallow/Open Water Indicators</u> :

Aquatic Vegetation < 25%

Above Surface Vegetation <25%

Clear, Stained, or Turbid Water > 25%

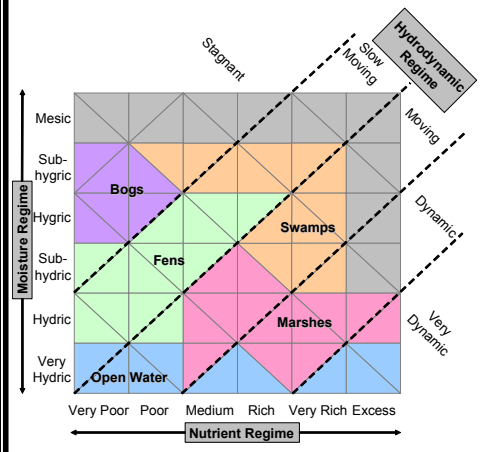
- The open water class includes lakes, ponds, rivers, and other water bodies.
- This class is commonly associated with all wetland types, but most commonly with marsh, fen, and swamp wetland classes. Water ranges from clear to stained to turbid.



Shallow/Open WaterClasses

AQUATIC BED

Aquatic Bed



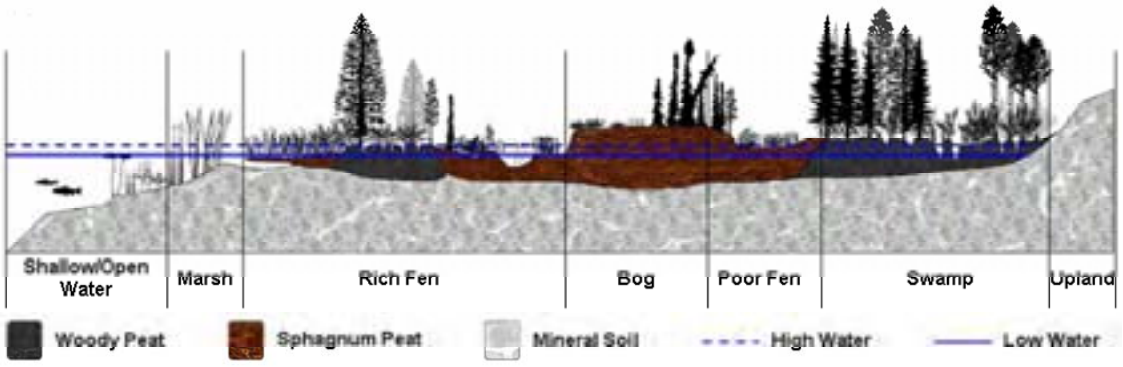
Aquatic Bed Indicators :

Aquatic Vegetation > 25%

Above Surface Vegetation <25%

Clear, Stained, or Turbid Water > 25%

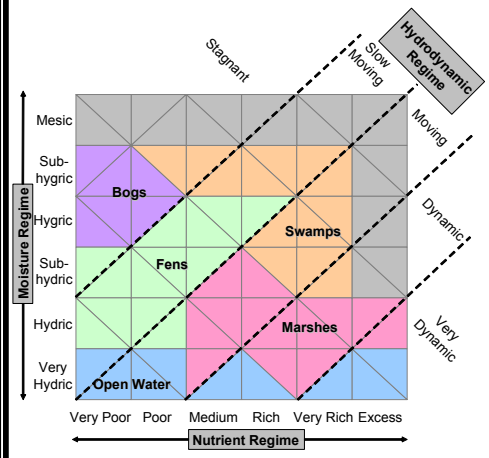
- The aquatic bed class consists of floating and submerged aquatic vegetation.
- This class is transitional between the open water and emergent marsh wetland classes.
- Common vegetation includes *Nuphar* spp., and *Potomogeton* spp.



Shallow/Open WaterClasses

MUDFLATS

Mudflats



<u>Mudflat Indicators</u> :

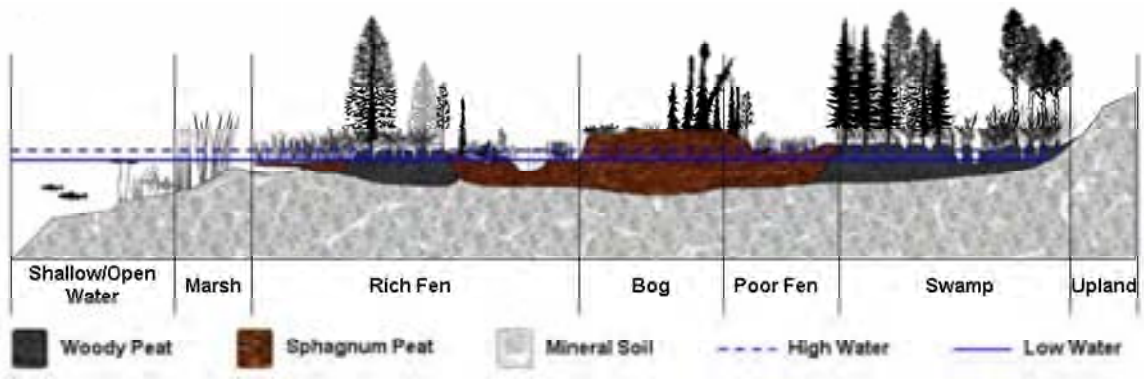
Aquatic Vegetation < 25%

Above Surface Vegetation <25%

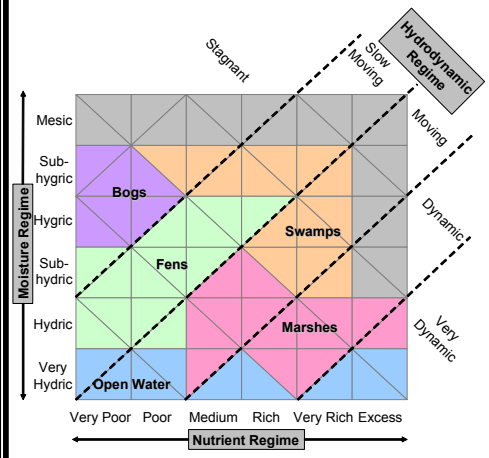
Clear, Stained, or Turbid Water,

Exposed Mud, Marl, Silt, or Sand Substrate

- This class is transitional between the open water and the shoreline and/or emergent marsh wetland classes.
- This class is temporal in nature, and is often associated with shallow water areas influenced by fluctuating vertical hydroperiods.

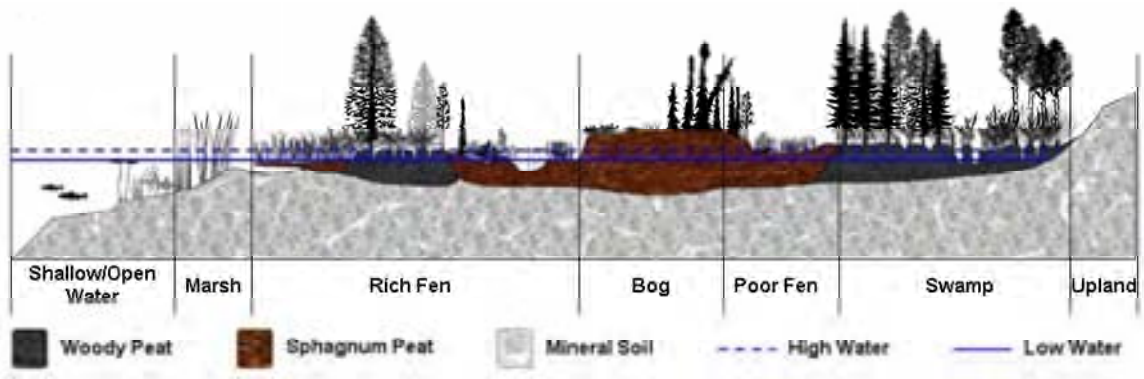


Marsh Classes	EMERGENT MARSH	Emergent Marsh

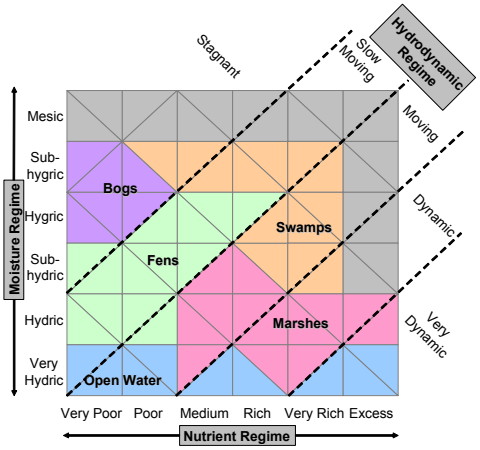


<u>Emergent Marsh Indicators</u>:
Aquatic Vegetation < 25%
Above Surface Vegetation >25%
Clear, Stained, or Turbid Water

- This class is transitional between the open water and meadow marsh wetland classes. Saturated to permanently flooded hydrologic conditions, but often experiences periodic drawdowns.
- Occurs in mineral soil or deposited organic soil environments.
- Common vegetation species include *Typha* spp., *Scirpus* spp., *Juncus* spp., *Eleocharis* spp.

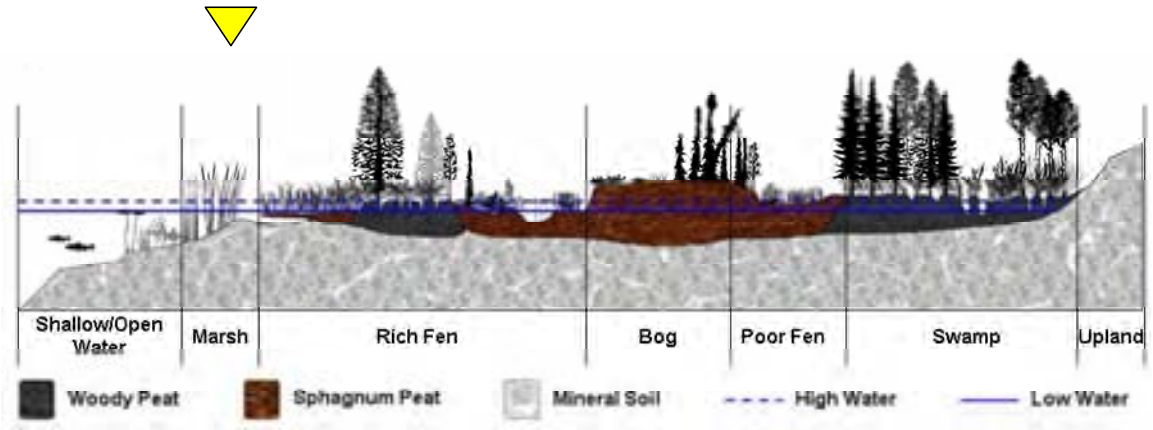


Marsh Classes	MEADOW MARSH	Meadow Marsh

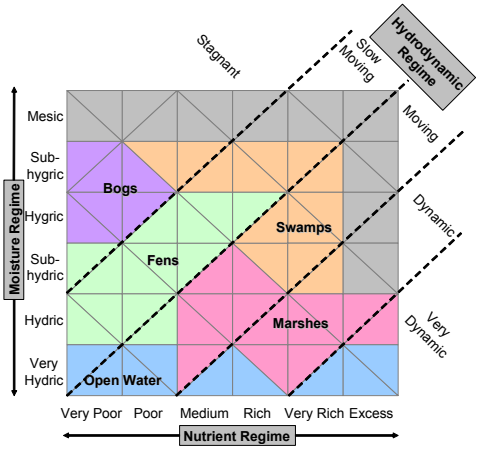


<u>Meadow Marsh Indicators</u>:
Above Surface Vegetation >25%
Broadleaf Sedge, Bluejoint
Clear, Stained, or Turbid Water < 25%

- Occurs in mineral soil or deposited organic soil environments.
- Saturated to mesic-dry hydrologic regime, but seasonally flooded (floodplain areas). Commonly located along shoreline areas.
- Vegetation primarily broadleaf sedges (*Carex atherodes, Carex aquatalis, Carex utriculata*) and bluejoint grass (*Calamagrostis canadensis*)



Rich Fen Classes	GRAMINOID RICH FEN	Graminoid Rich Fen



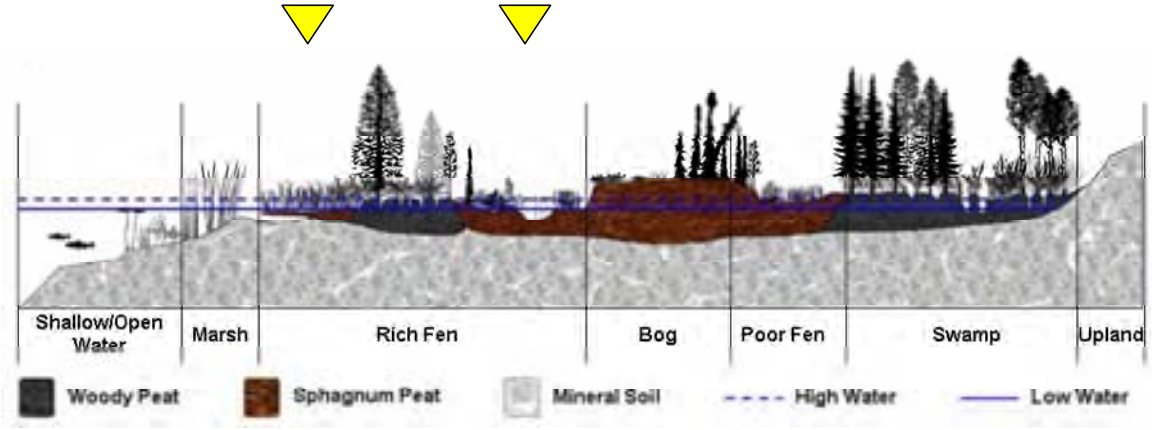
<u>Graminoid Rich Fen Indicators</u>:

Rich Fen Indicators (Buckbean,Wire Sedge (e.g. *Carex lasiocarpa*)

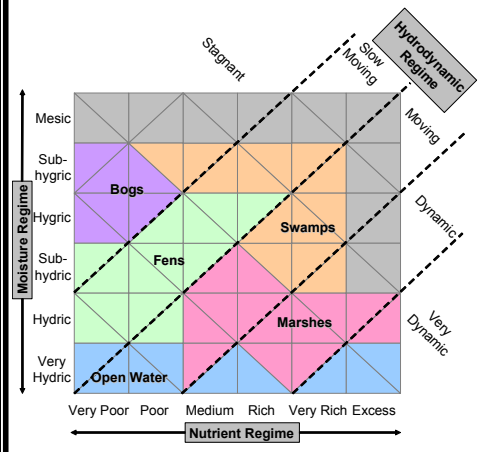
Sphagnum <20%

Tree/Shrub Cover < 25%

- High nutrient (groundwater influenced) peatland soil environments.
- Hydrologic regime is saturated to flooded.
- Vegetative species rich areas.

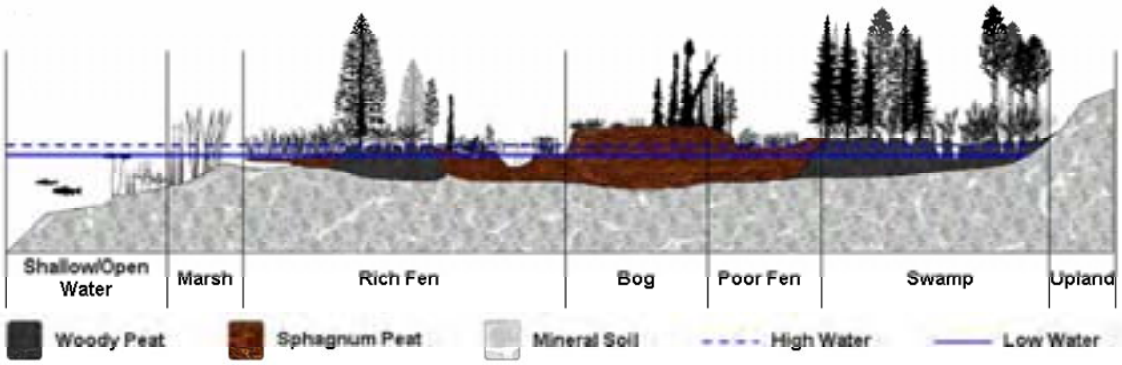


Poor Fen Classes	GRAMINOID POOR FEN	Graminoid Poor Fen

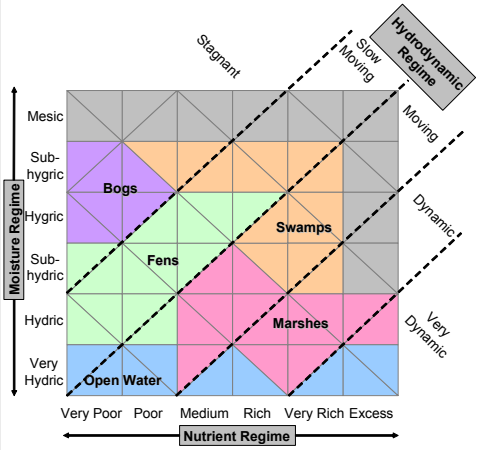


<u>Graminoid Poor Fen Indicators</u>:
Shrubs < 2m (Bog birch, Ericaceous, willow) <25%
Some Fen Indicators (Wire Sedge (e.g. *Carex lasiocarpa*))
Sphagnum > 20%
Tree Cover < 25%

- Peatland soil areas with components of both bogs (sphagnum moss, ericaceous shrubs) and fens (bog birch, willow).
- Hydrologic regime is saturated to flooded
- Typically less vigorous vegetation compared to rich fens



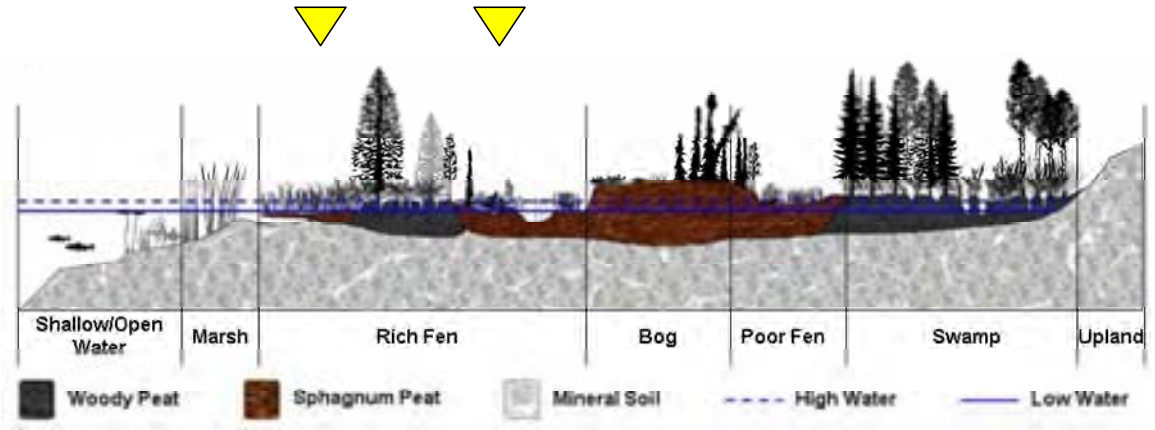
Rich Fen Classes	SHRUBBY RICH FEN	Shrubby Rich Fen



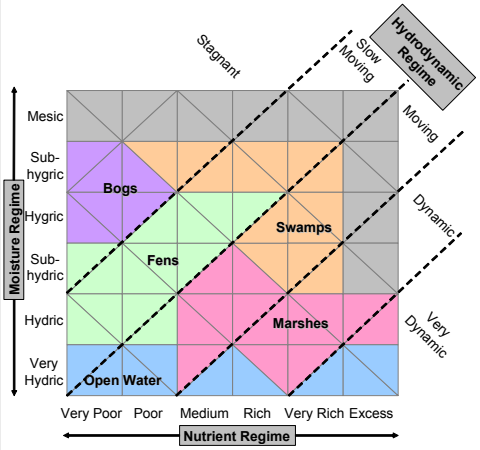
Shrubby Rich Fen Indicators:

Shrubs < 2m (Bog birch, Sweet Gale, willow) >25% Cover
Fen Indicators (Buckbean, Wire Sedge)
Sphagnum <20%
Tree Cover < 25%

- High nutrient (groundwater influenced) peatland soil environments.
- Hydrologic regime is saturated to flooded.
- Vegetative species rich areas.

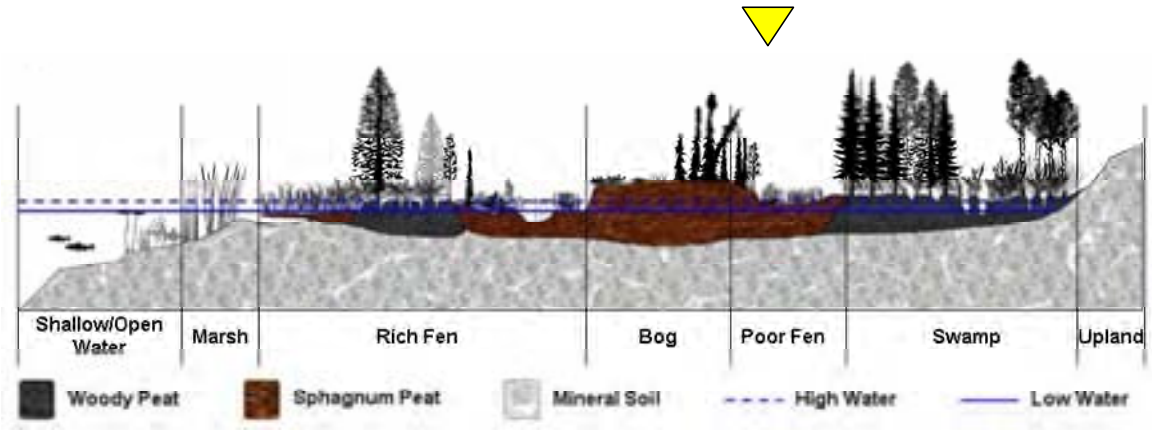


Poor Fen Classes	SHRUBBY POOR FEN	Shrubby Poor Fen

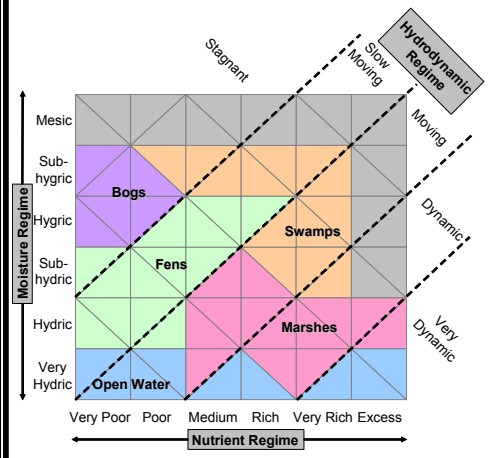


<u>Shrubby Poor Fen Indicators</u>:
Shrubs < 2m (Bog birch, Ericaceous, willow) >25%
Some Fen Indicators (Bog birch, Wire Sedge)
Sphagnum > 20%
Tree Cover < 25%

- Peatland soil areas with components of both bogs (sphagnum moss, ericaceous shrubs) and fens (bog birch, willow).
- Hydrologic regime is saturated to flooded

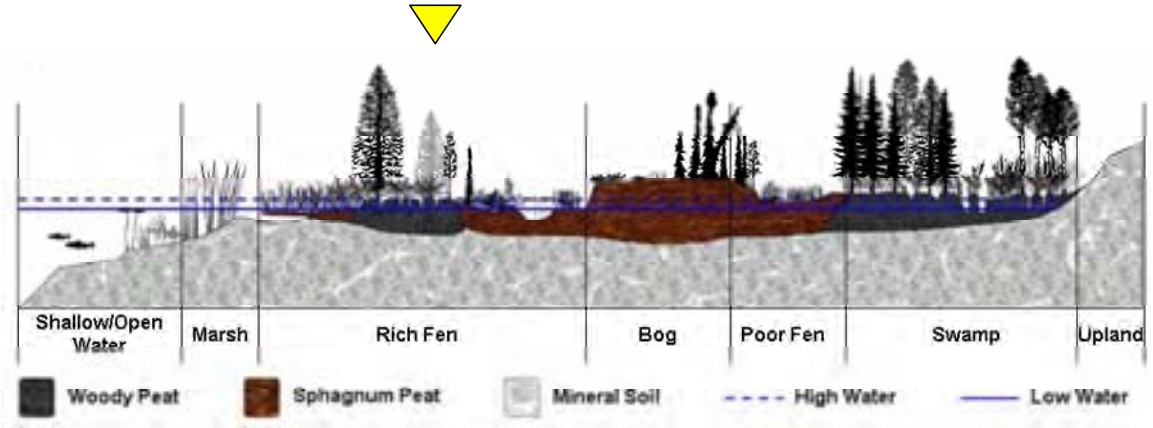


Rich Fen Classes	TREED RICH FEN	Treed Rich Fen

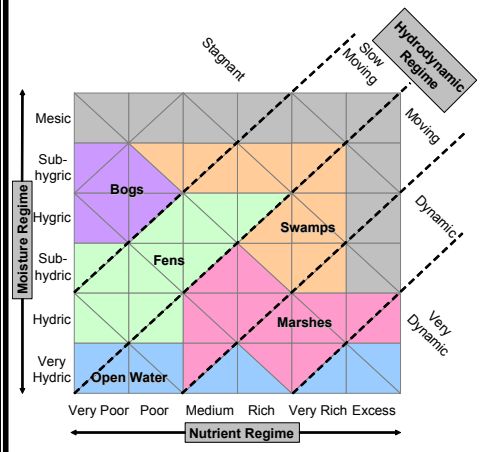


<u>Treed Rich Fen Indicators</u>:
Shrubs < 2m (Bog birch, Sweet Gale, willow)
Rich Fen Indicators (Buckbean, Wire Sedge)
Sphagnum <20%
60%< Tree Cover > 25%

- High nutrient (groundwater influenced) peatland soil environments.
- Hydrologic regime is saturated to flooded.
- Vegetative species rich areas.

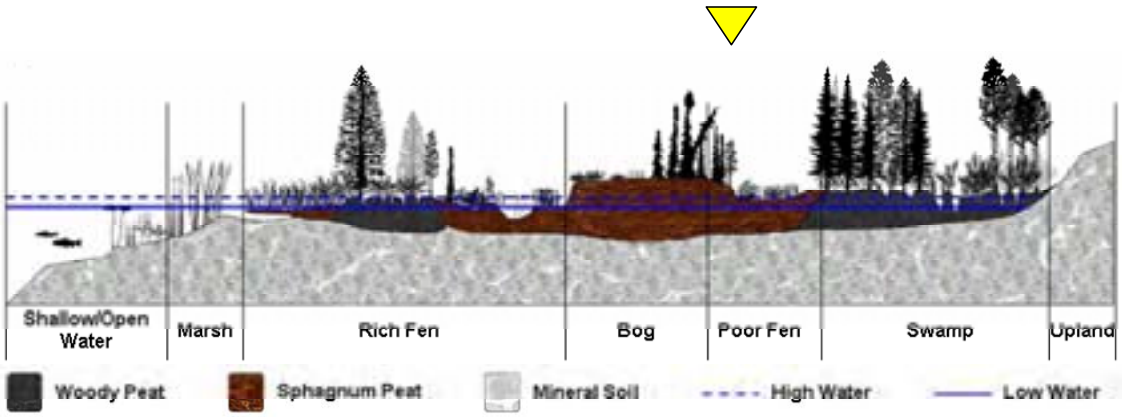


Poor Fen Classes	TREED POOR FEN	Treed Poor Fen

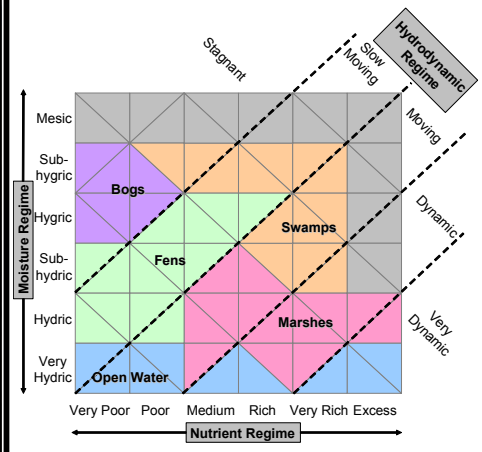


<u>Treed Poor Fen Indicators</u>:
Shrubs < 2m (Bog birch, Ericaceous, willow)
Tamarack, Lowland Black Spruce, Wire Sedge
Sphagnum > 20%
60% < Tree Cover > 25%

- Peatland soil areas with components of both bogs (sphagnum moss, ericaceous shrubs) and fens (bog birch, willow).
- Hydrologic regime is saturated to flooded

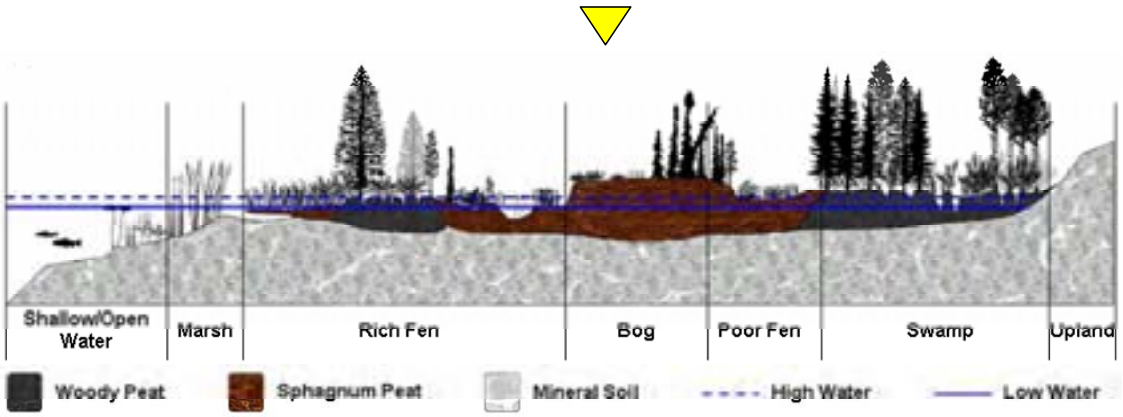


Bog Classes	OPEN BOG	Open Bog

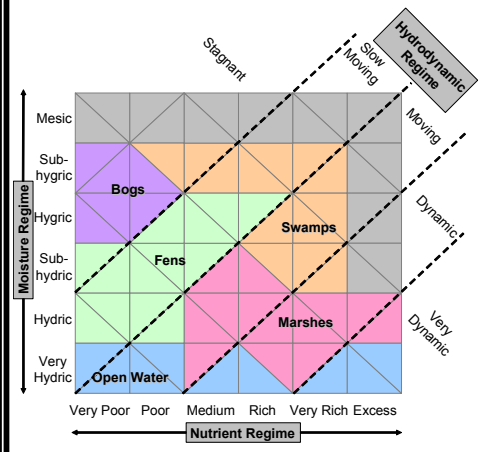


<u>Open Bog Indicators</u>:
Trees and Shrubs < 25%
Sphagnum Moss >20 %
Ericaceous Shrubs, Cottongrass, Wire Sedge

- Peatland areas with water table at or near surface with no standing water.
- Bog areas with higher percentages of moss, with some sedges, and few shrubs or trees.

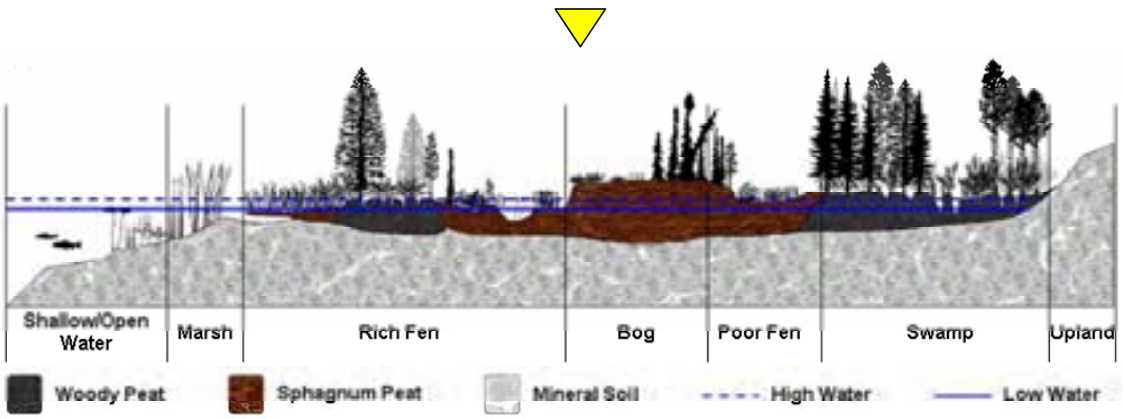


Bog Classes	SHRUBBY BOG	Shrubby Bog

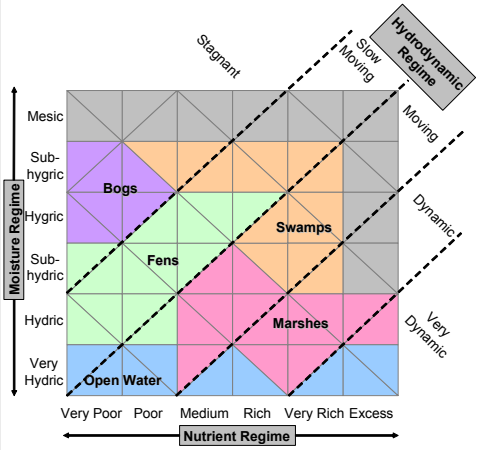


<u>Shrubby Bog Indicators</u>:
Lowland Black Spruce (<10m) < 25%
Sphagnum Moss > 20 %
Ericaceous Shrubs > 25 %,
Cottongrass, Wire Sedge

- Peatland areas with water table at or near surface with no standing water.
- Ericaceous shrub dominated bog areas.

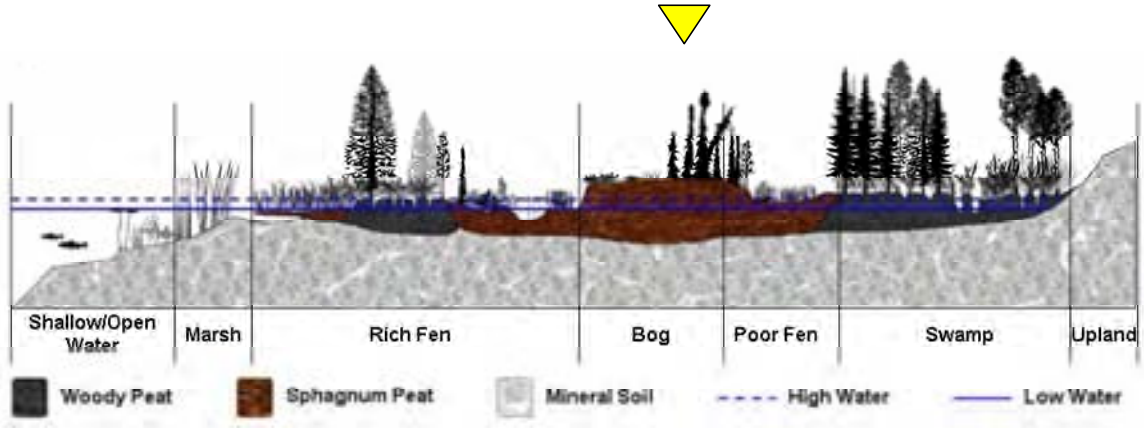


Bog Classes	TREED BOG	Treed Bog

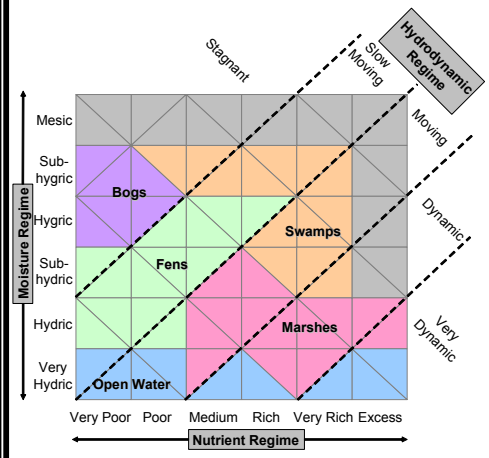


<u>Treed Bog Indicators</u>:
60% < Lowland Black Spruce > 25%
Sphagnum Moss >20 %
Ericaceous Shrub Dominance
Cottongrass, Wire Sedge

- Peatland areas with water table at or near surface with no standing water.
- Trees primarily black spruce (*Picea mariana*) in lowland form with heights less than 10 meters.

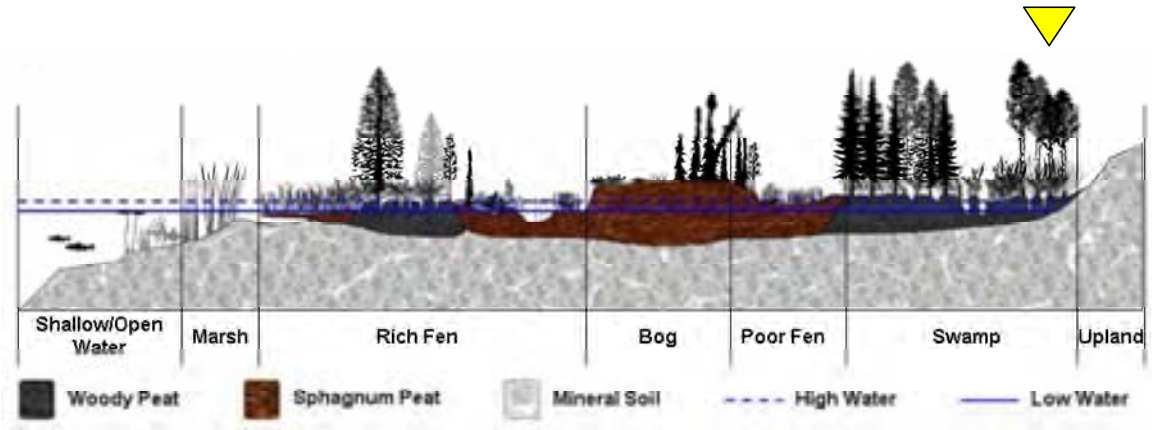


Swamp Classes	HARDWOOD SWAMP	Birch Swamp

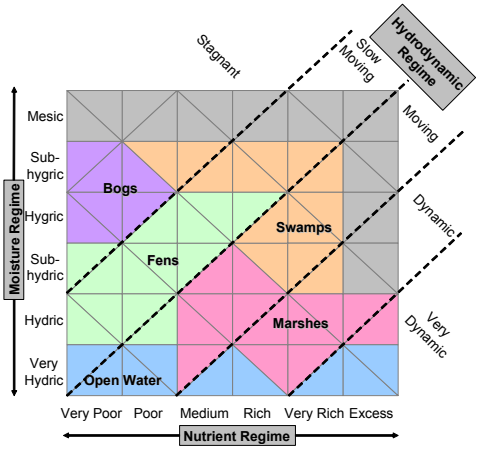


<u>Hardwood Swamp Indicators</u>:
Paper Birch or Balsam Poplar Dominance (>75% of tree species)
Sphagnum Moss
Pools of Water Sometimes Present
Tall Willow/Alder Understory

- Typically found in mineral soil drainage areas (Paper Birch) or riparian floodplain mineral soil areas (Balsam Poplar).
- Hydrologic regime is saturated to seasonally flooded.



Swamp Classes	MIXEDWOOD SWAMP	Mixedwood Swamp



<u>Mixedwood Swamp Indicators</u>:

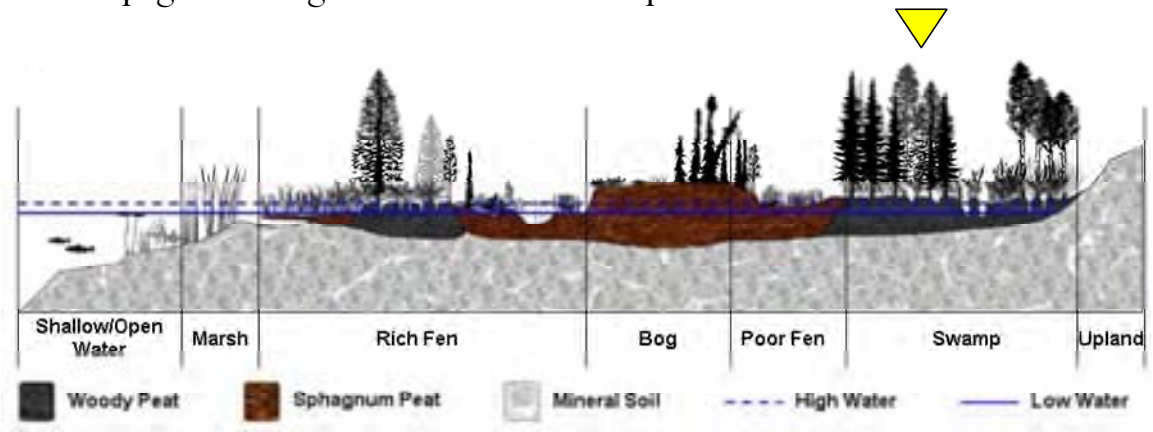
Mix of Tamarack, Paper Birch and Black Spruce, no dominance

Tree Heights > 10 m

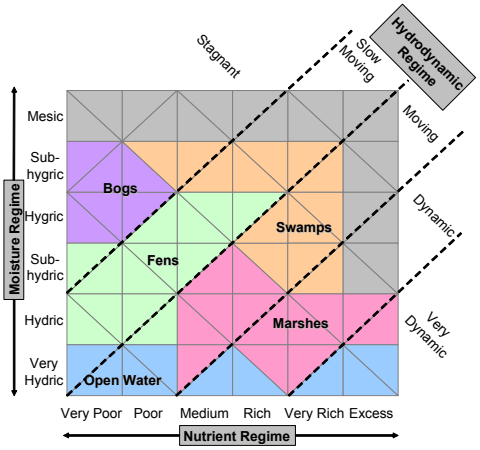
Pools of Water, Hummocky

Tall Willow, Birch Understory

- This class is transitional between the Tamarack swamp and the hardwood swamp.
- Hydrologic regime is saturated to flooded, and typically occurs in seepage/drainage areas of the landscape.

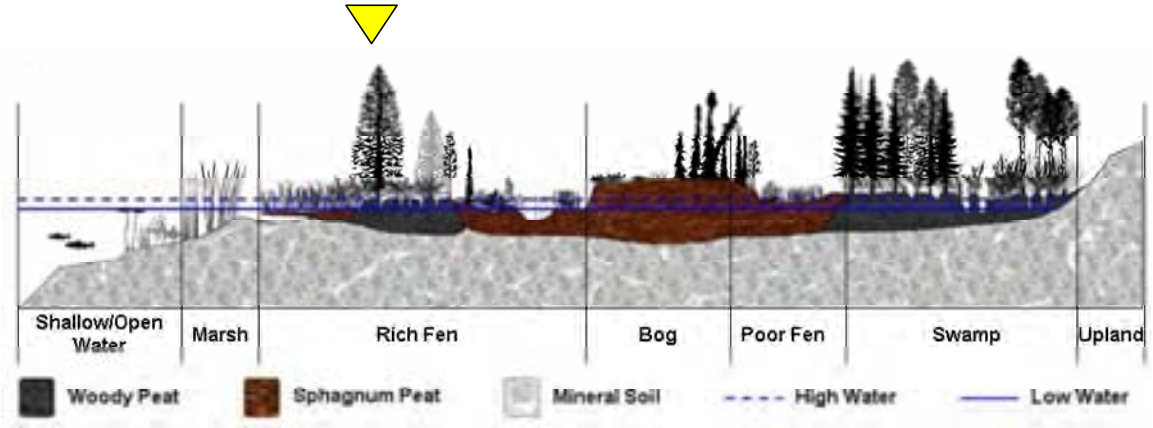


Swamp Classes	TAMARACK SWAMP	Tamarack Swamp

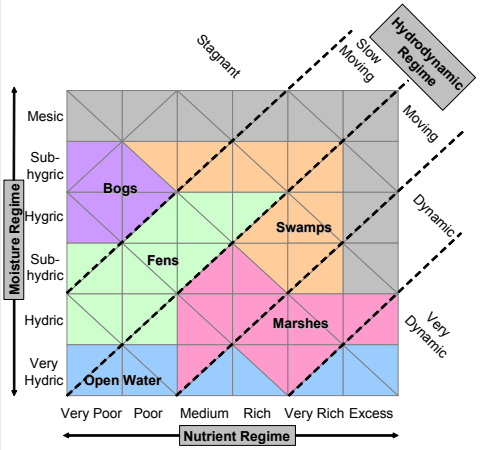


<u>Tamarack Swamp Indicators</u>:
Tamarack Dominance (>75% of tree species)
Tree heights > 10 m
Pools of Water
Tall Willow, Bog Birch Shrub Understory

- This class occurs in high nutrient drainage areas of peatlands
- Hydrologic regime is saturated to flooded, often with pools of water present.
- Transitional to Rich Treed Fen or other swamp classes.



Swamp Classes	CONIFER SWAMP	Conifer Swamp



Conifer Swamp Indicators:

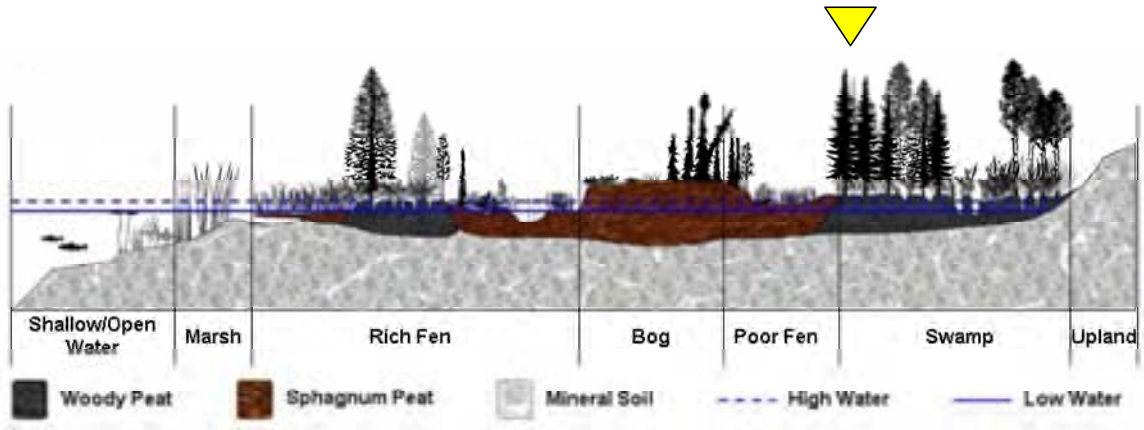
Transitional between bog/fen and upland

Sphagnum/ Brown Moss

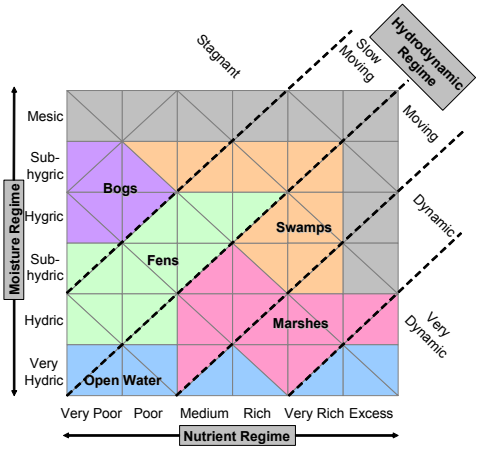
Pools of Water

Black Spruce Dominant, Tree Heights > 10 m

- Primarily densely spruce treed areas that can occur in mineral or peatland soil areas.
- This class is often located along the transition between peatland/upland environments.
- Hydrologic regime ranges from dry to saturated.



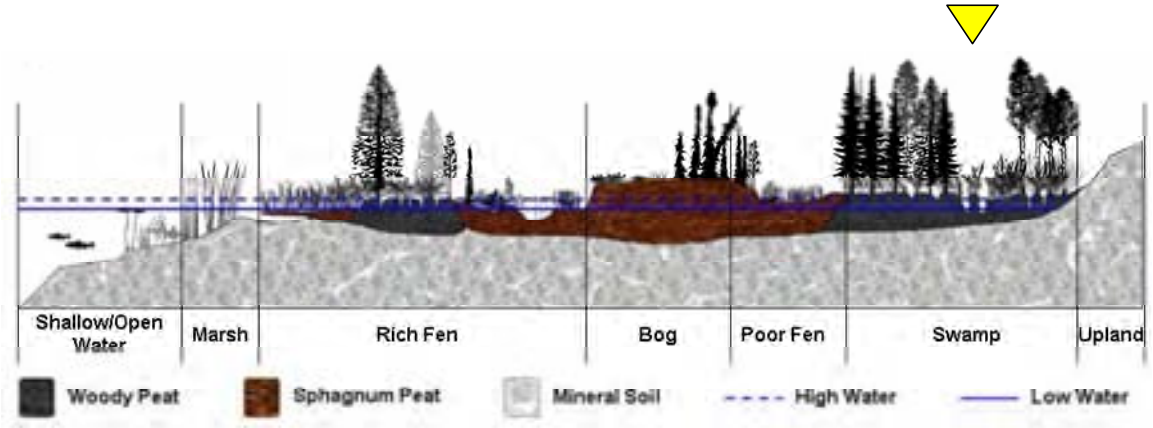
Swamp Classes	SHRUB SWAMP	Shrub Swamp



Shrub Swamp Indicators:

Speckled Alder/ Tall Willow
Shrubs > 25% Cover and >2m
Pools of Water
Broadleaf Sedge Understory

- Tall shrub drainages (>2m, *Salix* spp., *Alnus* spp.) in mineral soil environments.
- Often occurs in transition between upland areas and meadow marshes
- Beaver activity often influences the hydrology of these wetlands



Appendix D. - The von Post Scale of Decomposition

The von Post scale of decomposition is often used when describing peat soils. To determine the von Post scale of decomposition in the field, an organic sample is squeezed within the closed hand. The purpose is to remove most of the excess water and to observe the colour of the solution that is expressed between the fingers, the nature of the fibres, and the proportion of the original sample that remains in the hand. Three categories and ten classes are defined with this method.

Here the categories are given to highlight the difference in peat types, especially in relation to identifying soils in swamps and peatlands. Von Post decomposition scale is based on the information provided in the Canadian System of Soil Classification (Soil Classification Working Group 1998).

Fibric (Of)

1. **Undecomposed**: plant structure unaltered; yields only clear water coloured light yellow brown;
2. **Almost undecomposed**: plant structure distinct; yields only clear water coloured light yellow brown;
3. **Very weakly decomposed:** plant structure distinct; yields distinctly turbid brown water, no peat substance passes between the fingers, residue not mushy; and
4. **Weakly decomposed:** plant structure distinct; yields strongly turbid water, no peat substance escapes between the fingers, residue rather mushy.

Mesic (Om)

5. **Moderately Decomposed:** plant structure clear but becoming indistinct; yields much turbid brown water, some peat escapes between the fingers, residue very mushy;
6. **Strongly decomposed:** plant structure somewhat indistinct but clearer in the squeezed residue than in the undisturbed peat; about a third of the peat escapes between the fingers, residue strongly mushy.

Humic (Oh)

7. **Strongly decomposed:** plant structure indistinct but recognizable, about half the peat escapes between the fingers.
8. **Very strongly decomposed:** plant structure very indistinct; about two thirds of the peat escapes between the fingers, residue almost entirely resistant remnants such as root fibres and wood.
9. **Almost completely decomposed:** plant structure almost unrecognizable; nearly all the peat escapes between the fingers.
10. **Completely decomposed:** plant structure unrecognizable; all the peat escapes between the fingers.

Appendix E. Evaluation of existing classification systems for a satellite-remote sensing based classification of Canadian wetlands

DU - BPWCS	RAMSAR	Cowardin[7]	NWCS	AWI[6]	Stewart & Kantrud	Ecosite
Ecozone	**International**	**National**	**National**	**Provincial**	**Ecozone**	**Ecosite**
Treed Bog	**Inland Wetland**, Forested Peatlands (Xp)	**Palustrine**, *Forested Wetland*, Needleleaf Evergreen	Bog (w/subforms[1])	**Bog**,*Forested/Wooded*,---,---	Not Recognized	J1 –Treed Bog
Shrubby Bog	**Inland Wetland**, Non-Forested Peatlands (U)	**Palustrine**, *Shrub/Scrub*, Broad-leafed Evergreen or Needle-Leaved Evergreen	Bog (w/subforms[1])	**Bog**, *Open*, Shrub,---	Not Recognized	J2 - Shrubby Bog
Open Bog	**Inland Wetland**, Non-Forested Peatlands (U)	**Palustrine**, *Moss/Lichen or Shrub/Scrub*, Moss or Lichen or Broad-leafed Evergreen or Needle-Leaved Evergreen	Bog (w/subforms[1])	**Bog**,*Open*,Graminoid,---	Not Recognized	J2 – Shrubby Bog
Treed Rich Fen	**Inland Wetland**, Forested Peatlands (Xp)	**Palustrine**, *Forested or Shrub Scrub*, Needle-Leaved Deciduous, Needle-Leaved Evergreen or Broad-leaved Deciduous (Shrub only)	Fen (w/subforms[2])	**Fen**,*Forested/Wooded*,---	Not Recognized	L1 – Treed Rich Fen
Treed Poor Fen	**Inland Wetland**, Forested Peatlands (Xp)	**Palustrine**, *Forested or Shrub Scrub,* Needle-Leaved Deciduous, Needle-Leaved Evergreen or Broad-leaved Deciduous (Shrub only)	Fen (w/subforms[2])	**Fen**, *Forested/Wooded*,---	Not Recognized	K1 – Treed Poor Fen
Shrubby Rich Fen	**Inland Wetland**, Non-Forested Peatlands (U)	**Palustrine**, *Shrub Scrub*, Needle-Leaved Deciduous, Needle-Leaved Evergreen, or Broad-Leaved Deciduous	Fen (w/subforms[2])	**Fen**,*Open*,Shrub,---	Not Recognized	L2 - Shrubby Rich Fen
Shrubby Poor Fen	**Inland Wetland**, Non-Forested Peatlands (U)	**Palustrine**, *Shrub Scrub or Moss/Lichen*, Needle-Leaved Deciduous, Needle-Leaved Evergreen, or Broad-Leaved Deciduous or Moss	Fen (w/subforms[2])	**Fen**, *Open*, Shrub,---	Not Recognized	K2 – Shrubby Poor Fen

Graminoid Rich Fen	**Inland Wetland**, Non-Forested Peatlands (U)	**Palustrine**, *Emergent*, Persistent	Fen (w/subforms[2])	**Fen**, *Open*, Graminoid,---,---	Class VII	L2 - Shrubby Rich Fen
Graminoid Poor Fen	**Inland Wetland**, Non-Forested Peatlands (U)	**Palustrine**, *Emergent or Moss/Lichen*, Persistent or Moss	Fen (w/subforms[2])	**Fen**, *Open*, Graminoid,---,---	Class VII	K2 – Shrubby Poor Fen
Conifer Swamp	**Inland Wetland**, Forested Peatlands (Xp)	**Palustrine**, *Forested*, Needle-Leafed Evergeen	Swamp (w/subforms[3])	**Swamp**, *Forested/Wooded*,---,---	Not Recognized	Not Recognized
Tamarack Swamp	**Inland Wetland**, Forested Peatlands (Xp)	**Palustrine**, *Forested*, Needle-Leafed Deciduous	Swamp (w/subforms[3])	**Swamp**, *Forested/Wooded*,---,---	Not Recognized	Not Recognized
Mixedwood Swamp	**Inland Wetland**, Freshwater, Tree Dominated Wetlands (Xf)	**Palustrine**, *Forested*, Needle-Leaved Evergreen, Broad-Leaved Deciduous	Swamp (w/subforms[3])	**Swamp**, *Forested/Wooded*,---,---	Not Recognized	Not Recognized
Deciduous Swamp	**Inland Wetland**, Freshwater, Tree Dominated Wetlands (Xf)	**Palustrine**, *Forested*, Broad-Leaved Deciduous	Swamp (w/subforms[3])	**Swamp**, *Forested/Wooded*,---,---	Not Recognized	Not Recognized
Shrub Swamp	**Inland Wetland**, Shrub Dominated Wetlands (W)	**Palustrine**, *Shrub Scrub*, Broad-Leaved Deciduous	Swamp (w/subforms[3])	**Swamp**, *Open*, Shrub,---,---	Not Recognized	I1 – River Alder Gully (In Part)
Emergent Marsh	**Inland Wetland**, Various[8] L, M, N, O, P, Q, R, Sp, Ss, Tp, Ts	**Palustrine, Riverine, or Lacustrine**, *Emergent*, Persistent or Nonpersistent	Marsh (w/subforms[4])	**Marsh**, *Open*, Graminoid,---,---	Shallow Marsh Zone of Classes III, IV, V,	M1 – Marsh
Meadow Marsh	**Inland Wetland**, Various[8] L, M, N, O, P, Q, R, Sp, Ss, Tp, Ts	**Palustrine, Riverine, or Lacustrine**, *Emergent*, Persistent or Nonpersistent	Marsh (w/subforms[4])	**Marsh**, *Open*, Graminoid,---,---	Wet Meadow Zone of Classes II, III, IV	M1 – Marsh
Aquatic Bed	**Inland Wetland**, Various[8] L, M, N, O, P, Q, R, Sp, Ss, Tp, Ts	**Palustrine, Riverine, or Lacustrine**, *Aquatic Bed*, Rooted Vascular or Floating Vascular	Shallow Water (w/Subforms[5])	Shallow Open Water	Deep Marsh Zone of Classes IV, V	Not Recognized
	Inland Wetland,	**Palustrine, Riverine, or**				

Open Water	Various[8] L, M, N, O, P, Q, R, Sp, Ss, Tp, Ts	**Lacustrine**, *Rock Bottom or Unconsolidated Bottom or Streambed*, Bedrock or Rubble or Cobble-Gravel or Sand or Mud or Organic	Shallow Water (w/Subforms[5])	Shallow Open Water	Phases of Classes I, II, III, IV, V, VI, VII	Not Recognized
Mudflats	**Inland Wetland**, Various[8] L, M, N, O, P, Q, R, Sp, Ss, Tp, Ts	**Palustrine, Riverine, or Lacustrine**, *Unconsolidated Shore*, Mud or Organic	Shallow Water (w/Subforms[5])	Shallow Open Water	Phases of Classes I, II, III, IV, V, VI	Not Recognized
Algae/Eelgrass	**Inland Wetland, Marine/Coastal**, Various[8] A,B, L, M, N, O, P, Q, R, Sp, Ss, Tp, Ts	**Palustrine, Marine, Estuarine, Riverine, or Lacustrine**, *Aquatic Bed*, Algal or Rooted Vascular	Shallow Water (w/Subforms[5])	Shallow Open Water	Not Recognized	Not Recognized

[1] NWCS Bog Subforms (Palsa, Peat Mound, Mound, Domed, Polygonal Peat Plateau, Lowland Polygon, Peat Plateau, Plateau (Atlantic and Northern), Collapse Scar, Riparian, Floating, Shore, Basin, Flat, String, Blanket, Slope, and Veneer)

[2] NWCS Fen Subforms (String, Northern Ribbed, Atlantic Ribbed, Ladder, Net, Palsa, Snowpatch, Spring, Feather, Slope, Lowland Polygon, Riparian, Floating, Stream, Shore, Collapse Scar, Horizontal, Channel, Basin)

[3] NWCS Swamp Subforms {Tidal (Freshwater, Saltwater), Inland Salt, Flat (Basin, Swale, Unconfined), Riparian (Lacustrine, Riverine, Floodplain, Channel), Slope (Unconfined, Peat Margin, Lagg, Drainageway), Mineral Rise (Beach Ridge, Island, Levee, Mound), Raised Peatland)

[4]NWCS Marsh Subforms {Basin (Discharge, Isolated, Linked), Estuarine (Bay, Delta, Lagoon, Shore), Hummock, Lacustrine (Bay, Lagoon, Shore), Riparian (Delta, Meltwater Channel, Floodplain, Stream), Slope, Spring, Tidal (Basin, Bay, Channel, Lagoon)}

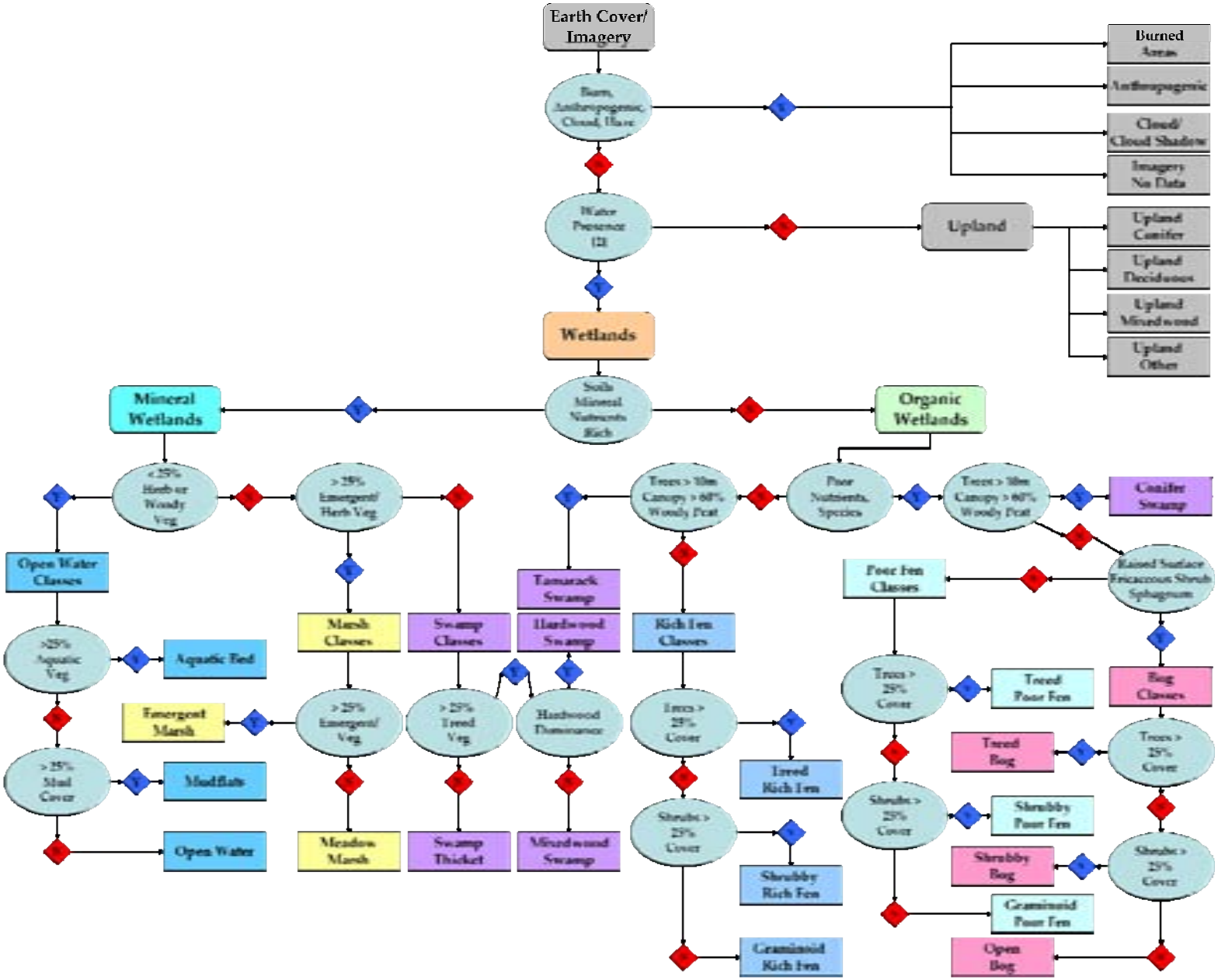
[5]NWCS Shallow Water Subforms {Basin (Discharge, Isolated, Linked, Polygon, Thermokarst, Tundra), Estuarine Water (Basin, Bay, Channel, Delta, Lagoon, Shore), Riparian Water (Delta, Floodplain, Meltwater, Stream), Tidal (Basin, Bay, Channel, Lagoon, Shore)}

[6]AWI Subclasses (local landform modifier) here pertain primarily to peatland classes only.

[7]Consideration for System (**Bold**), Class (*Italic*), and Subclass (Normal) only; Sub-system (applies only to emergent, aquatic bed, and open water BPWCS classes), Dominance Type, and Modifiers (Water Regime, Water Chemistry, Soil, Special) were not considered for this table for the sake of brevity and the detail of information required.

[8] RAMSAR Wetland Types: **L** (Permanent inland deltas, **M** – Permanent rivers/streams/creeks, **N**-Seasonal/intermittent/irregular rivers/streams/creeks, **O** -Permanent freshwater lakes (over 8 ha), **P**- Seasonal/intermittent freshwater lakes (over 8 ha), **Q** – Permanent saline/brackish/alkaline lakes, **R** – Seasonal/intermittent saline/brackish/alkaline lakes and flats, **Sp** – Permanent saline/brackish/alkaline marshes/pools, **Ss** - Seasonal/intermittent saline/brackish/alkaline marshes/pools, **Tp** – Permanent freshwater marshes/pools (Below 8 ha), **Ts** – Seasonal/intermittent freshwater marshes/pools on inorganic soils, **U** – Non-forested Peatlands, **Va** – Alpine wetlands, **Vt** - Tundra Wetlands, **W** – Shrub-dominated wetlands, **Xf** – Freshwater, tree-dominated wetlands, **Xp** = Forested peatlands, **Y** – Freshwater springs, **Zg** – Geothermal wetlands, **Zk** – Karst and other subterranean hydrologic systems

Appendix F. Boreal Plains Wetland Classification System Decision Hierarchy



Appendix G. Species distribution by wetland class (minor classes for swamps and marshes only)

Tree Species	Upland	Bogs	Poor Fens	Rich Fens	Conifer Swamps	Hardwood Swamps	Mixedwood Swamps	Tamarack Swamps	Shrub Swamps	Emergent Marshes	Meadow Marshes
Picea mariana	C,N	C,D	C,D	C,N	C,D	X	C,N	X	N/A	N/A	N/A
Larix laricina	X	X	C,D	C,D	C,N	X	C,N	C,D	N/A	N/A	N/A
Betula papyrifera	C,N	X	X	X	R,N	C,D	C,N	X	N/A	N/A	N/A
Populus tremuloides	C,D	X	X	X	X	E,N	E,N	X	N/A	N/A	N/A
Populus balsamifera	C,N	X	X	X	X	C[1],D	R[1],N	X	N/A	N/A	N/A
Pinus contorta	C,D	E,N	X	X	X	X	X	X	N/A	N/A	N/A
Pinus banksiana	C,D	E,N	X	X	X	X	X	X	N/A	N/A	N/A
Abies balsamaea	C,N	X	X	X	R,N	X	R,N	X	N/A	N/A	N/A
Ulmus Americana	L,N	X	X	X	X	L,N	X	X	N/A	N/A	N/A
Quercus macrocarpa	L,N	X	X	X	X	X	X	X	N/A	N/A	N/A
Acer negundo	L,N	X	X	X	X	L,N	X	X	N/A	N/A	N/A
Picea glauca	C,D	X	X	X	R[1],D	X	X	X	N/A	N/A	N/A
Thuja occidentalis	L,N	X	X	X	L,N	X	L,N	X	N/A	N/A	N/A

Codes (C=Common, R=Rare, E=Extremely Rare, L=Local, not distributed throughout Boreal Plain, X=Not Found, D=typically dominant species, N= typically non-dominant species, N/A = Not Applicable).

[1] Riverine swamps only

Shrub Species	Upland	Bogs	Poor Fens	Rich Fens	Conifer Swamps	Hardwood Swamps	Mixedwood Swamps	Tamarack Swamps	Shrub Swamps	Emergent Marshes	Meadow Marshes
Acer spicatum	L,N	X	X	X	X	L,N	L,N	X	X	N/A	N/A
Alnus crispa/rugosa	C,N	R,N	R,N	C[1], N	C,N	C,N	C,N	C,N	C,D	N/A	N/A
Amelanchier alnifolia	C,N	X	X	X	X	X	X	X	X	N/A	N/A
Andromeda polifolia	X	C,N	C,N	C,N	C,N	X	X	X	X	N/A	N/A
Arctostaphylos uva-ursi	C,N	X	X	X	X	X	X	X	X	N/A	N/A
Betula glandulosa	L,N	X	C,D	C,D	C,D	X	X	C,N	X	N/A	N/A
Betula pumila	L,N	X	C,D	C,D	C,D	X	X	C,N	X	N/A	N/A
Chamaedaphne calyculata	X	C,N	C,N	C,N	C,N	X	X	C,N	X	N/A	N/A
Cornus stolonifera	X	X	X	X	C,N	C,N	C,N	X	C,N	N/A	N/A
Corylus cornuta	C,N	X	X	X	R,N	C,N	C,N	X	X	N/A	N/A
Elaeagnus commutata	C,N	X	X	X	X	X	X	X	X	N/A	N/A
Empetrum nigrum	L,N	C,N	C,N	X	C,N	X	X	X	X	N/A	N/A
Gaultheria hispidula	X	C,N	C,N	X	C,N	X	X	X	X	N/A	N/A
Juniperus communis	C,N	X	X	R,N	R,N	X	X	X	X	N/A	N/A
Juniperus horizontalis	C,N	X	X	R,N	R,N	X	X	X	X	N/A	N/A
Kalmia polifolia	X	C,N	C,N	X	C,N	X	X	X	X	N/A	N/A
Lonicera villosa	X	X	X	C,N	C,N	C,N	C,N	C,N	X	N/A	N/A
Ledum groenlandicum	C,N	C,N	C,N	C,N	C,N	X	X	C,N	X	N/A	N/A
Myrica gale	X	X	X	C,N	X	X	X	X	X	N/A	N/A
Oxycoccus microcarpus	X	C,N	C,N	C,N	C,N	X	X	C,N	X	N/A	N/A
Potentilla fruticosa	C,N	X	X	C,N	X	X	X	C,N	X	N/A	N/A
Prunus virginiana	C,N	X	X	X	R,N	X	X	X	X	N/A	N/A
Rhamnus alnifolia	R,N	X	X	R,N	C,N	X	X	X	X	N/A	N/A
Ribes spp.	C,N	X	X	C,N	C,N	C,N	C,N	X	X	N/A	N/A
Rosa acicularis	C,N	X	X	X	R,N	C,N	C,N	X	X	N/A	N/A
Rubus idaeus	C,N	X	X	X	C,N	C,N	C,N	X	C,N	N/A	N/A
Salix spp.	C,N	C,N	C,N	C,N	C,N	C,N	C,N	C,N	C,D	N/A	N/A
Shepherdia canadensis	C,N	X	X	X	X	X	X	X	X	N/A	N/A
Sorbus spp.	L,N	X	X	X	X	L,N	X	X	X	N/A	N/A
Symphoricarpos spp.	C,N	X	X	X	X	X	X	X	X	N/A	N/A
Vaccinium spp.	C,N	C,N	C,N	C,N	C,N	X	X	C,N	X	N/A	N/A
Viburnum spp.	C,N	X	X	X	X	X	X	X	X	N/A	N/A

Codes (C=Common, R=Rare, E=Extremely Rare, L=Local, not distributed throughout Boreal Plain, X=Not Found, D=typically dominant species, N= typically non-dominant species, N/A = Not Applicable). [1] Shore Fens only

Herb Species	Upland	Bogs	Poor Fens	Rich Fens	Conifer Swamps	Hardwood Swamps	Mixedwood Swamps	Tamarack Swamps	Shrub Swamps	Emergent Marshes	Meadow Marshes
Acorus calamus	X	X	X	X	X	X	X	X	X	C,N	C,N
Alisma plantago-aquatica	X	X	X	X	X	X	X	X	X	C,N	C,N
Calamagrostis canadensis	X	X	X	C,N	X	C,N	C,N	C,N	C,N	X	C,N
Calla palustris	X	X	X	X	X	X	X	X	X	C,N	C,N
Caltha palustris	X	X	X	X	C,N	C,N	C,N	C,N	C,N	C,N	C,N
Carex **spp.**	C,N	C,N	C,D	C,D	C,N	C,N	C,N	C,N	C,N	C,N	C,D
Cornus canadensis	C,N	X	X	X	C,N	C,N	C,N	X	X	X	X
Drosera **spp.**	X	C,N	C,N	C,N	C,N	X	X	X	X	X	X
Equisitem fluviatile	X	X	C,N	C,N	C,N	C,N	C,N	C,N	C,N	C,N	C,N
Eleocharis **spp.**	X	X	X	X	X	X	X	X	X	C,D	C,N
Eriophorum spp.	C,N	C,N	C,N	X	C,N	X	X	X	X	X	X
Galium spp.	C.N	X	X	C,N	C,N	C,N	C,N	C,N	C,N	X	X
Hippuris vulgaris	X	X	X	X	X	X	X	X	X	C,D	C,N
Maianthemum trifolium	X	C,N	C,N	C,N	C,N	X	X	C,N	X	X	X
Menyanthes trifoliata	X	X	C,N	C,N	C,N	X	X	C,N	X	X	X
Parnassia palustris	X	X	X	C,N	C,N	X	X	C,N	X	X	X
Phragmites australis	X	X	X	X	X	X	X	X	R,N	C,N	C,N
Potentilla palustris	X	X	X	C,N	X	X	X	C,N	C,N	C,N	C,N
Rubus chamaemorus	X	C,N	X	X	X	X	X	X	X	X	X
Sarracena purpurea	X	C,N	C,N	C,N	C,N	X	X	X	X	X	X
Scheuchzeria palustris	X	C,N	C,N	R,N	R,N	X	X	R,N	X	R,N	R,N
Scirpus acutus	X	X	X	X	X	X	X	X	X	C,D	C,N
Scirpus validus	X	X	X	X	X	X	X	X	X	C,D	C,N
Sium suave	X	X	X	X	X	X	X	X	C,N	C,N	C,N
Sparganium eurycarpum	X	X	X	X	X	X	X	X	X	C,N	C,N
Tofeldia glutinosa	X	X	R,N	C,N	C,N	X	X	C,N	X	X	X
Typha latifolia	X	X	X	C,N	C,N	C,N	C,N	C,N	C,N	C,D	C,N
Zizania palustris	X	X	X	X	X	X	X	X	X	C,D	X

Codes (C=Common, R=Rare, E=Extremely Rare, L=Local, not distributed throughout Boreal Plain, X=Not Found, D=typically dominant species, N= typically non-dominant species, N/A = Not Applicable).

Appendix H. Species List

Latin Name	Common Name
Abies balsamea	balsam fir
Acer negundo	manitoba maple
Acer spicatum	mountain maple
Acorus calamus	sweet-flag
Alisma gramineum	narrowleaf water plantain
Alisma plantago-aquatica	broad-leaved water-plantain
Alnus crispa	green alder
Alnus rugosa	speckled alder
Alnus spp	alders
Amelanchier alnifolia	saskatoon serviceberry
Andromeda polifolia	bog rosemary
Arctostaphylos uva-ursi	bearberry
Betula glandulosa	scrub birch
Betula nana	dwarf birch
Betula neoalaskana	alaska birch
Betula papyrifera	paper birch / white birch
Betula pumila	bog birch
Betula spp	birch
Brasenia schreberi	water shield
Bryoria spp	horsehair lichen
Calamagrostis canadensis	bluejoint grass
Calla palustris	water arum
Caltha palustris	marsh marigold
Campylium stellatum	starry campylium
Carex aquatilis	water sedge
Carex lasiocarpa	slender sedge
Carex limosa	mud sedge
Carex rostrata	beaked sedge
Carex spp	sedges
Carex tenax	wire sedge
Ceratophyllum demersum	coontail
Ceratophyllum spp	hornworts
Chamaedaphne calyculata	leatherleaf
Cladina spp	reindeer lichen
Cladonia spp	club/cup lichens
Cornus canadensis	bunchberry
Cornus stolonifera	red-osier dogwood
Corylus cornuta	beaked hazel
Drosera anglica	english sundew
Drosera rotundifolia	roundleaf sundew
Drosera spp	sundews
Elaeagnus commutata	silverberry
Eleocharis spp.	spikerush
Elodea canadensis	canadian waterweed
Empetrum nigrum	crowberry
Equisetum fluviatile	horsetail
Equisitem fluviatile	water horsetail
Eriophorum angustifolium	tall cottongrass
Eriophorum spp	cottongrass
Fraxinus pennsylvanica	green ash
Galium spp	bedstraws
Gaultheria hispidula	creeping snowberry
Halophila spp	seagrass
Hippuris vulgaris	common mare's-tail
Hippurus vulgaris	mare's tail
Hylocomium splendens	stair-step moss
Juncus spp	rushes
Juniperus communis	common juniper
Juniperus horizontalis	creeping juniper
Kalmia microphylla	alpine laurel
Kalmia polifolia	bog laurel
Larix laricina	tamarack
Ledum groenlandicum	labrador tea
Lemna minor	common duckweed
Lemna trisulca	ivy-leaved duckweed
Linnaea borealis	twinflower
Lonicera involucrata	bracted honeysuckle
Lonicera villosa	fly honeysuckle
Maianthemum trifolium	three-leaved solomon's seal
Marchantia spp.	liverworts
Menyanthes trifoliata	buckbean
Myrica gale	sweet gale
Myriophyllum spicatum var. exalbescens	spiked water milfoil
Nuphar spp	pond lily
Nuphar variegatum	yellow pond lily
Nymphaea tetragona	white water-lily
Oxycoccus microcarpus	small bog cranberry
Oxycoccus oxycoccos	small cranberry
Parnassia palustris	grass of parnassis
Petasites frigidus	arrow-leafed coltsfoot
Phragmites australis	common reed
Picea glauca	white spruce
Picea marinana	black spruce
Pinus banksiana	jack pine
Pinus contorta	lodgepole
Pinus spp	pine
Pleurozium schreberi	big red stem moss
Polygonum amphibium	water smartweed
Populus balsamifera	balsam poplar
Populus tremuloides	trembling aspen
Potamogeton filiformis	thread-leaved pondweed
Potamogeton friesii	fries' pondweed
Potamogeton gramineus	variableleaf pondweed
Potamogeton natans	floating leaf pondweed
Potamogeton pectinatus	sago pondweed
Potamogeton praelongus	whitestem pondweed

Species List Continued

Latin Name	Common Name
Potamogeton pusillus	small pondweed
Potamogeton richardsonii	richardson pondweed
Potamogeton vaginatus	large-sheath pondweed
Potamogeton zosteriformis	flat-stemmed pondweed
Potentilla fruticosa	shrubby cinquefoil
Potentilla palustris	marsh five-finger / marsh cinquefoil
Prunus virginiana	chokecherry
Ptilium crista-castrensis	knight's plume moss
Quercus macrocarpa	burr oak
Ranunculus aquatilis var. capillaceus	large-leafed white water crowfoot
Ranunculus circinatus	firm white water-crowfoot
Rhamnus alnifolia	alder-leaved buckthorn
Ribes spp	currants
Rosa acicularis	prickly wild rose
Rubus chamaemorus	cloudberry
Rubus idaeus	red raspberry
Rubus pedatus	trailing wild raspberry
Rubus spp	brambles
Sagittaria cuneata	arum-leaved arrowhead
Salix spp	willows
Sarracena purpurea	pitcher plant
Scheuchzeria palustris	pod grass
Scirpus	bulrush
Scirpus acutus	hard-stemmed bulrush
Scirpus validus	soft-stemmed bulrush
Scorpodium scorpoides	scorpion tail moss
Shepherdia canadensis	canada buffaloberry
Sium suave	hemlock water parsnip
Smilacina trifolia	three-leaved false solomon's seal
Sorbus spp.	mountain ash
Sparganium angustifolium	narrowleaf bur-reed
Sparganium eurycarpum	giant bur-reed

Latin Name	Common Name
Sphagnum angustifolium	narrowleaf peat moss
Sphagnum capillifolium	acute-leaved peat moss
Sphagnum fuscum	rusty peat moss
Sphagnum magellanicum	midway peat moss
Sphagnum riparium	streamside sphagnum
Spirodela polyrhiza	larger duckweed
Symphoricarpos spp.	snowberry
Thuja occidentalis	eastern white cedar
Tofeldia glutinosa	sticky false asphodel
Tomenthypnum nitens	fuzzy brown moss
Typha latifolia	common cattail
Typha spp	cattails
Ulmus americana	american elm
Utricularia vulgaris	common bladderwort
Vaccinium caespitosum	dwarf blueberry
Vaccinium myrtilloides	common blueberry
Vaccinium spp	blueberry
Vaccinium vitis-idaea	bog cranberry
Viburnum spp.	viburnum
Zizania palustris	northern wildrice
Zostera marina	eelgrass