Klondike Placer Miners' Association

Wetland Classification Handbook

April 18, 2022

Published by Ecofish Research Ltd., 600 Comox Rd., Courtenay, B.C., V9N 3P6

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Citation:

Wright, N., D. Greenacre, and A. Smith. 2021. Klondike Placer Miners' Association Wetland Classification Handbook. Consultant's report prepared for the Klondike Placer Miners' Association by Ecofish Research Ltd., April 18, 2022. Project #1447.02

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Acknowledgments:

We thank Nadele Flynn and Brett Pagacz from Environment Yukon for insightful discussions during the planning phase of this handbook, providing access to Environment Yukon wetland photos and files, and thorough review of an earlier draft. We also thank Saleem Dar of Mining, Lands and Resources for review of the draft handbook. We thank Krista Prochazka and Brooke Rudolph for their photos. This handbook was funded by the Yukon Government Department of Education.

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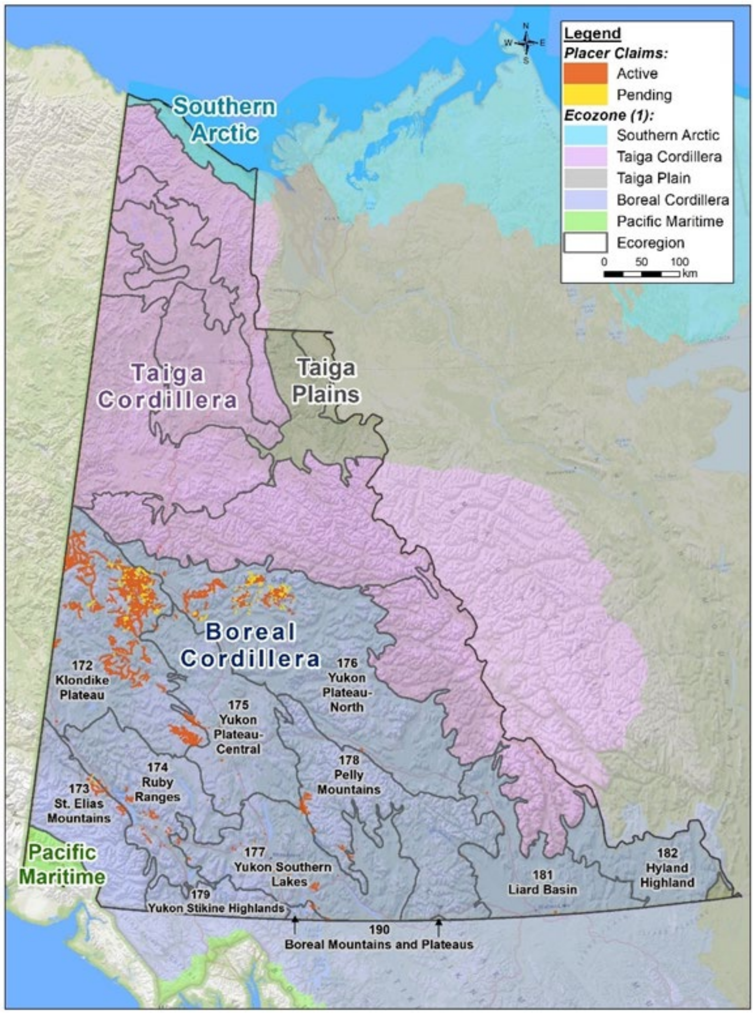
1. INTRODUCTION

This handbook is a Klondike Placer Miners' Association (KPMA) initiative to help users identify and classify wetlands in the field to support mine planning and permitting in Yukon Territory. The handbook covers wetlands commonly found within the Boreal Cordillera Ecozone (1, 2), where most mining claims occur (Map 1).

This handbook was developed using source material from the Klondike Plateau Boreal Low Subzone (BOLkp) Field Guide to Ecosite Identification (4) and the Southern Lakes Boreal Subzone (BOLsl) Field Guide to Ecosite Identification (5), which are based on the Canadian Wetland Classification System (6). Other source material used in developing this handbook included the Field Manual for Describing Yukon Ecosystems (7), the British Columbia Wetland Guide (8) and Alberta Wetland Classification System (9), since these guides cover boreal wetlands.



Map 1. Mining claims in the Yukon (3).

The objectives of this handbook are to promote a better understanding of wetlands and assist users in identifying the five wetland classes (bog, fen, swamp, marsh, and shallow open water) using readily observable soil, water, landscape, and vegetation characteristics, or indicators.

This handbook begins by defining what a wetland is (Section 2), why wetlands are important (Section 3), and where they are distributed in the Yukon (Section 4). It then provides a brief overview of how wetlands are classified (Section 5). The handbook describes key indicators or characteristics used to identify wetlands (Section 6), then describes wetland classes in more detail, according to their key characteristics (Section 7). Finally, tips for describing sites in the field based on the indicators (Section 8) and a key to identifying the wetland classes (Section 9) are provided.

This handbook is a living document, intended to be trialed by placer miners and revised as new information becomes available.

2. WHAT IS A WETLAND?

"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" (6).

Wetlands include a broad range of ecosystem types, from those permanently flooded by shallow water and dominated by aquatic plants (hydrophytic vegetation), to forested sites with wet soils. Some wetlands are isolated, surrounded by upland, while others are highly interconnected, forming wetland complexes.

Aishihik Lake wetland complex.
Photo credit: Yukon Government (10)

3. WETLAND FUNCTIONS

Wetlands can be essential for maintaining water flows, providing flood protection, purifying water, recharging groundwater, storing carbon, cycling nutrients, and providing habitat for fish and wildlife. Some wetlands support traditional sustenance and cultural and spiritual practices and provide recreational and educational opportunities. Wetlands also provide several additional valuable functions including:

- Slowing the flow of water and providing habitat for plants that help stabilize stream banks and shorelines, thereby reducing erosion;
- Trapping, oxidizing, or precipitating nutrients, metals, hydrocarbons, and other compounds;
- Regulating local climate;
- Creating and fertilizing floodplains;
- Supporting valued, rare, or at-risk plant species; and
- Providing wildlife corridors for migratory species.

Not all wetlands perform all functions, nor do they perform all functions equally well (11). The location, size, and landscape position (relative to other waterbodies, slopes, or uplands) of a wetland may determine what functions it will perform. How well a wetland will perform these functions depends on the amount and quality of water entering the wetland, climate conditions, and disturbances or alteration within the wetland or the surrounding landscape, among other factors.

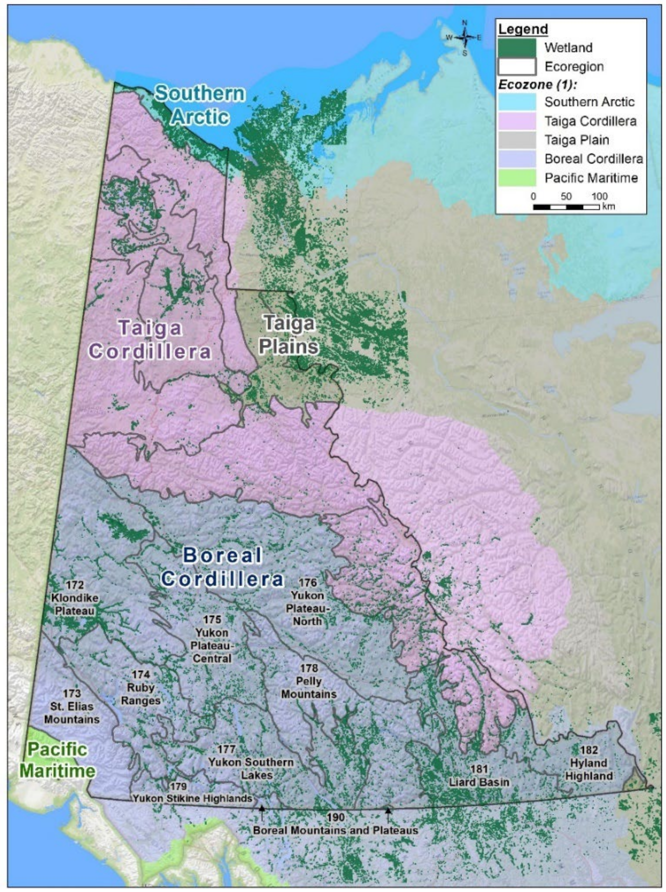
Photo credit: Krista Prochazka, 2021

Photo credit: Ecofish Research Ltd., 2018

4. WETLAND DISTRIBUTION IN YUKON

The largest concentrations of wetlands in the Yukon are in areas underlain by continuous permafrost (ground that remains below 0^{o}C for two or more years) from central to northern Yukon (12). Smaller wetlands and wetland complexes are scattered throughout the territory except for a few large marshes associated with active deltas, although these observations are based on incomplete wetland inventory data (e.g., from references 13, 14, 15) (Map 2).

The nature of wetlands varies within the territory and is influenced by landscape position and the presence of permafrost (12). Most wetlands exist in complexes with upland ecosystems, and shallow open water is a major component of many wetland complexes in all regions.



Map 2. Distribution of wetlands in the Yukon (16), based on incomplete wetland inventory data. There is no territory-wide inventory of wetland classes (12).

Wetlands within the Yukon Boreal Cordillera Ecozone are associated with different landforms or waterbodies (e.g., large river basins or lake deltas), and some by the presence of sporadic discontinuous permafrost (12).

Within the central and southeastern Yukon Boreal Cordillera Ecozone, wetlands are usually a complex of fen and plateau bog, where the bog portion of the wetland (and sometimes the fen) is underlain by permafrost. Palsas (peat mounds with a core of ice) have also been identified in this region (12).

In the calcareous soils of the Whitehorse area, wetlands tend to be largely without peat formation and are often characterized by marl (calcium carbonate or lime-rich mud) (5).

Wetland mapping in the Yukon is incomplete and the full extent of wetlands is not known. Wetland classification and mapping in the Yukon is ongoing and constantly changing. Current information on the extent of mapping for specific areas can be obtained by contacting the ELC (Ecological and Landscape Classification) program (ELC@yukon.ca).

WETLANDS IN THE YUKON BOREAL CORDILLERA ECOREGIONS

The following text has been extracted from Smith *et al.* (2004) as the main resource to summarize broad knowledge on wetlands in ecoregions (areas where environmental conditions such as climate, landforms, and soil characteristics, are generally similar) of the Yukon Boreal Cordillera.

Klondike Plateau Ecoregion - Wetlands are not extensive in the north part of the ecoregion, but occupy major valley floors in the south, where fluvial fans support wetlands complexes of fen and peat plateaus. Wetland soils tend to be composed of frozen sphagnum peat but are without permafrost under fen vegetation growing in areas of surface water through-flow. Black spruce–sphagnum communities exist in poorly drained depressions and at the toe of slopes on fine-textured soils. Shrub birch, willow, Labrador tea, blueberry, and other plants of the *Ericacea* family dominate the shrub layer, overlying extensive lichens and feathermoss.

Ruby Ranges Ecoregion - Wetlands are generally associated with lakes.

Yukon Plateau-Central Ecoregion - Wetlands are associated with thermokarst terrain (irregular surfaces that form as permafrost thaws) in the silty alluvial deposits of major floodplains. Shallow open water with water sedge and aquatic plants, and marshes dominated by graminoid species, are common along the shores of lakes and ponds. Willows, shrub birch, Labrador tea and shrubby cinquefoil, with a moss and sedge groundcover, commonly occur in bogs.

Yukon Plateau-North Ecoregion - Large wetland areas are primarily associated with the lower portions of the large river valleys. Willows, sedges, and aquatic plants dominate wetlands on the margins of small lakes, marshes, and shallow open water. Black spruce bogs containing sedge tussocks and peatmoss and underlain by permafrost, occur in lowland areas throughout the ecoregion.

Yukon Southern Lakes Ecoregion - Wetlands are typically alkaline fens and rest on mineral soil or marl at less than 50 cm depth. Willows and other shrubs dominate fen and marsh wetlands and are common in areas subject to flooding. Landforms associated with permafrost are palsas, with occasional peat plateaus, underlain by a metre or so of permafrost.

Liard Basin Ecoregion - Wetlands are common, though not extensive. The floodplains of most large rivers encompass wetlands, many of which have thick peat deposits. Basin fens are a common wetland form; these tend not to be underlain by permafrost. In areas where permafrost has established within the shrubby–herbaceous fens, peat plateau and palsa bogs are found. Shallow water wetlands include oxbows, sloughs, and backchannels of major rivers.

Hyland Highland Ecoregion – There is a low coverage of wetlands. Bogs form on north-facing lower slopes. Fen wetlands dominated by sedges and willows and peat plateau bogs are common along the major river valleys. Permafrost may be found under peaty ridges and bog islands within the northern ribbed fens and under the peat plateau bogs.

There is low wetland coverage in the **St. Elias Mountains Ecoregion** (wetlands that are present are underlain with permafrost), **Pelly Mountains Ecoregion** (some peat plateau wetlands on the Nisutlin Plateau), **Yukon Stikine Highlands Ecoregion** (some fen wetlands), and **Boreal Mountains and Plateaus Ecoregion** (some shrub wetlands).

5. WETLAND CLASSIFICATION

Wetlands are classified according to whether they have organic or mineral soils. They are then further divided into wetland classes, including bogs, fens, swamps, marshes, and shallow open water wetlands. If necessary, these can be further differentiated according to their vegetation structure, for example as a treed fen or a shrub fen.

5.1 Soils

Wetlands are divided into two major soil groups:

1. **Organic wetlands or peatlands** (also known as muskegs or mires) – characterized by accumulated organic matter (peat) typically ≥ 40 cm deep, but as low as 30 cm; and
2. **Mineral (non-peat forming) wetlands** – characterized by mineral soils (sand, silt, and clay) typically with little (≤ 30 - 40 cm) or no peat.

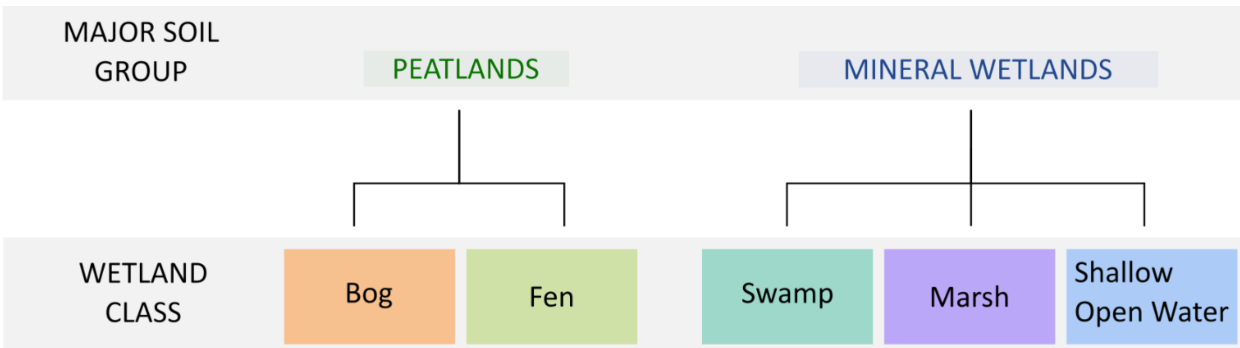
Organic (Peat) Soils

Mineral Soils

Note: Mineral wetlands can have > 40 cm of organic matter, and peatlands can have < 40 cm of organic matter, so classification should be based on other identifying characteristics (i.e., landscape position, hydrology, and vegetation).

5.2 Wetland Classes

There are five wetland classes in the Yukon; within the two major soil groups: the peatlands are bogs and fens, and the mineral wetlands are swamps, marshes, and shallow open waters.



Peatlands: Bogs and Fens

- Bogs and fens are characterized by the accumulation of partially decomposed organic matter (peat) that builds up slowly due to wet, cool, oxygen-deprived conditions.
  - In the Klondike Plateau Boreal Low Subzone (BOLkp), peat depths range from 20 cm to 150 cm (4), while in the Southern Lakes Boreal Subzone (BOLsl) peat depths have been measured to 300 cm deep in fens (5). Peat depths are typically around 30-35 cm deep (N. Flynn pers comm., October 12, 2021).
- The vegetation of bogs includes black spruce, lichen, ericaceous shrubs (plants that grow in infertile or acidic growing conditions such as leatherleaf and Labrador tea), and peat mosses. Fens have a similar groundcover to bogs (ericaceous shrubs and peat mosses) but are typically dominated by brown mosses and are more diverse and include graminoids (grasses, sedges, rushes) and forbs (herbaceous plants that are not graminoids).
- Bogs and fens tend to have permanently saturated (wet) soil and relatively stable water tables that range from at or near the surface to typically within 30 to 50 cm of the ground

surface, depending on the time of year, geographical location, landscape position, and soil texture.

- The major difference between bogs and fens is their water source which impacts the acidity and nutrient content of the soil:
    - Bogs are ombrotrophic, meaning they receive most of their water inputs from precipitation (rain or snow) and have limited connection to local or regional groundwater sources. However, they can receive water inputs from soil thaw during the growing season. Water from precipitation contains little or no dissolved minerals and nutrients, so the acids that are produced by decomposing vegetation cannot be neutralized, resulting in water that is acidic, with a low nutrient content.
    - Fens are minerotrophic, meaning they receive water from groundwater and/or surface water inflows in addition to precipitation, resulting in alkaline water and the accumulation of nutrients and minerals as the water interacts with soils and bedrock.

Mineral Wetlands: Swamps, Marshes, and Shallow Open Water

- Characterized by having no organic matter to shallow deposits of organics (typically less than 40 cm deep) that are usually well-humified, non-bryophytic material derived from sedges or wood. Some mineral wetlands (e.g., conifer swamps) may have organic soils with highly decomposed plant materials ≥ 40 cm deep.
- Tend to have naturally fluctuating water levels, with water tables near, at, or above the surface for variable periods during the year.
    - Swamps typically have occasional or periodic standing water and slow to moderate surface flow.
    - Marshes have occasional or persistent standing water or slow-moving surface flow.
    - Shallow water wetlands typically have standing water up to 2 m deep for most or all of the year.
- Water level fluctuations increase decomposition rates, and influence nutrient availability, water chemistry, and plant community composition and structure.
    - Swamps typically receive nutrient-rich groundwater and are neutral to slightly acidic. Vegetation is dominated by woody plants typically > 1 m tall.
    - Marshes are generally nutrient-rich, with neutral to alkaline waters. Vegetation is dominated by graminoids (herbaceous plants including grasses, sedges, rushes), shrubs, forbs, and/or emergent plants.

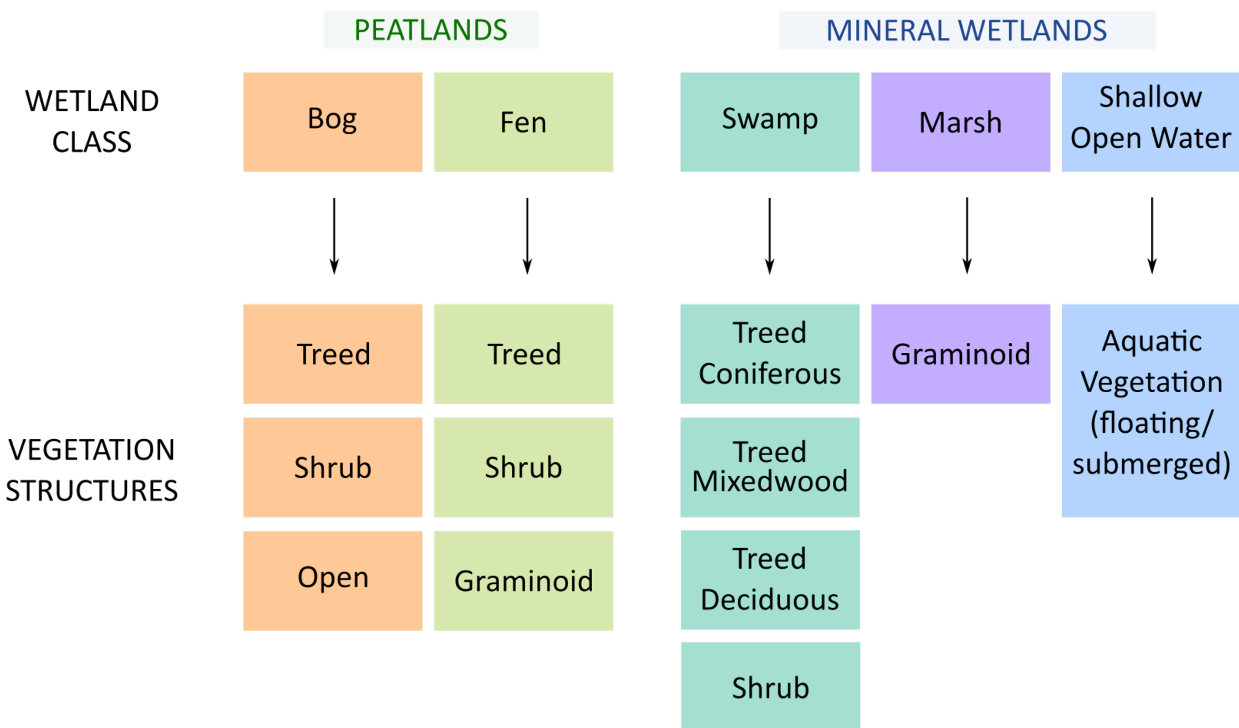
- Shallow water wetlands are typically neutral to alkaline, though may be slightly acidic. Vegetation is dominated by rooted submerged and floating-leaved aquatic plant species and < 10% emergent cover.

5.3 Wetland Vegetation Structures

This handbook is meant to be a guide on wetland classes, but it is helpful to break down the classes to show the variation of vegetation structure within each class to enhance wetland identification success.

Wetland vegetation structure is defined by the percent cover of the dominant vegetation. For example, if shrub cover is ≥ 15% and ≤ 10% of the area is covered by trees, then the wetland would be categorized as shrub-dominated. Some wetlands have multiple wetland vegetation structures (e.g., fens can be graminoid-, shrub-, or treed-dominated).

This handbook provides the key to distinguish 12 wetland vegetation structures. Treed deciduous-dominated wetlands within the Boreal Cordillera Ecozone are included, though they are uncommon (N. Flynn, pers. comm, March 30, 2022), and there are swamps with a mix of deciduous and coniferous trees (referred to herein as treed mixedwood swamps); all other treed wetlands are coniferous-dominated. Bogs, fens, and swamps all have treed and shrub forms. Marshes are graminoid-dominated (containing sedges, rushes, and/or grasses), as are some fens; while bogs have an open form characterized by scattered graminoids and forbs. Shallow open water wetlands typically have aquatic vegetation present.



Different wetlands develop because specific site conditions (e.g., microclimate, slope, soils, hydrology) support different vegetation communities. For example, open water for a sustained period is needed for the growth of submerged vegetation such as pond weeds (*Potamogeton* spp.). In addition, some plant species can influence the development of wetlands. For example, the presence of peat moss (*Sphagnum* spp.) can further promote the formation of peat moss because it contains chemicals that resist decomposition, thereby creating habitat for more peat moss to grow. The slow accumulation of peat moss eventually blocks the supply of mineral- and oxygen-rich groundwater, resulting in acidic conditions that are not tolerant to most plants, resulting in a wetland with low plant species diversity. Despite this, peat moss continues to thrive primarily on precipitation and water inputs from soil thaw because of peat's water wicking and high-water holding capacity. Because of these relationships, wetlands can be categorized by key characteristics or "**indicators**" that distinguish them from other landforms and waterbodies and provide clues to help identify the different wetland classes.

6. KEY WETLAND INDICATORS

Several indicators are useful for classifying wetlands; they fall into four broad categories: landscape; soil; hydrology; and vegetation. There is no one indicator that best identifies a wetland; rather, they should be used together to support wetland identification and classification. Note that wetlands that have been disturbed by natural events (e.g., wildfire, beaver activities, permafrost thaw) or human activities (e.g., linear development, mining, drainage) may not show the same characteristics (e.g., hydrology, vegetation) as undisturbed wetlands in the same biogeoclimatic region. It is therefore important to understand what drives wetland development to be able to understand how disturbance might alter key characteristics.

6.1 Landscape Indicators

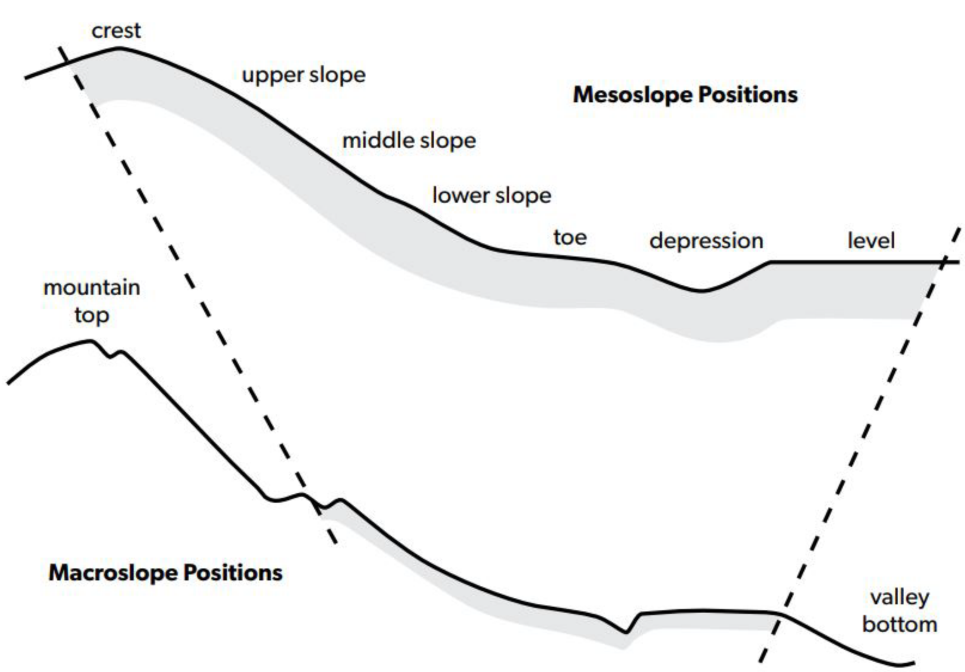
Latitude, elevation, slope (gradient), and aspect (the direction a slope faces with respect to the sun) influence the microclimate of a site (e.g., local air and ground temperatures, snowpack accumulation, rainfall amounts) and the development of Cryosols (mineral or organic soils that undergo annual. freeze thaw processes). These are important drivers of wetland development.

- Seasonal melt water and cool summer temperatures favour peatland development in poorly drained areas since seasonal melt water keeps the water table high and cooler temperatures reduce the loss of water to evapotranspiration and help maintain frozen soils conditions. The presence of peat further helps keep frozen ground cool due to its high water infiltration rates, capacity to hold large amounts of water, and its heat-insolation properties

- Cryosols, which have a relatively shallow (typically < 2 m) seasonally thawed (active) soil layer above an ice-rich perennially frozen sub-soil layer (permafrost), help to raise the water table and direct water flow during annual thaw, thereby influencing water and nutrient availability for plant growth.
- When active layers are shallow and permafrost is close to the ground surface, an ice lens can create a barrier to moisture percolating downwards and prevent groundwater from moving upward through peat, thereby producing drier conditions that can allow peatlands to support species more typical of upland areas and old peatland seral stages (i.e., palsa bogs with white spruce and willow).

Knowing where wetlands are typically located within the landscape can help determine presence. The positions in the landscape that are most conducive to wetland formation are low lying areas adjacent to open water such as lakes, ponds, and rivers. Other areas on sloping land can also have wet conditions. These include areas at the base of slopes or valleys where seepage water accumulates and drains away. In the Yukon, wetlands are common in valley bottoms, localized depressions, on the fringe of lakes, in proximity to rivers and streams, concave positions within a floodplain that have poorly drained soils, and at the toe, lower and mid slopes with cool (north) aspects that have poorly drained soils (Figure 1). Wetlands on north facing slopes are often associated with Cryosols.

Figure 1. Landscape slope positions, from the Yukon Field Manual for Describing Yukon Ecosystems (4).



6.2 Soil Indicators

This section describes typical wetland soils found in the Klondike Plateau Boreal Low Subzone (BOLkp; (4)) and Southern Lakes Boreal Low Subzone (BOLsl; (5)).

Organic Soils

The presence of organic matter (peat) is a key soil indicator. Peat is partially decomposed plant matter from bryophytes (moss), herbaceous (non-woody) plants, and woody debris. Thick surface layers of peat insulate the ground against summer thaw, which helps to retain permafrost, where present. When peat is seasonally frozen and permafrost is present, the soils are referred to as Organic Cryosols. One of the unique properties of Cryosols, that distinguishes it from others, is the presence of a permafrost sub-layer. Mineral soil can also be classified as a Cryosol, if the soil has both cryogenic (freeze-thaw) properties, and permafrost.

- Soils classified as Organic or Organic Cryosols are composed of fibric (undecomposed), mesic (moderately decomposed), and humic (well-decomposed) peat materials.
- Organic soils that are water saturated can have ≥ 40 cm of organic matter on surface if mesic or humic peat, or ≥ to 60 cm if fibric peat.
- Bog soils are typically comprised of fibric peat, while fens may have fibric and mesic peat, sometimes layered over mineral soils. Both peatlands may be underlain by permafrost, but bogs are more consistently so, especially in the BOLsl region.

Mineral Soils

Mineral soils may be comprised of sand, silt, clay, loam (i.e., soil with roughly equal proportions of sand, silt, and clay), and/or marl. In the Yukon, marl is calcium carbonate primarily mixed with silt.

The redox potential of soil or water, a measure of electrochemical potential or electron availability, is a key diagnostic for determining whether an area is functioning as wetland. Mottles and gleyed conditions are soil redox features of wet (hydric) soils and are indicators of past hydrologic processes.

- Mottles are orange or reddish-brown (resembling rust) spots, patches, or streaks interspersed with the dominant soil color (Figure 2). Mottles result from oxidation of iron in the soil when exposed to oxygen and indicate the mineral soils experience short or seasonal periods of saturation.
- Gleyed is a soil condition caused by prolonged saturation (indicative of flooding), which is manifested by the presence of bluish or greenish colours throughout the soil (Figure 2).

Figure 2. Mottled (left) and gleyed (right) wetland soils.

- Note that fine-textured Cryosols commonly have high moisture content, especially above the permafrost layer, which results in gleying and mottles; in this case, other indicators are required to confirm whether the site is a wetland.

6.3 Hydrology Indicators

Wetland formation is strongly influenced by the source, movement (fluctuations), and availability (temporal stability or permanence) of water.

The **source of water** to a wetland affects soil and water acidity and nutrient availability, and thus the plant communities that will grow.

- Bogs primarily receive atmospheric water inputs and little to no groundwater, resulting in soils that are moderately to very acidic (Table 1) and nutrient poor. These soil conditions support plants that can grow in infertile or acidic growing conditions.
- Marshes may receive multiple sources of water, including groundwater inputs and surface and subsurface runoff. They tend to have greater nutrients available and support alkali-tolerant plants (pH > 7.4).
- Because wetland formation depends on a range of conditions, other wetland types such as fens and swamps are associated with a range of pH conditions (neutral to moderately acidic) (Table 1), that is reflected in the wider variety of plant associations (4, 5).
- Acidity is easily measured in the field and can be used as an indicator to test whether a wetland is maintained by shallow groundwater inputs (fens), because wetlands fed by

groundwater tend to be less acidic than those obtaining water primarily from precipitation (bogs). Bogs undergoing permafrost thaw typically have a greater hydraulic connection to groundwater, and thus, have a higher pH.

- Testing acidity of the water is only helpful when distinguishing peatlands from mineral wetlands and bogs from richer fens; it is not typically used to characterize mineral wetlands because they have a large, overlapping range in pH. The timing of measurements must also be carefully considered (discussed more in Section 9).

Table 1. Summary of wetland types and corresponding acidity levels, modified from the BC Wetland Guide (8), with wetland characteristics from Yukon Field Guides to Ecosite Identification for BOLkp (4) and BOLsl (5).

Acidity	pH	Wetland Classes	Wetland Characteristics
Very Acid	<4.5	Bogs	High cover of *Sphagnum* moss
Moderately Acid	4.5-5.5	Bogs, poor fens, coniferous swamps	High cover of *Sphagnum* moss. Poor fens can be distinguished from bogs by the presence of *Salix spp*. and *Betula spp*. in fens (amongst other minerotrophic indicators)
Slightly Acid	5.5-6.5	Fens, swamps, shallow water wetlands	Brown mosses (*Tomenthypnum spp*., *Warnstorfia spp*., and *Drepanocladus spp*.) are typical for sites with a stagnant or sluggish hydrodynamic index
Neutral	6.5-7.4	Fens, swamps, marshes, shallow water wetlands	Species are often a combination of species found on slightly acid and alkali sites. Temporary to permanent seepage
Alkaline	>7.4	Marshes, shallow water wetlands	Dominated by minerophilic broyophytes such as *Scorpidium* and *Campylium* mosses on peatland sites. Alkali tolerant species occur in marshes

Water movement and availability within a wetland is generally described in terms of the timing, magnitude, frequency, and duration of water flow and water table fluctuations (i.e., when, how much, how many times, and for how long).

- Horizontal and vertical water movement to, from, and within a wetland is driven by gradients (slope), the source and amount of water (e.g., from groundwater seepage, precipitation, snowmelt, soil thaw), soil water storage capacity (the ability of a wetland to hold and store water), and for some wetlands, the depth of the seasonally thawed active layer and depth of permafrost.
- Stable, high-water tables (stagnant or sluggish hydrodynamics) promote peat formation and high bryophyte (moss) cover, conditions favorable for bog and fen development.
- Sites with more dynamic water tables that experience surface flooding followed by late-season drawdown, such as swamps, marshes, and shallow-water wetlands, usually have few bryophytes because most mosses are intolerant of prolonged submergence. On these

sites, the depth and duration of flooding and the rate of water movement are primary factors determining the vegetation structure and composition.

Identifying wetlands based on hydrology can be difficult because of seasonal and year-to-year variability in water availability that can be caused by early or late freshet, a drought year, or a disturbance such as a fire. For this reason, at least two site visits during the growing season are recommended to assess the persistence of wet conditions and flow patterns under different hydrologic conditions.

6.4 Vegetation Indicators

Wetland plants are adapted to saturated soils and water table fluctuations, but not all species present in wetlands are unique to wet environments nor do all species adapted to wet environments prefer them (e.g., *Picea* spp. or spruce). In addition, several species are present in two or more wetland classes (e.g., *Chamaedaphne calyculata* or leatherleaf in fens and bogs), making it difficult to identify a wetland based on vegetation characteristics alone.

However, there are a few unique species and groups of species (or dominant plant communities) that are indicators for different wetland classes. These plant communities often share a similar environmental tolerance, such as soil acidity or the depth of water. For example, a marsh can be distinguished from shallow open water by the dominant species; these are graminoid species (e.g., *Equisetum fluviatile* or water horsetail is a key indicator) in marshes, and aquatic species (C*alla palustris* or wild calla is a key indicator) in shallow open waters.

Water levels fluctuate throughout the growing season and from year-to-year depending on weather conditions (i.e., the site may be drier or wetter than normal or average) and what is typical for a particular climatic region, which influences the types of vegetation growing at a site. This is especially true of mineral wetlands and care should be taken when identifying and classifying a wetland based on vegetation indicators observed during a single site visit.

7. WETLAND CLASS SUMMARIES

This section provides a high-level description of the five wetland classes (bog, fen, swamp, marsh, and shallow open water) based on the key indicators (landscape, soil, hydrology, and vegetation characteristics), followed by photos of each wetland class and vegetation structure.

BOG

Landscape Indicators

- Typically form on level or depressional sites, but also found on slopes
- Occur in two different site positions in the BOLkp: 1) within large tussock fens on gentle to level terraces in silty reworked loess or fluvial deposits with a cover of peat, and 2) on very steep cold north-facing slopes, where the lack of solar warming helps maintain cold conditions favourable for peat development. In the BOLsl region, bogs are sensitive to disturbance as permafrost temperatures are close to 0^{o}C.
- Bog area is sometimes elevated above surrounding terrain due to peat accumulation and/or subsurface permafrost formation. Ground surface is characterized by undulating *Sphagnum* moss hummocks (or raised mounds) in some bogs (hummocks are also found in some swamps and uplands)

Soil Indicators

- Peatland – minimum peat depth is typically 30-60 cm
- Soil is primarily comprised of poorly decomposed Sphagnum moss. Material typically ranges from live or undecomposed moss at surface to poorly decomposed at depth (i.e., can tell it was once moss)
- Soils are primarily Organic Cryosols, usually fibric. Permafrost commonly found 20-60 cm from surface
- Soil is acidic (pH typically ≤ 4.5) and nutrient poor

Hydrology Indicators

- Water inputs primarily from precipitation, but occasionally also from seepage
- Relatively stable water table, but can vary from at or slightly below the surface to 50 cm below the surface, depending on the type of bog and the season. Bogs are seldom flooded, except during snowmelt.
- Sphagnum moss at surface moist to dry depending on the season. Water may be visible in low lying spots (e.g., between raised moss hummocks).
- Poorly to very poorly drained. Water flow stagnant to slow, dominantly subsurface.

Vegetation Indicators

- Trees: open, sparse, to closed black spruce (*Picea mariana*) and sometimes open to sparse white spruce (*Picea glauca)* and willow (*Salix spp.*)
- Shrubs: Labrador tea (*Rhododendron* spp.) dominant; crowberry (*Empetrum nigrum*), red bearberry (*Arctous rubra*), lowbush cranberry (*Vaccinium vitis-idaea*), bog cranberry (*Vaccinium oxycoccos*), cloudberry (*Rubus chamaemorus*), and blueberry (*Vaccinium uliginosum*) may also be present
- Ground cover: Peat mosses (*Sphagnum* spp.) dominant. Lichens (*Cladina* spp.) may be present. Some feathermoss (*Hylocomium splendens, Pleurozium schreberi*) and brown mosses (e.g., *Aulacomnium palustre, Tomentypnum nitens*) may be present, but more common on palsa bogs and in bogs that have had many years between wildfires.

Bog Description: Bogs are peat-forming wetlands which are maintained primarily from precipitation. Bogs are typically sparse to densely treed and have acidic nutrient-poor organic soils which are dominated by *Sphagnum* moss and support relatively few other species. Black spruce typically dominates, but a small proportion of white spruce can be present.

Treed bog (Peat Plateau):

Palsa Bog:

Shrub bog:

Open bog:

Photo credit: Ducks Unlimited, 2008

FEN

Landscape Indicators

- Typically form on mid to toe slopes, or level or depressional sites. Fens are typically flat (level), but gradient can be gently sloping or moderate to steeply (with northern aspects) sloping. Fens with hummocky surfaces common.
- Fens may be intersected by channels, found in deeper peat deposits of old meander channels, or along the margin of ponds, and are often part of larger wetland complexes comprised of other wetland classes
- Influence by groundwater sometimes causes fens may form patterns of alternating wet and dry areas, creating what are known as “Patterned fens”

Soil Indicators

- Peatland – organic matter (peat) typically 10-50 cm in depth, can be underlain by mineral soil
- Soil primarily comprised of partially decomposed brown mosses, plants, and woody debris
- Soils can be Organic (fibric, mesic), Organic veneer (typically mesic) over mineral soil, or Organic Cryosols. When permafrost present, typically within 20 to 50 cm of the ground surface but can be deeper.
- Soil is moderately acidic (pH 4.5-5.5) to neutral (pH 6.5-7.4), and nutrient regime poor to rich

Hydrology Indicators

- Water sources can include precipitation, groundwater, and/or surface runoff
- Relatively stable water table typically above, at, or within 50 cm depth of the ground surface, depending upon the time of season and runoff. Seepage often present on top of the thawed soil layer, sometimes right to the surface.
- Can have from up to 25% to 85% open water
- Imperfect to very poor drainage. Water flow stagnant to slow; rates of surface or subsurface water flow may be greater during snowmelt and large rainfall events

Vegetation Indicators

- Trees: mostly non-treed, but can contain sparse to open black spruce (*Picea mariana*) or white spruce (*Picea glauca*)
- Shrubs: shrub birch (*Betula glandulosa*) and willow (*Salix* spp.), also leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda polifolia*), Labrador tea (*Rhododendron* spp.), blueberry (*Vaccinium uligonosum*), bog cranberry (*Vaccinium oxycoccus*)
- Ground cover: *Aulacomnium spp*. (e.g., *A. palustre*), *Scorpidium spp. (S. scorpioides* and *S. cossonii*), angled paludella moss (*Paludella squarrosa*), golden fuzzy fen moss (*Tomentypnum nitens*), hook mosses (*Drepanocladus spp*., *Calliergon* spp.), feathermoss (*Hylocomium splendens*), sedges (*Carex* spp., *Eriophorum* spp.), bog buckbean (*Menyanthes trifoliata*), marsh cinquefoil (*Comarum palustre*), clubrush (*Trichophorum cespitosum*), horsetail (*Equisetum fluviatile*)

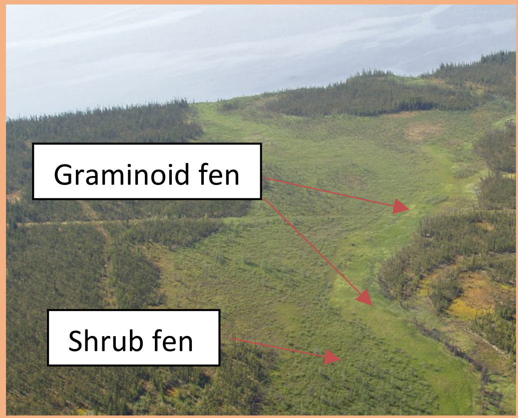
Fen Description: Peatlands that are fed by groundwater and/or surface water in addition to precipitation. Fens come in a variety of forms and can be treed, shrubby, or open, and have organic soils that range from slightly acidic to slightly alkaline and nutrient-poor to nutrient-rich. Fens support a wider variety of plant species than bogs and are typically dominated by brown mosses and sedges.

Note photo of collapse scar fen: Formed at the perimeter of treed bogs where permafrost thaw caused subsidence of the bog surface. Characterized by dead trees often leaning in all directions with other drowned vegetation. Water table the same as that surrounding the bog.

Treed Fen:

Shrub Fen:

Graminoid Fen:



Collapse Fen:

SWAMP

Landscape Indicators

- Typically form on mid to toe slopes, or level or depressional sites. Gradient typically level to gently sloping, but can be moderate to steeply sloping
- Usually found in transitional zones (floodplains) between uplands and streams, wetlands, or lakes where high water tables and/or frequent temporary or seasonal flooding occur
- Hummocks may be present in treed swamps

Soil Indicators

- Mineral wetland – generally shallow layer (0-30 cm) of peat over mineral soil (sandy, silty, or loamy)
- Organic matter typically in a more advanced stage of decomposition than observed in peatlands; plant material ranges from structures that are indistinct (e.g., can barely tell it was once a leaf) to amorphous (e.g., black muck)
- Soils may be non-organic Cyrosols with shallow organic veneer and permafrost may be present
- Soils frequently show signs of mottling or gleying (blue-grey colour) within 50 cm of the ground surface

Hydrology Indicators

- Water comes from a mix of inputs (groundwater, surface and subsurface water, and precipitation)
- Water table at or near the surface but experiences frequent temporary or seasonal water level fluctuates
- Imperfect to very poor drainage. Surface and subsurface water flow, particularly during snowmelt and large rain events
- Flooding (often frequent) common
- Seepage over permafrost common within 50 cm of ground surface

Vegetation Indicators

- Trees: open to closed canopy of black and/or white spruce (*Picea mariana* and *P. glauca*)
- Shrubs: river alder (*Alnus incana*), green alder (*Alnus alnobetula*), willow (*Salix* spp.), shrub birch (*Betula glandulosa*), Alaska paper birch (*Betula neoalaskensis*), Labrador tea (*Rhododendron* spp.), blueberry (*Vaccinium uligonosum*), leatherleaf (*Chamaedaphne calyculata),* lowbush cranberry (*Vaccinium vitis-idaea*)
- Ground cover: sedges (*Carex* spp.), horsetails (*Equisetum arvense, E. pratense*), bluejoint reedgrass (*Calamagrostis canadensis*), marsh cinquefoil (*Comarum palustre*), red bearberry (*Arctous rubra*), brown mosses (e.g., *Aulacomnium spp., Tomentypnum nitens* or golden fuzzy fen moss), feathermoss (*Hylocomium splendens, Pleurozium schreberi*), *Sphagnum* moss, leafy mosses (*Mnium, Plagiomnium* spp.)

Swamp Description: Swamps are mineral wetlands that are covered by trees and/or tall shrubs, where the water table is close to the surface and frequent temporary or seasonal flooding occurs. Treed swamps may resemble upland spruce forests or treed bogs until the vegetation and soil are characterized. Coniferous swamps may have up to 40 cm of organic (peat) soil. Bare soils are also common due to water fluctuations. Trees growing in swamps are usually closer in size to uplands and typically have a hummocky ground surface of moss. Vegetation indicators can be used to distinguish swamps from other wetland classes.

Coniferous Swamp:

Mixedwood Swamp:

Shrub Swamp:

MARSH

Landscape Indicators

- Form in depressional or level sites. Gradient level to gently sloping
- Found in a variety of locations, but common along margins of ponds or lakes, streams, and low-lying areas where the water table is at or near the surface for some or all of the year

Soil Indicators

- Mineral wetland - mineral soil with shallow (typically 0-8 cm but up to 40 cm) organic material
- Organic material is relatively well decomposed. Mineral soils comprised of loam (fine to coarse), clay loam, to sand
- Soils are mainly wet or saturated and frequently have mottling or gleying (blue-grey colour) within 40 cm
- Gleysols common. Permafrost may be present, but typically absent
- Nutrient regime medium to very rich

Hydrology Indicators

- Water comes from a mix of inputs (groundwater, surface water, and precipitation)
- Water table at surface or fluctuating within 50 cm of surface
- Water table fluctuates so that flooding/open water ranges from temporary to semi-permanent
- Open water ranges from 5-90% of marsh area, depending on site and weather conditions
- Imperfect to very poor drainage. Flooding frequent.

Vegetation Indicators

- Shrubs <10% cover. One species of graminoid tends to dominate or co-dominate with another.
- Graminoids: bluejoint reedgrass (*Calamagrostis canadensis*), beaked sedge (*Carex utriculata*), water sedge (*Carex aquatalis*), mannagrasses (*Glyceria* spp.), rushes (*Eleocharis* spp.)
- Forbs: marsh cinquefoil (*Comarum palustre*), vernal water-starwort (*Callitriche palustris*), bladderwort species (*Utricularia spp*.), horsetails (*Equisetum* spp.), common mare's-tail (*Hippuris vulgaris*), seaside arrow-grass (*Triglochin maritima*), white water crowfoot (*Ranunculus aquatilis*)
- Mosses: mosses (*Bryophyta* spp.), giant water moss (*Calliergon giganteum*), hook-mosses (*Drepanocladus* spp.)

Marsh Description: Mineral wetlands where water levels create temporary to semi-permanent flooding, and which are characterized by open conditions (< 1-3% shrub cover). Marsh plants are typically water-tolerant grass and sedge species and/or emergent vegetation such as rushes. Note, can be challenging to identify due to lack of standing water in dry seasons or dry years.

Graminoid Marsh:

SHALLOW OPEN WATER

Landscape Indicators

- Level and depressional sites. Gradient level to gently sloping
- Low lying areas or ponds that are naturally flooded seasonally to permanently
- May be associated wetland complexes or adjacent to lakes and river deltas

Soil Indicators

- Mineral wetland – characterized by loamy soil
- Organic material is relatively well decomposed
- Soils are mainly wet or saturated and frequently have mottling or gleying (blue-grey color)
- Soil may be exposed at surface in intermittent flooded systems
- Soils may be Gleysols, Brunisols, and Cryosols. Permafrost absent
- Nutrient regime medium to rich

Hydrology Indicators

- Permanent standing water up to 2 m deep; 15-70% open water
- Water comes from a mix of inputs (groundwater, surface water, subsurface runoff, and precipitation)
- Water table fluctuates with flooding, which may be frequent
- Little to no drainage (aquatic)

Vegetation Indicators

- Graminoids/Forbs: lesser panicled sedge (*Carex diandra*), water sedge (*Carex aquatilis*), marsh cinquefoil (*Comarum palustre*), bog buckbean (*Menyanthes trifoliata*)
- Aquatics: wild calla (C*alla palustris*), pond lilly (*Nuphar* sp.), water milfoil (*Myriophyllum* sp.), water-milfoil (*Myriophyllum spp.*), common hornwort (*Ceratophyllum demersum*), duckweed (*Lemna sp*.), bladderwort (*Utricularia* sp.), pondweeds (*Potamogeton*), muskgrass (*Chara spp*.)
- Mosses: notchwort (*Lophozia* sp.), giant water moss (*Calliergon giganteum*), hook-mosses (*Drepanocladus* spp.)

Shallow Open Water Description: Wetlands with standing water ≤ 2 m depth (NWWG 1997). Vegetation is predominantly floating or submerged aquatic plants. Note, some shallow open water wetlands may not have open water during the driest part of the year, and/or during drought years.

Shallow Open Water:

8. IDENTIFYING WETLANDS IN THE FIELD

This section outlines key field observations and data needed to help identify a wetland and determine wetland class and is based on the indicators described above (Section 6). Wetland classification can be difficult, and wetlands can occur in complexes with more than one wetland type.

1. Record **landscape** details of the site, including **position** of the site (i.e., is it located on elevated ground surface, in a depression, or toe of a slope), as well as the **condition** of the site and surrounding area that may indicate the wetland is in a natural or altered/disturbed state. If a wetland is disturbed by human or natural causes, it may exhibit atypical characteristics.
   - A description of slope gradients and positions can be found in Section 2 (Table 2.1 and Table 2.4, respectively) of the Yukon Field Manual for Describing Yukon Ecosystems (7).
2. Characterize the **soils** where possible. One way to do this is to characterize soils from a soil pit. This method entails selecting an area within the wetland representative of the site as a whole (similar topography and vegetation) and digging a soil pit of at least 50 cm or until mineral or frozen soil is identified. A soil auger could also be used.
   - Note the depth (in cm) of the organic soil layer above mineral or frozen soil, as referenced from the ground surface. There may be more than one organic layer, each representing different degrees of decomposition. Noting the characteristics and depth of the different layers may help distinguish the wetland class.
   - For organic soils, note the degree of decomposition to determine if the soil or soil layer is fibric, mesic, or humic. The von Post (VP) scale classifies peat decomposition from 1 (completely undecomposed, with all plant tissues identifiable) to 10 (completely decomposed with little or no plant tissue identifiable). The following method for determining peat decomposition using the VP scale is described in the Yukon Field Manual for Describing Yukon Ecosystems (7).
     - To determine the degree of composition, squeeze a sample of the organic soil between your fingers and observe the colour of the solution that is squeezed out, the nature of the fibre, and the proportion of the original sample that remains in your hand. Fibric peat consists of well-preserved fibre (40% or a VP = 1-4), identified after rubbing; mesic peat is intermediate composition between fibric and humic (VP = 5-6); and humic peat consists of decomposed organic material (10% or VP = 7-10), identified after rubbing. Table 3.21 in the Yukon Field Manual

for Describing Yukon Ecosystems (7) provides a thorough key for interpreting the rub tests to obtain a VP number.

- If permafrost is present, record the depth to the top of the frozen soil. Note that if frozen soil is encountered prior to September, the depth recorded may be seasonal frost.
- Record the depth of the water table from the ground surface and seepage, if present.
- For mineral soils, describe the texture of the soil including whether it is predominantly sand, silt, clay. Mineral soils can be roughly characterized in the field based on their texture, which varies according to the fraction of sand, silt, and clay that the soil contains (Table 2), as well as larger particles (e.g., pebbles and larger stones). Section 3 of the Yukon Field Manual for Describing Yukon Ecosystems provides more details on texturing and describing soils (7).

Table 2. Summary of primary soil particle textures.

Type	Particle size	Texture
Sand	0.06 - 2 mm	Texture is gritty to the touch, individual grains are visible to the naked eye; does not hold shape when wet unless mixed with clay.
Silt	0.003 - 0.06 mm	Smooth or floury to the touch, but gritty between teeth
Clay	<0.003 mm	Smooth texture, sticky to touch when moist

- Record if there is evidence of gleying, and the depth of prominent or distinct mottles (described in Section 8 of the Yukon Field Manual for Describing Yukon Ecosystems, 7). Mottles are typically characterized in the field by their abundance (% of mottles observed in the soil matrix), size (average diameter in mm), and contrast (difference in color between the mottles and soil matrix, where the difference is described as faint, distinct, or prominent).

3. Characterize the **hydrology** of the site.

- Review **weather conditions** leading up to the site visit (e.g., had it just rained in an otherwise dry period, was the freshet later or earlier than normal), as this information can help determine if the site is typical of normal conditions. Current weather and historical weather trends for the Yukon can be found at https://yukon.ca/en/your-government/about-yukon/find-weather-forecast.

- Note the proximity of the site to a stream or other flowing water course, lake and ponds, basins and depressions with poor drainage, upland, and/or other wetlands to determine potential sources of water or locations the wetland may contribute water to.
- Record the size and of depth of open water areas and the water table depth in reference to the ground surface (this may have been completed during a check of the soils if a test pit was dug or hole(s) augured).
- Describe the vertical and lateral movement of water, if any observed. Table 3.14 in the Yukon Field Manual for Describing Yukon Ecosystems (7) provides a description of the speed and extent of different drainage patterns of mineral soils. Similarly, the hydrodynamic index (Table 3) is a useful tool for characterizing water movement through soil at wet and very wet sites.
    - Horizontal flow can be either directly observed or inferred from drainage patterns adjacent to the site, the presence of bent vegetation, eroded soils, sediment deposits, and/or drift deposits.
    - The direction, magnitude, and rate of vertical (surface-subsurface) water movement can be observed by watching and timing the seepage of water into a freshly dug soil pit. Other indicators include water marks on trees or water-stained (blackened) leaves. Inundation may be visible from good quality aerial imagery, if available.

Table 3. Hydrodynamic Index (HI) describing the magnitude of vertical and lateral water movements in the soil on wet and very wet sites.

HI	Hydrodynamic Index (HI) Code Description
Stagnant (St)	Stagnant to very gradually moving soil water. Vertical fluctuations minimal. Permanent surface saturation but minimal or no surface flooding. Basins or hollows with stable water regimes. Abundant organic matter accumulation and high bryophyte cover.
Sluggish (Sl)	Gradual groundwater movement through peat or fine-textured mineral soils along a hydrological gradient. Minor vertical water table fluctuations. Semi-permanent soil saturation with some elevated microsites or brief periods of surface aeration. Hollows, slopes, and water tracks in basins or lake flats not directly influenced by the waterbody. Abundant peat accumulation and bryophyte cover.
Mobile (Mb)	Distinct flooding and drawdown or pronounced lateral water movements. Peripheral areas of peatlands, sites adjacent to open water tracks, small rivulets or ponds, small potholes with relatively stable water regimes, protected lake embayments, or backmarshes in estuaries. Can have deep but well-decomposed accumulations of peat. Patchy bryophyte cover.
Dynamic (Dy)	Significant lateral flow and/or strong vertical water table fluctuations through mineral soils. Potholes in arid climates that experience significant drawdown, wave-exposed shores, floodplain back channels, and protected estuary sites. Little organic accumulation, few bryophytes.
Very Dynamic (VD)	Highly dynamic surface water regime. Exposed tidal sites, shallow potholes in arid climates that experience significant drawdown, wave-exposed shores, and sites directly adjacent to and influenced by river flows. No organic accumulation or bryophytes.

- Test water or soil acidity (pH) during a period with little rain if uncertain whether wetland is a bog or a fen. Bog soils tend to be more acidic (pH < 4.5) than fens (pH > 4.5) when measured during drier periods. pH can be tested with a relatively inexpensive pH meter that has been calibrated following the manufacturers instructions.
  - Note: the acidity of a wetland will be diluted when there are high amounts of water within or passing through the wetland, such as during freshet. It is recommended that pH measurements be taken after freshet and not during or straight after large rain events.

4. Identify and record percent **vegetation** cover (described below) of as many species as possible within the wetland area. Photograph and collect a sample of unknown species to identify later. Multiple photos are recommended that include the unknown species in its surrounding habitat (including vegetation growing around it), and close-ups of the stem, leaf configuration, and seed or flower head to allow key characteristics to be assessed from field guides.

   Vegetation cover is measured by visually estimating the percent of the ground that would be covered by each form of vegetation if one were looking at the site from directly overhead (a.k.a. a bird's eye view). Figure 3 provides a visual guide to what various percentages of cover look like, and Figure 4 demonstrates how percent cover of different vegetation structures might be estimated. Recently taken drone imagery may be a useful aid for assessing tree cover if the image quality is good, but ground observations are needed to identify species.

Species are typically recorded by layer:

- Trees: woody plants > 5 m tall and >7 cm diameter at breast height (dbh)
- Tall shrubs: woody plants >2 m high and ≤7 cm dbh
- Medium shrubs: woody plants 0.5 - 2 m high and <7 cm dbh
- Low shrubs: woody plants 0.1 - 0.5 m high
- Herbaceous species and dwarf shrubs: non-woody species (forbs, graminoids, ferns), aquatics (floating and submerged plants), and dwarf shrubs (woody species < 10 cm tall at maturity)
- Bryophytes (mosses, liverworts, and hornworts) and lichens.
- Non-vegetated: recent disturbance (e.g., fire, flood) and no vegetation, or less than 5% cover of vegetation has established

Note On Field Planning:

The prevailing weather, hydrological, and ecological conditions should be considered when planning site visits. For example, field visits should be scheduled to coincide when plants are flowering, for easiest identification. Not all plants will go to seed at the same time, nor will they necessarily go to seed at the same time every year. More than one visit to an area during the grown season might be needed to collect sufficient information to identify an area as a wetland, and to identify the wetland (especially when considering changes in hydrological conditions over the growing season).

Figure 3. Visual guide for estimating percent cover of vegetation species, from the Manual for Describing Yukon Ecosystems (7).

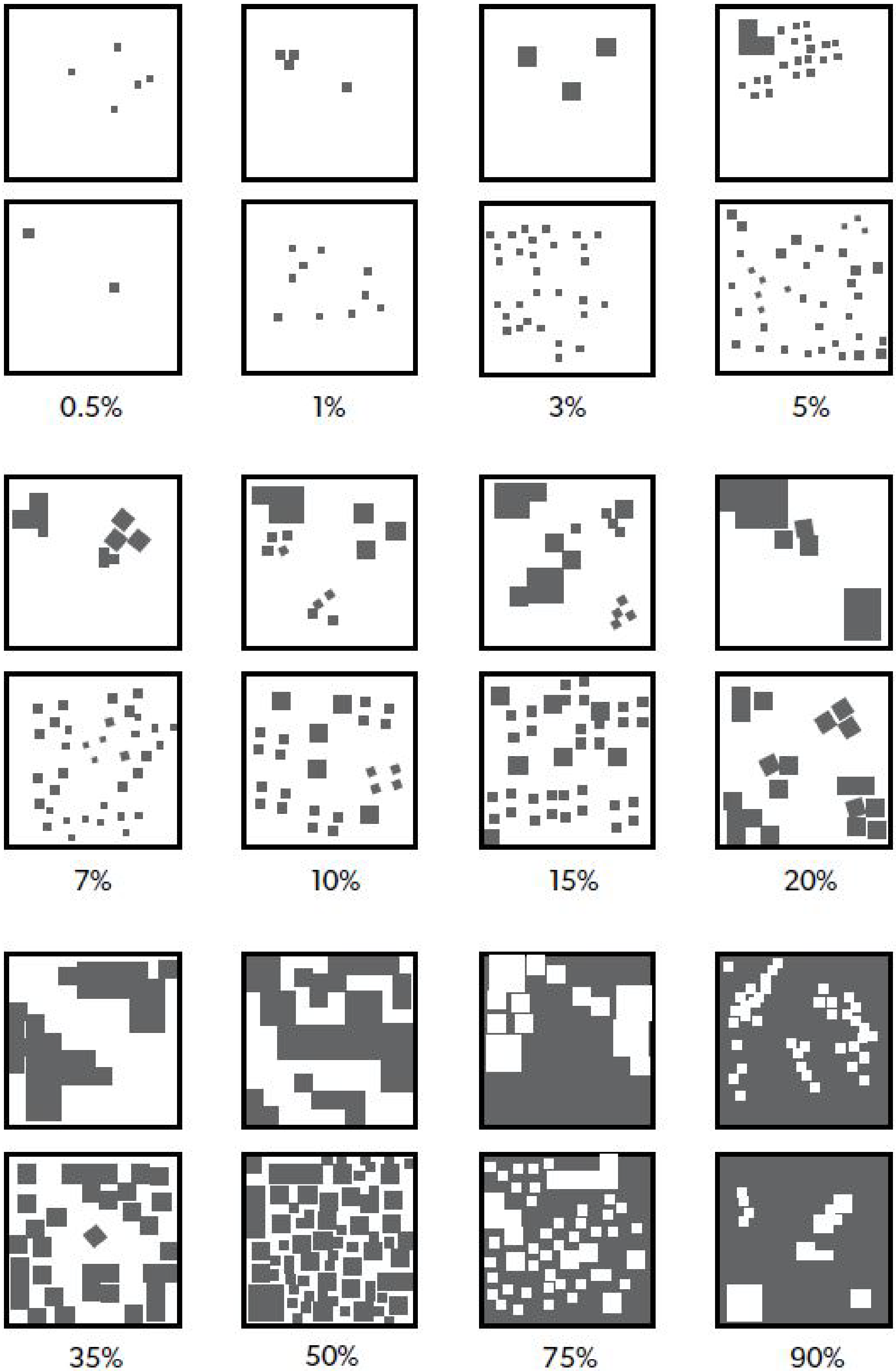
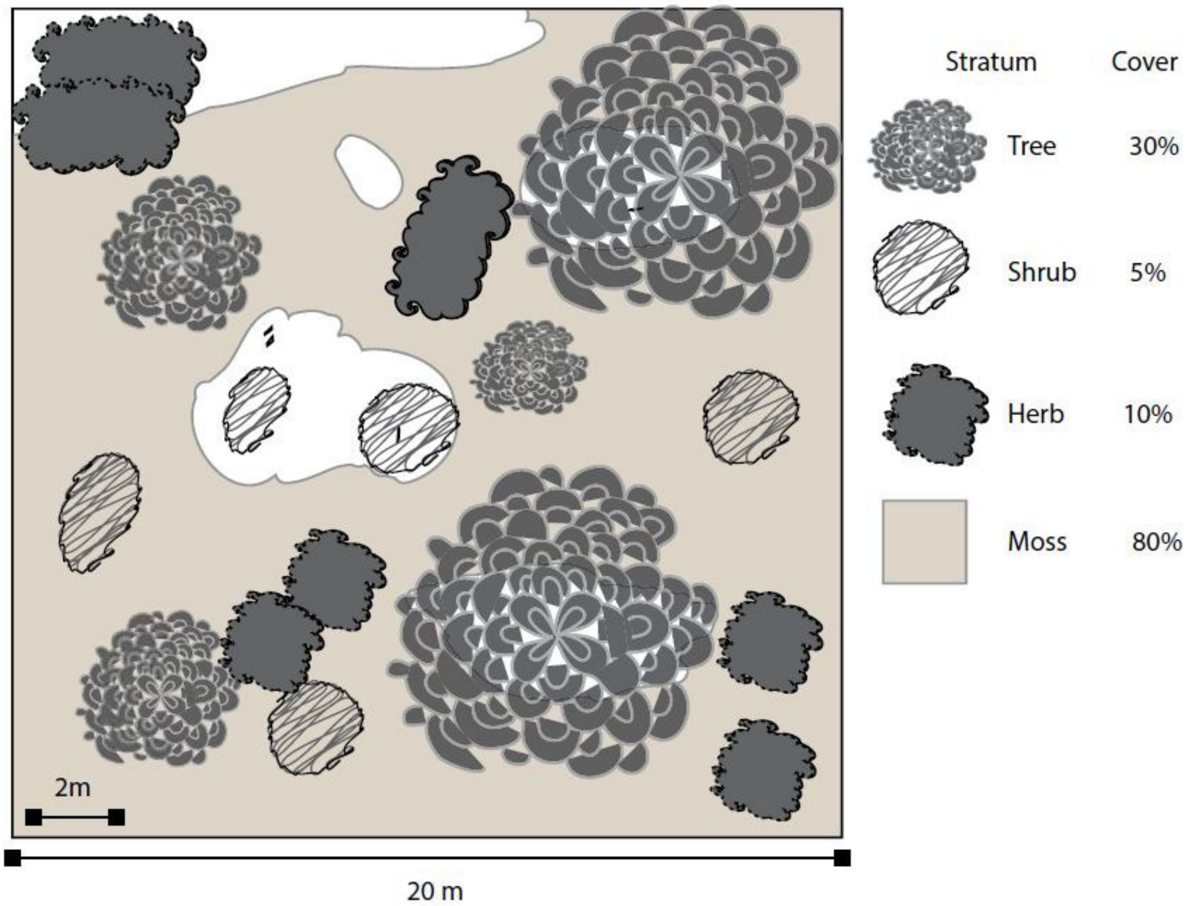


Figure 4. An example of determining percent cover of vegetation species, from the Manual for Describing Yukon Ecosystems (7).



9. IDENTIFICATION KEY

The following identification key is split into three charts:

- Chart 1 provides the pathways to identify treed wetlands
- Chart 2 provides the pathways to identify shrub wetlands
- Chart 3 provides the pathways to identify open, graminoid-dominated, and aquatic (open water) wetlands

The identification key assumes that the site is very moist or wet.

Following the sequence of questions will help lead you to identify the wetland classes. The wetland indicators and class summaries described in Sections 6, 7, and 8 are useful references for using the key.

Chart 1 Treed Wetlands

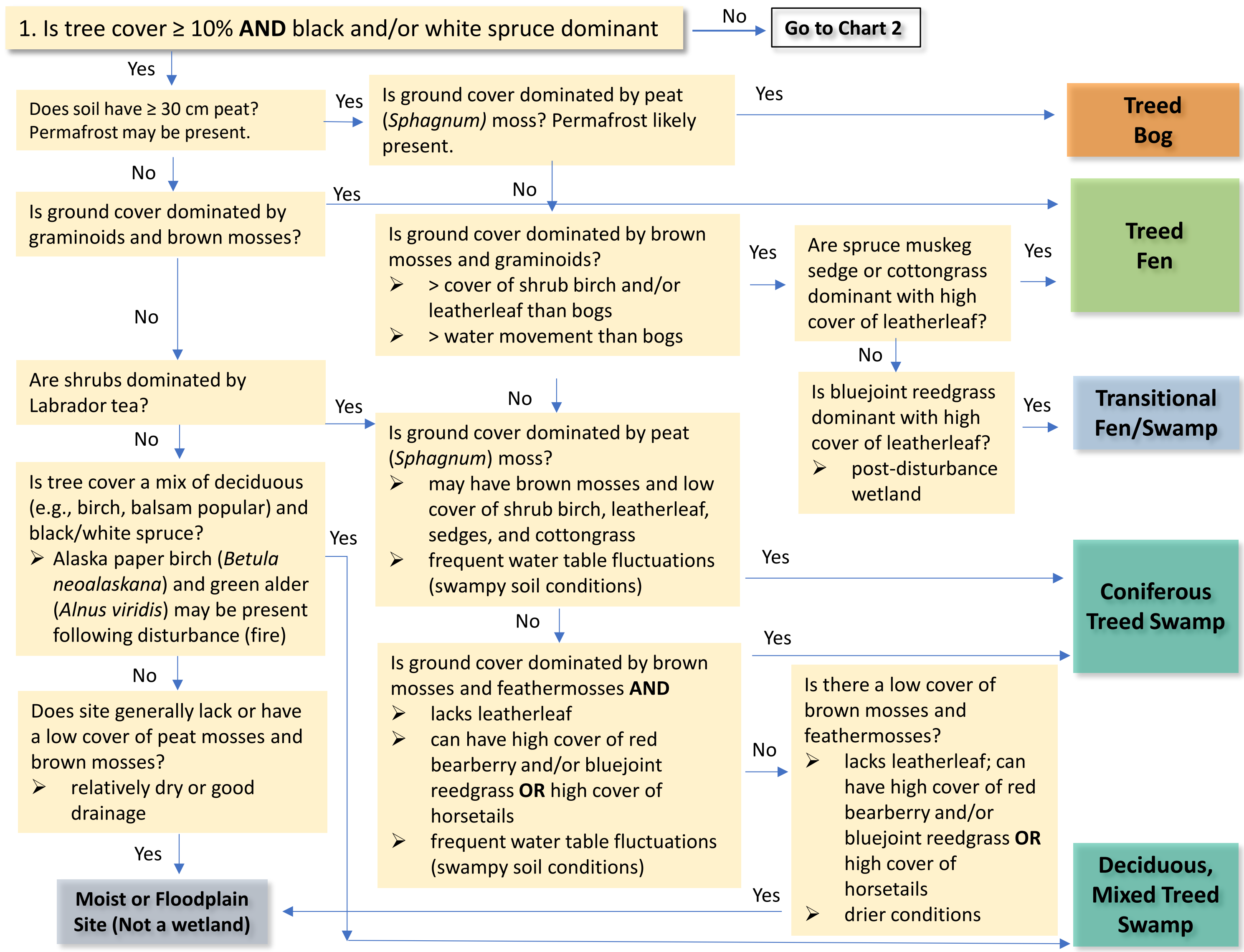


Chart 2 Shrub Wetlands

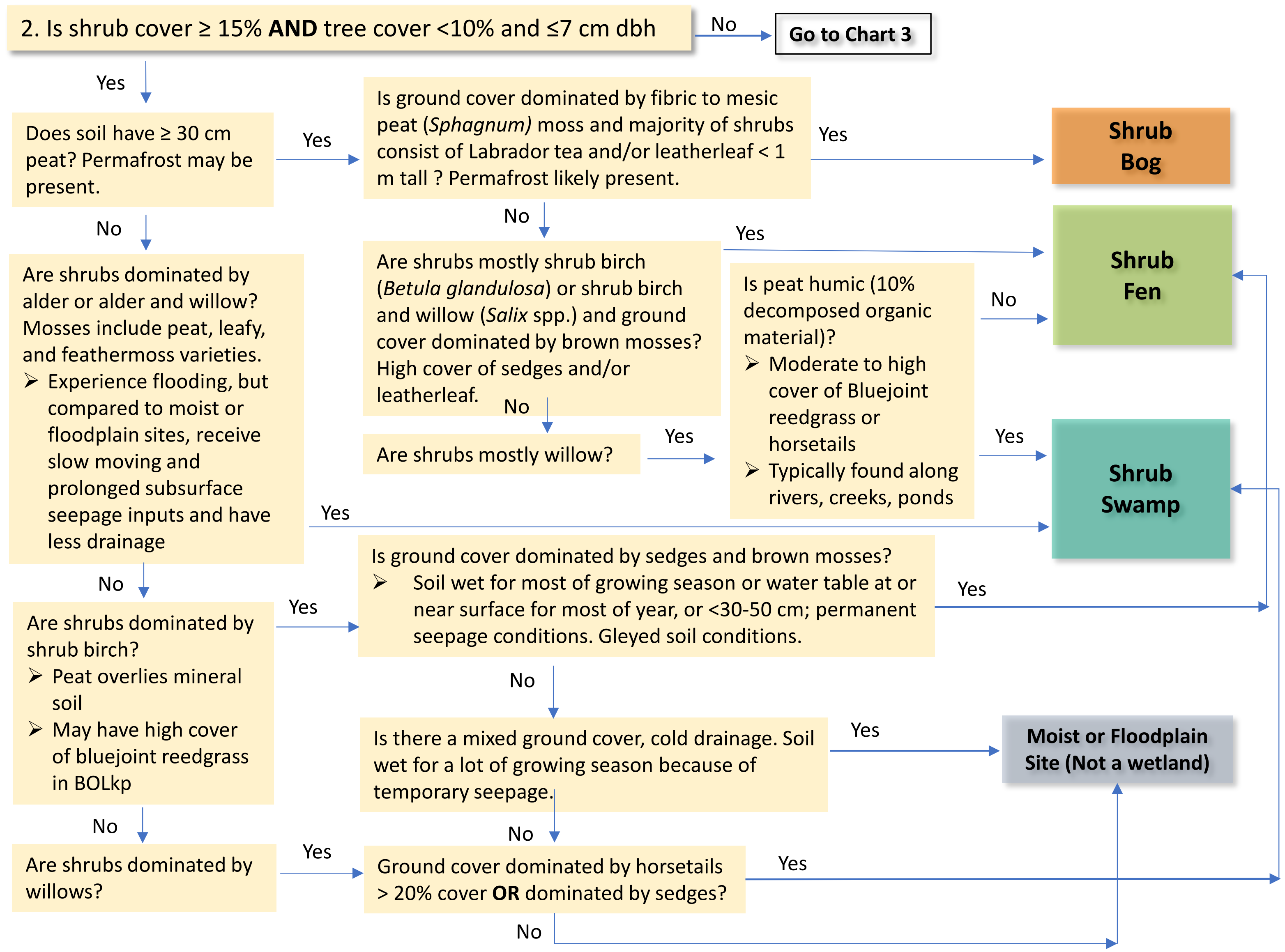
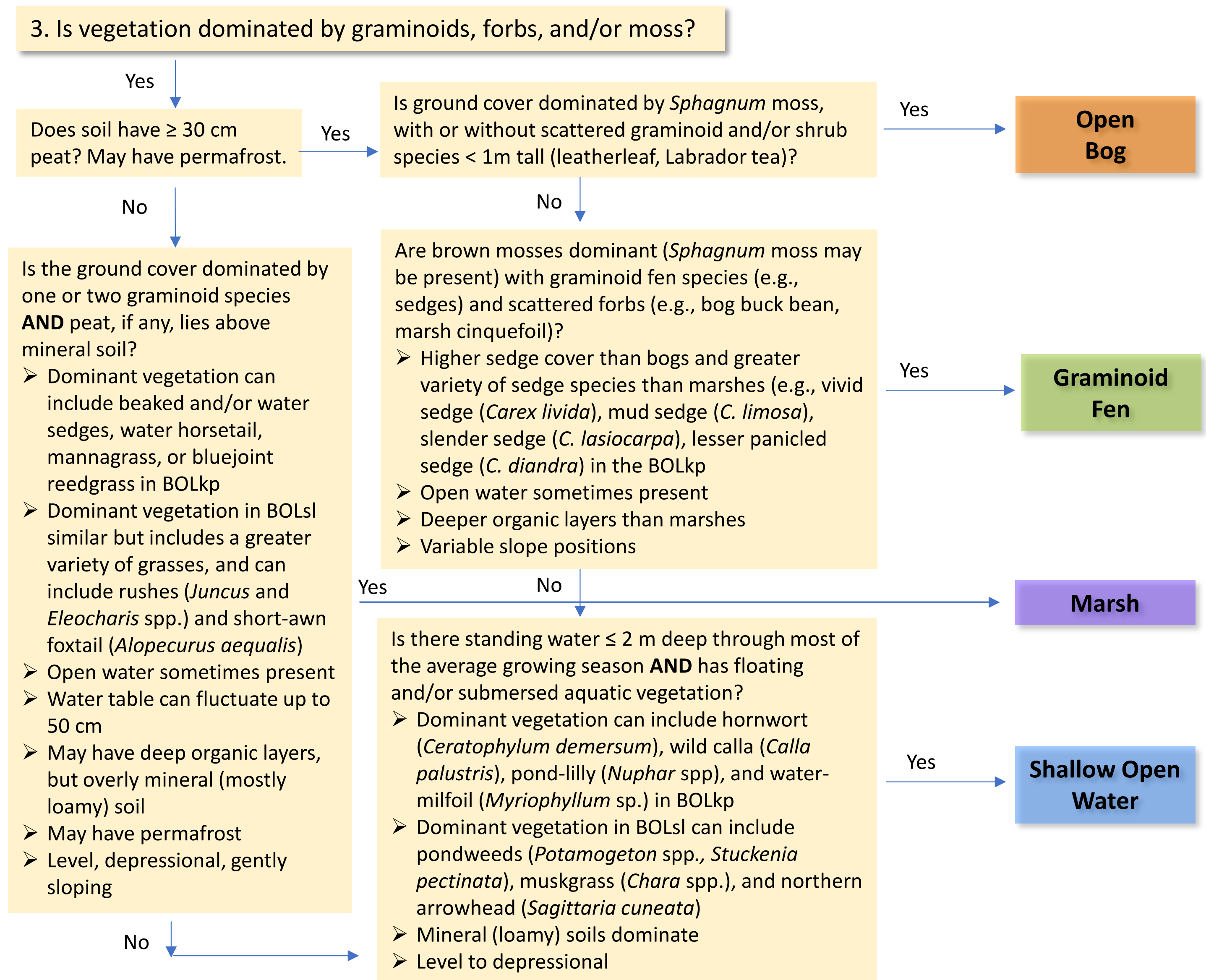


Chart 3 Open, Graminoid, and Aquatic Wetlands



10. CLOSURE

This KPMA handbook is intended to assist users identify wetlands commonly found in the Boreal Cordillera Ecozone using readily observable landscape, soil, water, and vegetation indicators. There are several resources available for further information, which have been cited throughout the document and are included in the reference list. This handbook is a living document, intended to be trialed by placer miners and revised as needed.

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