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SYNTHESIS OF TECHNICAL INFORMATION ON FOREST WETLANDS IN CANADA

TECHNICAL BULLETIN NO. 938

AUGUST 2007

by

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PRESIDENT'S NOTE

Forested wetlands represent a significant source of timber supply for forestry operations. Additionally, forested wetlands provide water filtration, carbon sequestration, peat, wildlife habitat and other non-timber values. To maintain wetland function across all uses, wetlands must be properly identified and managed. Understanding and identifying the location, features, functions and interconnectedness of wetlands across the range of Canadian ecotypes is a significant challenge to landscape planning.

Wetland inventories and classification systems have been developed by industry and both federal and provincial governments, but are limited in spatial extent and data quality according to the needs and tools available to developers. Unfortunately, existing standards are not consistent across jurisdictions. The Canadian Wetland Classification Scheme is the primary classification tool used; it delineates wetlands according to gradients of richness and wetness, organic versus inorganic, and major classes or types of wetlands, such as bogs, fens, marches, swamps, and shallow open water. When considering landscape use and planning, it is important to understand the definitions and ecological significance of these designations.

This report, written by Ducks Unlimited Canada, represents the most comprehensive effort toward understanding current forested wetlands in Canada. The report reviews existing definitions used in wetland classification, as well as classification schemes, standards, and limitations. Existing provincial and federal wetland protection guidelines and legislation, along with their ecological underpinnings, are detailed. The report also reviews the effects of industrial development on wetland function, along with approaches for, and effectiveness of, measures to mitigate impact.

Due in part to the various definitions used across jurisdictions, the level of protection afforded wetlands across Canada varies, with at least a minimum level of protection in all regions. Effects of industrial management in and around wetlands are difficult to assess, and are complicated by the position of a wetland within the surface and groundwater flow of an area, the hydrological connectivity of an area, and the often limited spatial and temporal scale of the studies in question. Current research is focused on understanding wetland hydrology, and the link between wetlands and uplands.

The report suggests that a greater understanding in three major axes of wetland research is needed: wetland identification and delineation, wetland spatial and temporal dynamics, and wetland hydrology. Each of these areas is co-dependent, and critical to understanding wetland function, management, and protection.

Ronald A. Yeske

August 2007

MOT DU PRÉSIDENT

Les milieux humides forestiers représentent une source significative d'approvisionnement en bois pour les opérations forestières. En plus, ils filtrent l'eau, séquestrent le carbone, contiennent des tourbières et des habitats pour la faune et représentent d'autres atouts non associés à l'exploitation forestière. Pour maintenir tous les usages associés à ces milieux humides, ils doivent être correctement identifiés et aménagés. La compréhension et l'identification de l'emplacement, des caractéristiques, des fonctions et des interconnexions entre les milieux humides des différents écotypes canadiens représentent un défi considérable pour l'aménagement du paysage.

L'industrie et les autorités fédérale et provinciales ont développé des inventaires des milieux humides et des systèmes de classification mais ces derniers sont limités au niveau spatial et au niveau de la qualité des données car ils dépendent des besoins et des outils utilisés lors de leur développement. Malheureusement, les normes existantes ne sont pas uniformes d'une juridiction à l'autre. Le système canadien de classification des terres humides est le principal outil de classification. Il définit les limites des milieux humides à partir des gradients de richesse et d'humidité, de la matière organique vs inorganique et des principales classes ou types de milieux humides tels que les bogs, fens, marécages, marais et eaux peu profonde. En matière d'utilisation et d'aménagement du paysage, il est important de comprendre les définitions et la signification écologique de ces désignations.

La firme Canards Illimités Canada a rédigé ce rapport qui renferme les résultats de recherche les plus détaillés permettant de comprendre les milieux humides forestiers présents au Canada. Les auteurs ont fait la revue des définitions actuellement utilisées dans la classification des milieux humides de même que les systèmes de classification, les normes et les restrictions. Le rapport présente la réglementation et les lignes directrices provinciales et fédérales portant sur la protection des milieux humides de même que leurs fondements écologiques. Le rapport fait également la revue des effets du développement industriel sur les fonctions des milieux humides ainsi que les approches et l'efficacité des mesures de mitigation des impacts.

La diversité des définitions de milieux humides d'une juridiction à l'autre est en partie responsable de la variation du niveau de protection à travers le Canada mais il existe un niveau minimum de protection dans toutes les régions. Les effets de la gestion industrielle à l'intérieur et autour des milieux humides sont difficiles à évaluer et sont compliqués par la position d'un milieu humide par rapport à l'écoulement de l'eau de surface et de l'eau souterraine d'une zone, la connectivité hydrologique d'une zone et les échelles spatiale et temporelle trop souvent limitées dans les études en question. La recherche actuelle met l'emphase sur la compréhension de l'hydrologie des milieux humides et la relation entre les milieux humides et les terres hautes.

Les auteurs mentionnent la nécessité d'améliorer la compréhension des milieux humides dans trois axes de recherche principaux : l'identification et la délimitation des milieux humides, les dynamiques spatiales et temporelles qui les caractérisent et leur hydrologie. Chacun de ces domaines est codépendant et crucial pour la compréhension des fonctions, de l'aménagement et de la protection des milieux humides.

Ronald A. Yeske

Août 2007

SYNTHESIS OF TECHNICAL INFORMATION ON FOREST WETLANDS IN CANADA

TECHNICAL BULLETIN NO. 938
AUGUST 2007

ABSTRACT

The present total estimated wetland coverage in Canada is 1,240,368 km^2 (Tarnocai 2001). The Canadian Wetland Classification System recognizes five major classes or types of wetlands: bogs, fens, marshes, swamps, and shallow open water. Wetlands can be broadly grouped into organic wetlands (also called peatlands) and mineral wetlands. Organic wetlands include fens and bogs, while mineral wetlands include swamps, marshes, and shallow open water. Both peatlands and mineral wetland classes have gradients in richness and wetness that produce a number of sub-classes (e.g., thicket swamp, conifer swamp etc.) within the five major classes. These classes and their ecological properties are discussed in detail. In addition, we supply a listing and brief review of classification systems used for wetlands across the country.

Wetlands provide a range of ecological goods and services that contribute to the Canadian economy and our well being. These services include timber production, non-timber forest products such as peat moss, habitat for wildlife, water filtration, and carbon sequestration. Wetlands are also a critical component of the lifestyle and values of Canada's Aboriginal peoples.

While federal-, provincial- and industry- developed inventories exist throughout the country, it should be noted that the quality and extent of wetland inventories depend on mapping limitations (e.g., mapping scale, remote sensing limits), data availability, and inventory purposes; thus, records of wetlands can be incomplete. We provide a list of inventories and standards that exist for forest wetlands.

An extensive body of Federal and Provincial legislation, policies and guidelines can affect wetland ecosystems. We review these in detail for Canada and each of the provinces individually. While most provinces have some protection for wetlands, the definition of a wetland varies across the country and thus, so does the degree of protection different wetland types receive.

A review of the literature regarding effects of industrial development including timber harvesting and silvicultural activities on forest wetlands clearly illustrates that this topic is not well studied. Recent work has demonstrated that examining wetland position within a surface and groundwater flow system can be a useful approach to identifying regional and local disturbance effects on wetlands and other systems. It is known that wetlands are susceptible to alterations in hydrologic connectivity which can, in turn, alter nutrient and water levels with subsequent effects on wetland function. Road placement on the landscape for example can potentially alter hydrologic connectivity by acting as a dam. Nevertheless, studies are often spatially and temporally too limiting to properly characterize wetland hydrology let alone predict disturbance effects. In addition to working to gain a better understanding of the connection between surface and ground water hydrology, researchers are currently trying to characterize forest wetland hydrology and identify connections between uplands and wetlands.

KEYWORDS

boreal, ecological functions, forest wetlands, roads, temperate, traditional values, wetland classification, wetland hydrology

RELATED NCASI PUBLICATIONS

None

SYNTHÈSE DE L'INFORMATION TECHNIQUE SUR LES MILIEUX HUMIDES FORESTIERS DU CANADA

BULLETIN TECHNIQUE N^{O} 938
AOÛT 2007

RÉSUMÉ

L'estimation de la superficie actuelle des milieux humides au Canada est de 1 240 368 km^2 (Tarnocai 2001). Le système canadien de classification des terres humides reconnaît cinq classes principales ou types de milieux humides : les bogs, fens, marécages, marais et les eaux peu profondes. Les milieux humides peuvent être grossièrement divisés en deux groupes : les milieux humides organiques (aussi appelés tourbières) et les milieux humides minéraux. Les fens et les bogs se classent parmi les milieux humides organiques et les marais, les marécages et les eaux peu profondes se classent, quant à eux, parmi les milieux humides minéraux. Les classes tourbières et milieux humides minéraux possèdent des gradients de richesse et d'humidité qui génèrent un nombre de sous classes (par ex., forêt marécageuse, marécage avec conifères, etc.) à l'intérieur des cinq principales classes mentionnées précédemment. Ce rapport comprend une discussion détaillée sur ces classes et leurs propriétés écologiques. De plus, nous incorporons une liste et une brève revue des systèmes de classification utilisés pour les milieux humides à travers le pays.

Les milieux humides fournissent un large éventail de biens et services écologiques qui contribuent à l'économie canadienne et à notre bien être. La production de bois, les produits forestiers non associés à l'exploitation comme la sphaigne, les habitats pour la faune, la filtration de l'eau et la séquestration du carbone entrent dans la catégorie des services. Les milieux humides sont également une composante essentielle du style de vie et des valeurs des peuples autochtones canadiens.

Les autorités fédérale et provinciales de même que l'industrie ont développé des inventaires des milieux humides à travers le pays mais la qualité et l'étendue de ces inventaires dépendent des restrictions de la cartographie (par ex., l'échelle des cartes, les limites de la télédétection), de la disponibilité des données et des objectifs des inventaires. Par conséquent, les données sur les milieux humides peuvent être incomplètes. Nous incluons dans ce rapport une liste des inventaires et normes reliés aux milieux humides forestiers.

Les écosystèmes des milieux humides peuvent être touchés par une panoplie de réglementations, de politiques et de lignes directrices, autant fédérales que provinciales. Nous effectuons la revue de ces outils en détail pour le pays en entier et pour chaque province. La définition de milieu humide varie à travers le pays, même si la plupart des provinces ont émis des mesures de protection pour les milieux humides. Par conséquent, le degré de protection associé aux différents types de milieux humides varie lui aussi.

Une revue de la littérature portant sur les effets du développement industriel (incluant l'exploitation forestière et les activités de sylviculture) sur les milieux humides forestiers illustre clairement que ce sujet n'est pas suffisamment étudié. Les travaux récents ont démontré que l'examen de l'emplacement des milieux humides par rapport au système d'écoulement de l'eau de surface et de l'eau souterraine peut s'avérer une approche utile pour identifier les effets des perturbations régionales et locales sur les milieux humides et les autres systèmes. Le fait que les milieux humides sont sensibles aux modifications de la connectivité hydrologique est reconnu. Ceci peut altérer les éléments nutritifs et les niveaux, altération qui produira à son tour des effets sur la fonction des milieux humides. L'emplacement d'une route dans le paysage, par exemple, peut potentiellement altérer la connectivité hydrologique en agissant comme un barrage. Néanmoins, les études sont souvent trop limitées au

niveau spatial et au niveau temporel pour caractériser adéquatement l'hydrologie des milieux humides et encore moins prédire les effets des perturbations. En plus d'améliorer la compréhension de la connexion entre l'hydrologie des eaux de surface et celle des eaux souterraines, les chercheurs tentent actuellement de caractériser l'hydrologie des milieux humides forestiers et d'identifier les connections entre le terres hautes et les milieux humides.

MOTS CLÉS

Boréal, fonctions écologiques, milieux humides forestiers, routes, tempéré, valeurs traditionnelles, classification des milieux humides, hydrologie des milieux humides

AUTRES PUBLICATIONS DE NCASI DANS CE DOMAINE

Aucune

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SYNTHESIS OF TECHNICAL INFORMATION ON FOREST WETLANDS IN CANADA

1.0 OVERVIEW: EXTENT, SPATIAL DISTRIBUTION AND ECOLOGY OF FOREST WETLANDS IN CANADA

1.1 Extent and Spatial Distribution

Canada has over 1,240,368 km^2 of wetlands representing 14% of the total land area (Tarnocai 2001). Peatlands represent 12% of the total, while mineral wetlands account for only 2% (Tarnocai 2001). Wetland distribution is driven by Canada's natural history, and past and present climates. For the purposes of this report, forest wetlands include all wetlands that are in forested regions of boreal and temperate regions of Canada.

1.1.1 Canada's Terrestrial Ecozones: Temperate and Boreal Forests

Ecozones represent large areas characterized by biotic and abiotic factors including regional climate, vegetation, soils, geology, and physiographic features. Canada has 15 terrestrial ecozones (Ecological Stratification Working Group 1996), ten of which contain boreal or cool temperate forests – and forest wetlands. These ecozones include the Boreal Plains, Boreal Shield, Boreal Cordillera, Taiga Plains, Taiga Shield, Taiga Cordillera, Montane Cordillera, Hudson Plains, Pacific Maritimes, and Atlantic Maritimes (Figure 1.1). While the scope of this report does not include the Prairie and Parkland ecozones it does include southern portions of the forested ecoregions undergoing permanent conversion from forest cover (e.g., agricultural conversion).

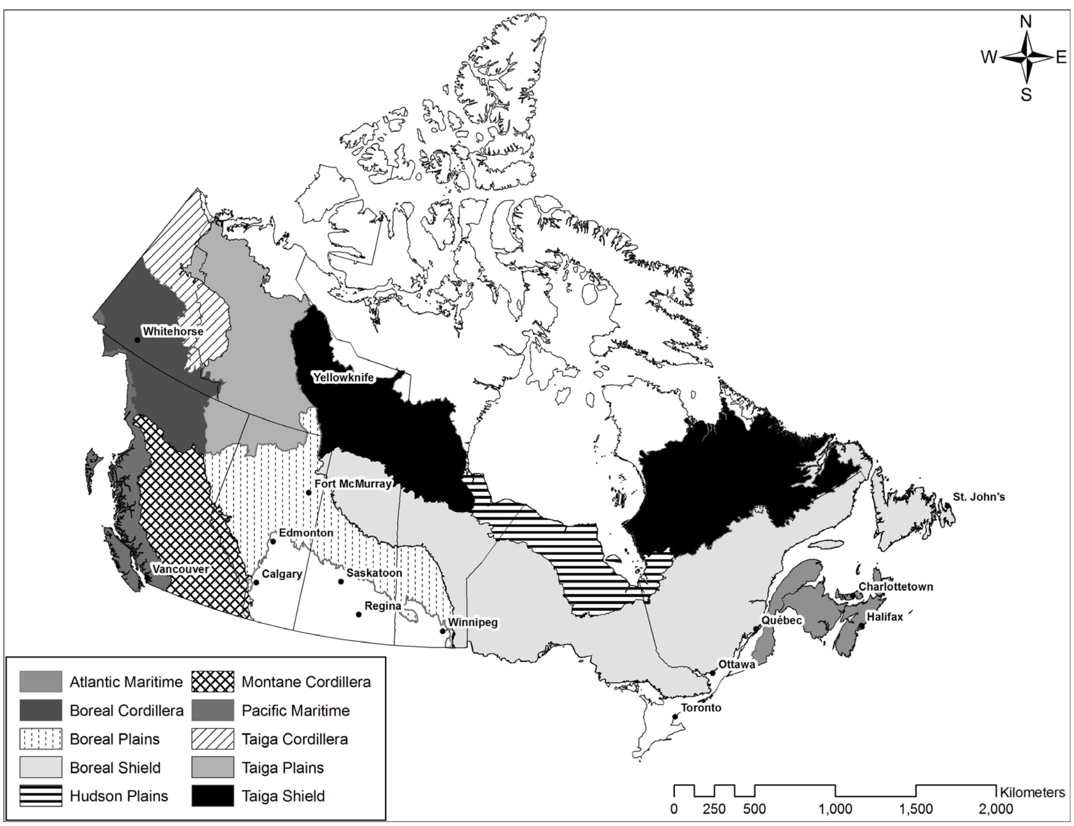

Figure 1.1 Canadian Ecozones That Include Temperate and Boreal Forests

1.1.2 Description of Boreal and Temperate Forest Ecozones

Variations in mean annual precipitation and temperature (Table 1.1), coupled with biophysical attributes, determine wetland distribution in the temperate and boreal forests of Canada. Most prominent are moisture and temperature differences between oceanic and continental climates. For example, the Pacific Maritime Ecozone can have a mean annual precipitation of up to 4000 mm compared the Taiga Plains or Boreal Shield that see as little as 200 mm mean annual precipitation. Mean annual temperatures show similar extremes with the lowest mean annual temperatures of -10°C in the Taiga Plains and Taiga Cordillera Ecozones and the warmest mean annual temperatures of + 9°C in the Pacific Maritimes Ecozone.

Table 1.1 Mean Annual Precipitation (P) and Mean Annual Temperature (T) for Boreal and Temperate Terrestrial Ecozones (based on data from the Ecological Stratification Working Group 1996)

Ecozone	Mean annual precipitation and temperature, wetlands area
Boreal Plain	P: 300 mm in northern Alberta to 625 mm in SW Manitoba T: -2°C to + 2°C
Boreal Shield	P: 400 mm in the NE to 1600 in maritime- influenced areas T: - 4°C in the NE to + 5.5°C in the east
Boreal Cordillera	P: < 300 mm in the rain shadow but up to 1500 mm coastal T: +1°C to + 5.5°C
Taiga Plain	P: Snow & freshwater ice for 6 – 8 months of the year; 200 – 500 mm precipitation T: - 10°C to - 1°C
Taiga Shield	P: 200 mm to 800 mm; but up to 1000 mm near Labrador T: - 8°C in the NE to 0°C in the east
Taiga Cordillera	P: < 300 mm in the north to 700 mm in the southeast T: - 10°C to – 4.5°C
Montane Cordillera	P: 500 mm to 1500 mm; but as low as 300 mm in arid regions in the south T: + 0.5°C to + 7.5°C
Hudson Plains	P: 400 mm to 800 mm T: - 4°C to – 2°C
Pacific Maritimes	P: 600 mm to 4000 mm T: + 4.5°C to + 9°C
Atlantic Maritimes	P: 900 mm to 1500 mm T: + 3.5°C to + 6.5°C

Further, soil parent material and surficial geological deposits characterize ecozones. Bedrock material strongly influences soil and water pH where there are shallow soils and bedrock outcrops. Such landscapes, e.g., the Boreal Shield Ecozone, have numerous wetlands and small to medium size lakes. Other ecozones, e.g., the Boreal Plains Ecozone, have deep surficial geological deposits and deep soils that result in a flat to rolling landscape and permit the development of extensive peatland and other wetland complexes. Because climate influences soils genesis, and soils and climates determine plant species distribution, ecozones represent these differences. Detailed descriptions are provided in Appendix A.

1.1.3 Wetland Distribution by Ecozone, Province and Territory

The present total estimated wetland coverage in Canada is 1,240,368 km^2 (Tarnocai 2001). The Canadian Wetland Classification recognizes five major classes or types of wetlands: bogs, fens, marshes, swamps, and shallow open water (NWWG 1997). A more detailed description of these wetland classes is provided in Section 1.1.4. The highest wetland densities (hectares of wetland/ecozone) are in the Hudson, Boreal, and Taiga Plains (Figure 1.2), but the total number of wetland hectares is highest in the Boreal Shield (Table 1.2).

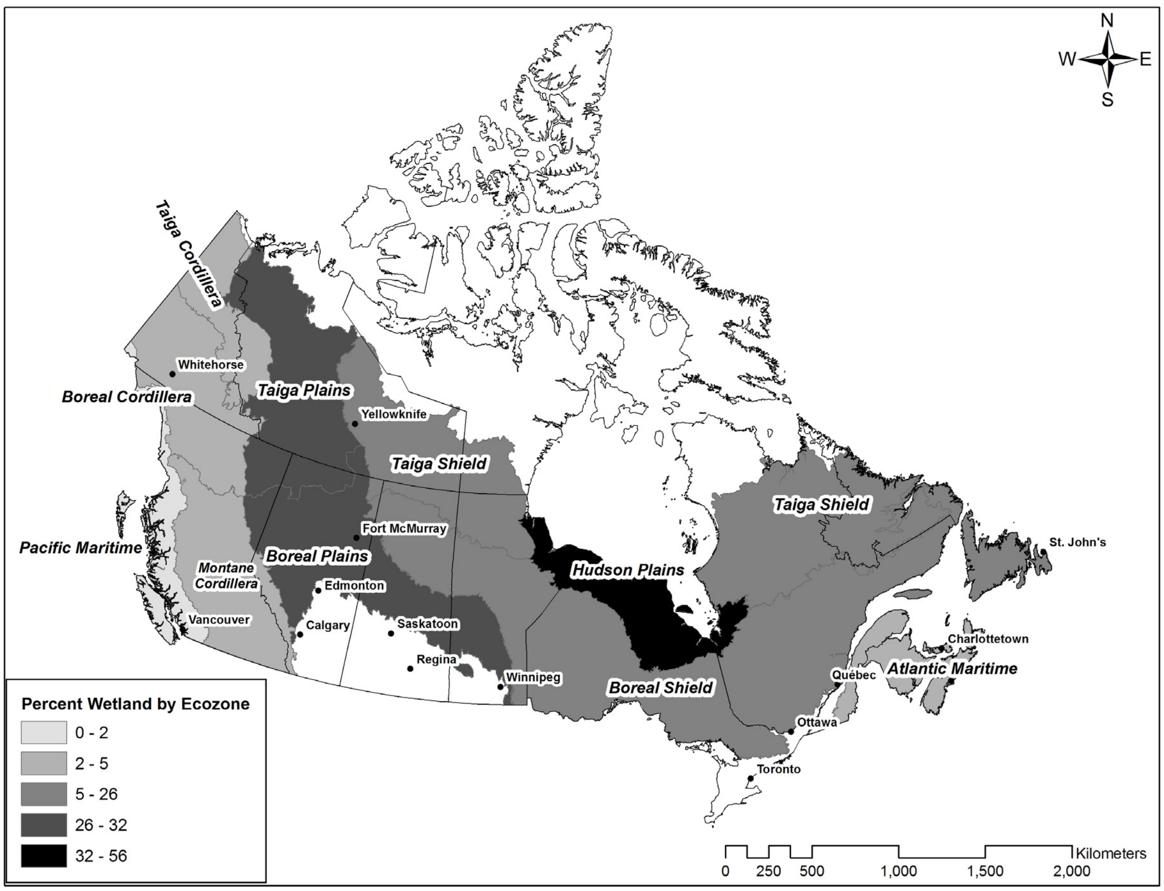

Figure 1.2 Map Representing Wetland Densities (hectares/ecozone) Stratified by Ecozones (Densities tend to be highest in the Hudson, Boreal, and Taiga Plains. The Boreal shield contains the highest number of wetland hectares. Map developed based on Polestar Geomatics: National Wetland Dataset, Environment Canada 1997).

Peatlands (bogs and fens) represent the larger portion of all wetland classes. Canada's climate and natural history promote and support the development and accumulation of peat across large areas. In Canada's boreal regions, peatlands cover large stretches of land that connect with other wetland types to create large (e.g., > 500 km^2) wetland complexes (DUC wetland database, unpublished). Peatlands generally exist where annual precipitation is >500 mm/year, biotemperature is <8°C, and evapotranspiration/precipitation ratios are <1 (Gignac, Vitt, and Bayley 1991). Thus, most Canadian peatlands are distributed in boreal and temperate regions where present climate can support this wetland type.

Table 1.2 Wetland Type Distribution by Province or Territory in km^2 (based on Tarnocai 2001)

Province or Territory	Bogs	Fens	Total Peatlands	Marshes	Swamps	Shallow Open Water	Total Mineral Wetlands
Alberta	64,488	33,992	98,480	15,833	0	1,999	17,832
British Columbia	49,350	11,166	60,516	47	9	39	95
Manitoba	134,117	71,943	206,060	9,377	202	6,154	15,733
New Brunswick	3,287	94	3,381	70	193	0	263
Newfoundland & Lab.	26,690	34,860	61,550	0	0	93	93
Nova Scotia	4,327	1,284	5,611	6	0	0	6
NWT and Nunavut	110,484	69,061	179,545	9,888	0	28,383	38,271
Ontario	231,115	115,816	346,931	398	5,460	510	6,368
Prince Edward Island	0	0	0	0	0	0	0
Québec	89,475	25,225	114,700	1,366	2,831	4,805	9,002
Saskatchewan	27,054	17,315	44,369	17,370	370	2,187	19,927
Yukon Territory	9,843	1,714	11,557	0	0	78	78
Total Canada	**750,230**	**382,470**	**1,132,700**	**54,355**	**9065**	**44,248**	**107,668**

Other wetland types, such as marshes, swamps, or shallow open water, exist in the boreal and temperate regions, but only contribute 2% of Canada's total wetlands (Tarnocai 2001). Such wetlands also exist throughout the more northern peatland regions but are more dominant south of peatland limits.

It should be noted that the quality and extent of wetland inventories depend on mapping limitations (e.g., mapping scale, remote sensing limits), data availability, and inventory type; thus, records of wetlands can be incomplete. Despite using the best available spatial data for Canada at the time, Tarnocai's 2001 wetland inventory for Canada faces some of the above limitations. For example, Tarnocai (2001) records no swamps for Alberta; however, finer scale inventories confirm that balsam poplar, tamarack, spruce and shrubby swamps do exist in this province (Forest et al. 2000; DUC inventory data, unpublished). Therefore, it must be recognized that in some areas, total wetland coverage may actually be higher than what is recorded in this latest data set.

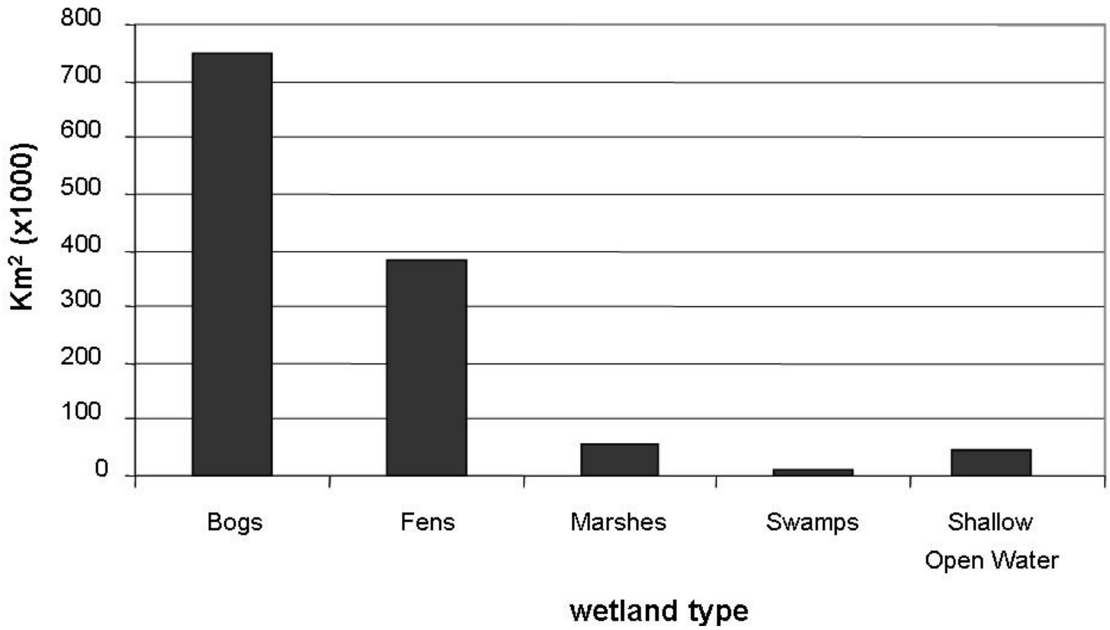

Figure 1.3 Graph of Distribution of Wetlands by Area in Canada by Each of the Five Major Classes [Wetland sizes combined with mapping constraints and conventions have likely resulted in under representation of marsh, swamp and shallow open water wetland classes (based on data from Tarnocai 2001)].

1.1.4 Description of the Five Wetland Classes: Bog, Fen, Swamp, Marsh, and Shallow Open Water

Wetland classes in Canada's temperate and boreal forest were based on research by wetland and soil scientists (NWWG 1987; Mitsch and Gosselink 1993; Sjörs 1982). The classification was developed based on hydrology, nutrient availability and representative vegetation. As a starting point, wetlands can be grouped into organic wetlands (also called peatlands) and mineral wetlands. This grouping is driven by peat accumulation and degree of decomposition that represents wetland hydrology (flooding regime) and ecology. In some classifications , wetlands are classified as peatlands based on an accumulation of at least 40 cm of *weakly* decomposed peat (NWWG 1988; MacKenzie and Moran 2004). Decomposition rates are measured on the von Post decomposition scale where weakly decomposed peat has a von Post value of <5. See Appendix B for full explanation. Organic wetlands/peatlands include fens and bogs, while mineral wetlands include swamps, marshes, and shallow open water. Both peatlands and mineral wetland classes have gradients in richness and wetness.

Swamps are occasionally also classed as peatlands; however, peat material found in swamps of temperate and boreal forests is often more decomposed (von Post > 5) and typically of silvic origin (see description of swamps below). Thus, better definitions for peatlands incorporate not only peat depths but also type and rate of decomposition of organic material that accumulates.

Other ecological factors that support the natural split into these five classes include a) flooding regime and associated nutrient inputs and water table fluctuations; b) connection or isolation to/from mineral-rich water; and c) climate and landscape position. Vegetation is a reflection of these combined factors and is generally used as a surrogate to classify wetlands. In many classifications, indicator species are used in conjunction with other variables, e.g., surface morphology, patterns, underlying soil, vegetation structure (see Section 1.3). The use of indicator species also allows for a more detailed classification of wetlands for in-depth management applications such as the conservation of rare species habitat. The following is a brief description of the wetland classes.

1.1.4.1 *Peatlands (Organic Wetlands)*

Peatlands are carbon sequestering systems because plant decomposition is slow in this cool, wet, acidic and anoxic environment (Turetsky, Wieder, and Vitt 2002). The major distinction between fen and bog peatlands is the connection or lack of connection to mineral and nutrient-influenced water. Bogs have no connection to groundwater but receive water mainly through precipitation. Fens, on the other hand, are hydrologically connected to the landscape by water that can carry dissolved minerals and nutrients that originate from rock, mineral soil, or decomposing materials.

Bogs

Bogs generally have a water table 40-60 cm below the peat surface, except coastal bogs in oceanic climates where the water table can be near the surface because of high precipitation and low evaporation levels. Bogs are typically considered ombrogenous peatlands, meaning they mainly receive moisture, and hence, nutrients from precipitation. However, recent research indicates that some mineral inputs may be occasionally delivered by hydraulic conductivity (capillary action) in the peat column. Despite this finding, bogs are nutrient poor-systems and minerals and nutrients are mainly introduced by aerial deposition (dust, ash, pollen, etc.). Bog systems are dominated by *Sphagnum*, a moss genus that can acidify its surroundings by giving off hydrogen ions and locking up cations. Thus, bogs are acidic ecosystems with pH below 4.5 and are dominated by oligotrophic *Sphagnum* sp., feathermosses (*Pleurozium schreberi* and *Hylocomium splendens),* and lichens (*Cladonia* sp. and *Cladina* sp.*)*.

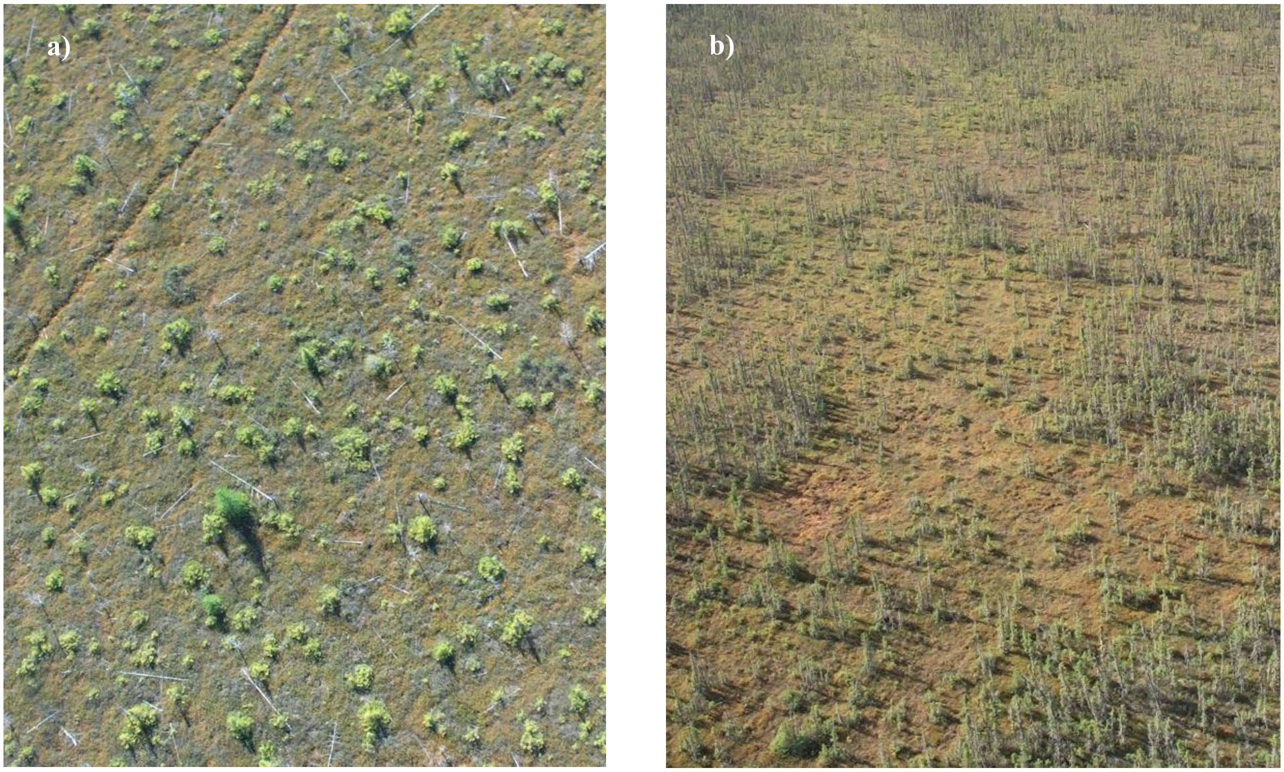

Figure 1.4 a) Continental Bog *Sphagnum fuscum* (brown-coloured *Sphagnum*) with Stunted Sparse Black Spruce [Deadfall are remnants from an old forest fire; note caribou trails in upper left]
b) Continental Bog with Typical *Sphagnum fuscum* (brown-coloured *Sphagnum*) Species That Grows in Hummocks in Bogs and Poor Fens

There are four main types of bogs: open (i.e., no trees), lichen covered, shrubby, wooded or forested (Figure 1.4). In oceanic climates bogs may have concentric or parallel patterns of wet sections (flarks) and dry sections (strings). In Canada, the only tree species in bogs is black spruce (*Picea mariana*) which is usually sparse and stunted.

Bogs have two distinct peat layers: the acrotelm and catotelm. The top living *Sphagnum* layer (acrotelm) can contain and release large amounts of water to maintain the water table. The lower, dead layer (catotelm) can store large amounts of water. We know from peat harvesting and restoration work that there is a fragile balance between the living top layer and hydrology (Wieder and Vitt 2006; Rydin and Jeglum 2006). Once the acrotelm is removed, as for road building or peat harvesting, establishment of a new living acrotelm layer can be difficult (see also Section 3.0).

An additional feature in bogs is permafrost. Permafrost is common in large regions in northern Canada, but at its southern limits it is discontinuous and restricted to bogs where it forms peat plateaus and peaty permafrost mounds called palsas (Vitt 1994). Permafrost exists at the southern limits because *Sphagnum* has high insulation values and maintains lower surface water temperatures.

Fens

In fens, the water table is at or near the peat surface. Fens are influenced by surface and/or groundwater that can vary in mineral and nutrient richness and as a result, they are important systems in many boreal regions where they connect with other wetlands and deliver water and nutrients. For example, in the lower MacKenzie River valley, many channel fens funnel runoff from snow melt and rain events into river and lake basins (Quinton, Hayashi, and Pietroniro 2003).

Three broad categories are generally recognized for fen peatlands: poor, moderate-rich and extreme rich. Poor fens have a lower number of plant species, while extreme-rich fens have a higher number of plant species. The wetland chemical gradient was first correlated with a number of plant species (vascular and non-vascular species) by Sjörs (1952). Other research since then also supports these or similar classifications (Vitt, Bayley, and Jin 1995; Vitt and Chee 1990; Belland and Vitt 1995).

1. Poor fens are acidic (pH 4.5-5.5). They are dominated by oligotrophic and mesotrophic species of Sphagnum (Figure 1.4). Poor fens are more similar to bogs than to the richer fen classes because as Sphagnum builds up and separates the fen system from the mineral-influenced water, the Sphagnum community becomes more oligotrophic and in turn further acidifies its surroundings. Poor fens have few mineral inputs and the low pH promotes species similar to those in bogs. Continental poor fens are also drier when compared to the richer fen classes. Oceanic fens, as bogs, are much wetter due to higher precipitation and lower evaporation.

2. Moderate-rich fens have slightly acidic to neutral pH (5.5-7.0) and have low to moderate alkalinity with a ground layer of brown mosses (Drepanocladus, Brachythecium, Calliergonella), and low abundances of mesotrophic species of Sphagnum (Vitt, Bayley, and Jin 1995; Vitt and Chee 1990; Belland and Vitt 1995).

3. Extreme-rich fens have a basic pH (above 7.0) and thus high concentrations of base cations, and high alkalinity. They are characterized by species of Drepanocladus, Scorpidium, and Campylium and in areas where the underlying material is calcareous, may contain calcium-rich mud called marl deposits (Vitt and Chee 1990, Belland and Vitt 1995). The fens in the Churchill, Manitoba region where calcium carbonate-rich sedimentary rock provide high alkalinity and pH are one example.

While the only tree species in Canadian bogs is black spruce (*P. mariana)*, fens contain both black spruce and tamarack or larch (*Larix laricina)*. Treed moderate-rich fens typically contain both species while extreme-rich fens are dominated by tamarack and contain little or no black spruce (Figure 1.5).

a) b)

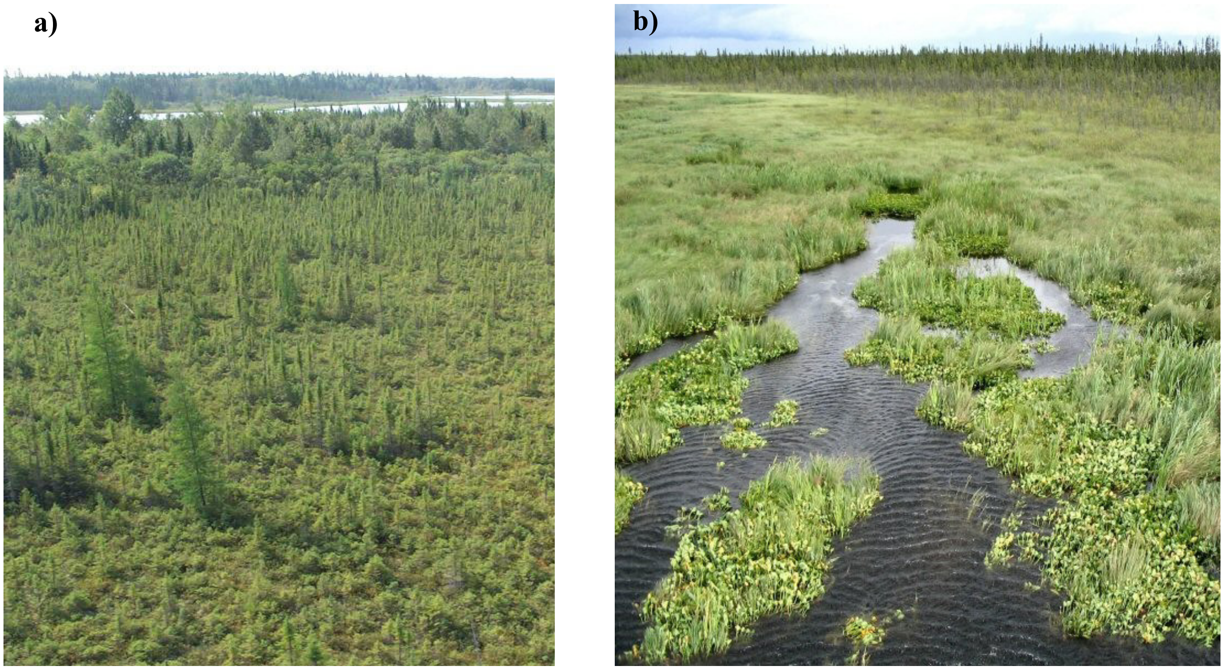

Figure 1.5 a) Treed Poor Fen with Tamarack and Black Spruce in Foreground and Swamp in Background b) Graminoid-rich Fen with Flowing Water, Buckbean and *Carex* spp., with Bog in Background

1.1.4.2 *Mineral Wetlands: Swamps, Marshes, Shallow Open Water*

Mineral wetlands are nutrient-rich systems with some organic accumulation but without the deep, weakly decomposed deposits of peat. Because of high nutrient cycling and decomposition rates caused by fluctuating water levels, relative to peatlands, mineral wetlands do not sequester large amounts of carbon.

Swamps

Swamps are associated with fluctuating water tables and woody vegetation (shrubs and trees). Generally they are adjacent to open water bodies (lakes or rivers) or are transitional zones between fens or marshes and uplands. Canopy cover is generally high (>70%) and peat accumulation consists of silvic peat that is generally well decomposed. Swamps can be nutrient-poor or -rich, representing a gradient from the rich swamp to the treed bog. Species richness (the number of species) may be a reflection of nutrient richness.

As mentioned above, swamps are sometimes considered peatlands but lack the weakly decomposed peat of sedge or Sphagnum-like bogs or fens. Rather, the substrate is silvic peat and well decomposed. Decomposition is driven by fluctuating water levels absent in peatlands. Some swamps soils may be termed peatyphase soils (Racey et al. 1996) but do not have the weakly decomposed peat of peatlands (see Soil Classification Working Group and Agriculture and Agri-Food Canada 1998 for definition and detail of organic order).

Swamps are mineral wetlands that are treed or dominated by shrubs. Treed or forested swamps are wetlands but are often treated as upland forests from a forestry perspective because they are often included in forest inventories, are of merchantable quality and size, and are therefore eligible to be harvested. Productivity of swamps is driven by seasonal, nutrient-rich flooding and thus swamps also exhibit a gradient in nutrient richness, productivity, and species assemblage. Vascular vegetation consists of trees, shrubs, graminoids and herbs that can be rather large (showing a lot of vigour/extreme growth). Bryophytes are limited by their sensitivity to changing water levels but can be abundant in poor conifer swamps where water table fluctuations are not as severe and nutrient inputs are lower. Because of the flooding regime, water chemistry is influenced by the flood occurrences and associated nutrients. Generally, swamps are more nutrient-rich than bogs and have a higher pH.

Depending on the regional climate and other conditions, the same tree species may not be swamp species in all areas. For example, yellow birch can be found in swamps in northwestern Ontario but is considered an upland species in Québec. Tamarack may also be associated with swamps, fens, and upland sites. Thus, swamp tree species can include black spruce (*Picea mariana)*, tamarack (*Larix laricina),* balsam fir (*Abies balsamea),* eastern white cedar *(Thuja occidentatlis),* balsam poplar *(Populus balsamifera),* white birch *(Betula papyrifera),* yellow birch *(Betula alleghaniensis),* green ash (*Fraginus pensylvanica*), black ash (*Fraginus nigra*), silver maple (*Acer saccharinum*), American elm (*Ulmus Americana*), western red cedar *(Thuja plicata)* and yellow cedar *(Chamaecyparis nootkatensis)* in varying combinations.

Bare, silvic peat is often typical of a deciduous swamp forest floor and hollows are common in both deciduous and conifer swamps. Depending on the season, these hollows may be water-filled but are generally not vegetated. Swamps may have gentle water flow or pooling water, although the water table level may drop below the rooting zone of the vegetation. When this occurs, roots are in an aerated zone, at least seasonally, that allows for healthy plant growth and decomposition processes.

Water table fluctuations and nutrient inputs into swamps can be influenced by river or lake water levels or by overland flow. Flooding is seasonal and is generally related to precipitation patterns and run off. Swamps on floodplains (including islands in rivers or lakes) may be flooded annually in the spring and/or fall depending on the annual snow/rainfall. However, flood patterns are not necessarily annual events, being dependent on precipitation patterns and in northern regions, ice jams.

Swamps may be described by the dominant species or group of species, e.g., ash swamp, hardwood swamp, cedar swamp, spruce swamp, or conifer swamp (Figure 1.6). Swamps dominated by shrubs such as willow, alder, or dogwood are often called thicket or shrubby swamps. If a swamp is forested, trees are generally tall (at least >10 m, but in most cases much taller) and the understorey consists of shrubs, herbs, graminoids, and bryophytes on raised areas.

Depending on moisture levels, swamp soils are typically composed of gleysols (type of soils that develop under wet or permanently saturated conditions) and have mottling in the upper horizons and gleying (dull grey to olive-green or blue colour) in the lower horizons (Soil Classification Working Group and Agriculture and Agri-Food Canada 1998). Mottling (the mottles are iron and manganese oxides) occurs in a soil that has been inundated with water intermittently (Soil Classification Working Group and Agriculture and Agri-Food Canada 1998). Gleying occurs during the chemical reduction of iron, thus changing the soil colours (Soil Classification Working Group and Agriculture and Agri-Food Canada 1998).

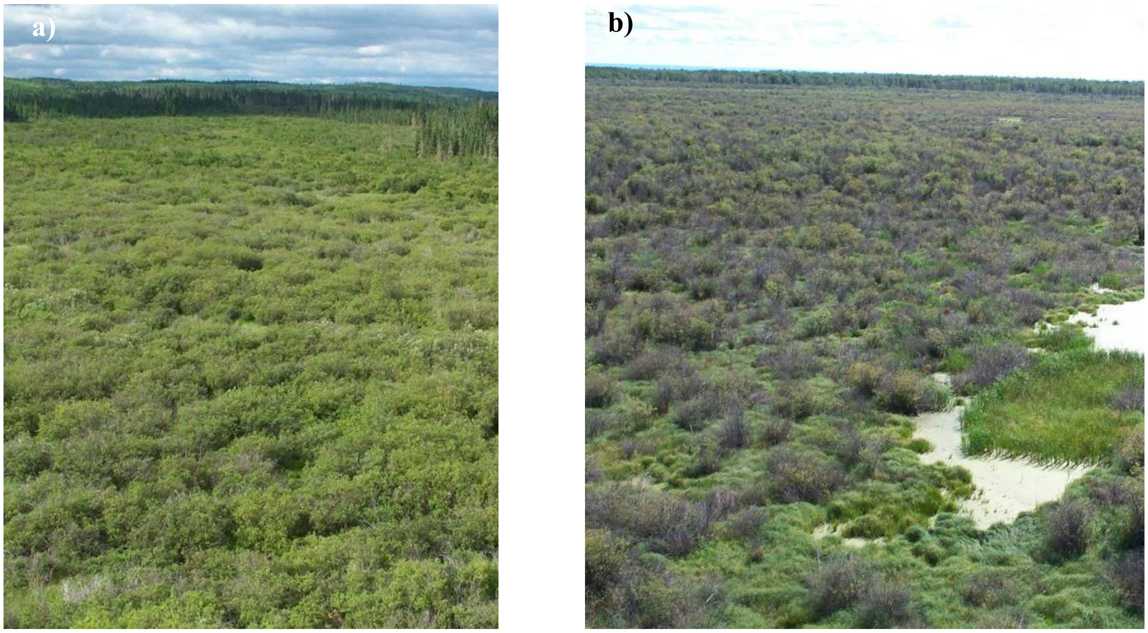

Figure 1.6 a) Thicket (shrub) Swamp with Willow and Alder b) Thicket Swamp with Open Water, Willows, and Alder [Note dead shrubs caused by fluctuating water levels.]

Marshes

Marshes occur in shallow water, along the shorelines of lakes and ponds, slow-moving rivers or in oxbows, channels, and deltas (e.g., Peace-Athabasca Delta). Vegetation is typically dominated by emergent and submerged plants, and plant cover is > 25% (Figure 1.7). Marshes are mineral wetlands that are permanently or seasonally inundated by standing or slow-moving water. Surface water levels may fluctuate seasonally with draw-down periods, especially in late summer and fall. They are nutrient-rich systems with high rates of production and decomposition; thus peat accumulation is limited. They can be distinguished from aquatic systems by midsummer water depths of less than 2 m.

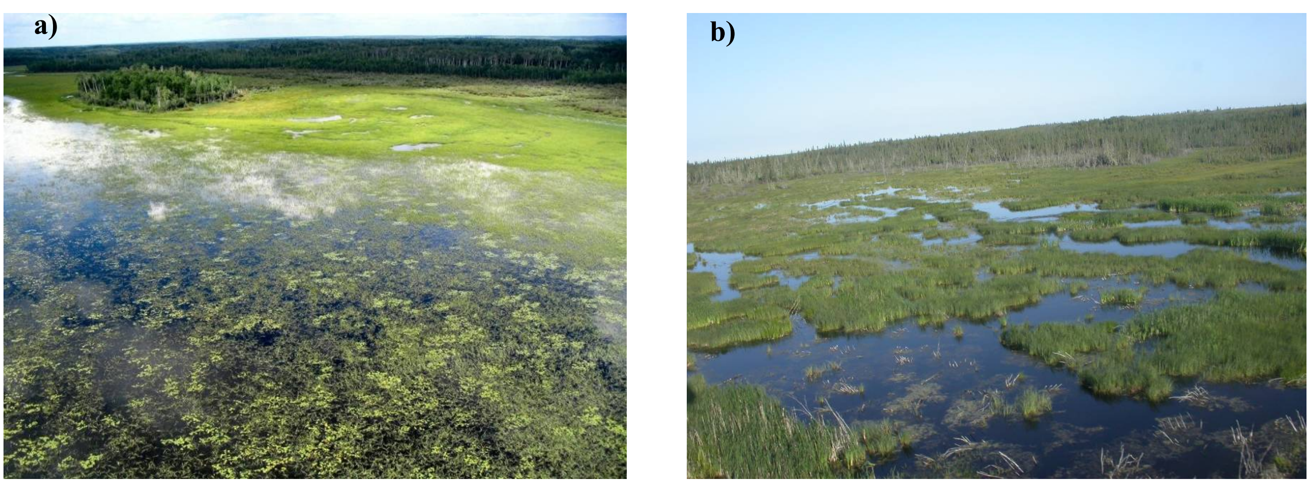

Figure 1.7 a) Emergent Marsh with Wild Rice, *Carex* spp. and Floating *Nuphar* spp. b) Emergent Marsh with Cattails

Some marshes (meadow marsh/beaver meadow) have little or no standing water for most of the growing season, are densely covered with graminoids (e.g., *Calamagrostis canadensis*) and have a tussocky or hummocky terrain, whereas open water marshes can have as little as 25% emergents, floating or submergent species. Some marshes may have less plant cover during poor production years (e.g., cool summer) but may still be classified as a marsh. They are nutrient-rich systems with high plant production rates during the summer months. Marsh water chemistry is related to associated water sources and surrounding land. Marshes are often named by the dominant vegetation (Table 1.3) such as *Typha, Scirpus* or a descriptive name of the community type (e.g., graminoid marsh).

Marsh substrate is mineral or organic soil. Organic substrate is composed of soft, unconsolidated sedimentary material formed beneath standing water and made up of a mixture of mineral material and well decomposed organic material, colloquially known as *muck* or professionally as *gyttja*. The material is soft, oozy, and semi-suspended. Mineral substrates can include or be composed of sands, gravel, rock, bedrock, or gleysols.

Table 1.3 Vegetation Classes in Marshes (after Harris et al. 1996)

Vegetation Type	Description	Example
Emergent	An upright plant rooted in substrate beneath the water or exposed to seasonal flooding but emerging above water surface; does not include plants that have flowering parts above the water surface but are otherwise entirely under water.	*Scirpus* spp., *Phragmites australis, Zizania palustris*, *Typha* spp., or *Sparganium* spp.
Floating	Rooted or free-floating, leafed plants with leaves normally floating on the water surface. Some species such as *Potamogeton* have floating as well as submerged leaves; however, the submerged leaves represent a larger part of the plant and the genus is considered a submergent species.	*Nuphar spp., Brassenia schreberi, Nymphaea spp., Spirodela polyrhiza,* or *Lemna spp.*
Submergent	Plants that are normally submerged under water. Some species may have flowering parts that break the water surface. Some species such as *Potamogeton* have floating as well as submerged leaves; however, the submerged leaves represent a larger part of the plant and the genus is considered a submergent species.	*Potamogeton* spp., *Ceratophyllum demersum, Elodea canadensis*, or *Utricularia vulgaris*

Shallow open water

The shallow open water wetland class has less than 2 m water depth and less than 25% plant cover of emergent, floating or submerged vegetation. Areas that have a water depth of less than 2m but over 25% vegetation (e.g., floating such as *Nuphar*, or emergent such as *Zizania*) are considered marshes (Figure 1.8).

Shallow open water is a distinct wetland type often located between saturated and seasonally wet sites, marshes and typical deep “lake-like” aquatic ecosystems (e.g., ponds, lakes, rivers). The class exists because the shallow depth subjects the substrate to nutrient and gaseous exchange, oxidation, decomposition, and light penetration regimes which are different in deeper aquatic systems (Mitsch and Gosselink 1993; NWWG 1988). These reactions allow for the presence of a host of different species, plants and animals (especially invertebrates), and thus create a unique ecological class.

The substrate, as in marshes, is mineral or organic soil. Organic substrate is composed of soft, unconsolidated sedimentary material formed beneath standing water and made up of a mixture of mineral material and well decomposed organic material (*muck* or *gyttja*). The material is soft, oozy, and semi-suspended. Mineral substrates can include or be composed of sands, gravel, rock, bedrock, or gleysols.

Figure 1.8 a) Shallow Open Water Pond [Note vegetated portion in the foreground is a marsh but where the vegetation thins out to less than 25 % cover, the wetland class becomes shallow open water.] b) Shallow Open Water with Surrounding Meadow Marsh

1.2 Ecological Function

1.2.1 Wetland Classes and Ecological Function

Most of Canada's present landscape was strongly influenced by the last glacial period and the surface areas that were left behind after glaciers and glacial lakes melted. Climate and hydrology strongly influenced the development of both mineral and organic wetlands. Wetlands can exist where precipitation exceeds evapotranspiration or where groundwater systems feed surface water wetlands. Organic wetlands however, generally exist where annual precipitation is >500 mm/year, biotemperature is <8°C, and evapotranspiration/precipitation ratios are <1 (Gignac, Vitt, and Bayley 1991). Therefore, most Canadian peatlands are distributed in boreal and temperate regions where the present climate can support this wetland type.

Wetland types are driven by hydrology and flooding regimes that determine nutrient inputs and water table changes or stability. In addition to these factors, the regional climate influences the degree of precipitation inputs and evaporation losses. Plant species respond to these environmental variables and species composition reflects a combination of complex interactions.

Another factor in wetland ecology is whether the wetlands are surface or groundwater fed. Surface water fed wetlands are more or less connected to the surrounding uplands via run off, by creeks or ephemeral draws, or adjacent wetland types. Surface water fed wetlands can be more susceptible to land use development if run off (precipitation or snow melt) is interrupted, whereas groundwater fed wetlands are less likely to be interrupted by land use. Exceptions are land uses such as oil and gas explorations. Water sources also influence wetland productivity. Surface water generally carries nutrients and minerals, whereas groundwater can be relatively nutrient-poor. The pH is often determined by the water sources as well. For example, surface water on the Canadian Shield (granite) can have a low pH but water exposed to limestone (calcareous rock) can have a high pH.

Wetlands can have many different surface expressions that indicate a number of complex functions. For example, fens can be patterned in various ways indicating water flow and degree of flow. Strings (higher, dryer areas) and flarks (the lower, wetter areas) can be of various patterns from almost parallel to reticulate. Water generally flows perpendicular to the strings and flarks (Glaser 1987). Further, bogs, oceanic bogs and fens can have concentric patterns that show the high water tables. Bogs situated amid fen complexes have a rounded end (heads) and a tapered end (tails) reflective of water flow. The tapered tails are downslope of the fen water flow direction (Glaser 1987).

Permafrost and permafrost remnants also create surface expressions in peatlands. Permafrost areas are raised above the surroundings and create peat plateaus, or further north, pingos (earth and vegetation covered ice mounds). Pingos that have collapsed, such as in areas of melting permafrost, leave a ring of leaning trees and a mote. Depending on the degree of decline, the centre may be an open wet area or still have permafrost remnants. Depending on the age of the collapse, the melted area can be very wet or similar to the surrounding matrix.

1.2.2 Permafrost: Extent and Distribution in Peatlands

Canada's north is underlain by permafrost and discontinuous, sporadic pockets or smaller lenses exist far south into the lower boreal forest. In the lower boreal, permafrost occurs mostly in peatlands and underlies both small areas that cover less than 10% and larger regions where permafrost exists in up to 50% of the land area. Overall, more than 50% of the ground surface of Canada is underlain by permafrost. In continuous permafrost zones, all ground except large bodies of water are underlain by permafrost which can reach a thickness of over 500 m (e.g., MacKenzie Valley; Natural Resources Canada 2006b). South of the 60th parallel, discontinuous permafrost is confined to peatlands, predominantly bog systems. Permafrost stores and influences both ground and surface water movement.

1.2.3 Wetland Hydrology

Canada's landscape ranges from pronounced mountains and peaks, over cliffs and rugged terrain, to gently rolling hills and plains. Large areas have little or no soils and bedrock clearly defines where water pools and drains. In other regions, deep geological deposits covered the bedrock and resulted in extremely complex hydrology that is difficult to define (Devito et al. 2005). Further, climate in the boreal and temperate regions of Canada ranges from dry continental climate of < 300 mm mean annual precipitation to wet maritime with > 4000 mm mean annual precipitation. Temperatures between regions are equally extreme and the mean annual temperatures can range from - 10°C in the Taiga and Cordillera Plains to + 9°C in the Pacific Maritimes. Peatland hydrology has been examined in the north by Quinton, Hayashi, and Pietroniro (2003) who demonstrated that permafrost peatlands and fens generate run off and connect to other wetlands and upland areas. Similar hydrological behaviour can be expected south of 60 degrees latitude in areas where fens dominate. However, considering the range of surface variability created by glaciations, other natural history events and climate variations, it is not surprising that hydrology, wetland connectivity, should be examined regionally.

1.3 Wetland Classifications Used in Canada

1.3.1 Intended Use of Classification and Inventory

Wetland classes are determined by complex biophysical interactions and therefore convey important information for land use planning and managing. Development of classification systems is driven by inventory needs for such purposes as general land use planning, resource extraction inventory, wildlife management, and protection of rare or endangered habitat and species. Understanding the intended purpose for which a classification and inventory system was designed helps establish whether a classification is suitable for alternate applications through a better understanding of underlying theory and data. Hence, it must be cautioned that all classification schemes and inventories cannot serve all purposes.

A classification system is generally developed to provide a common terminology for users and to identify unique classes, but does not necessarily provide units that can also be used for inventory or mapping purposes. For example, wetland ecosite classifications are very specific and use wetland indicator species including bryophytes, sedges, and many other small vascular plants that respond to water chemistry and levels (Harris et al. 1996; MacKenzie and Moran 2004). As such, ecosites can easily be used as unique classes but cannot be mapped or inventoried, easily or cheaply even at a large scale (e.g., 1:5,000). On the other hand, resource classifications such as peat resource inventories are designed for the purpose of resource assessment. Such inventories often include attributes that can be identified on aerial photos, satellite images, or by other remote sensing means, and are often specifically intended for mapping.

Classification features (attributes and indicators) will determine the scale at which a given classification can be applied. Ecosite classifications are on-ground classifications and are meant for very local fine scale purposes, whereas a satellite based classification is limited by its pixel size (e.g., 30 m pixels). Depending on the scale, aerial photographs fall in between.

Limitations imposed by capacity to recognize identifying features, by scale (e.g., polygon size) or by availability of resources (i.e., time and/or money), will often further define the scale at which classification takes place. Identifying features such as vegetation, especially species identification, easily limit mapping scale. Also, at a mapping scale of 1:250 000 a 625 ha wetland on the ground is shown as a 1 cm^2 polygon on the map, and at a mapping scale of 1:50 000 a 25 ha wetland on the ground is shown as a 1 cm^2 polygon on the map. Hence, small wetlands are often not included in coarse-scale wetland inventories but many wetlands, especially marshes and swamps, are smaller and not well represented despite accounting for a large portion of the total landscape when mapped at finer scales.

1.3.2 Wetland Classification Systems: National, Provincial, and Territorial

The National Wetlands Working Group (1997) established the five major classes of bog, fen, swamp, marsh, and shallow open water using decades of wetland research that included water chemistry, vegetation, hydrology, flooding regime, and soils (e.g., DuRietz 1949; Toumikoski 1942; Malmer 1986; Gorham 1950; Sjörs 1950, 1952; Kivinen and Pakarinen 1981; Vitt and Bayley 1984; Chee and Vitt 1989; Vitt and Chee 1990; Jeglum 1991).

Research across Canada led to the development of the *Canadian Wetland Classification System* by the National Wetlands Working Group (NWWG 1987, 1997). The body of research at that time and the wetland descriptions were summarized in *Wetlands of Canada* (NWWG 1988). Wetland classes are discussed in their regional context of boreal, arctic, subarctic, prairies, eastern temperate, Atlantic, Pacific, and coastal (salt marshes). To date it is the best known and only Canada-wide classification system that recognizes regional differences and landscape influences.

The *Canadian Wetland Classification System* recognizes two main categories of wetlands: organic wetlands (also called peatlands) and mineral wetlands. Mineral wetlands include swamps, marshes and shallow open water, while organic wetlands include fens and bogs. See Section 1.1.4 for a more extensive description.

More recently Ducks Unlimited Canada has also developed a classification that recognizes these five major classes. Ducks Unlimited's 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).The classification is based on the *Canadian Wetland Classification System* (National Wetlands Working Group 1997), but adapted for regional use (by ecozone) via a satellite-based remote sensing classification system. The classification system utilizes remotely observable site characteristics at multiple scales to infer ecological processes and functions and ultimately determine wetland type. Nineteen total classes, representing the major wetland types found throughout the Boreal Plains are in this classification.

Other classifications systems, such as Cowardin et al. (1979) and Stewart and Kantrud (1971), are well recognized and used in Canada. The Stewart and Kantrud (1971) classification was developed for the prairie regions and is limited to prairie wetlands. The Cowardin et al. (1979) classification is broader geographically but has limitations for classifying northern wetlands. The following is a comparison of some of the major wetland classifications used in Canada.

All provinces and territories have some level of land and/or wetland classification standard for land use management. Classifications include wetland classifications at the ecosite or inventory level (units that can be mapped), but also forest inventory standards that include, at least to some degree, wetland classes (see Appendix C for a list of classification/inventory systems). In regions where peat harvesting is a commercial venture, peat resource inventories or standards often exist (Keys and Henderson 1987; Pollet, Ryament, and Robertson 1977). All wetland classifications and inventories are land management tools, but congruency between wetland classifications and merchantable forests are not always present. However, in some provinces an effort has been made to document overlap of wetland and terrestrial ecosite classifications. Examples are the *Field Guide to the Wetland Ecosystem Classification for Northwestern Ontario* (Harris et al. 1996) and the *Terrestrial and Wetland Ecosites of Northwestern Ontario* (Racey et al. 1996). Racey et al. (1996) included wetland and terrestrial systems in their field guide and several site types overlap between the forested ecosite key and the wetland ecosite key. Overlaps important to note for forest management are those between conifer and hardwood swamp wetlands and classifications that group these as upland areas.

Provinces in which peat is an economic resource developed peat classifications and inventories. Peat inventories exist, at least partially, for Newfoundland and Labrador, New Brunswick, Nova Scotia, Ontario, Manitoba, Saskatchewan, and Alberta. These inventories often do not include other wetland types, but can be incorporated in land use management. However, most inventories are older (e.g., Keys and Henderson 1987), and a digital database is not available at this point.

1.3.3 Riparian Areas with Specific Reference to Forest Wetlands and Definitions Used

The term riparian is often ambiguous because a variety of definitions are used across disciplines and applications. The variety of existing definitions is partly explained by whether the definition is intended for application in an ecological or a management context.

The simplest ecological definitions consider that riparian areas are transition areas or "ecotones" (e.g., Naiman and Décamps 1997; Gregory et al. 1991). A more thorough definition builds on this idea by defining riparian areas as "… 3 dimensional ecotones of interactions that include terrestrial and aquatic ecosystems, that extend down to the ground water, up above the canopy, outward across the floodplain, up the near slopes that drain to the water, laterally into the terrestrial ecosystem, and along the watercourse at variable width" (Ilhardt, Verry, and Palik 2000). This definition addresses several important elements of riparian habitats such as their proximity to a water body, their probabilistic nature, and their temporal and spatial variability.

The inherent landscape variability of boreal forest ecosystems is carried through to the presence of a wide range of aquatic habitat types (e.g., rivers, lakes, marshes, bogs, fens and swamps). Each of these wetland types supports riparian habitats with diverse vegetation communities that also vary with respect to interactive factors such as topographic setting, soils, and hydrologic features (Gregory et al.

1991). Additionally, drying events and flooding events in riparian areas vary in space and in time, thus creating a complex series of habitat types across landscapes. The undulations and meanderings of flowing systems throughout the landscape often result in what some authors term riparian wetlands or wetlands associated with a body of flowing water (Devito et al. 2005; Toner and Keddy 1997). These factors considered, riparian areas are not restricted to any particular vegetation class but can generally be identified by their proximity to a water body.

In a management context, the term riparian is often used to refer to land adjacent to any type of water body. A *riparian management area* (RMA) can be defined as the area near water in which special management practices by forestry or other industry can occur (e.g., 100% exclusion, partial harvest). In most jurisdictions, regulations governing industrial forestry require that an RMA, or strip of forest of specified width be left unharvested (buffer strip/greenbelt) adjacent to a water body. The width of the RMA can be measured in several ways including starting at the high water mark or edge of merchantable species. Thus, an RMA is not always entirely mature forest. To help eliminate some ambiguity with related terminology, upland forests associated with a body of water will be termed *shoreline forests* reserving the term RMA for the management context (Rempel pers. com. - Province of Ontario). The Canadian Council of Forest Ministers (CCFM) has developed a working definition of the term riparian suitable for most purposes: a strip of land of variable width adjacent to and influenced by a body of freshwater (CCFM 2006). This simple definition is less cumbersome than the definition put forward by Ilhardt, Verry, and Palik (2000), but also makes no attempt to delimit a definitive riparian boundary on the landscape.

1.4 Wetland Values

1.4.1 Ecological Goods and Services

The stock of natural resources, environmental and ecosystem resources, and land has been called natural capital—capital in the sense that these resources are assets that yield goods and services over time (Olewiler 2004). Examples of Ecological Goods and Services (EGS) include air quality, carbon storage, raw material for industry (e.g., timber), erosion control, water quality and supply, recreation and habitat for wildlife species.

Economic valuation of the marketed goods produced from natural capital is well established. For example, in 2005 the forest industry contributed 2.9% to Canada’s gross domestic product, was worth $80.3 billion (estimated shipments), and contributed $31.9 billion to Canada’s trade balance (NRCAN 2006a). Similar statistics can be generated for other commodity products.

Forest products from forested wetlands are primarily derived from conifer and hardwood swamp. However, there seems to be no reporting that compares wetland timber extraction to upland forests (Trettin et al. 1997b). Trettin et al. (1997b) report that current logging practices include the logging of black spruce swamps in northern Ontario and Québec. It is also estimated that 18% or almost 80,000 km^2 of peaty wetlands in Ontario support commercial black spruce stands (Ketcheson and Jeglum 1972). Conifer swamps, often located between peatlands and upland forest, are also logged in boreal Manitoba.

Historic commercial uses of wetland tree species include harvesting eastern white cedar as fence posts, railroad ties, and telegraph, telephone, or electric lights poles. Tamarack was used for fence posts and to some degree in log house construction (Trettin et al. 1997a). In temperate forest regions, hardwood swamp species have been used as fire wood and construction lumber, but many areas were cleared to convert swamps for agricultural purposes (Trettin et al. 1997a). No dollar values are available for past or current timber harvested in wetlands.

Many non-timber forest products are derived from wetlands. For example, commercial harvest of peat moss or *Sphagnum* in Canada comprises a large industry. *Sphagnum* is well known for its high absorbency and is used for personal hygiene products and absorbent materials in industrial settings or oil spill controls. Further, horticulturalists use large quantities of *Sphagnum* peat as a growing medium or soil conditioner. In 1999, revenue for horticultural peat production was $170 million in Canada and the industry employed thousands of people in rural areas (Keys 2001).

Wild rice thrives in many shallow water wetlands and marshes in Canada's boreal region and is an introduced crop in several provinces. Commercial wild rice operations exist in Alberta, Saskatchewan, Manitoba, and Ontario. Saskatchewan is the largest producer with 70% of the Canadian market (Agriculture and Agri-Food Canada 2006). Natural Resources Canada reported a market value of almost $3.5 million for the 2003 wild rice harvest of 1,013 tonnes (Natural Resources Canada 2006a).

Berries such as cranberries (*Oxycoccus macrocarpus*) are produced commercially in peatlands. Natural peatland vegetation is removed and cranberries are produced as a horticultural rather than wild crop. The biggest producers are British Columbia, Nova Scotia and Québec. British Columbia produces about 17 million kilograms of cranberries a year, valued at $25 million (Government of British Columbia 2001). In 1999, Nova Scotia reported a cranberry production of nearly 198,245 kilograms at a value of almost $600,000 (Province of Nova Scotia 2006). In 2004, Québec cranberry production amounted to 24.5 million kilograms at a value of over $22.1 million (Association des Producteurs de Canneberges du Québec 2006).

Other non-timber forest products include wreaths, baskets, crafts and any other items that are marketed in a cottage-type industry. Further, wetlands are used for their resources in edible or medicinal foods most commonly utilized by aboriginal peoples and include various berries, rat root (*Acorus calamus*) and fiddleheads (shoots of *Matteucia struthiopteris*, Ostrich fern). Fiddleheads are considered a delicacy and have commercial value (Gerry Ivanochko, Saskatchewan Agriculture and Food pers. comm..). Many other wetland plants are used regionally but are not harvested for commercial use, including cattails (*Typha angustifolia*) used in flour. The quantity and value of some edible non-timber forest products have been listed by Natural Resources Canada (2004-2005) and are shown in Table 1.4.

Table 1.4 Estimated Non-timber Forest Products Values in Canada (from Natural Resources Canada website, The State of Canada's Forests 2004 -2005[a]).

Non-Timber Forest Products	**Tonnes or Litres (x 1000)**	**Economic Value in Millions**
Honey	37,072	160,805
Tree syrup (maple or birch)	34,761	163,968
Berries	149,373	278,654
Mushrooms	1.14	43,000
Understorey plants	2.30	75,321
Wild rice	1,013	3,492
		Total $725.240 million

[a]based on S. Wetzel et al., *Bioproduct from Canada's Forest: New Partnerships in the Bioeconomy*. In preparation.

As noted, wetlands also provide habitats for a variety of wildlife species including moose, caribou, waterfowl and other waterbirds, spawning grounds for fish species, and habitat for aquatic invertebrates, thus contributing indirectly to the socioeconomic values associated with hunting and fishing. In addition wetlands provide habitat for plant species such as pitcher plants (*Sarracania spp*.), orchids, or sundews (*Drosera spp.*) not found in other habitats.

The status and economic value of non-market ecosystem services is more difficult to determine and is the current focus for a number of resource economists (see Anielski and Wilson 2005, 2007). Specific to wetlands, ecosystem services include carbon sequestration, water supply and treatment, nutrient cycling, flood control, sediment abatement, and habitat for wildlife. Wetland ecosystem services have recently been examined by resource economists to help understand the values (in dollars) of these services and how these services are publicly perceived (e.g., Millennium Ecosystem Assessment 2005). Table 1.5 provides an overview of ecosystem services provided by or derived from wetlands. Specific to Canada's boreal ecosystems, the total non-market value of boreal ecosystem services is estimated at $93.2 billion of which over $80 billion is attributed to services provided by wetlands (Anielski and Wilson 2005).

Table 1.5 Overview of Ecological Goods and Services Provided by or Derived from Forest Wetlands

Services	**Comments and Examples**
Provisioning	
Food	production of fish, wild game, fruits, and grains
Fresh water	storage and retention of water for domestic, industrial, and agricultural use
Fibre and fuel	production of logs, fuel-wood, peat, fodder
Biochemical	extraction of medicines and other plant biota
Genetic materials	genes for resistance to plant pathogens, ornamental species, and so on
Regulating	
Climate regulation	source of and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes
Water regulation (hydrological flow)	groundwater recharge/discharge
Water purification and waste treatment	retention, recovery, and removal of excess nutrients and other pollutants
Erosion regulation	retention of soils and sediments
Natural hazard regulation	flood control, storm protection
Pollination	habitat for pollinators
Cultural	
Spiritual and inspirational	source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	provide opportunities for recreational activities such as hunting, hiking, fishing, camping, bird watching, etc.
Aesthetic	many people find beauty in aspects of wetland ecosystems
Educational	opportunities for formal and informal education and training
Supporting	
Soil formation	sediment retention and accumulation of organic matter
Nutrient cycling	storage, recycling, processing, and acquisition of nutrients

1.4.2 *Values of Wetlands to Aboriginal Peoples*

For Aboriginal peoples the quality of the water in rivers and streams, wetlands and lakes remains a top environmental issue (Bill, Crozier, and Surrendi 1996). Aboriginal groups have expressed concerns related to water issues across Canada including pollution, hydroelectric projects, pipeline development, and fish populations.

Historically, hunting, trapping, and gathering have been essential for life to the native people of the Canada. These traditional methods of living off the land have endured over thousands of years, and remain important to many of today's First Nations and Métis peoples. Wetlands and associated animals and plants have clearly played a large role in pre-colonial subsistence gathering. Because some types of wetlands have a relatively stable resource base, they could be depended upon as a likely place to find moose or a needed plant. The value of wetlands in particular, lies in the wide variety and reliability of their resources.

1.4.2.1 *Historical Importance*

It is difficult to put a price on historical or current economic value of wetlands to the Aboriginal peoples of Canada. Traditional (especially before contact) hunting and gathering was the economic base of First Nation peoples. Wetlands and the surrounding forest provided food, clothing, tools, and medicine. Trade of these products between First Nations groups was widespread (Brigham, Ralph, and Dick 2005). First Nations peoples made use of what was available and their diet was dependent upon the season. Autumn was moose and caribou hunting season. Waterfowl like geese and ducks were also hunted at this time. Winter brought ice fishing and trapping. Spring brought back the waterfowl, and the fresh meat was appreciated after the long winter, but they were only hunted until nesting began. As spring changed to summer, muskrat and beaver were harvested, fishing continued, and tender plant roots were collected. Bird eggs were collected in the summer, and as fall approached, it was time to collect berries, to dry meat and to fish (Nuttall 2005). Typically, water consumption was from moving sources like creeks, rivers, and lakes. Stagnant water was never used for consumption, although there are accounts that muskeg water was considered very good to drink despite its brown colour (Bill, Crozier, and Surrendi 1996).

Beaver, perhaps the most obvious wetland-associated mammal, was the most significant animal during the fur trade; its overall availability was one reason it was important, but another was its high caloric meat. There are historical accounts of Cree bands managing for healthy beaver populations by rotating trapping areas on a four-year cycle (Berkes, Colding, and Folke 2000). This is an early example of watershed management. Other wetland fur bearers which were trapped on a regular basis were muskrat, marten, and fisher.

Duck broth was used as medicine. Aboriginal peoples also collected eggs (e.g., coot, grebe, goose, and duck) along wetland shorelines and vegetation. Non-consumptive bird uses include collection of down and feathers. Down was often used to make down-filled clothing like parkas and pants, or blankets. Long feathers and entire wings of large waterbirds were used for sweeping floors and cleaning utensils. Aboriginals were innovative with using other parts of birds (e.g., waterfowl skin could be used to make waterproof bags), and beaks, nails, and bones had ornamental uses (Sherry and Vuntut Gwitchin First Nation 1999).

Plants were eaten, used to create herbal teas and medicine, and provided material for everyday items, like mats, baskets, and cordage. Harvesting of wetland plants still exists. The list of wetland associated plants and their uses is extensive. Information on the traditional use of plants used in the text below was collected from two sources: Marles et al. 2000, and Johnson et al. 1995.

One of the most abundant trees of the boreal forest is black spruce. The Dene used spruce resin to treat eye ailments, the Chipewyan boiled the cones to treat tooth aches and sore throats, and Woodland Cree drank a similar concoction to relieve diarrhoea. Non-consumptive uses included the use of spruce boughs as flooring and insulation, and rotten spruce, which had been dried, was crushed into baby powder or deodorant. Various species of willow were also used. Medicinal tea was made from willow bark, and its wood was used to construct sweat lodges and furniture. Spring willow buds could be used to create a red dye, and the tannin in its bark used to tan animal hides.

Bog cranberries (lingonberries) were used in a fish egg mix, in pemmican, cooked and mixed with grease and used as a condiment for meat, or eaten raw as a medicine for fevers and sore throats. The Chipewyan dried the leaves as a tobacco stretcher. Wild mint leaves were boiled to make a medicinal tea to cure chest colds, headaches, and fevers; or mixed stronger and used as a mouthwash. Labrador Tea, a widely therapeutic plant, can be chewed or made into a tea to treat a variety of symptoms, like stomach flu, headaches, and fevers, or mixed with other herbs to treat kidney problems, urination difficulties, hair loss, and eye infections.

There are some aquatic plants that are considered very special. The Cree mixed the pitcher plant with herbs or into teas which were given to the very sick and used in child birth. It is credited with saving many lives. Ratroot is a widely used plant among Aboriginal peoples. The rhizome was usually chewed as medicine for upset stomachs, tooth ailments, or as preventive cold medicine.

Wetland rushes, sedges, and grasses were also used. Many parts of bulrush and cattail were eaten, mainly in the spring, while they were tender. Woodland Cree used the pith of the bulrush as a compress to stop bleeding. Slough grass seeds were boiled whole and eaten as porridge, or ground to make flour. Long stems of the plant were woven together to create mats, baskets, and even duck decoys. Sweet grass is considered a sacred plant for many Aboriginal groups. The grass was often burned as an offering, or smoked in ceremonies. Sweet grass also had medicinal properties, and was used in teas to treat coughs, vomiting, and sore throats. The smoke of sweet grass was used to purify and to treat skin conditions, sore eyes, and to prevent hair from falling out.

As a food source, wild rice was perhaps the most important wetland-based plant. Wild rice grows well in many wetland types across the southern boreal. It is especially abundant in the boreal shield, and it was a staple food source for Aboriginals who lived around the Great Lakes, like the Algonquin, Ojibwa, and Cree. The Ojibwa tribe cultivated wild rice and managed the plant to promote its growth (Abel and Friesen 1991).

Even peat moss has a traditional use. Due to its absorbent and antiseptic properties, varieties of peat moss were applied to open sores and cuts, used to treat diaper rash and other skin conditions, and used as toilet paper, for feminine hygiene, and in general cleaning.

1.4.2.2 *Current Importance*

The importance of sustenance off the land has diminished over the past one hundred years; however, even today, animal food harvest is essential among Aboriginal peoples. The traditional foods, medicines, and supplies related to wetlands described above are still very much a part of the lives of many Aboriginal individuals and communities. Big game animals, fur bearers, and waterbirds, are still considered an important resource for First Nations and Métis peoples.

Moose and caribou continue to be a fundamental part of the diet of many Aboriginal people (Bill, Crozier, and Surrendi 1996). A 1990 study in Fort Chipewyan, Alberta and Fort Smith, Northwest Territories showed that one in every three meals for people living in those communities was comprised of “country” food (Adams 1998). Waterfowl were traditionally hunted, and ducks and geese continue to make up a significant portion of wild game taken for sustenance and social events.

A study from 1982 showed that ducks and geese make up 25%, by weight, of the total wild animals harvested by the northern Cree of James Bay and Hudson Bay (Scott 1987).

Before contact, furs were used only for clothing and other domestic purposes. Trapping became economically important as the fur trade and trading posts were established (Saskatchewan Environment 1998). Now, the commercial value of pelts is relatively diminished and, while trapping is still a traditional practice in many communities, few people still use this as a primary source of income. However, there are some other commercial activities which occur on or in proximity to wetlands that do have an economic value to Aboriginal peoples. Examples include cultivation of wild rice, cranberries, and peat moss as well as renewable resource extraction, like forestry.

The economic and dietary importance of access to traditional and local food is still crucial to First Nations and Métis peoples. Cultural and local foods can be nutritionally superior and less expensive than the processed foods brought into these northern communities. The benefits are not just economic, but also social and cultural (Parsons and Prest 2003). Land, water, and plants and animals are not seen as merely commodities. Wetlands were and still are clearly important to the Aboriginal peoples of Canada. Since Aboriginal communities are beginning to have an increased presence as forest stakeholders (*e.g.,* partners, owners, managers), it is expected that the cultural and economic importance of wetlands to these communities will receive more emphasis in future forest planning (Parsons and Prest 2003).

2.0 LEGISLATION, REGULATIONS, AND FORESTRY GUIDELINES: MANAGEMENT AND CONSERVATION OF FOREST WETLANDS

2.1 Responsibility and Management of Forests, Water, and Wetlands

With the exception of federal lands, the responsibility and management of forests in Canada falls under provincial/territorial jurisdiction. This includes the responsibility of individual provinces and territories in developing the policies, legislation, regulations and specific guidelines pertaining to wetlands and water.

Since wetlands and water are intrinsically linked, an overview of the responsibilities for water is required. With the exception of federal land, for the most part, water that lies solely within a provincial boundary falls within the constitutional authority of that province. For the Northwest Territories, Indian and Northern Affairs Canada is mandated to manage water resources. As of April 2003, responsibility for the management of water resources in the Yukon was transferred from the federal government to the Government of the Yukon (Environment Canada 2006). For coastal waters and the Great Lakes, Fisheries and Oceans Canada has significant responsibilities.

2.2 Federal Strategies, Policies, and Legislation

Although the majority of responsibilities for forests, freshwater and associated wetlands fall within the constitutional authority of the provinces and territories, there is specific federal policy and legislation that influences forest wetland conservation and management.

Canada has a National Forest Strategy which is developed through a collaborative process facilitated by the Canadian Council of Forest Ministers (CCFM). The Strategy is revised every five years and results from consensus building and a public engagement process (CCFM 2006). The Strategy provides a national vision and framework for action across the country in several theme areas including ecosystem-based management. Under this theme, an action item has been identified related to the development of guidelines for integrating watershed-based management into forest management practices (National Forest Strategy Coalition 2003) which will include wetlands. The

National Forest Strategy Coalition oversees the implementation of the National Forest Strategy and provides a reporting mechanism to document progress.

The policy that has the most potential to significantly influence wetland conservation is the Federal Policy on Wetland Conservation (Environment Canada 1991). This policy applies to all federal lands and also to provincial/territorial lands where federal government funding is in place for infrastructure projects such as road development. The significance of this policy is that it provides the strategies for the use and management of wetlands including the development of mitigation guidelines and, where appropriate, compensatory measures.

Federal legislation that is most applicable to forest management activities related to water and wetlands is listed in Table 2.1. All industrial activities are required to address the elements of these acts on an ongoing basis.

Table 2.1 Summary of Federal Legislation Relevant to Wetland Conservation and Management*

Federal Authority	Legislation	Relevance to Wetlands
Fisheries and Oceans Canada	*Fisheries Act*	Regulates the environmental impacts of projects and activities which may affect fish and fish habitat. Many wetlands are fish habitat.
Transport Canada	*Navigable Waters Protection Act*	Regulates activities that can interfere with navigation on waterways including stream crossings. Improper stream crossings can impact hydrology and wetlands.
Environment Canada	*Species at Risk Act*	Provides for legal protection of wildlife species including species dependent on wetlands.
Environment Canada	*Migratory Birds Convention Act*	Protects migratory birds and their habitats including during the time of the year when migratory birds are nesting.
Department of Justice Canada	*Canadian Environmental Assessment Act*	Provides for the environmental assessment of projects that may result in a change in the environment, including any change to a federally listed endangered species.
Environment Canada and Health Canada	*Canadian Environmental Protection Act*	Act respecting pollution prevention including toxic substances and hazardous waste.

* Adapted from The Forestry Corporation and Watertight Solutions 2004

Fisheries and Oceans Canada has a policy of no net loss of fish habitat (Fisheries and Oceans Canada 1986) and the Fisheries Act (Government of Canada 1985a) regulates activities that can impact fish and fish habitat including forest management activities, road construction and stream crossings. Some wetlands are fish habitat as defined by the Fisheries Act.

The Navigable Waters Protection Act (Government of Canada 1985b) regulates activities that can interfere with passage on a navigable waterway. The relevance of this Act relates largely to streams that have been deemed navigable and the construction of stream crossings that could have impacts on adjacent wetlands by interrupting water flow.

The Species at Risk Act (Government of Canada 2002) provides for the legal protection of wildlife species that are listed under the Act, some of which are dependent on wetlands. Of particular importance is the provision making it illegal to destroy or damage the residence or critical habitat of species listed as endangered or threatened.

The Migratory Birds Convention Act (Government of Canada 1994) is intended specifically to protect migratory birds and their habitat including their eggs and nests during the nesting season. In some instances this may preclude industrial activities during the nesting season, including activities in wetlands if they are deemed to impact eggs and nests (e.g., timber harvesting and road construction).

The Canadian Environmental Assessment Act (Government of Canada 1992) outlines where a federal environmental assessment must take place on specifically listed “projects” that have the potential to have environmental effects. This Act includes projects taking place on federal land (including aboriginal lands) where the federal government is a proponent, projects related to oil and gas, and projects that can influence species that are covered under federal acts (e.g., migratory bird regulations, Fisheries Act). For this Act to take effect there must be a federal authority with specific decision-making responsibility associated with a project.

The enforcement of federal acts is typically undertaken collaboratively between provincial/territorial and federal government agencies and in recent years there has been an increased provincial presence of federal agencies, in particular Fisheries and Oceans Canada (related to enforcing the Fisheries Act). Freshwater wetlands responsibility resides primarily with the provincial/territorial governments; however, when federal government funding is in place for infrastructure projects such as road developments, relevant federal policies legislation must be adhered to.

2.3 Provincial/Territorial Policies, Legislation, and Guidelines

Each province and territory has developed legislation to protect water resources, regulate forest management activities and protect wildlife and other resources. Currently there is no wetland-specific legislation in Canada; the protection of wetlands falls, for the most part, under other existing legislation, policies and guidelines.

Flowing out of legislation are regulations and guidelines that govern on-the-ground activities necessary to comply with the relevant legislation. Guidelines do not have direct legislative authority. Enforcement is based on the legislated statutes and regulatory requirements upon which guidelines are based (The Forestry Corporation and Watertight Solutions 2004).

In some jurisdictions overarching strategies and policies are developed to guide the management of natural resources. These are typically used to set new directions for government and public policy and include a public consultation process. This is particularly relevant to forests as the expectations and uses of these mostly public resources have changed significantly in recent years (e.g., desire for more protected areas, wildlife habitat protection, Aboriginal rights and responsibilities).

For the purpose of this review the focus will be on relevant strategies, legislation, policies and guidelines that relate to water/wetlands and which regulate forest management planning and operations with specific reference to the management and conservation of forest wetlands (including timber harvesting, road development and stream crossings, and riparian protection).

2.3.1 *Newfoundland and Labrador*

2.3.1.1 *Policies and Strategies*

There is currently no strategy or overarching policy for water or wetlands for Newfoundland and Labrador. The protection and conservation of wetlands falls under policy directives flowing out of the Water Resources Act.

A Provincial Sustainable Forest Management Strategy was released in 2003; it outlines a vision for the province's forest ecosystems and identifies strategic directions, structured from the Canadian Council of Forest Ministers' (CCFM) six criteria of sustainable forest management including ecologically based forest management. The strategy includes a sustainable forest assessment that recognizes no-cut Riparian Management Areas (RMAs) around watercourses and also provides some focus on water by identifying a goal to maintain naturally occurring flow rates and water quality (Government of Newfoundland and Labrador 2003).

2.3.1.2 *Legislation*

Legislation for Newfoundland and Labrador most applicable to forest management activities and to water and wetlands is provided in Table 2.2.

Table 2.2 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Newfoundland and Labrador

Legislation	Description	Relevance to Wetlands
Water Resources Act	Creates provisions for the protection of water and water resource management	Under provision for the protection of water - restrictions apply to activities harmful to wetlands.
Lands Act	Law respecting Crown land which includes water	Reference to a Crown reserve around water (including ponds) restricting activities unless licensed.
Forest Act	Law respecting the management, harvesting and protection of the forest	Provides the legislative structure from which forests are managed and which can influence wetland resources.
Endangered Species Act	Law governing the designation, management, protection of habitat for endangered species.	Some species that get listed under the Endangered Species Act may be dependent on wetlands.

The Water Resources Act (Government of Newfoundland and Labrador 2002) makes specific reference to the protection of water and restrictions on activities harmful to wetlands; several policy directives that flow out of this Act are designed to protect wetlands. The two most relevant policy directives are Infilling Bodies of Water (Government of Newfoundland and Labrador 1991b), which restricts the filling of a water body and outlines permitting requirements, and Development in Wetlands (Government of Newfoundland and Labrador 1997). The latter policy's objective is to prevent developments in wetlands that adversely affect the water quantity, water quality, hydrologic characteristics or functions, and terrestrial and aquatic habitats of the wetlands. There is specific reference to activities that are not permitted (e.g., infilling, drainage, dredging, canalization, removal of vegetation cover or removal of soil or organic cover). Developments that require written permission include preparing the area for agriculture, peat extraction, and forestry activities.

The Lands Act (Government of Newfoundland and Labrador 1991a), although it does not make reference to wetlands, does make specific reference to a Crown reserve around water (including ponds). The reserve, either 10 or 15 m, requires the grantee, lessee or licensee to be licensed to use this Crown reserve.

2.3.1.3 *Forest Management Planning and Associated Guidelines*

Flowing from the Provincial Sustainable Forest Management Strategy, five-year operating plans are developed for the 24 Forest Management Districts. These plans are developed by the Department of Forest Resources and Agrifoods in consultation with various stakeholders including the forest industry and the public who are represented on a planning team. In some instances the forest industry takes the lead for the development of these plans for submission to government.

These planning teams develop the operating criteria for the planning area, including the protection of wildlife habitat and water resources. There are no specific wetland-related protection guidelines. The province has guidelines requiring that all water bodies visible on 1:50,000 map sheets are given a minimum 20 meter uncut, treed RMA; thus, some wetland systems are captured through the establishment of these areas. In addition to these guidelines, district managers, in consultation with Planning Teams, can increase RMA widths beyond 20 meters.

Wider RMAs of up to 400 m are recommended if the area is to be used for more than just harvesting (pesticide storage, logging camp, landing, etc.). RMA width is measured from the high water mark and must be treed. If the bank slope is greater than 30% then the RMA must be 20m plus 1.5 times the slope (%) e.g., 30% slope=65 m RMA (Decker 2003).

Based on the plans reviewed (Abitibi-Consolidated 2002; Department of Forest Resources and Agrifoods 2002, 2003) there is considerable variability in the criteria established for protecting water/wetlands, although specific attention afforded to protecting water supplies for communities and water in general is in each plan. In some cases there is specific reference to providing RMAs around streams of a particular width as per the provincial guidelines. In other cases there is reference to the importance of providing RMAs around marshland. A specific treed RMA width adjacent to bogs and marshes for animal travel was prescribed in one case.

2.3.2 *Nova Scotia*

2.3.2.1 *Policies and Strategies*

Nova Scotia does not have an overarching water strategy or wetland policy. A forest strategy for Nova Scotia was released in 1998 which outlined the strategic direction for the province toward sustainable forestry and in which recommendations on the environmental aspects of forestry operations are made. In particular, the forest/wildlife guidelines would become mandatory on all lands and a code of practice would be developed for Crown lands.

In 2004, the Code of Forest Practice was released; it outlines a framework for the implementation of sustainable forest management on Crown lands in Nova Scotia. This document describes the general principles that will form the basis of forest practices described in future guidebooks. While no specific reference to wetlands is made, there is a commitment to conserve biodiversity, protect habitat for species at risk, and maintain water quality (Government of Nova Scotia 2004)

2.3.2.2 *Legislation*

A summary of legislation that is most applicable to forest management activities and to water and wetlands in Nova Scotia is provided in Table 2.3.

Table 2.3 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Nova Scotia

Legislation	Description	Relevance to Wetlands
Environment Act	Act to reform the environmental laws of the province and to encourage and promote the protection, enhancement and prudent use of the environment	Water resource management is a separate section in the Act with specific reference to watercourses. Outlines the authority to regulate the infilling and alteration of wetlands.
Forest Enhancement Act	Act to encourage the development and management of forest land in Nova Scotia	Links to wetlands include specific reference to maintaining or enhancing wildlife habitat and water quality and the designation of Crown lands along watercourses as special management zones.
Forests Act	Act respecting the administration and management of Forests	Specific reference to maintaining water quality; outlines the forest management planning process
Crown Lands Act	Act respecting the administration and management of Crown lands	Special areas identified in the Act can be set aside. Includes the protection and regulation of water flow as well as the "integrating protective measure" to ensure the integrity of water supply watersheds.
Water Resources Protection Act	Act to protect the water resources of Nova Scotia	No direct relevance since the reference is most specific to preventing large-scale removal of water.

Wetlands and watercourses in Nova Scotia receive some level of protection under the Environment Act (Government of Nova Scotia 1994). Part of the Act is a policy directive regarding the alteration of wetlands. Alterations are defined as filling, draining, flooding or excavating (http://www.gov.ns.ca/snsmr/paal/el/paal586.asp; accessed September 10, 2006) and wetlands are defined as per the Canadian Wetlands Classification System (see Section 1.1.4). An approval for alteration of wetlands is required and includes any activity that would result in an alteration of existing wetlands (http://www.gov.ns.ca/enla/water/wetlandalteration.asp; accessed September 10, 2006). In addition, numerous enabling regulations related to watershed protected area designations outline specific criteria for operating in these designated watersheds (http://www.canlii.org/ns/laws/sta/1994-95c.1/index.html; accessed September 10, 2006).

Specific to forestry, the Forests Act, Forest Enhancement Act, and the Crown Lands Act (Government of Nova Scotia 1989a, 1989b, 1989c) are important pieces of legislation that regulate forest management and other activities on Crown land. In particular, the Forests Act has in place a Wildlife Habitat and Watercourse Protection Regulation which governs activities around watercourses, including ponds and marshes, in the form of operating criteria in what is termed “Special Management Zones” (Government of Nova Scotia 2004) and wetlands (there is specific reference to ponds and marshes). Details of this regulation are described below.

2.3.2.3 *Guidelines*

Watercourse protection including RMAs and wetlands is law in Nova Scotia and required for all commercial harvesting operations on both private and Crown land. The most important guidelines that influence water and wetlands are those that fall under the Wildlife Habitat and Watercourse Protection Regulation (Government of Nova Scotia 2006). Other guidelines include Forest/Wildlife Guidelines and Standards for Nova Scotia under the Forest Act (Government of Nova Scotia 1989d); however, the most relevant watercourse protection criteria are included the Wildlife Habitat and Watercourse Protection Regulation which came into effect in 2002 (Government of Nova Scotia 2006).

Wildlife Habitat and Watercourse Protection Regulation (Government of Nova Scotia 1989d)

As outlined in this regulation, watercourse protection including riparian RMAs is legally required in all commercial harvesting operations—private or Crown land. These areas are typically called greenbelts, buffer zone or Special Management Zones (SMZs). Watercourse is defined in two parts:

1. “Watercourse” means the bed and shore of a river, stream, lake, creek, pond, marsh, estuary or salt-water body that contains water for at least part of each year.
2. “Marsh” means an area of permanent standing or slow moving water that is vegetated in whole or in part with aquatic or hydrophytic plants.

A minimum 20 m RMA is required on all streams wider than 50 cm, lakes, marshes, permanent open water, and salt water bodies. Partial harvesting is allowed, but operators must leave 20m^2/ha of basal area in the zone; disturbance to small trees and shrubs (understory trees) must be minimized; no vehicles/machinery may be operated within 7m of watercourse; openings in the dominant canopy must be 15 m or less; and no sediment should enter the watercourse. Slope is an additional consideration where slopes 20% or greater require that one meter of RMA be added for each 2% of slope over 20% up to 60m.

2.3.3 *New Brunswick*

2.3.3.1 *Policies and Strategies*

New Brunswick currently has two policy documents that relate to the protection and conservation of wetlands, the *Wetland Conservation Policy* (Government of New Brunswick 2002) and *The New Brunswick Public Forests: Our Shared Future* (New Brunswick Natural Resources 2005). The first policy states that the government of New Brunswick will prevent the loss of provincially significant wetland habitat and achieve the goal of no net loss of wetland function of all other wetlands. This comprehensive policy outlines a number of policy objectives and definitions, and identifies the linkages to existing legislation for implementing the policy.

The second, released in 2005, is *The New Brunswick Public Forests: Our Shared Future* which provides the strategic direction for the management of New Brunswick Crown forest. This document outlines forest management responsibilities and a vision which specifically includes the protection of watercourses and wetlands. Flowing from this strategy, the Department of Natural Resources released the Objectives and Standards for the New Brunswick Crown Forest for the 2007- 2012 period which details the specific objective levels prescribed by government for forest management plans on Crown land (Beale and Monaghan 2004). These prescriptions are discussed in the guidelines section.

2.3.3.2 *Legislation*

Legislation for New Brunswick that is most applicable to forest management activities and to water and wetlands is provided in Table 2.4.

Table 2.4 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in New Brunswick

Legislation	Description	Relevance to Wetlands
Crown Lands and Forests Act	Act outlining the authority, administration and management of Crown lands and forestry	Specific reference to public reserves adjacent to a river or lake
Clean Water Act	Act outlining the authority of government and overarching activities as related to the protection of water resources	Specific reference to wetlands, including definition. Outlines criteria for 1) operating around water and wetlands including projects that alter a watercourse or wetland including flow and 2) the need for approval.
Clean Environment Act	Act outlining authority and overarching activities related to air, soil and water	Specific reference to wetlands including definition. Allows for designating wetlands for protection and associated use.
Endangered Species Act	Act respecting the designation, management, protection of habitat for endangered species.	Some species that get listed under the Endangered Species Act may we dependent on wetlands.

The Clean Environment Act (Government of New Brunswick 1989a) contains a wetland designation order which designates a wetlands or portions of a wetland as protected and outlines the associated prohibitions and uses. Regulatory mechanisms for managing development in or near wetlands are provided through the Environmental Impact Assessment Regulation under this Act.

Within the Clean Water Act (Government of New Brunswick 1989b), there is specific reference to wetlands, including a definition. The Act also outlines criteria for operating around water and wetlands including projects that alter a watercourse or wetland.

Crown Lands and Forests Act (Government of New Brunswick 1980) makes specific reference to public reserves adjacent to rivers and lakes, but more importantly provides the legal framework for government to develop a comprehensive forest management system for Crown land by establishing goals, objectives, and standards, including for the protection of water and wetlands.

2.3.3.3 *Guidelines*

Objectives and Standards for the New Brunswick Crown Forest (Beale and Monaghan 2004)

This document outlines standards and guidelines for operating on Crown land. Under the Clean Water Act, all watercourses in New Brunswick on Crown land require an RMA at least 30 m wide. A watercourse is

> "the full width and length, including the bed, banks, sides and shoreline, or any part, of a river, creek, stream, brook, lake, pond, wetland or other natural channel, the primary function of which is the conveyance or containment of water whether the flow be continuous or not."

Watercourses are classified and regulations are developed for each license. Partial harvesting within the RMA is permitted under specific circumstances as long the function of the RMA is not compromised. No more than 30% of basal area can be removed over 10 years and openings in the dominant canopy must be less than 10 m wide. Specific provisions are also made for waterfowl production wetlands (supporting cavity nesting waterfowl), provincially significant wetlands, and watersheds designated as drinking water sources.

Watercourse Buffer Zone Guidelines

These guidelines provide the background on the administrative requirements for watercourse buffer zones, criteria for determining watercourse buffer zones, and guidelines for forestry activities in watercourse RMAs. There is no definition of what constitutes a watercourse in these guidelines and wetlands are referenced only when RMAs are required for waterfowl production areas as noted above. These guidelines have been revised and incorporated into the *Forest Management Manual for New Brunswick Crown Land* (New Brunswick Natural Resources 2004a).

Forest Management Manual for New Brunswick Crown Land (New Brunswick Natural Resources 2004a)

The *Forest Management Manual* provides the most up-to-date and comprehensive set of criteria for preparing Forest Management Plans on Crown land. This manual incorporates and provides updates for relevant standards provided in other provincial guideline documents including the *Watercourse Buffer Zone Guidelines* and the *Guidelines for Roads and Watercourse Crossings* (New Brunswick Natural Resources 2004b). Further, this manual provides criteria to ensure compliance to the various provincial and federal acts.

Wetlands are incorporated into the definition of a watercourse, which also includes the banks, sides and shoreline or part of a river, creek, stream, brook, lake, pond or other natural channel. There is no specific definition of a wetland in the manual.

The standards include the retention RMAs adjacent to watercourses (and wetlands) which range from 15-100 m depending on the drainage area, channel width, bank slope and other site-specific concerns. Included under site-specific concerns are critical fish habitats, provincially significant wetlands, waterfowl production areas, and designated watersheds that provide drinking water and require additional protection measures. Operations are allowed within these established RMAs although there is a minimum no vehicle travel zone which also ranges in width depending on the identified RMA feature.

Provincially significant wetlands are formally listed by the Department of Natural Resources and waterfowl production areas are all wetlands 0.25 ha or larger that have been evaluated based on a wetlands inventory conducted by the Canadian Wildlife Service.

The use of herbicides is permitted in New Brunswick and the manual provides the required setbacks when herbicides are applied. This includes a 65 m setback from surface water. There is no specific reference to wetlands.

*Guidelines for Roads and Watercourse Crossings (*New Brunswick Natural Resources 2004b)

These guidelines provide detailed information on road planning/development and watercourse planning and crossing criteria. There is no reference to wetlands in these guidelines although a well planned road, proper culvert sizing and placement and a properly designed watercourse crossing helps prevent impacts on wetlands by minimizing blockage of natural flows.

2.3.4 *Québec*

2.3.4.1 *Policies and Strategies*

The province of Québec does not currently have a wetland conservation policy. It does, however, have a Water Policy (Government of Québec 2002) with goals that include protection and management in a perspective of sustainable development and the maintenance of human and ecosystem health. There are specific references to watershed-based management and to the protection of water quality and aquatic ecosystems which would include wetlands. Commitments 20, 21, and 25 of this policy relate more specifically to wetlands (Government of Québec 2002). Acting on the recommendation of the Minister of the Environment and Wildlife (now Ministry of Sustainable Development, Environment, and Parks) under the Environment Quality Act, in 1987 the Québec government adopted the Protection Policy for Lakeshores, Riverbanks, Littoral Zones, and Floodplains to ensure the sustainability of water bodies and watercourses, and to maintain and improve their quality by ensuring adequate minimum protection of lakeshores, riverbanks, littoral zones and floodplains (R.Q., chapter Q-2, r.17.3).

Québec's Forest Protection Strategy was released by the Minister of Natural Resources in 1994 (Government of Québec 2003b). Although this strategy is primarily aimed at protecting forests against fire, insects, and pathogens, it addresses environmental problems related to forest activities in sensitive environments particularly wetlands.

2.3.4.2 *Legislation*

A summary of legislation for Québec that is most applicable to forest management activities and to water and wetlands is provided in Table 2.5.

Table 2.5 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Québec

Legislation	Description	Relevance to Wetlands
Environment Quality Act	Sets out regulatory guidelines for environment including water, air, hazardous materials, and environmental impact assessment.	Regulates any activity in a marsh, a swamp, a pond or a peat bog by requiring a certificate of authorization prior to the activity.
Forest Act	Fosters recognition of the forest as a common heritage and promotes sustainable forest development.	Has specific reference to the conservation of soils and water; outlines the authority to regulate forest management on the public lands.
Sustainable Development Act	Outlines the authority of government and overarching activities related to sustainable development.	Has specific reference to the protection and development of water resources.
An Act Respecting Threatened or Vulnerable Species	Provides the means to both designate a species as being at risk and to legally protect endangered species.	Ensures the total protection of the wetlands containing the habitats of the threatened or vulnerable faunal and floristic species.

The Environmental Quality Act (R.S.Q., chapter Q-2) recognizes the importance of wetlands in the Québec territory. This Act does not provide direct protection to the wetlands, but it indirectly allows their management by defining an authorization framing suitable practices in these areas.

The Forest Act (R.S.Q., chapter F-4.1) of 1986 is an important piece of legislation for sustainable forest development in Québec. From this Act ensues a regulation titled the Regulation Respecting Standards of Forest Management for Forests in the Domain of State (R.Q., chapter F-4.1, r.1.001.1) which is aimed at protecting lakes and watercourses, wildlife habitats, landscapes and other forest components during management activities (there is a specific reference to marshes, swamps and peatlands). Details of this regulation will be described in the guidelines section below.

The Sustainable Development Act (R.S.Q., chapter D-8.1.1) does not make explicit reference to wetlands but places sustainable development at the core of government action by establishing clear rules. There is specific reference to environmental protection and the maintenance of biodiversity. Through this act, the government is committed to integrate sustainable development into policies, programs and actions of the Administration, at all levels and in all areas of intervention. The government must, among other things, adopt a sustainable development strategy.

2.3.4.3 *Guidelines*

The Forest Act (R.S.Q., chapter F-4.1) stipulates that the Ministry of Natural Resources and Wildlife Protection (MNRWP) may determine forest resource protection and development objectives for the lands in the domain of the State intended for forest production. Pursuant to this act, the MNRWP produced consultation and implementation documents (Government of Québec 2003a) that set out the protection and development objectives which will apply to the general forest management plans for the period 2005-2010. These objectives must, among others, be conducive to compliance with the six criteria for sustainable forest development proposed by the Canadian Council of Forest Ministers and contained in the preamble to the Forest Act since 1996.

The Regulation respecting standards of forest management for forests in the domain of the State (R.Q., chapter F-4.1, r.1.001.1), is designed to protect lakes and watercourses, wildlife habitats, landscapes and other forest components during management activities. Thus, the holder of a management permit shall maintain a 20 m wide forest RMA strip along the banks all permanent lakes, ponds, watercourses, flooded swamps, marshes, peatlands (bogs and fens) with a pond. The forest RMA strip is measured from the edge of the forest stand adjacent to the riparian ecotone. Partial harvest is allowed in the RMA. Along salmon rivers, the width of RMA strips is increased to 60 m.

2.3.5 *Ontario*

2.3.5.1 *Policies and Strategies*

Ontario does not have a provincial water strategy or wetland policy. Recognition of wetland protection is imbedded in the various acts.

For Crown forest resources, Ontario developed a Policy Framework for Sustainable Forests in 1994 (http://www.nofc.ca/index.php?menu=Resource&section=Regime; accessed September 19, 2006) The framework outlines a set of principles and objectives for achieving sustainable forest management, including forest sustainability, community and resource use sustainability, and effective decision making. Included in the principles of sustaining forests are references to maintaining ecological processes and minimizing adverse effects on soil, water, remaining vegetation, fish and wildlife habitat and other values which would include wetland systems.

2.3.5.2 *Legislation*

Legislation for Ontario that is most applicable to forest management activities and to water and wetlands is provided in Table 2.6.

Table 2.6 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Ontario

Legislation	Description	Relevance to Wetlands
Crown Forest Sustainability Act	Defines forest sustainability and provides mechanisms to ensure that sustainability.	Requires the development of forest management plans and that each plan incorporates multiple values including water.
Environmental Assessment Act	Sets out the conditions for undertaking an environmental assessment for any major new project that will have an impact on the environment including on Crown lands.	There is specific reference to water in the Act. Forest Management activities are covered under a Class Environmental Assessment (Forest Management Class EA) under the Environmental Assessment Act. Sustainable forest management includes the sustainability of water resources which includes wetlands.
Clean Water Act	Protects existing and future sources of drinking water.	Limited for Crown land. Primary focus is protection of primary water supplies for municipalities
Lakes and Rivers Improvement Act	Provides for the management, protection, preservation and use of the waters of the lakes and rivers.	Includes provisions for the protection of the natural amenities of the lakes and rivers and their shores and banks (will include wetlands).
Planning Act	Establishes planning criteria for municipal land use planning system.	Sets out criteria for protection measures for wetlands – primarily for private land.

Ontario does not have specific wetlands legislation. Wetlands receive indirect protection through various acts. Following are key acts that influence wetland conservation of forest wetlands on Crown land.

The Crown Forest Sustainability Act (Government of Ontario 1994) provides the legal authority for four manuals that outline the rules and procedures for forest management on Crown land in Ontario. Two of these manuals have relevance to water/wetlands: the *Forest Management Planning Manual,* and the *Forest Operations and Silviculture Manual.*

Forest management is considered one of a group of "projects" that are approved through a Class Environmental Assessment (EA) under the Environmental Assessment Act (Government of Ontario 1990a) rather than undertaking environmental assessments for each forest management plan individually. The Forest Management Class EA and decision which was undertaken in 1994 and a subsequent EA Declaration Order in 2003 set out the conditions for carrying out sustainable forest management activities on Crown lands in Ontario (http://ontariosforests.mnr.gov.on.ca/ timbereaoverview.cfm).

Although the Lakes and Rivers Improvement Act (Government of Ontario 1999) provides for the management, protection and preservation and use of waters, the emphasis of this Act relates to regulating water management and activities that directly discharge material into the water.

Under the Planning Act (Government of Ontario 1990b), a Provincial Policy Statement (PPS) provides policy direction on matters of provincial/territorial interest in municipal land use planning under the Act (Ontario Ministry of Natural Resources 1999). Flowing out of this PPS (Section 2.3) there is a *Natural Heritage Reference Manual* that provides additional information on technical issues including specific protection criteria for wetlands. For the most part the *Planning Act* relates to lands other than Crown forest but in some instances may influence land use decisions for northern planning authorities.

2.3.5.3 *Guidelines*

The province of Ontario has a large number of guidebooks and an individual *Codes of Practice* that have been applied since the 1980s. Currently the Ontario Ministry of Natural Resources (OMNR) is in the process of consolidating these guidebooks as a result of an independent review of all guides undertaken in 2000 (Ontario Ministry of Natural Resources no date). Based on this review and recommendations from the Provincial Forest Technical Committee, the OMNR had decided to rewrite the guides into five guidebooks including *Landscape Guide* (completion 2007), *Stand/Site Guide* (completion 2007), *Silviculture Guide* (completed 2003), *Tourism and Recreation Guide* (completed 2001) and *Cultural Heritage Values Guide* (completed 2006) More information about the guides can be found at http://ontariosforests.mnr.gov.on.ca/spectrasites/internet/ontarioforests/guides.cfm (accessed March 2007).

Although some of the existing guidelines are no longer widely used, until the new guidebooks are completed the existing guidelines remain in place. Guidelines that have relevance to water/wetlands are discussed below.

Code of Practice for Timber Management Operations in Riparian Areas (Ontario Ministry of Natural Resources 1998)

In Ontario, riparian management guidelines apply to water bodies as defined by the timber management guideline for the protection of fish habitat. Water bodies are defined as "…headwater lakes, lakes greater than 10 ha or that possess fisheries potential, and/or permanent and intermittent streams which provide habitat for fish". The primary objective of the code of practice is to protect water quality. Best management practices in the guidelines include guidelines prohibiting the maintenance of equipment near the water body, and recommendations for roads, bank protection, and logging debris and rehabilitation of portages and trap lines. A narrow filter strip of 3m of undisturbed forest floor or vegetation is to be left on banks except where necessary to cross a stream.

Timber Management Guidelines for the Protection of Fish Habitat (Ontario Ministry of Natural Resources 1988)

This document provides guidelines where shoreline areas adjacent to fish habitat have been selected for timber operations. It identifies riparian management zones as Areas of Concern (AOC) and outlines specific AOC widths based on the shoreline as measured from the high water mark. Forest management activities covered include roads, landings, harvesting, and mechanical site preparation for silvicultural activities. These guidelines define wetlands as areas of shallow water characterized by the presence of aquatic vegetation and which provide spawning or nursery for fish. As such not all wetland types (e.g., bogs and swamps) are covered in these guidelines.

Environmental Guidelines for Access Roads and Water Crossings (Ontario Ministry of Natural Resources 1990*)*

This document provides direction related to stream crossings on access roads on Crown land in Ontario. Included are mitigation techniques with specific reference to beaver problems and fish habitat. These guidelines do not make specific reference to wetlands although under the section on access roads there are specific guidelines for crossing "swamps" without a definition of what a swamp is. The primary emphasis of these guidelines with respect to water resources is related to ensuring water movement and that fish habitat is not impacted.

Habitat Management Guidelines for Birds of Ontario Wetlands (Ontario Ministry of Natural Resources 1985a)

This report profiles the importance of wetlands for both wildlife and society at large and includes a good description of the different classes of wetlands consistent with the Canadian Wetland Classification System (NWWG 1997). It provides an overview of factors that should be considered when undertaking management around wetlands and outlines a set of recommended management guidelines that are not specific to any particular industry although there is reference to logging and riparian areas.

Habitat Management Guidelines for Waterfowl in Ontario (Ontario Ministry of Natural Resources 1985b)

This publication provides guidelines to assist forest managers in protecting and enhancing waterfowl habitat in conjunction with timber harvesting. The guidelines recognize all classes of wetlands consistent with the Canadian Wetland Classification System (NWWG 1997) and outline special management considerations for fish, wetlands, ponds, beaver ponds, openings and erosion and sedimentation. The section dedicated to openings outlines criteria for creating openings in riparian areas through harvesting for waterfowl management purposes and there is a section dedicated to recommended cutting guidelines that include restrictions during the nesting season.

2.3.6 *Manitoba*

2.3.6.1 *Policies and Strategies*

The Manitoba Water Strategy outlines an integrated approach to the sustainable management of watersheds (Government of Manitoba 2003). The Manitoba Water Strategy sets a goal of developing watershed-based planning across the entire province, although to date such planning activities have been limited to portions of the agricultural landscape in the province.

Manitoba does not have a wetland policy. Within the Manitoba Water Strategy are six water policies covering water quality, conservation, use and allocation, water supply, flooding, and drainage. However, these policies are not entrenched in legislation and thus are not enabled or authorized beyond the context of guidelines. The policy on conservation has the most relevance for forest wetland conservation where there is reference to wetlands. To date actions flowing out of the strategy have been primarily outside of the forested regions of the province.

2.3.6.2 *Legislation*

Legislation for Manitoba that is most applicable to forest management activities and to water and wetlands is provided in Table 2.7.

Table 2.7 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Manitoba*

Legislation	Description	Relevance to Wetlands
Water Protection Act	Provides for the protection and stewardship of water resources.	Ensures that watershed planning is ingrained into the legislation and recognizes source water protection which includes wetlands and riparian areas.
Forest Act	Provides for the administration and regulation of forests on Crown lands.	No specific reference to water or wetlands; however, forest management activities can have an impact on these resources.
Environment Act	Provides for environmental licensing process for forest management including environmental assessment.	Reference to flowing and standing water. Environment Act license will outline water protection measures.
Endangered Species Act	Provides for the protection of endangered and threatened species in the province.	Some species listed under the Endangered Species Act may be dependent on wetlands.

* Adapted from The Forestry Corporation and Watertight Solutions 2004

Manitoba does not have specific wetlands legislation. Wetlands receive indirect protection through various acts.

The Act which has the most relevance to forest wetland conservation is the Manitoba Environment Act (Government of Manitoba 1997) which requires licensing of developments that may have significant environmental effects. Forest management plans must be licensed; the license includes operating conditions that typically reference operating guidelines for the protection of the environment, including aquatic ecosystems.

The Endangered Species Act (Government of Manitoba 1990) can have implications for wetland conservation if the habitat of a listed species includes wetlands (e.g., woodland caribou). Once a species is listed, additional restrictions to forest operations can be implemented.

Although the Water Protection Act (Government of Manitoba 2005) has the potential to influence forest operations, to date activities related to this Act have focused primarily on the private lands of southern Manitoba.

2.3.6.3 *Guidelines*

Manitoba has a series of guidelines which have been developed by the branches within Manitoba Conservation (formerly Manitoba Natural Resources). In 2000 Manitoba Conservation established the Forest Practices Committee comprised of representatives of the various branches within the department, Manitoba Water Stewardship, and the forest industry. This committee is responsible for the development of new forest practices guidebooks for resource managers to plan, conduct, mitigate and/or assess forestry operations.

Consolidated Buffer Management Guidelines (Manitoba Natural Resources 1996a)

This guidebook provides a summary of various guidelines in effect that have relevance to buffer establishment and management, including riparian areas. The guidelines provide a watercourse classification system that includes streams, lakes, ponds and wetlands. The definition of a wetland is not comprehensive and does not conform to any wetland classification system such as the Canadian Wetland Classification System (NWWG 1997). Recommended Riparian Management Areas (RMAs) are provided.

The guidelines specific to Riparian Management Areas are currently under redevelopment by the above noted Forest Practices Committee. The proposed new guidelines consider wetland classes including marshes, fens and thicket swamps. For logistic reasons related to operational constraints (i.e., flagging of boundaries), bogs were excluded from the new guideline but are typically protected by Best Management Practices (BMPs). Treed swamps can be harvested in Manitoba.

*Timber Harvesting Practices for Forestry Operations in Manitoba (*Manitoba Natural Resources 1996b*)*

These guidelines outline the acceptable day-to-day harvesting operating practices for the forest industry in Manitoba. Cutting practices, debris disposal and clean-up, cut-block design, riparian management, watercourse crossings and drainage, and road construction are covered. Criteria for locating roads, trails and landings in association to water are outlined and operational criteria for watercourse crossings provided. Riparian areas management is discussed but specific criteria are not provided.

Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat (Manitoba Natural Resources and Department of Fisheries and Oceans Canada 1996)

This document provides criteria for appropriate mitigation measures for the protection of fish and fish habitat during the planning, design, construction, clean-up, and maintenance of roads and stream crossings. Stream crossings refer to any temporary or permanent structures that are built to cross a water body. These guidelines are mainly focused on roads, but also include crossings related to transmission lines, cable crossings, pipelines, and railroads. Criteria for buffer maintenance when developing a stream crossing are provided and crossing locations with respect to spawning areas, important feeding, rearing and over-wintering areas are provided. There is no specific reference to wetlands in the document.

*Forest Management Guidelines for Wildlife in Manitoba (*Manitoba Natural Resources 1989)

Commonly called the Wildlife Guidelines, this document outlines recommended forest management procedures for activities associated with road development, harvesting (including configuration and timing of harvest) and forest renewal. Specific reference to water includes recommended set back distances for roads and RMA guidelines including criteria for clearcut setbacks (100 m) from water bodies. Species-specific guidelines are provided and include waterfowl habitat.

2.3.7 *Saskatchewan*

2.3.7.1 *Policies and Strategies*

Saskatchewan has a Water Policy which was developed in 1995 (Saskatchewan Environment 1999). Policy implementation is based on five key objectives: to increase awareness of the benefits of wetlands; to increase wetland monitoring; to coordinate government policies and programs to improve wetland management; to develop land use planning guidelines for wetland management; and to encourage landowners to maintain wetlands. Unfortunately this policy does not have strong wetland protection elements and is designed primarily for portions of the province dominated by private land and the agricultural industry.

The Saskatchewan Water Management Framework (WMF) was written following the North Battleford Inquiry (Saskatchewan Environment 1999). This framework identifies the need for source water protection and goals associated with the protection, restoration and best management of wetlands, riparian areas and upland cover, and relates mostly to agricultural landscapes.

In 1995 a *Forest Management Policy Framework* was released which reflected a shift from traditional allocation and harvesting to sustainable forest management including a commitment to maintaining a diversity of forest species and air, soil and water protection (Saskatchewan Environment 1995). This policy framework laid out the direction for the Forest Resources Management Act.

2.3.7.2 *Legislation*

Legislation for Saskatchewan most applicable to forest management activities and to water and wetlands are provided in Table 2.8.

Table 2.8 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Saskatchewan*

Legislation	Description	Relevance to Wetlands
The Environmental Assessment Act	Regulates developments which have significant impact on the environment including Industrial Forest Management Activities.	All water is included in the definition of environment.
Environmental Management and Protection Act	Protects the air, land and water resources and regulates and controls potentially harmful activities and substances.	Regulates aquatic habitat alteration and water quality impacts.
The Forest Resources Management Act	Promotes the sustainable use of forest land.	Provides framework for regulated standards including working around water and wetlands.
Saskatchewan Watershed Authority Act	Provides the mandate to manage, develop and conserve water resources and related land resources in Saskatchewan.	Provides framework for the protection of wetlands, including their quality and quantity.
Watersheds Association Act	Gives authority to Watershed Boards to act within the province's watersheds.	Watershed boards would have input on wetlands protection within a watershed.

* Adapted from The Forestry Corporation and Watertight Solutions 2004

Saskatchewan does not have specific wetlands legislation. Wetlands receive indirect protection through various acts. Following are key acts that influence conservation of forest wetlands on Crown land.

The Environmental Assessment Act (Government of Saskatchewan 1980) makes specific reference to forest management activities and requires that twenty-year forest management plans have an assessment which will include activities that have the potential to impact aquatic systems.

Through the Environmental Management Protection Act (Government of Saskatchewan 2002), forest managers are required to secure an Aquatic Habitat Protection Permit when installing and removing all lake, river, stream and creek crossings including winter crossings that use culverts, log or ice bridges, snow fills, skid bridges, and alterations to waterways.

The Forest Resources Management Act (Government of Saskatchewan 1996) and associated regulations provides a results-based framework for how forests are to be managed in Saskatchewan. This Act makes reference to forest resources and although there is no reference to wetlands, does include water. Prior to this Act there was no framework for regulated standards that detailed how the forest industry should operate. Regulated standards include forest planning and forest operations which both have the potential to influence how aquatic resources are protected.

The Watershed Authority Act (Government of Saskatchewan 2005) makes specific reference to waterfowl conservation and wetland habitat. The Saskatchewan Watershed Authority operating under the direction of this Act has the responsibility to develop watershed-based conservation planning. These plans are ongoing in Saskatchewan and are focused on the agricultural landscape and will eventually include watersheds associated with the forested Crown lands.

2.3.7.3 *Guidelines*

As noted the Forest Resources Management Act provides the framework for the development of standards. New manuals to regulate planning and operating standards are being developed (Forest Planning, Forest Operations, Compliance and Scaling). Some of these manuals will have an influence on operations around water and wetlands. Information on the status of these legislated manuals can be viewed on the Saskatchewan Environment website http://www.se.gov.sk.ca/forests/forestmanagement/Sask_Leg_Manuals.htm#ForestPlanningManual.

Currently the four provincial Forest Management Agreement (FMA) areas in Saskatchewan (Mistik Management Ltd, Weyerhaeuser Canada Ltd including the Prince Albert and Pasquia Porcupine FMA areas, and L&M Wood Products) have FMA-specific Standards and Guidelines for forest management activities in their respective FMA areas. Actions identified within these Standards and Guidelines that have relevance to water and wetland conservation and protection include criteria for road development, stream crossings and riparian management areas. These Standards and Guidelines are similar to each other except for riparian area management standards. As the provincial standards and guidelines are developed and approved, the FMA standards and guidelines will be superseded. Information on these current Standards and Guidelines can be viewed on the Saskatchewan Environment website http://www.se.gov.sk.ca/forests/forestmanagement/Sask_Leg_Manuals.htm #ForestPlanningManual.

It should be noted that for road construction and stream crossings, the current FMA standards must follow the Fish Habitat Protection Guidelines, Road Construction and Stream Crossings guidelines prepared by Fisheries and Oceans Canada and Saskatchewan Environment in 1995 (D. Weedon pers. comm.). Similar to those in Manitoba, these guidelines provides criteria for appropriate mitigation measures to protect fish and fish habitat during the planning, design, construction, clean-up, and maintenance of roads and stream crossings.

Overview of Riparian Guidelines per Existing FMA Standards and Guidelines

With one exception, forest management areas apply a 15, 30 or 90 m Riparian Management Area width depending on the size of water body and presence or absence of fish. In the FMA that is the exception, a variable retention harvesting prescription is applied to all water bodies. There is a 10 m no harvest zone followed by 30 m where 25% of the volume is retained. The RMA width measurement begins at the point where vegetation shifts from non-merchantable to merchantable species.

2.3.8 *Alberta*

2.3.8.1 *Policies and Strategies*

In 2003, the Alberta Government released the provincial water strategy called Water for Life to address growing pressures on Alberta's water resources (Alberta Environment 2003). The strategy is based on 3 main goals: 1) to provide safe drinking water to Albertans, 2) to maintain and protect Alberta's aquatic ecosystems, and 3) to effectively manage sustainable economic growth. Work on implementing this strategy is ongoing and will result in a number of provincial policies including a wetland policy which will strengthen the protection of water, including source water and wetlands province-wide and including the forest zone.

The Alberta Forest Legacy is an implementation framework built upon the recommendations provided through public consultation to the Government of Alberta. The Alberta Forest Legacy framework makes use of this integrative approach under the guiding principles of adaptive resource management and sustainable development.

The Alberta Forest Conservation Strategy is a commitment made by the Government of Alberta. This strategy follows that laid out under the National Forest Strategy and aims to guide the future use of Alberta's forests.

2.3.8.2 *Legislation*

Similar to other provinces, Alberta does not have specific wetlands legislation although policies that will flow out of the Water for Life Strategy will strengthen wetland protection. Wetlands currently receive indirect protection through various acts.

Legislation for Alberta most applicable to forest management activities and to water and wetlands is provided in Table 2.9.

Table 2.9 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in Alberta*

Legislation	Description	Relevance to Wetlands
Water Act	Focuses on managing and protecting Alberta's water and administrative processes (e.g. compliance and license issues).	Application process is required when conducting work in the vicinity of water. Requirements for stream crossings, culvert and bridge crossings and water diversion construction are included.
Environmental Protection and Enhancement Act	Supports the protection, enhancement and wise use of the environment. Is the legal basis for environmental assessment process.	Applies to activities in and around water, includes pesticide regulations and disposal of wastewater.
Public Lands Act	Deals with ownership titles of beds and shores of all permanent and naturally occurring bodies of water.	Prohibits any activities on public land that may have a negative watershed affect. Establishes provincial ownership of beds and shores of permanent and naturally occurring water bodies. Approval under this Act is required for shoreline modifications or encroachments on bed and shore.
Forests Act	Provides the legislative framework for administering forest lands including allocation of timber, annual allowable cut, dues etc.	No specific reference to water or wetlands; however, forest management activities can have an impact on these resources.

* Adapted from The Forestry Corporation and Watertight Solutions 2004

The Water Act provides the legislative framework for regulating activities around water and water bodies that can have an impact on the aquatic environment including sedimentation, siltation and blockage of flow. For forestry this will include road development, stream crossings and potentially harvest and silvicultural activities. The definition of a water body includes wetlands although a specific definition of a wetland is not included. Flowing out of the Water Act are regulations including a Code of Practice for Watercourse Crossings which is discussed below. (Water Act Chapter W-3; http://www.qp.gov.ab.ca/Documents/acts/W03.CFM; accessed February 22, 2007).

The Public Lands Act (Government of Alberta 2000, http://www.qp.gov.ab.ca/documents/Acts/P40.cfm?frm_isbn=0779751329, accessed February 22, 2007) establishes provincial/territorial ownership of beds and shores of permanent and naturally occurring water bodies. Under this Act, approval is required for shoreline modifications or encroachments on the bed and shorelines of water bodies. The Act defers to the Codes of Practice for Watercourse Crossings during construction and post-construction activities associated with watercourse crossings (The Forestry Corporation and Watertight Solutions 2004; Government of Alberta 2000).

2.3.8.3 *Guidelines*

In Alberta there are provincial and individual FMA Operating Ground Rules. The provincial ground rules provide the provincial standards which are modified for individual FMAs to reflect the regional forest conditions and specific company operations.

The province also has other ground rules and manuals that provide guidance for operating around water which are summarized below.

Alberta Timber Harvest Planning and Operating Ground Rules Framework for Renewal (Alberta Sustainable Resource Development 2006)

This recently released document provides criteria for operational planning, utilization, integration with other users, watershed protection, habitat management, silviculture, forest health and roads. Although there is no specific reference to wetlands, the section on watershed protection is particularly relevant to wetlands and outlines a watercourse classification system and riparian management strategies including standards for tree felling and machine activity. In addition, the section on road development is relevant to water and wetlands.

Code of Practice for Watercourse Crossings (Alberta Environment 2001)

The objectives of the code of practice are based on the principles of sustainable water management. These principles are: 1) water management must be sustainable; 2) water is a vital component of the environment; 3) water plays an essential role in the economy; 4) water must be managed using an integrated approach with other natural resources; 5) water must be managed in consultation with the public; and 6) water must be managed and conserved in a fair and efficient manner. This document establishes criteria for construction and removal of a water crossing. Causeway crossings through lakes and sloughs within the province require approval under the Water Act, Public Lands Act, and Federal Fisheries Act. Code of Practice for water bodies depends upon class of the water body.

Fish Habitat Manual: Guidelines and Procedures for Watercourse Crossings in Alberta (Alberta Transportation 2001)

This manual outlines guidelines for the construction, maintenance, and repair of road structures at or near a watercourse. It primarily deals with activities that have the potential to negatively impact fish and fish habitat. Wetlands are considered within a drainage basin when development plans may affect the drainage of those wetlands.

Forest Management Herbicide Reference Manual (Alberta Sustainable Resource Development 2004)

This document outlines the proper use of herbicides in forestry. The manual establishes guidelines for the application of herbicides within or adjacent to riparian zones.

2.3.9 *British Columbia*

2.3.9.1 *Policies and Strategies*

British Columbia (BC) does not have a wetland policy or water strategy. As such, strategies and policies for wetland sustainability and conservation flow out of existing acts and associated regulations. In 2004 the BC government announced it would implement the Working Forest Policy (Integrated Land Management Bureau 2007, http://ilmbwww.gov.bc.ca/lup/policies_guides/workingforest/index.html). This forest policy will be implemented by using existing planning tools, including regional land use plans and the Provincial Forest. The goals of the working forest policy include maintaining BC's forest stewardship standards to protect water quality, biodiversity, fish and wildlife, recreation and other forest attributes. The working forest policy also provides support for forest practices reform through the new *Forest and Range Practices Act*.

In 1992 a strategic land use planning process was initiated to be administered by the Integrated Land Management Bureau (Integrated Land Management Bureau 2007, http://ilmbwww.gov.bc.ca/lup/policies_guides/new_direction/index.html). Intended to provide a future vision for land and resources, the process involves significant public and stakeholder participation. It strives to balance opportunities for economic development with wise stewardship and protection of natural resources, including wildlife habitat and endangered species. Strategic Land Use Planning includes large-scale regional plans (Land and Resource Management Plans or LRMPs and Sustainable Resource Management Plans or SRMPs).

In December 2005 the Integrated Land Management Bureau released a paper titled "A New Direction for Strategic Land Use Planning in BC" (Government of British Columbia 2006). This document proposes a new direction for a strategic land use planning program that reflects current and emerging government goals and priorities.

2.3.9.2 *Legislation*

BC does not have specific wetlands legislation; wetlands receive indirect protection through various acts. Following are key acts that influence wetland conservation of forest wetlands on Crown land (Table 2.10).

Table 2.10 Summary of Provincial Legislation Relevant to Forest Management and Water/Wetlands in British Columbia*

Legislation	Description	Relevance to Wetlands
Water Act	Deals with the use and transport of water and alteration of streams and rivers. Wells and groundwater are included.	Focus is on streams and rivers; however, the regulations are relevant to all water, above or below ground.
Water Protection Act	Promotes sustainable use of water resources.	Also focuses on the removal and transport of water which will include wetlands.
Environment Management Act	Regulates waste disposal, waste discharge, and spills (solid waste, hazardous waste). Also deals with contaminated sites and the remediation process.	Management plans for soil conservation, water resource management, fisheries and aquatic life forms.
Environment Assessment Act	Regulates environmental assessment process for development proposals including ways to eliminate, minimize, mitigate or compensate impacts of such projects.	Impacts on wetlands would be included in the environmental assessment of proposals.
Forest Act	Establishes the framework for forest management, including technical and practical aspects of harvesting and industrial development.	This Act does not focus on water or wetlands.
Forest Practices Code of British Columbia Act	Legislation and regulations that addresses the sustainable use of forest resources.	Provides a range of guidelines to regulate and control the impacts of forest management on the environment, including on water and wetlands.
Forest and Range Practices Act	Legislation, regulations, standards, and guidelines dealing with forests and range lands.	Includes protection of watersheds and wildlife habitat and classifies streams.
Wildlife Act	Provides for the legal protection of wildlife including species listed as endangered	Will include species dependent on wetlands including endangered species.

* Adapted from The Forestry Corporation and Watertight Solutions 2004

The acts and regulations guiding forest management are currently in transition in BC. The Forest Practices Code of British Columbia Act (FPCBCA) (Government of British Columbia 1996) is being phased out in favour of the Forest and Range Practices Act (Government of British Columbia 2002a). Under the FPCBCA a number of forest management guidelines in the form of guidebooks were established. The method of having a Forest Development Plan is also being phased out, and replaced by a Forest Stewardship Plan.

Currently a number of the regulations are being repealed, and industry is acting under both old and new regulations while the transition occurs. As such, the existing forestry management guidelines under the FPCBCA are still being utilized and are considered core reference documents under the new Forest and Range Practices Act.

There is now more emphasis on foresters having freedom to practice, while justifying their management actions (D. Regimbald, pers. comm.). This introduces a results-based forest practice code—a forest management system that focuses on an end result of responsible forest management, rather than on a specific method by which it is achieved. The Forest and Range Practices Act and its regulations took effect on January 31, 2004, outlining the requirements for planning, road building, logging, reforestation and grazing. This Act makes specific reference to making future regulations related to a) community watersheds, b) lakeshore management zones, and c) streams, wetlands and lakes. Until the regulations under the Act are developed, regulations and guidelines under the FPCBCA will apply. Further, any activities already approved under the existing Forest Practices Code may continue and are governed by the regulations in the FPCBCA. After the transition period ends, a licensee may submit an operational plan only under the Forest and Range Practices Act.

2.3.9.3 *Guidelines*

The Fish Stream Crossing Guidebook (B.C. Ministry of Forests 2002)

This guidebook outlines the technical statutory references and requirements for selecting and designing stream crossings on forest roads to avoid harming fish and fish habitat and to provide fish passage at stream crossings sites (The Forestry Corporation and Watertight Solutions 2004). It provides guidance and outlines a process for selecting the appropriate type of structure for any given site, based on stream gradient and fish habitat presence.

Timber Harvesting and Silviculture Practices Regulation (Government of British Columbia 2002b)

Under the FPCBCA this regulation outlines criteria for operating in a community watershed; harvesting adjacent to unidentified or incorrectly classified streams, wetlands and lakes; felling or modification of trees in a riparian reserve zone; and constraining slash and debris in and around aquatic environments (including wetlands).

Riparian Management Guidebook (B.C. Ministry of Forests 1995)

The *Riparian Management Guidebook* defines attributes of riparian areas and the classification of RMAs, Management Zones, and Reserve Zones (The Forestry Corporation and Watertight Solutions 2004). The guidebook includes a stream and wetland classification system and provides recommended widths for the management and reserve zone within the RMA. Wetlands are classified based on size and whether they are considered simple or complex. Riparian management guidelines do not apply to large peatland wetlands greater than 1000 ha.

*Community Watershed Guidebook (*B.C. Ministry of Forests 1996*)*

This guidebook puts a focus on watershed values including water quality, quantity, and timing of flow. The guidelines protect watersheds by guiding and regulating the activities of the forest sector. There is detail on resource development practices that help prevent long-term changes to water quality, quantity, and timing of flow. Guidelines focus on topics like water quality monitoring, contingency planning, road planning, riparian management, range management, harvest schedule, forest fire suppression and management, range management, pesticide and fertilizer management, spring sources, and recreational activities. Short-term changes to a water supply may occur within its range of natural variability.

2.3.10 *Yukon Territories*

2.3.10.1 *Policies and Strategies*

The Yukon Government is responsible for management of forest resources on public lands in consultation with stakeholders including First Nation Governments. The majority of First Nations have settled their land claim so that the responsibilities for forest management have been given to Yukon Government, First Nations and Renewable Resource Councils. Renewable Resource Councils (RRCs) are six-person councils formed out of Final Agreements to provide community input into resource management and wildlife issues within the respective First Nation traditional territories (http://www.emr.gov.yk.ca/forestry/planning.html).

In 2004 the Yukon Government published a discussion paper outlining a Forest Policy Framework which was a collaborative effort between representatives of the Yukon government, Yukon First Nations and Resource Councils (Yukon Energy Mines and Resources 2004). This document was the culmination of a series of consultations relevant to Yukon Forest Policy dating back to 2001. The framework document outlines a vision for Yukon forest ecosystems and is built on six main themes: Relationships and Participation; Forest Economy; Forest Environment (with reference to water); Management and Planning; Education, Training and Capacity Building; and Research and Innovation.

The status of this Policy Framework is uncertain. The paper notes that the Devolution Transfer Agreement (between the Federal Government and Yukon) contains a commitment to a Successor Resource Legislation Working Group that at the time of writing had yet to be established. This partnership between Yukon and First Nation governments will have responsibility for making recommendations on issues related to developing new resource legislation in the Yukon.

2.3.10.2 *Legislation*

Yukon does not have specific wetlands legislation; thus, wetlands receive indirect protection through various acts. Table 2.11 presents key Acts that influence wetland conservation of forest wetlands on Crown land.

Table 2.11 Summary of Legislation Relevant to Forest Management and Water/Wetlands in the Yukon Territories*

Legislation	Description	Relevance to Wetlands
*Water Act***	Governs any use of waters including diversion, obstruction, alteration of flows or alteration of the bed or banks of any water body.	Focus is on streams and rivers; however, the regulations are relevant to all inland water, above or below ground.
*Environment Act***	Regulates waste disposal, waste discharge, and spills (solid waste, pesticides, hazardous waste).	Regulates the disposal of waste water, pesticides, and thermal water pollution into water bodies.
Environmental and Socio - Economic Assessment Act	Legislative framework for the Development Assessment Process	Social and economic impacts of proposed developments and environmental impacts of development are independently assessed. Impacts on wetlands would be included.
Mackenzie River Basins Agreement Act	Agreement between the Yukon and Northwest Territories to manage and protect the Mackenzie River Basin.	All water within the basin is included with this agreement.
Forest Protection Act	Relates to the protection of forests (e.g., from fires)	This Act does not focus on water or wetlands.
*Territorial Lands Act***	Covers administration and regulation of forests, including the cutting and removal of timber	This Act does not include any reference to water or wetland protection.

* Adapted from The Forestry Corporation and Watertight Solutions 2004
** Mirrored legislation (see below)

The Yukon has recently assumed the federal government's responsibilities for managing most of the Yukon's natural resources. After April 1, 2003, the Yukon became responsible for managing forests, and the Forest Management Branch of Energy Mines and Resources oversees the development and management of the Yukon's forest resources (The Forestry Corporation and Watertight Solutions 2004). The existing federal acts and regulations have been "mirrored" into corresponding territorial acts and regulations and will be used until the Yukon government develops and implements new legislation.

Related to the Yukon Environmental and Socio-economic Assessment Act (Yukon Government 2003), forestry projects are assessed and depending on the projected volume needs, the assessment will be done by designated offices across the territory with approval by the Forest Management Branch. For projects greater than 20,000m^3 the assessment and approval will occur by the Executive Committee of the Forest Management Branch.

2.3.10.3 *Guidelines*

Timber Harvest Planning and Operating Guidebook (Yukon Government 1999)
The Yukon's Guidebook is currently under review and is not part of legislation; thus, the recommendations are not mandatory. However, once the practice is included in an approved plan or as a permit condition it becomes binding (The Forestry Corporation and Watertight Solutions 2004).

The guidebook focuses on cutblock design and layout, access and operational recommendations for incorporating timber and non-timber values. Included are riparian management guidelines, similar to those in BC, that define an RMA that includes a Reserve Zone and a Management Zone. A definition of a wetland is included and there is reference to swamps, marshes and bogs. The main factors for establishing RMAs are wetland size and whether they occur as simple or as complex. Wetland complexes are areas larger than 5 ha that consist of two or more individual wetlands with overlapping riparian management areas. Wetland size is determined either from vegetation and water characteristics in 1:20000 aerial photographs or on the ground surveys identifying a transition from shrub-dominated to tree-dominated plant communities and areas of standing water or saturated soils. Harvesting is not permitted in the Reserve Zone but some harvesting may be permitted in the Management Zone.

Guidelines for the Management and Protection of Historic Resources for Timber Harvest Planning (Yukon Tourism and Culture 2003)
A minimum 100 m buffer must occur around known historic sites. Areas of high potential for the occurrence of historical sites (e.g., water bodies, streams, ridges) must be identified and mapped by qualified archaeologists as part of the harvest plan.

2.3.11 *Northwest Territories*

2.3.11.1 *Policies and Strategies*

The Northwest Territories (NWT) has not developed a territorial-specific water or forest strategy. However, given that the responsibility for land use activities rests with the federal government, the NWT has embraced the National Forest Strategy. In addition, the Federal Policy on Wetland Conservation (Environment Canada 1991) will apply to the NWT. A summary of the National Forest Strategy and the Federal Wetland Policy is provided in Section 2.2.

2.3.11.2 *Legislation*

Indian and Northern Affairs Canada (INAC) is the governing body for the development, implementation and interpretation of all policy and legislation relating to water management in the NWT. The Renewable Resources and Environment Directorate of the Division of the Department of Indian Affairs and Northern Development (DIAND) are made up of The Water Resources Division and three other divisions. Until this responsibility is transferred to the government of the NWT, the Water Resources Division's mandate is to manage the water resources of the NWT and advise the Minister of DIAND on water-related issues.

An additional complexity is the division of the NWT into land claim areas, individually negotiated with the First Nations and the federal government. Within negotiated land claim areas some lands may be set aside as settlement lands, which can be viewed as privately held lands owned by the First Nation where permits would not be required for forestry related activities (The Forestry Corporation and Watertight Solutions 2004).

However, forestry is under territorial authority in the NWT and is administered by the Forest Management Division of the Department of Renewable Resources and Economic Development. The Forest Management Division provides the policy and regulates the planning and framework for the stewardship, protection, and sustainable management of the Northwest Territories forest resources (http://forestmanagement.enr.gov.nt.ca/home.htm)

The NWT does not have specific wetlands legislation; wetlands receive indirect protection through various acts. Table 2.12 presents key acts that influence wetland conservation of forest wetlands.

Table 2.12 Summary of Legislation Relevant to Forest Management and Water/Wetlands in the Northwest Territories*

Legislation	Description	Relevance to Wetlands
Northwest Territories Water Act	Provides for the protection of the whole or any portion of any river or stream.	Regulates water in relation to waste disposal. Also includes enforcement and compensation legislation.
Mackenzie Valley Resource Management Act	Provides for an integrated system of land and water management in the Mackenzie Valley.	Focus is on the Mackenzie Valley and the establishment of land and water planning boards.
Water Resources Agreement Act	Regulates the use or indirect use or discharge of water or body of water.	Regulates water resources management, including the control of quality and quantity of water resources.
Forest Management Act	Provides for the administration, allocation and regulation of forests	This Act does not focus on water or wetlands.
Forest Protection Act	Relates to the protection of forests (e.g., from fires)	This Act does not focus on water or wetlands.

* Adapted from The Forestry Corporation and Watertight Solutions 2004

The Act that has the most relevance to the influence of forest management activities on water and wetlands is the Forest Management Act although there is no reference in this Act to these features.

2.3.11.3 *Guidelines*

Commercial Timber Harvest Planning and Operations Standard Operating Procedures Manual (Northwest Territories Environment and Natural Resources 2005)

These Standards provide criteria for forest management planning; field work and mapping; operational planning; and timber harvesting. Included in the operational planning chapter are guidelines related to watershed protection and harvesting constraints in riparian zones. Water bodies are classified in a similar fashion to the Alberta guidelines based primarily on permanency and size and defined as a lake, stream, river, creek, pond, swamp, marsh, channel, gully, coulee or draw that continuously drains water. A watercourse is defined as the bed, bank or shore of a river, stream, creek, draw or lake or other natural body of water, whether it contains or conveys water continuously or intermittently.

RMA widths vary depending on the water feature, and larger features receive a wider RMA. Based on the classification used, most wetlands with open water would receive a 10-30 m buffer. A 10 m machine-free zone also occurs adjacent to watercourses, and all equipment is to cross water bodies at approved locations. Harvesting within an RMA can only occur when permitted with explicit criteria. In addition no harvest is permitted when migrating birds are nesting in the Annual Operating Plan area and clearcut harvesting is not permitted in a water source area where soils are not frozen.

3.0 EFFECTS OF INDUSTRIAL DEVELOPMENT ON WETLANDS

3.1 Road Development

Like other industrial resource operations in the boreal and temperate forests, forestry tends to create large road access networks. Roads can be broadly grouped into three categories: permanent, temporary, or winter roads. Depending on province and local standards, certain widths, right of way clearances, and construction and surface materials may be required. Water crossings may also be legislated, often around the presence of fish and the federal Fisheries Act. Temporary roads will have lower standards, again, depending on province. Winter roads are used when access requires travel through areas where soils are wet and operations would otherwise be impossible. What follows is a brief discussion of specific effects of roads on wetlands. A review of road building practices and general effects of roads on forest communities is beyond the scope of this report.

3.1.1 *Overview of Impact of Roads Including Stream and Wetland Crossings*

Few studies exist with respect to road development impacts on wetlands in Canada. An overarching concern is the maintenance of existing natural hydrology. Culverts and/or bridges tend to be used near open water wetlands, marshes, and shallow open water because of their connection to fish-bearing water bodies and engineering approaches. However, bogs, fens, and swamps may be treated differently because these wetland types may not always be identified or mapped as wetlands and their hydrological connection may not be recognized. The following summarizes some background for pertinent factors related to development in peatlands and/or swamps, i.e., wetlands with peat or mineral soils with a high organic content.

Bulk density, porosity, water retention, and hydraulic conductivity are major considerations in infrastructure development. Hydraulic conductivity and overall hydrological connections should be maintained to minimize impacts and conserve ecosystem health. Understanding and classifying peat soils can help to better understand potential road impacts and to develop better management practices.

There is some confusion as to what is peat or organic soil, and how these soils are classified. Users and managers of land need to distinguish peat soils and adhere to a common naming convention and classification. The Canadian Soil Classification Working Group describes the differences in peat types and defines a peat soil as having > 17% organic carbon (or approximately 30% or more organic matter) by weight (Soil Classification Working Group and Agriculture and Agri-Food Canada 1998). Organic soils are grouped into peat materials and folic materials (forest floor peats – leaves, twigs, feathermosses).

Often peat types are named based on their organic origin (e.g., graminoid, *Sphagnum*, silvic or sedimentary peat such as gyttja or aquatic peats of lake bottoms and marshes), but descriptive terms such as feathermoss peat, woody peat, or brown moss-sedge peat are also common (e.g., Tarnocai 1984). Such terms do describe origin but do not provide information related to hydraulic conductivity or bulk density that may also be useful in forest operations.

Degree of decomposition provides useful information with respect to hydrology and conductivity and is determined by the von Post scale. The von Post scale is a scale of 1 (not decomposed) to 10 (highly decomposed) (Soil Classification Working Group and Agriculture and Agri-Food Canada 1998). The von Post categories are sometimes rolled into three broad categories: fibric/fibrisols (Of), mesic/mesisols (Om), or humic/humisols (Oh) (e.g., Beckingham and Archibald 1996) (see Appendix B for von Post detail). Frozen peats are generally referred to as organic cryosols (Soil Classification Working Group and Agriculture and Agri-Food Canada 1998).

Bulk density varies with degree of decomposition, botanical composition (e.g., silvic compared to *Sphagnum* peat), mineral content, and compaction. However, fibre content and decomposition are not related (Price et al. 2005). Overall, peats have a relatively low bulk density of 0.07 to 0.25 Mg/m^3 (Turchenek, Abboud, and Dowey 1998), compared to uncultivated clay soils that can have an average bulk density of 0.98 Mg/m^3 (Glenn et al. 2006).

Hydraulic conductivity describes the velocity of water flow over an area in response to a hydraulic gradient (Turchenek, Abboud, and Dowey 1998). Hydraulic conductivity is influenced by pore size and compaction. Thus, lower peat layers (the catotelm) have a lower hydraulic conductivity compared to top layers (acrotelm) (Turchenek, Abboud, and Dowey 1998). Lower layers are more decomposed (pore size decreases with decomposition) and because of the weight of top layers, they are also more compacted.

Porosity is described as the volume of pore spaces as a percentage of pore spaces and solids (Brady and Weil 1999). Porosity in peats is very high with an average value of 92% (Turchenek, Abboud, and Dowey 1998). Weakly decomposed peats have large pores while humic peats have small pores. An overview of the major physical characteristics is given in Table 3.1.

Table 3.1 Bulk Density, Percent Porosity, Percent Water Retention, and Hydraulic Conductivity of Peat Soils

Parameters	**Bulk Density in Mg/m^3**		**Porosity in %**	**Water Retention in %**	**Hydraulic Conductivity**
Turchenek, Abboud, and Dowey 1998	0.07 to 0.25 Mg/m^3		average 92%	up to 3000%	10^{-2} to 10^{-6} ms^{-1}
Canadian Soil Classification Working Group, 1998	fibric	< 0.075	> 90	n/a	> 6 cm/hr
	mesic	0.075 – 0.195	90 - 85	n/a	6-0.1 cm/hr
	humic	> 0.195	< 85	n/a	< 0.1 cm/hr
ecological implications	strongly correlated to ash and fibre content – indicator of decomposition; changes with compaction		controls water retention and transmission; weakly decomposed peats have larger pores compared to strongly decomposed peats	weakly decomposed peats have a higher water retention capacity than strongly decomposed peats	hydraulic conductivity is larger in the top layer (acrotelm) of a peatland; 80% of the water in the acrotelm can be released whereas only 15% of the lower layer (catotelm) can be released; determines ground water movement

Lowering of the water table or physical compaction by machinery will affect hydraulic conductivity and bulk density. While intentional drainage of wetlands in forestry is not common practice, indirect effects can be caused by road building through wetlands, especially peatlands. When fens are dissected perpendicular to water flow by a road, the upstream side becomes wetter and existing vegetation can die and be replaced by species more suited to wetter habitats. On the downstream side, the water table is lowered, allowing for more vigorous plant growth (Figure 3.1). Although there is a clear visual change in vegetation and species, no research seems to have documented this interruption of hydrological connectivity. Further, little is known about the peat compaction during winter operations, but weight of equipment and ice roads compress the peat and more than likely affect hydraulic conductivity as well.

Figure 3.1 Example of Potential Effects of a Road Running across a Wetland Perpendicular to Water Flow, Causing the Water Table to Increase on the Right and Decrease on the Left

3.2 Timber Harvesting

Buttle, Creed, and Moore (2005) and Price et al. (2005) summarized recent research developments in Canadian forest hydrology and wetland hydrology, respectively. Buttle, Creed, and Moore (2005) give an overview of impacts of harvesting and wildfires on indicators of surface water quality (dissolved organic carbon, P and N concentrations, phytoplankton, zooplankton, and fish biomass). Their analysis compared the Boreal Shield and Boreal Plains regions. Overall, the number of water quality indicators affected by forest disturbance was greater in oligotrophic Boreal Shield lakes than in more eutrophic Boreal Plains lakes. Wildfire seemed to have had a greater effect on these factors than forest harvesting, but disturbance by wildfire generally also covered a larger area of the studied basin (Buttle, Creed, and Moore 2005).

While these studies focus on lakes and forest hydrology, they do not specifically address forest disturbance in relation to wetlands. Indirect disturbances can impact or interact with surface or groundwater hydrology and affect wetland–upland linkages at the regional scale (Price et al. 2005). Such linkages are important in maintaining the hydrology and associated ecosystem health of wetlands (Hayashi and Rosenberry 2001, cited in Price et al. 2005). Recent work has demonstrated that examining wetland position within a surface and groundwater flow system can identify regional and local disturbance effects on wetlands and other systems (Devito et al. 2001; Hill 2000). Nevertheless, studies are often spatially and temporally too limited to characterize wetland hydrology (Price et al 2004). In addition to gaining a better understanding of the connection between surface and ground water hydrology, researchers are currently trying to characterize wetland hydrology and identify connections between uplands and wetlands (e.g., Buttle, Devito).

With respect to forest hydrology, Buttle, Creed, and Moore (2005) highlight the following research issues: improved understanding of forest subsurface hydrology; effects of climate variability and change; continuation of basin-scale monitoring programs across Canada; greater integration of forest hydrology and forest ecology; and experimental basin research. No doubt, these questions are important to wetlands as well but focused studies don't seem to exist. Further, the authors point out that management and science must be connected so that adaptive ecosystem management strategies can be studied.

3.3 Silvicultural Activities

In areas where black spruce only grows in poor conditions and is not a merchantable species, drainage programs to improve timber production have occurred in the past (e.g., in Alberta by Hillman, Johnson, and Takyi 1997). While the overall conclusion was that drainage programs are not cost-effective for timber production, the study also illustrated the effects of peatland drainage on vegetation and hydrology. Hillman, Johnson, and Takyi (1997) observed that bryophytes (mosses, *Sphagnum*, and liverworts) were the first group of plants that showed a negative response to drainage, in addition to such plants as sundew (*Drosera rotundifolia*), sticky false asphodel (*Tofieldia glutinosa*), swamp lousewort (*Pedicularis parviflora*), and northern green bog orchid (*Habenaria hyperborea*). These are typical wetland plants and while it is expected that these species would disappear or at least decrease in number or percent cover in response to drainage, few studies exist to document these changes.

Rothwell, Silins, and Hillman (1996) showed that bulk density and soil water content increased on some sites in a study of this drainage. Drainage generally causes peat to compress and as a result the peat has less or no capillary action. However, in this study soil capillary action was maintained and high soil water content (within top 30 cm) was recorded, depending on ditch spacing at a given site. Sites in the study included fen and swamp sites, but no clear pattern could be determined by site type or spacing.

Hillman, Johnson, and Takyi (1997) also report that water draining into the 0.90 m drainage ditch mainly drained from the organic–clay soil (mineral soil) interface. This observation suggests that it may be possible to reduce unintended peatland drainage when building roads parallel to peatland margins by leaving a buffer around peatlands and assessing depth to organic–mineral soil interface. If drainage ditch depth is above the organic–mineral soil interface, unintended drainage can possibly be avoided. However, how far above the interface the ditch should be placed is not known and focused studies are needed.

3.4 Other Industrial Activities

Although legislation currently exists to protect riparian areas from the effects of forestry, there are few operating guidelines to prevent agricultural development, urban expansion, and oil and gas activities in and around boreal wetlands. In some cases (e.g., agricultural uses) the risk of water resource exposure to excess nutrient levels and contaminants is much greater than that posed by harvesting operations (Castelle et al. 1992).

3.5 Carbon and Methane in Wetlands

Wetlands occupy 4-6% of the earth's land area (Mitra, Wassmann, and Vlek 2005) but are estimated to contain 350-535 Gt C, or between 20 to 25% of the world's soil organic carbon stock (Gorham 1991). Forested wetlands of boreal and sub-arctic Canada are comprised almost entirely of peatlands and these peatlands account for the majority of carbon stored in forested wetlands. In general carbon accumulation in wetlands is determined by the difference between primary production and the decomposition of organic material. Although peatlands are relatively unproductive compared to other types of wetlands, the cool and anoxic nature of these systems causes production to exceed decomposition and leads to a net accumulation of carbon. As a result of these conditions, peatlands represent a significant stock of C and therefore play an important role in the global carbon cycle (Strack and Waddington 2007).

In Canada, of the 158 Gt of C stored in wetlands 154 Gt of C are stored in peatlands. Of this 154 Gt, 98.5 % is in the form of peat while only 1.5% is in the form of vegetation (Gorham 1991). According to Vitt et al. (2000), peatlands in Alberta, Saskatchewan, and Manitoba combine to store approximately 48 Gt of C or approximately 31% of the C stored in Canadian peatlands. The C stored in this region represents 2.1% of terrestrial carbon globally within 0.25% of the global land base.

Based on long-term average C accumulation rates, Canadian peatlands sequester between 0.025 and 0.037 Gt of C yr^{-1} (Roulet 2000). However, peat accumulation rates have varied by more than an order of magnitude over the last 10,000 years and this variability needs to be considered when trying to estimate the present and future sink strengths of these peatlands (Bridgham et al. 2006).

In addition to the difficulties associated with predicting the sink capacity of peatlands due to the variability in past peat accumulation rates, rates of C sequestration also differ between the types of peatlands examined. Yu (2006) found that fens accumulated more carbon relative to bogs of the same age. This is of particular interest because most peatland studies where C accumulation rates have been determined were conducted in bogs but fens comprise 64% of the peatland area in continental western Canada.

Though peatlands are large C stores and can sequester significant amounts of CO_2 through photosynthesis, they can lose C as CO_2 from plant respiration and aerobic peat decomposition; and as CH_4 from the anaerobic decomposition of peat (Clair et al. 2002). In Canada and globally, peatlands are a significant source of methane and this is of particular concern as methane is 21 times more effective at trapping radiation than CO_2. Peatlands are estimated to contribute approximately 3.2 Tg CH_4 yr^{-1} to the atmosphere in Canada and 36.6 Tg CH_4 yr^{-1} globally (Bridgham et al. 2006). Emissions of CO_2 and CH_4 from natural sources such as peatlands are strongly influenced by environmental variables that are likely to be impacted by future climate change. For example, under the drier conditions that are predicted for areas of northern Canada, lowering of the water table in peatlands would potentially switch these systems from net sinks to large sources of CO_2 by exposing previously flooded peat to aerobic conditions and facilitating decomposition (Glenn et al. 2006). Furthermore, by lowering the water table, a greater volume of peat is also susceptible to fire, which could also release enormous amounts of C to the atmosphere. This is a significant concern as the oxidation of 1% of the organic C stored in Canadian peatlands would release the equivalent of 10 times Canada's anthropogenic CO_2 emissions in the year 2000 (Glenn et al. 2006). Conversely, lowering of the water table will also reduce the volume of peat exposed to anoxic conditions resulting in a shift from a net release of CH_4 to a net uptake from the atmosphere (Harriss et al. 1988; Strack, Waller, and Waddington 2006).

The impacts of disturbance and human activities can significantly alter the role of peatlands in the global carbon cycle. Gorham (1991) found that the combustion of peat for fuel adds approximately 0.026 Gt of C yr^{-1} back to the atmosphere, while the long-term drainage of peatlands released approximately 0.009 Gt of C yr^{-1} back to the atmosphere. Overall, about 0.035 Gt of C yr^{-1} are released from drained and mined peatlands compared to 0.096 Gt of C yr^{-1} sequestered by undisturbed sites (Gorham 1991). The net amount sequestered is 0.061 Gt of C yr^{-1} or 64%. Conversely, 36% more carbon per year would be locked in carbon sinks if peatlands were not drained or harvested for fuel. Within Canada, Turetsky, Wieder, and Vitt (2002) found that disturbances, mainly in the form of wildfires, reduced the accumulation of carbon in continental peatlands by 0.006 Gt of C yr^{-1} or 85% compared to undisturbed peatlands. Furthermore, these authors concluded that a 17% increase in the area of peatland burned annually would result in peatlands being a net source of C to the atmosphere regionally.

3.6 Effectiveness of Legislation, Policy and Guidelines

3.6.1 *Legislation and Policy*

With respect to legislation, policies, and guidelines, we found examples where guidelines or policies from different departments within the same province are in conflict with each other. For example, in New Brunswick where there is a strong wetland policy with protection measures, there is a separate peatland policy that is geared to the development of peatland resources. Although both policies incorporate wetland restoration as a component of the policy, clearly the wetland policy was developed to protect existing wetland resources while the peatland policy outlines a regulatory process for developing the peat resource.

3.6.2 *Guidelines*

Although there is a relatively extensive body of Canadian research regarding the effectiveness of riparian RMAs, most studies were carried out along rivers and streams (e.g., Darveau et al. 1995; Darveau et al. 1997; Kinley and Newhouse 1997; Whitaker and Montevecchi 1997; Machtans, Villard, and Hannon 1996) while another set looked at lakes (e.g., Hannon et al. 2002; Harper and MacDonald 2001; Macdonald et al. 2006; Prepas et al. 2001; Steedman and France 2000). To the best of our knowledge few studies have looked at the effectiveness of RMA guidelines specifically for wetlands. However, in the north-central U.S., studies on the effectiveness of RMA guidelines for amphibians have been conducted (Palik et al. 2001; Semlitsch and Bodie 2003).

Although most provinces acknowledge wetlands in their definition of a water body or watercourse, few riparian guidelines consider wetland type as a provision driving the guideline itself (Appendix D, but see Yukon and BC guidelines for noteworthy exceptions). Also, the definition of a water body in riparian guidelines varies by province and territory, so there is no national standard for wetland protection in riparian guidelines. Despite these variations wetlands also receive some protection under riparian management guidelines. Some wetland classes are not directly protected by the guideline (i.e., included in the RMA) but depending where RMA delineation begins, some wetland types may be indirectly protected. For example, in New Brunswick the edge water body begins at willows and alders so thicket swamps and some shrubby fens are likely indirectly considered under that RMA guideline. Treed swamps can comprise merchantable species and merchantable diameter trees. This may be particularly true in harvesting operations supplying mills with a smaller minimum piece size. Often these areas are recognized as sensitive areas because of soils, vegetation, and moisture level; thus, harvesting in these areas is governed by best management practices (e.g., Ontario, Saskatchewan). However, it is not always formally recognized (through mapping) that these areas represent wetland ecotypes.

Current regulations regarding riparian areas appear to have been developed with a limited range of values in mind. Many regulations were designed with an intent to protect fish and fish habitat (the Fisheries Act that protects fish/spawning habitat and fisheries contributes to this emphasis) whereas non-fish bearing waters typically receive less or in some areas no RMA protections. Larger water bodies also tend to receive more protection because of the perceived higher ecological and social value of these water bodies (Castelle et al. 1992). Interestingly, New Brunswick has an RMA guideline for wetlands known for waterfowl production of cavity nesting species. Across all regions current guidelines are also perceived to provide additional benefits by also protecting water quality, fish habitat, and maintaining corridors for wildlife. Within a given jurisdiction, all aquatic habitats meeting a specified set of criteria have typically been managed the same way regardless of their landscape context. Wetlands classified as bogs and muskegs receive little or no RMA protection. Whether or not RMA designations for these areas are necessary has, to our knowledge, not been studied.

As another example, in Manitoba there are sometimes conflicting guidelines when it comes to RMAs. For example, in the current Consolidated Buffer Management Guidelines (Manitoba Natural Resources 1996a) the recommended RMA for most water bodies, including streams, is 100 m. However, in the guidelines developed specifically for protecting fish resources, the RMA varies depending on the class of the stream and slope (Manitoba Natural Resources and Department of Fisheries and Oceans Canada 1996). In Saskatchewan, as noted in Section 2, RMA standards are not consistent between FMA licensees with three FMA holders having one standard and one other having a different standard. In recognition of this issue, the governments of Manitoba and Saskatchewan are currently in the process of developing new or revising current forestry standards or guidelines.

In addition to provincial/territorial guidelines, some forest companies have developed their own Standard Operating Procedures (SOPs) to guide forest management planning and operations on their Forest Management Areas. The purpose of these SOPs is variable and in some cases is designed to assist with current forest certification objectives and requirements. In a review of a sample of company SOPs in Western Canada undertaken by The Forestry Corporation and Watertight Solutions for Ducks Unlimited Canada, the authors note that SOPs are developed based on current guidelines and research results, with the intent of ensuring that operations follow the existing guidelines. In some cases these SOPs provide additional detail on watercourse classification to aid in management prescriptions (e.g., in Manitoba); however, to our knowledge enhanced wetland classification schemes have not been developed. Most SOPs include a clear listing of objectives, planning and operational procedures, and stop work criteria. They also outline, for a specific task, actions to take proactively or in response to a problem, operating details tailored to specific areas, landscapes and monitoring requirements (Forestry Corporation and Watertight Solutions 2004), and in some cases criteria for managing RMAs.

In reviewing the various acts, regulations and guidelines we noted considerable variation in the definition of a wetland. Definitions ranged from being very comprehensive (e.g., New Brunswick conforms to the Canadian Classification System) to having no definition at all (e.g., in Manitoba). In order to provide wetland conservation strategies and guidelines to the forest industry (and other industries), it is important that a proper definition of a wetland based on ecological parameters is provided with a definitive link to a classification system that can be transmitted to the field.

There are undoubtedly other examples where conflicting guidelines and policies are in place. The intent of providing the above examples was simply to profile the need for appropriate revisions that reflect a consistent approach and clear direction to both the industry and the regulators.

4.0 KNOWLEDGE GAPS

Throughout the document we have highlighted knowledge gaps surrounding forest wetlands. Information needs can be broadly categorized under three main groupings: mapping and inventory, spatial and temporal dynamics, and hydrologic function. These knowledge gaps create a significant challenge for forest management planning and monitoring wetlands over time.

At a most basic level, there are a number of gaps regarding the definition, classification, and mapping of wetlands. A broad range of classification systems and inventories do exist but we have demonstrated that there are challenges regarding scale (e.g., small wetlands can be missed) and for some classes there is even disagreement in what constitutes a wetland vs. an upland ecosite (e.g., treed swamps).

Another key knowledge gap lies in wetland temporal and spatial dynamics (i.e., predicting presence and absence of wetlands on landscape over time). While successional trajectories are well defined for wetlands, modeling these trajectories over time is challenging and has not been undertaken. Developing suitable predictors and models of forest wetland presence over time, especially those that consider climate change, would be an asset not only to monitoring efforts but also to long-term forest management planning.

Flowing from this process is the need to address the sensitivity of each wetland type to various forest management activities. Some of this work has been initiated (e.g., Devito et al. through Al-Pac Boreal Conservation Project) and to date includes integrating a wetland classification and mapping system with known hydrology information to predict areas of high risk for road development. Natural disturbance dynamics are poorly understood adjacent to and within wetlands. This is partly due to mapping issues. While we know that shorelines of wetlands do burn there is not much guidance in terms of developing forest management guidelines that emulate natural disturbance patterns around wetlands. A review of the literature regarding effects of industrial development including timber harvesting and silvicultural activities on forest wetlands clearly illustrates that this topic is not well studied.

Knowledge of the types of wetlands and the spatial distribution can assist in providing an initial indication of potential sensitivity. For example, lateral flowing water in peatlands is indicative of fen communities and suggests a potential for road building and other activities to cause impacts by interrupting this water movement. Similarly many swamps are seasonally flooded indicating that machine activity in these wetland communities can result in impacts such as rutting. Recent work has demonstrated that examining wetland position within a surface and groundwater flow system can identify regional and local disturbance effects on wetlands and other systems (Devito et al. 2005).

While an understanding of the spatial distribution of different wetland types is a good start it cannot replace the need for research regarding hydrologic function. It is known that wetlands are susceptible to alterations in hydrologic connectivity which can, in turn, alter nutrient and water levels and subsequently alter or impair wetland function. Nevertheless, studies are often spatially and temporally too limited to properly characterize wetland hydrology let alone predict disturbance effects. Research is needed to gain a better understanding of the connection between surface and ground water hydrology and to identify connections between uplands and wetlands (Devito et al. 2005; Buttle, Creed, and Moore 2005). Finally, the cumulative effects of multiple disturbances particularly in industrial landscapes are also not well studied. Filling these knowledge gaps would contribute greatly to the development of watershed-based forest management plans, monitoring initiatives and conservation planning.

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APPENDIX A

ECOZONE DESCRIPTIONS

Ecozone description is after Ecological Stratification Working Group (1996) and wetland area data from Tarnocai (2001). Table A1 shows the mean annual precipitation range, mean annual temperature range, and wetlands area by ecozone.

Table A1 Ecozone Descriptions

Ecozone mean annual precip. (P), mean annual temperature (T), and wetlands area in ha	**Biophysical Description**
Boreal Plain P: 300 mm in northern Alberta to 625 mm in SW Manitoba T: -2° C to + 2° C **ha of wetlands:** **30,325,308**	Underlain by Cretaceous shales; level to gently rolling plain with glacial moraines and lacustrine deposits. Surface materials are usually deep. High concentration of wetlands, mainly peatlands. Soils largely luvisols – grading into black chernozems in the south and into brunisols and organics northward. Conifers are white and black spruce, jack pine, and tamarack; broadleaf trees include white birch, trembling aspen, and balsam poplar. Balsam fir is present but not prominent.
Boreal Shield P: 400 mm in the NE to 1600 in maritime-influenced areas T: - 4° C in the NE to + 5.5° C in the east **ha of wetlands:** **73,020,987**	Rolling terrain creates a mosaic of uplands and wetlands; Precambrian granite bedrock outcrops intermixed with glacial moraines, fluvioglacial material and colluvium. Area has a high concentration of small to medium-size lakes and peatlands – especially in central Manitoba, northwest Ontario, and Newfoundland. Soils: humo-ferric podzols in the south and brunisols in the north – and some luvisols. Dominated by closed conifer stands: generally white and black spruce, balsam fir, and tamarack but white, red, and jack pine and eastern white cedar also present. At the southern portion broadleaf trees include white birch, trembling aspen, and balsam poplar. Exposed bedrock and soil generate a mosaic with a range of communities dominated by lichens, shrubs, and forbs
Boreal Cordillera P: < 300 mm in the rain shadow but up to 1500 mm coastal	Mountain ranges including numerous high peaks and large plateaus - separated by wide valleys and lowlands. Permafrost widespread in the north and at higher elevations. Soils: cryosols in the north; brunisols, podzols, and luvisols in the south and/or lower elevations.

T: +1° C to + 5.5° C **ha of wetlands:** **3,029,844**	In the British Columbia portion of the ecozone, there are grasslands on south-facing slopes with boreal forest vegetation on the north-facing slopes (similar occurrence as in the Montane Cordillera) - a feature unique within Canada's boreal forests. Plant cover ranges from closed to open and tree species include white and black spruce, alpine fir, lodgepole pine, trembling aspen, balsam poplar, and white birch. In the northwest, stands are more open; lodgepole pine and alpine fir are usually absent. Extensive areas of rolling alpine tundra - sedge-dominated meadows and lichen-colonized rock fields are present at higher elevations.
Taiga Plain P: Snow & freshwater ice for 6 – 8 months of the year; 200 – 500 mm precipitation T: - 10° C to - 1° C **ha of wetlands:** **30,325,308**	Gentle relief of lowlands and plateaus cut by major rivers; river valleys can show large elevational differences of several hundred metres. Area underlain by horizontal sedimentary rock - limestone, shale and sandstone. Covered with organic deposits and, to a lesser degree, with undulating to hummocky moraine and lacustrine deposits - alluvial deposits along river. Soils: cryosols, gleysol, and organic. High percentage of wetlands – mainly peatlands. Permafrost is widespread and influences regional hydrology.
Taiga Shield P: 200 mm to 800 mm; but up to 1000 mm near Labrador T: - 8° C in the NE to 0° C in the east **ha of wetlands:** **48,209,530**	Rolling terrain mosaic of uplands and wetlands; dominated by Precambrian bedrock outcrops and discontinuous hummocky and ridged moraine – also some lacustrine and marine deposits. Largest concentration of long, sinuous eskers. High concentration of lakes and wetlands in glacial depressions; dominated by peatlands. Discontinuous permafrost zone. Innumerable lakes, wetlands and open forests give way to shrublands and meadows more typical of the arctic tundra. Forest stands with lichen-covered understorey. Northern edge of the ecozone is the tree line. Soils: brunisolic and humo-ferric podzolic soils in the south; cryosols in the north; gleysols and organic cryosols lowlands. Characterised by open, conifer dominated forests – mainly black spruce and a well-developed shrub layer (e.g., dwarf birch, Labrador tea, and willow) and understorey (e.g., bearberry, mosses, and sedges Large areas are covered with stunted black spruce and jack pine, alder, willow, and tamarack. Upland sites support he growth of white spruce, balsam fir (in the Québec portion), trembling aspen, balsam poplar, and white birch.

Taiga Cordillera P: < 300 mm in the north to 700 mm in the southeast T: - 10° C to – 4.5° C **ha of wetlands:** **2,032,562**	Steep, mountainous topography, with ridges and narrow valleys; foothills and basins also present. Sedimentary bedrock with small igneous areas. Area covered with colluvial debris but frequent bedrock exposures and minor glacial deposits. The northwest portion was not glaciated. Soils: brunisols, regosols, and cryosols. Wetlands are regionally extensive and permafrost underlain. Permafrost features include peat hummocks, palsas, and peat plateaus. Permafrost is present except on the western half of the Mackenzie and Selwyn Mountains ecoregions. Vegetation is mix of arctic tundra (dwarf or low shrubs, mosses and lichens, and sedges) in the north, and alpine tundra (dwarf shrubs, lichens, saxifrages, and mountain avens) in higher elevations, and taiga or open woodland in the south (white spruce and white birch), mixed with medium to low shrubs (dwarf birches and willows), mosses, and lichens.
Montane Cordillera P: 500 mm to 1500 mm; but as low as 300 mm in arid regions in he south T: + 0.5° C to + 7.5° C **ha of wetlands:** **2,936,089**	Mountainous with several major interior plains; plains more extensive in the north—extend towards the south as intermontane valleys; mainly covered by glacial moraine and some fluvial and lacustrine deposits; mountains consist largely of colluvium and rock outcrops. Soils: luvisols and brunisols common; podzols in the mountain ranges in the wetter eastern portion and chernozems in the lower valley floors to the south. South-facing slopes have grasslands while north-facing slopes have typical boreal forest vegetation—a unique feature in the British Columbia region of the ecozone. Tree species include white and black spruce, alpine fir, lodgepole pine, trembling aspen, balsam poplar, and white birch. Higher elevations have extensive areas of rolling alpine tundra that are sedge-dominated meadows and lichen-covered rock. Plant species are diverse: alpine environments support various herb, lichen, and shrub; subalpine environments support lodgepole pine, alpine fir, and Engelmann spruce. At lower elevation, species can be separated into three groups: a) forests of Engelmann spruce, alpine fir, and lodgepole pine; b) forests of ponderosa pine, interior Douglas fir, lodgepole pine, and trembling aspen (in the southwest and central portions); c) and forests of western hemlock, western red cedar, interior Douglas fir, and western white pine in the southeast.

Hudson Plains P: 400 mm to 800 mm T: - 4° C to – 2° C **ha of wetlands:** **47,825,418**	The Plains are underlain by flat-lying palaeozoic and proterozoic sedimentary rocks which slope gently towards the Hudson and James bays. Elevations less than 500 m asl in most of the area. Covered by extensive wetlands, mainly peatlands and shallow open water; belt of raised sandy beaches. Coastal marshes and extensive tidal flats along coastline. Soils: organic cryosols and mesisols. Saline regosols and silty to clayey marine sediments along the coastal shore. Permafrost ranges from continuous in the northwest to isolated patches in the southeast. Species assemblages consist of arctic tundra and boreal forest transition plants. Large areas support dense sedge-moss-lichen covers, and better drained sites support open woodlands of black spruce and tamarack. White spruce is present in areas where calcareous rock influences the pH.
Pacific Maritimes P: 600 mm to 4000 mm T: + 4.5° C to + 9° C **ha of wetlands:** **800,290**	Mountainous topography with numerous fjords and glacial valleys but bordered by coastal plains along the ocean. Mainly igneous and sedimentary rocks but colluvium and glacial deposits. Soils are predominantly podzols and brunisols. Queen Charlotte Islands and part of Vancouver Island were not glaciated. Temperate coastal forest composed of western red cedar, yellow cedar, western hemlock, Douglas fir, amabilis fir, mountain hemlock, Sitka spruce, and alder forming ancient or old growth forests. Differences in altitude create widely contrasting ecosystems within the ecozone—altitude changes the climate from mild, humid coastal rainforest to cool boreal and alpine conditions at higher elevations.
Atlantic Maritimes P: 900 mm to 1500 mm T: + 3.5° C to + 6.5° C **ha of wetlands:** **903,451**	Dominated by Appalachian upland and the Northumberland coastal plain. Uplands are composed of granite, gneiss, and other hard, crystalline rocks. Upland terrain covered by glacial till; soils are humo-ferric podzols; luvisols in coastal lowland areas. Forests are mixed stands of conifers and deciduous trees, including red spruce, balsam fir, yellow birch, and sugar maple, while red and white pine, and eastern hemlock occur less frequently. Boreal species include black and white spruce, balsam poplar, jack pine, and white birch. Shrub species include pin cherry, willow, speckled alder, meadow sweet, and blueberry.

APPENDIX B

VON POST SCALE OF DECOMPOSITION

The von Post scale of decomposition is often used when describing peats. To determine the von Post scale of decomposition in the field, an organic sample is squeezed in 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 peats, 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 (see Soil Classification Working Group 1998 in references). For further information on organic and wetland soils refer to The Canadian System of Soil Classification.

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.
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 C

WETLAND CLASSIFICATIONS, ECOSITE GUIDES AND CLASSIFICATION, AND INVENTORIES OR STANDARDS

Note: additional classifications, inventories or standards may exist but are not always readily available or officially used in land-use management. For example, Alberta has the Alberta Wetlands Inventory Standard (Halsey and Vitt 1996) but no formal classification has been adopted by the Alberta government at this point. Further, classification, inventories or standards may be older, out of print, and not digitally available (e.g., Riley and Michaud 1988).

Legislation and guidelines related to forestry will identify how wetlands are treated in respect to land use management.

Canada	National Wetlands Working Group (NWWG). 1987. *The Canadian wetland classification system.* Canada Committee on Ecological Land Classification, Environment Canada. National Wetlands Working Group (NWWG). 1988. *Wetlands of Canada.* No. 24. Ottawa, Ontario; Montreal, Québec: Sustainable Development Branch, Environment Canada, Polyscience Publications.
Newfoundland/ Labrador	Meades, W. J. and L. Moores. 1989. Forest Site Classification Manual. A field guide to the Damman forest types of Newfoundland. For. Resour. Dev. Agree., FRDA. Report 003. Pollet, F.C. , A.F. Rayment, and A. Robertson. 1977. A Diversity of Peat. Newfoundland and Labrador Peat Association. St. John's, Newfoundland.
New Brunswick	Keys, D. and R.E. Henderson. 1987. An investigation of the peat resources of New Brunswick. Report No: open file report 83-10. Catalogue No: ISSN 0712-4562. Ministry and Minerals Division; Department of Natural Resources and Energy, Fredericton, New Brunswick. New Brunswick Department of Natural Resources, Fish and Wildlife Branch. 2006. New Brunswick Wetland Classification for 2003-2012 Photo Cycle. DRAFT. (pers. comm. Robert Capozi, Wildlife Habitat Specialist, Fish & Wildlife Branch. Dept. of Natural Resources (506) 453-2440 robert.capozi@gnb.ca) NB Department of Natural Resources. 1997. Ecological land classification for New Brunswick: Ecoregions, Ecodistricts and Ecosite Levels. New Brunswick Dept. of Natural Resources and Energy, Forest Management Br., 59p.
Nova Scotia	NSDNR. 1999. Forest resources inventory report. Nova Scotia Dept. of Natural Resources, Renewable Resources/Forestry Div., Cat.Log. Report FOR 1999-1, 29p. + Tables. NSDNR. 2001. Ecological Land Classification Map of the Province of Nova Scotia. N.S. Dept. of Natural Resources, Map DNR 2001-1. Peter D. Neily, Eugene Quigley, Lawrence Benjamin, Bruce Stewart, Tony Duke. 2003. Ecological Land Classification for Nova Scotia. Volume 1 - Mapping Nova Scotia's Terrestrial Ecosystems. Nova Scotia Department of Natural Resources, Renewable Resources Branch. Report DNR 2003 -2

Québec	Buteau, P., N. Dignard, and P. Grondin. 1994. Système de classification des milieux humides du Québec. Ministère de l'Énergie, des Mines et des Ressources naturelles du Canada et Ministère des Ressources naturelles du Québec, Ottawa et Québec. Létourneau, J. P. 2000. Norme de cartographie écoforestière - Confection et mise à jour - Troisième programme de la connaissance de la resssource forestière. Code de diffusion RN99-3044, Ministère des Ressources naturelles du Québec, Québec. (>10 guides exist and >10 others to come. Provide ecosites identification keys by ecoregions). Example: Gosselin, J. 2001. Guide de reconnaissance des types écologiques - Région écologique 3c–Hautes collines du Bas-Saint-Maurice. Direction des inventaires forestiers, Ministère des Ressources naturelles du Québec, Québec.
Ontario	Racey, G.D., A.AG. Harris, J.K. Jeglum, R.F. Foster, and G.M. Wickware. 1996. Terrestrial and Wetland Ecosites of Northwestern Ontario. Ontario Ministry of Natural Resources, Northwest Science & Technology. Thunder Bay, Ontario, Field Guide FG-02. pp 94 & Appendix. Harris, A.G., S.C. Murray, P.W.C. Uhlig, J.K. Jeglum, R.F. Foster, and J.D. Racey. 1996. Field Guide to the Wetland Ecosystem Classification for Northwestern Ontario. Ontario Ministry of Natural Resources, Northwest Science & Technology. Thunder Bay, Ontario, Field Guide FG-01. pp 74 & Appendix. Plus additional ecosites for other regions. Riley, J.L. and L. Michaud. 1988. Peat and peatland resources of northwestern Ontario. Ontario Geological Survey. Miscellaneous Paper 144. 175 pp.
Manitoba	Zoladeski, C.A., R.J. Delorme, G.M. Wickware, I.G.W. Corns, and D.T. Allan. 1998. Forest ecosystem toposequences in Manitoba. Natural Resources Canada. Canadian Forest Service. Northern Forestry Centre, Edmonton, Alberta, Canada. Special Report 12. Zoladeski, C.A., G.M. Wickware, R.J. Delorme, R.A. Sims and I.G.W. Corns. 1995. Forest Ecosystem Classification for Manitoba: field guide. Natural Resources Canada. Canadian Forest Service, Northwest Region. Northern Forestry Centre, Edmonton, Alberta, Canada. Special Report 2.
Saskatchewan	Beckingham, J.D., V.A. Futoransky, and I.G.W. Corns. 1999. Ecological classification of Saskatchewan's mid-boreal ecoregions using resource maps and aerial photographs. Natural Resources Canada. Canadian Forest Service. Northern Forestry Centre, Edmonton, Alberta, Canada. Special Report 14. Beckingham, J.D., D.G. Nielsen, and V.A. Futoransky. 1996. Field guide to ecosites of the mid-boreal ecoregions of Saskatchewan. Natural Resources Canada. Canadian Forest Service, Northwest Region. Northern Forestry Centre, Edmonton, Alberta, Canada. Special Report 6.

Alberta	Beckingham, J.D. and J.H. Archibald. 1996. Field Guide to Ecosites of Northern Alberta. Natural Resources Canada. Canadian Forest Service, Northwest Region, Northern Forestry Centre. Special Report 5. Edmonton, AB. Archibald, J. H., G.D. Klappstein, and I.G.W. Corns. 1996. Field guide to ecosites of southwestern Alberta. Natural Resources Canada. Canadian Forest Service, Northwest Region, Northern Forestry Centre. Special Report 8. Beckingham, J.D., I.G.W. Corns, and J.H. Archibald. 1996. Field guide to ecosites of west-central Alberta. 540 pages, 106 color illustrations. Special Report 9. Halsey, L. and Vitt, D.H. 1996. Alberta wetland inventory standards, Version 1.0 *In:* Alberta vegetation inventory standards manual. Version 2.2. ed. R. Nesby. Alberta Environmental Protection, Resource Data Division. pp. 131.
British Columbia	BC Ministry of Sustainable Resource Management. 2002. Vegetation Resources Inventory. The B.C. Land Cover Classification Scheme V. 1.3. Terrestrial Information Branch for the Terrestrial Ecosystems Task Force – Vegetation Resources Inventory Committee. MacKenzie, W.H. and J.R. Moran. 2004. Wetlands of British Columbia: a guide to identification. Research Branch, BC Ministry of Forestry, Victoria, BC. Land Management Handbook No. 52.

APPENDIX D

SUMMARY OF PROVINCIAL AND TERRITORIAL RIPARIAN MANAGEMENT GUIDELINES FOR FOREST HARVESTING

Table D1 illustrates range of terms, and factors used to measure and assign width and whether partial harvest is permitted. "Wetland classification" is "no" when a formal classification system is not being used to guide the buffer width. "Considerations" refers to site- or landscape-level factors considered when guiding buffer width prescriptions or operations. "Delineation" refers to characteristics used to delineate the measurement of the treed RMA. A 0 m width means that no treed RMA is required but does not mean that harvesting up to the water's edge is permitted.

Table D1 Summary of Provincial and Territorial Riparian Management Guidelines for Forest Harvesting

Province	Terminology	Delineation (buffer measured from…)	Water Body Type	Width (m)	Considerations	Wetland Classifica-tion	Selective Harvest Permitted in Buffer
Yukon	Riparian Management Area/Reserve Zone	Zone of transition between shrubs and trees dominated canopy or saturated soils or vegetation that indicates saturated soils.	Stream, lakes, wetland class	RZ -0-60 RMA 60-140 Total:60-200	Size, single or complex, presence or absence of fish, wildlife, permafrost, soils	Yes	Not in the reserve zone but with supporting data and plan RMA may have some prescriptions
Northwest Territories	High water mark	High water mark	Streams, lakes and ponds	0-100	Size and permanence	No	Yes
British Columbia	Riparian Management Area/Reserve Zone	Aerial photos-canopy greater than 15% and evidence of wetland processes or same as Yukon	6 stream classes 5 wetland classes with modifiers	30-50	Size; single or complex; biogeoclimatic zone	Yes	Yes
Alberta	Riparian area or Management Zone	High water mark	Lakes and ponds Streams and rivers	30-100	Size and permanency; presence of fish	No	No- except where specifically described in an AOP or by approval of forest superintendent
Saskatchewan		Merchantable species		15, 30 or 90 (except one)	Slope, fish	No	No-1 FMA uses variable retention harvesting.

(Continued on next page. See notes at end of table.)

Table D1 Continued

Province	Terminology	Delineation (buffer measured from…)	Water Body Type	Width (m)	Considerations	Wetland Classifica-tion	Selective Harvest Permitted in Buffer
Manitoba	Riparian Area; Riparian Management Zone	High water mark or Merchantable size timber	All	100 (regionally negotiable)	Slope, forest health, cultural features, fish, wildlife, water quality	No	No
Ontario	Riparian Area or Area of Concern (AOC) under fish guidelines	High water mark	Headwater lakes, lakes greater than 10 ha of containing fish, permanent streams intermittent when fish habitat	3 of undisturbed understorey BMPs for fish are 30-90 and include wetlands that are "fish habitat"	NDM; slope, soil, vegetation, season and equipment available	No	Yes
Québec	RMA	Merchantable species	All watercourses	20-60	Fish	Yes	Yes
Nova Scotia	Greenbelt/ Special Management Zone	Specified for streams but not other water bodies	All watercourses	20-60	Slope Special reference to marshes	No	Yes-with BMPs
New Brunswick	Watercourse buffer zone	Wetland edge begins at alder or willows	All watercourses	20 +	Slope, size of watershed; waterfowl productivity	No	Yes but only in certain stand types and to manage for forest health objectives
Newfoundland/ Labrador	Riparian Buffer	High water mark	All watercourses	20+	Slope	No	No

NOTES: NDM = natural disturbance management; AOP = annual operating plan