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WETLANDS, LAND USE, AND POLICY:
ALBERTA'S KEYSTONE ECOSYSTEM AT A CROSSROADS



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Green Paper
Presented at the Annual Conference of the
Alberta Institute of Agrologists,
Banff Alberta
March 16, 2011

Wetlands, Land Use, and Policy: Alberta’s Keystone Ecosystem at a Crossroads

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The opinions expressed in this report are solely those of the author and in particular do not reflect the views of the Alberta Institute of Agrologists.

EXECUTIVE SUMMARY

Worldwide, governments, the private sector, and non-government organizations face the challenge of balancing wetland conservation with promotion of wise use of resources and appropriate associated economic development. Similar challenges exist in Alberta. Over the span of a few decades the province has evolved from no wetland policy to a leader on *no-net-loss* policy and practice. However, as a revised policy is poised to be announced, Alberta may now become a province with potentially diminished wetland protection if replacement of lost wetlands is not considered. As growth continues in the province, Albertans are becoming increasingly concerned about environmental issues, as are those elsewhere in the world. At this juncture, Alberta has the unique opportunity to continue the leadership charge on wetland policy and practice, and can set the precedent for effective and balanced wetland conservation and management in Canada, and elsewhere.

Wetlands are Alberta's keystone ecosystem and resource. Keystone ecosystems are those that are particularly important from the perspective of ecology or management, and whose influence and significance is greater than their geographic presence. In Alberta, wetlands are found in all biomes and are inextricably linked to the province's aquatic and terrestrial ecosystems. Alberta's wetlands provide a wide range of functions and values. This keystone ecosystem will become progressively more important with increased development and climate change. The state of Alberta's wetlands is a bellwether for the condition of the province's aquatic resources and, ultimately, the quality of life for Albertans.

In Alberta there are two primary wetland types in two geographic regions that require two different management strategies. Most of the province's wetlands are peatlands (bogs, fens, conifer swamps) in the *Peatland Zone*. This region coincides with, but is larger than, the green area (78% vs. 61%). Here wetland loss is generally unknown but likely relatively smaller compared to the south. Current and planned developments, however, will likely lead to significant wetland losses here. The remaining wetlands in Alberta are mineral soil wetlands (marshes, shallow water wetlands, and shrub swamps) found primarily in the province's *Mineral Soil Wetland Zone*. The zone is similar to, but smaller than, the white area (22% vs. 39%). Here wetland loss approaches 65% and it is critical to preserve what remains, restore what has been impacted, and construct new wetlands to add value.

The *Peatland* and *Mineral Soil Wetland* regions differ significantly by wetland type, area, land ownership, population, land use pressure, and authority to set regulations. Herein lays the opportunity for Alberta to lead the development of two novel policies and practices that will address the different requirements of both zones. Examples of wetland policy and practice exist in other provinces and countries that can be used as models. In Alberta, policy for wetlands in the *Mineral Soil Wetland Zone,* where the highest loss has occurred, would benefit from a *no-net-loss* and a mitigation sequence of 1) avoid impacts, 2) mitigate or minimize impacts, and 3) compensate for irreducible impacts. The established 3:1

compensation ratio with a sliding scale for distance from original wetland is a useful replacement for lost wetland function and value until a standardized wetland evaluation system can be developed for this zone. Application of the mitigation sequence concept in Alberta has recently been identified as disfavouring avoidance of wetlands with resulting wetland loss. However, with some adjustment, *no-net-loss* and wetland compensation can remain proven concepts that enhance wetland conservation in Alberta.

Mineral Soil Wetland Zone policy is the low-hanging fruit in Alberta. Policy development in the *Peatland Zone* is more challenging and will require extensive consultation, resources, funding, and research. Here, time is of the essence. Nothing less should be acceptable given that the province's most ambitious development plans are in the region with the most wetlands. In the interim, priority should be given to conserving wetlands in the region until the creative solutions can be explored and a *Peatland Zone* policy developed.

Both wetland policies would be enhanced with support from the following programs and products: a validation program for qualified wetland workers and agencies; a provincial wetland inventory; a made-in-Alberta wetland classification, and; individual evaluation systems for the *Peatland* and *Mineral Soil Wetland Zones* using holistic broad-based indicators including hydrological, biological, social, rarity, and other aspects. Care must be taken when determining function and placing values on wetlands. Wetland rarity is independent of function and value as much as function is independent of value. Rarity or importance must not be used at the cost of the lost function and value in 'common' wetland types that are deemed nonessential. There is an important temporal aspect of value. Value judgements made on wetlands today may not reflect future values, the same way that past value judgements have not served us in the present. Wetlands must remain a legacy.

The province, industry, and academic institutions can support a research centre of excellence for applied wetland science in western Canada. Scientists have been conducting wetland research in Alberta for over 30 years. The research continues to grow and there is excellent expertise and top-rate research facilities. Through consolidation of expertise and resources, Alberta can become an international exporter of wetland knowledge, technology, and innovation. Current climate change models are forecasting an overall movement of development northwards into peatland-rich areas of Canada and Alberta is uniquely placed to develop progressive techniques for wetland construction, restoration, and mitigation.

Wetlands in Alberta are at a crossroads. They are the province's keystone resource. The challenge is to balance conservation of our wetland legacy with wise use of resources and appropriate economic development. Alberta now has the opportunity to be among those jurisdictions that play a key leadership role in the development of novel and effective wetland policy, practice, research, and technology.

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Keystone Ecosystem

A portion of the landscape that is particularly important from the perspective of ecology or management and whose influence and significance is greater than its geographic extent.

1. INTRODUCTION

Purpose and Objectives

Wetlands are unique ecosystems that are often found at the interface between terrestrial and aquatic ecosystems. They are the only ecosystem in the world recognized by international treaty, the Ramsar Convention (Ramsar, Internet). Wetlands also remain among the world's least understood environments and most abused resources. Because they are one of the world's most important ecological assets they are subject to political, social, and economical sensitivities (Smardon 2009). The wetland functions and values so important to the environment and society are often lost within legislative, administrative, and litigative debate. This repeatedly leads to deficient short-term land-use decisions. Nowhere is this as evident as in Alberta.

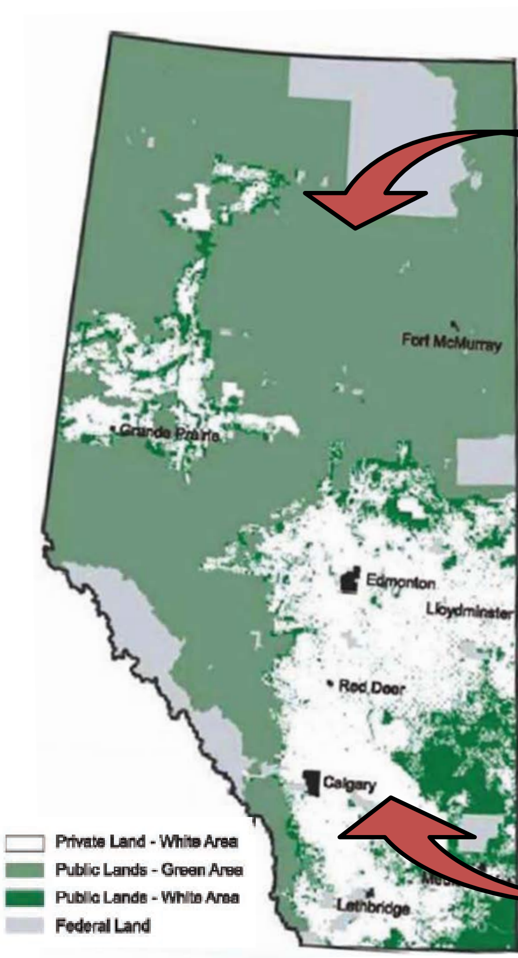
Wetlands in Alberta have come a long way from being obstacles to be filled, ploughed, corduroyed, and drained. High wetland loss in southern Alberta, a significant threat to northern wetlands, and controversy over wetland policy and land use have drawn wetlands to the attention of Albertans, and those outside the province. Indeed, the state of Alberta's wetlands may well be one of best bellwethers for water issues in the province. Wetlands vary in type, cover, function, and value across Alberta. However, the common thread is their importance to other ecosystems and society. Wetlands are keystone ecosystems critical to the health of our watersheds and life as we know it in Alberta.

The purpose of the 2011 Alberta Institute of Agrologists' Green Paper is to provide context to those interested in the issues surrounding our wetlands. Through this paper I hope to provide fact, provoke thought, incite discussion, stir creativity, and energize leadership to address the complex wetland issues facing the province. Using the best available information the following questions will be addressed:

1. What and where are Alberta's wetlands and how much area do they cover?
2. How do we define function and value and are Alberta's wetlands important?
3. What are the past, present, and future impacts to Alberta's wetlands?
4. What is the evolution of wetland policy and practice in Alberta?
5. What is wetland policy and practice in other jurisdictions?
6. What observations and insights can be made on wetlands in Alberta?

A central theme throughout this report is comparison of the two principle 'land-use' regions used in Alberta: the green area (unsettled) and the white area (settled) (Figure 1.1). The two regions differ significantly by area, land ownership, population, land use type, authority to set regulations, and wetland type. Because the areas are based on settlement and land use patterns it is not improbable that the boundaries will change over time. Management and conservation strategies would need to follow suit. For wetlands, the use of natural boundaries, rather than the green and white areas, may be more appropriate for wetland identification, monitoring, and management. Therefore, the green and white areas will be contrasted with two wetlands zones that are based on Alberta Natural Region and Subregion boundaries.

The range of wetland topics covered in this paper is broad, the quality of the available information and data is variable, and some of the content is changing swiftly. Every attempt has been made by the author to use the latest and most up-to-date information and data. However, the author acknowledges that there may be some omissions or inaccuracies.



Green Area	White Area
Unsettled Area	Settled Area
Covers 61% of Alberta	Covers 39% of Alberta
Nearly all Crown land	75% privately owned
Unpopulated northern Alberta, some mountain and foothills	Populated southern, central, and Peace River areas
Land Uses: forestry, oil and gas, oil sands, mining, tourism	Land Uses: settlements, agriculture, oil and gas, mining, tourism
Authority to Set Regulations: provincial government	Authority to Set Regulations: municipal government on private land, provincial government on Crown land
Main Wetland Type: muskeg	Main Wetland Type: sloughs

Figure 1.1. Alberta's green area (unsettled) and white area (settled) with societal, geographical, land-use, and wetland attributes. Map modified from AWC (2008) with data from GoA (2010).

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2. WETLANDS IN ALBERTA: WHAT, WHERE, AND HOW MUCH

What and Where: A Tale of Two Types

Wetlands are distinct ecosystems unto themselves, not transitionary states of terrestrial and aquatic ecosystems. While they may be found between uplands and water bodies they can as easily form in isolation on the landscape. Specifically, the Canadian Wetland Classification System defines wetlands as "lands saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, water-loving vegetation, and wetland adapted biological activity" (NWWG 1997).

Alberta has been administered according to the 'settled' white area (39%) and 'unsettled' green area (61%) (Figures 1.1 and 2.1). Ecologically, the white area includes the Grassland and Parkland natural regions, plus part of the Boreal Forest Natural Region, the Dry Mixedwood Subregion. The green area encompasses the remainder of the Boreal Forest Natural Region, and the Rocky Mountain, Foothills, and Canadian Shield Natural Regions. Albertans identify two wetland types associated with the 'settled' and 'unsettled' areas of the province: sloughs, or prairie potholes in the white area, and muskeg in the green area. This intuitive divide is actually based on technical characteristics, particularly soil type and vegetation. In Alberta (and Canada), wetlands are separated into two broad categories based on soil organic matter: mineral soil wetlands and peatlands (NWWG 1997). Sloughs are mineral soil wetlands, wetlands with gleysolic soil with little organic matter (< 40cm). Muskeg is peatland, wetland with mostly organic soils (> 40cm). This delineation is supported by Canadian soil classification standards (CSSC 1978).

Climate is a significant driver of wetland type and distribution and is the reason mineral soil wetlands are found in the south and peatlands to the north. Peatlands require a climate with a moisture surplus to form and generally sustain themselves. This condition occurs in regions where mean annual precipitation is between 500 and 3000 mm, potential evapotranspiration ratio is 0.125 and 0.800, and where mean annual temperatures remain between 3 ^{o}C and 6 ^{o}C (Wieder et al. 2006). This generally coincides with a region slightly larger than the green area.

Alberta can be divided broadly into two wetland regions: a Peatland Zone with "muskeg" and a Mineral Soil Wetland Zone with "sloughs"

Thus, based on climate, soil criteria, and the boundaries of Alberta's natural regions, Alberta can be divided into two broad wetland regions: the *Peatland Zone* and the *Mineral Soil Wetland* (MSW) *Zone* (Figure 2.1). The *Peatland Zone* includes the Boreal Forest, Rocky Mountain, Foothills, and Canadian Shield natural regions. The *MSW Zone* includes the Parkland and Grassland Natural Regions. The *Peatland Zone* represents 78% of Alberta compared to 61% for the green area. The *MSW Zone* represents 22% of Alberta compared with 39% for the white area. The *Peatland* and *MSW Zones* are permanent delineations based on natural boundaries. They are more intuitive and useful than the changing boundaries of the white and green areas (based on degree of land use), or treating Alberta as one wetland region.

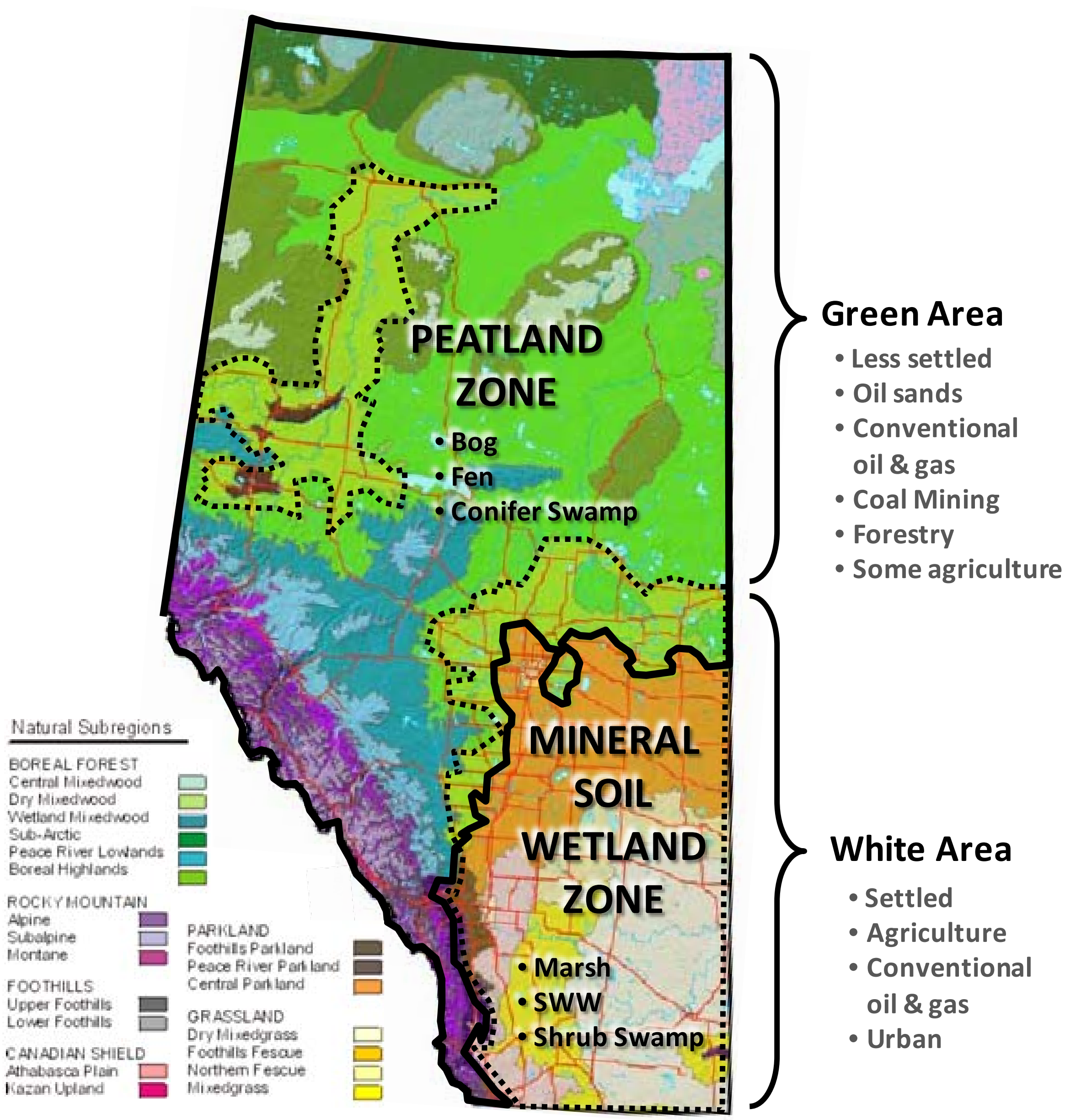


Figure 2.1. Alberta's *Peatland Zone* and *Mineral Soil Wetland Zone* delineated by bold lines and overlain the Natural Regions and Subregions. Primary wetland types are listed below each zone. The two regions roughly coincide with Alberta's unsettled green area and settled white area (dotted lines) except for the two components of the Dry Mixedwood Subregion (light green) which are in the *Peatland Zone*. SWW is the shallow water wetland class. Modified from AENV (2005).

How to Classify Wetlands in Alberta

Of the number of wetland classification systems being used simultaneously in Alberta, no one classification system is appropriate for the whole province based the scale required for detailed identification, inventory, and monitoring (Table 2.1). Although the Canadian Wetland Classification System (NWWG 1997) covers all Canadian wetland classes, not enough detail exists for comprehensive identification. For example, classification of peatlands requires plant indicator species, water chemistry boundaries, and other attributes which are mostly covered by A Field Guide to the Wetlands of the Boreal Plains Ecozone Canada (Smith et al. 2007). Classification of mineral soil wetlands requires an ephemeral to permanent aspect which is mostly covered by a Classification of the Natural Ponds and Lakes in the Glaciated Prairie Pothole Region (Stewart and Kantrud 1971). However, the latter classification does not address shrub swamp, a common wetland types in the north part of Alberta's *MSW Zone*.

A made-in-Alberta wetland classification is required to most effectively identify and manage provincial wetlands

To most effectively identify and manage provincial wetlands the development of a made-in-Alberta wetland classification system is required. Properly designed and incorporating elements from a number of key classification systems (e.g., NWWG 1997 and Stewart and Kantrud 1971), it would have great utility by standardization of terminology, facilitating mapping, and in the application of wetland policy. A made-in-Alberta wetland classification may be under development by the Alberta government.

Table 2.1: Wetland Classifications currently in use or proposed for Alberta. Arranged in order of (potential) utility.

Classification System	Authors	Year	Intended Use	Utility in Alberta
Alberta Wetland Classification System	?	?	Peatlands & Mineral Soil Wetlands	Not yet developed but potentially Very High
Classification of the Natural Ponds and Lakes in the Glaciated Prairie Region	Stewart and Kantrud	1971	Mineral Soil Wetlands	High for most mineral soil wetlands
Field Guide to the Wetlands of the Boreal Plains Ecozone of Canada	Smith, Smith, Forest, Richard	2007	Peatlands & Mineral Soil Wetlands	High for most peatlands and mineral soil wetlands in the boreal region
Alberta Wetland Inventory Standards Version 2.0	Halsey and Vitt	2003	Peatlands & Mineral Soil Wetlands	Moderate
Canadian Wetland Classification System	National Wetlands Working Group	1997	Peatlands & Mineral Soil Wetlands	Moderate
Wetland Classification in Western Canada: A Guide to Marshes and Shallow Open Water Wetlands in the Grasslands and Parklands of the Prairie Provinces	Millar	1976	Mineral Soil Wetlands	Low
Wetlands of the United States	Cowardin , Carter, Golet, and Roe	1997	Primarily Mineral Soil Wetlands	Low

Lack of a comprehensive provincial classification notwithstanding, a good basic description of the five wetland classes in Alberta can be provided: bogs, fens, swamps (shrub and conifer), marshes, and shallow water wetlands (Figure 2.2). The following outlines the differences among these as grouped under mineral soil wetland (sloughs, etc.) and peatland (muskeg) with fortification from other sources:

Mineral Soil Wetlands

Sloughs are mineral soil wetlands of a single type or varying proportions of shallow water wetland, marsh, and shrub swamp. Shallow water wetlands often form the centre of a pothole, with marsh ringing the shoreline, and shrub swamp encircling marsh and open water.

Shallow Water Wetlands

These are open mineral wetlands that are seasonally inundated with water no deeper than 2 m at midsummer and with dominant plants as submergent to floating vegetation. Considered transitional to truly aquatic ecosystems, the water chemistry is variable and does not distinguish this wetland class from the other four classes. Prairie potholes often have shallow water wetland habitat in their centre.

Marshes

Marshes are generally considered to be mineral wetlands and characterized by seasonal water level fluctuations and generally high water levels that are influenced by ground and surface waters. This wetland class is open, being dominated by emergent plants including sedges, bulrushes, and cattails, with few bryophytes (mosses and liverworts). Prairie potholes are often ringed with marsh habitat.

Shrubby swamps

Mineral soils swamps are influenced by seasonally fluctuating ground and/or surface waters and are dominated by shrubs, deciduous trees, with some herbs and grasses, and few bryophytes. Shrub swamps are the common form and generally have willows, alders, and perhaps some small birch. These sites often comprise riparian areas.

Deciduous treed swamps in Alberta are not common because there are few deciduous trees here adapted to long periods of standing water. Sites in Alberta may have water birch, and/or various large willows or alders, but true deciduous treed swamps are dominated by black ash and soft maples and are primarily found east of Manitoba.

Ephemerality and Permanence

The previous describes the general mineral soil wetland types in Alberta but the reader is directed to a Classification of the Natural Ponds and Lakes in the Glaciated Prairie Pothole Region (Stewart and Kantrud 1971) for details on ephemeral to permanence of mineral soil wetlands. There is high utility in this classification except for the lack of a shrub swamp class; shrub swamps are an important component on the landscape in the northern portion of the *Mineral Soil Wetland Zone*.

Table 2.2. Ephemerality and permanence classification of the Natural Ponds and Lakes in the Glaciated Prairie Pothole Region following Stewart and Kantrud (1971). [1]Pond = < 20 ha (50 acres); [2] Lake = > 20 ha (50 acres).

Seasonality Class	Attribute
I – Emphemeral Pond[1]	water usually disappears in early spring
II – Temporary Pond[1]	water disappears after a few weeks
III – Seasonal Pond1 & Lake[2]	water often disappears early summer
IV – Semi-permanent Pond[1] & Lake[2]	water often year round but may dry out
V – Permanent Pond[1] & Lake2	water year round, but shore is variable
VI – Alkali Pond1 & Lake2	summer open water often disappears to reveal salt flats
VII – Fen Pond[1]	usually always saturated

Peatlands

Muskeg is peatland comprised of three classes: bog, fen, and conifer swamp. These classes can occur singly or in complexes and are the principle wetlands in Alberta's *Peatland Zone* (Figure 2.1).

Bogs

Of all of the five wetland classes, bogs are the only wetland class that derives all water and nutrients from precipitation or atmospheric deposition. They are, more or less, consistently isolated from ground or surface water inputs. With characteristically low water tables and flow, these wetlands are extremely acidic (pH 3.5 – 4.5), a condition brought on and mediated by the characteristic sphagnum moss. Sphagnum moss modifies its environment through acidification by metabolically releasing acidifying hydrogen ions upon uptake of minerals. This effectively creates challenging growing conditions for all but the most adapted plants. Bogs are always dominated by bryophytes, chiefly sphagnum moss and/or feather mosses. Lichens are often common. Bogs can be wooded with black spruce, shrubby with various birches and ericaceous species, or open with sedges.

Fens

Fens are peatlands influenced by subsurface or surface waters that are generally high in dissolved minerals, such as calcium and magnesium. They range from slightly acidic to highly alkaline. Vegetatively, fens are quite variable, being wooded by black spruce and tamarack, shrubby with various birches and ericaceous species, or open with sedges and herbs. Fens are further divided into three types based on number/dominance of calciphile indicator species, which closely coincides to pH, alkalinity, and dissolved mineral gradients (Sjors 1952):

> *Extreme-rich fens* have the highest number of indicator species, have high pH (+7.0), alkalinity, and minerals, and are often the wettest.

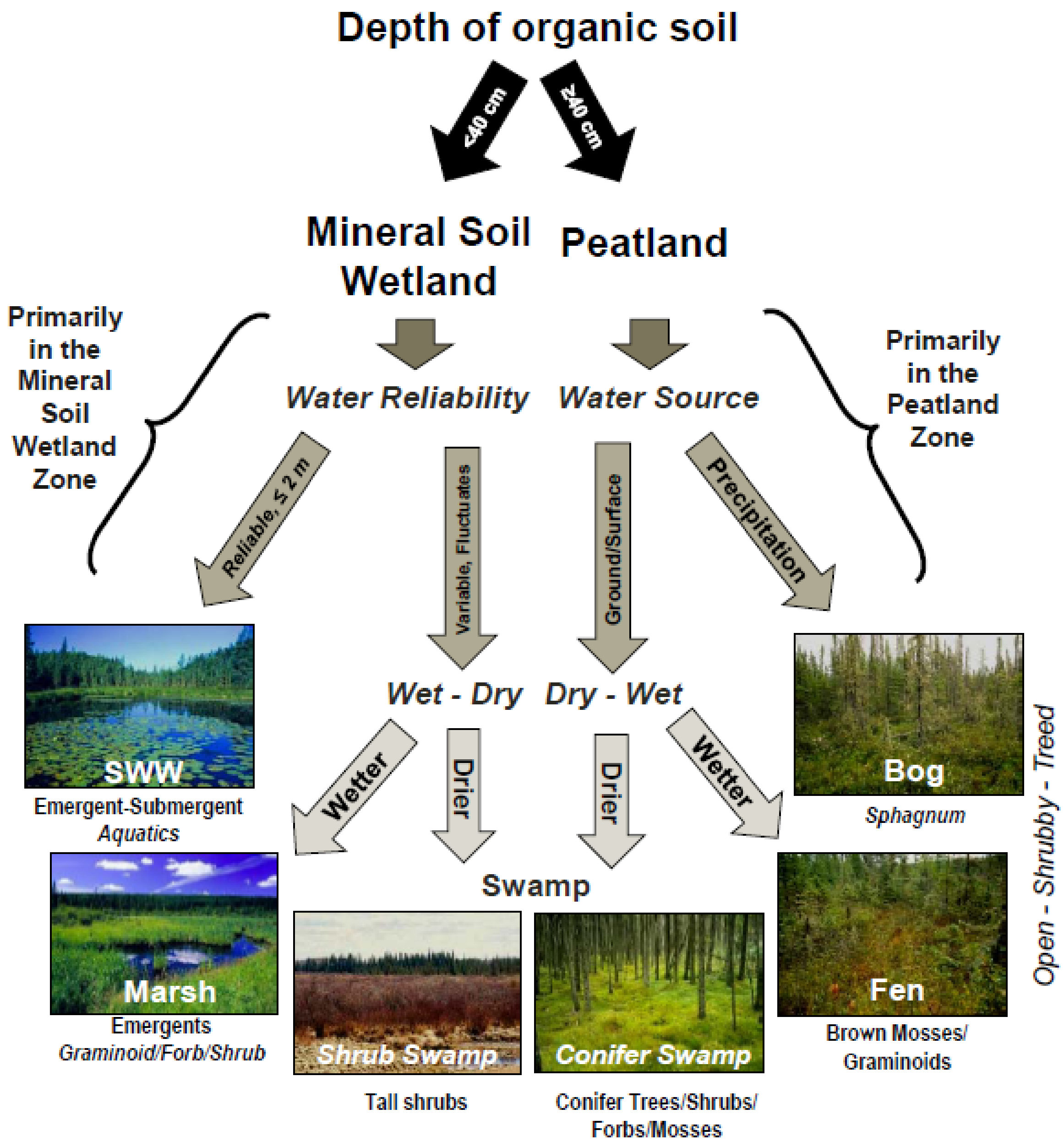


Figure 2.2. Simplified view of the five wetland classes in Alberta. Classes on the left are found primarily in the *Mineral Soil Wetland Zone*, whereas classes on the right are primarily in the *Peatland Zone*. Soil type based on peat depth separates mineral soil wetlands from peatlands. Hydrology is the prime determinant among shallow water wetland (SWW), marsh, and shrub swamp. Bogs are the only type that derives water and nutrients from the atmosphere. Separation of conifer swamp and fens is based on landscape attributes, hydrology, and trees and other vegetation. Note that swamp can be either mineral soil or peat soil. Refer to text for further details on hydrology, plant communities, and water chemistry.

Fens Continued

Moderate-rich fens have a moderate number of indicator species, moderate pH (5.5 – 7.0), alkalinity, and minerals, and degree of inundation. This is the most common wetland type in Alberta, particularly those that are wooded.

Poor fens have low number of indicator species and generally lower pH (4.5 - 5.5), alkalinity, and minerals. They are generally driest and are closer to bogs floristically.

Wooded moderate-rich fens are likely the most common wetland type in Alberta

Conifer Swamps
These peatlands are influenced by seasonally fluctuating ground and/or surface waters and are peat-forming wetlands. Of all peatland types black spruce swamps have the largest and tallest black spruce, which may make them comparatively more valuable for logging. Many classifications do not include them but recent work suggests that they are relatively common in the western boreal region (Locky et al. 2005a), but often mistaken for uplands, given the large size of their trees. In western Canada, conifer swamps are dominated by a denser cover of large black spruce and sometimes tamarack. The understory is herb rich and characterized by a significant ground cover of bryophytes. Conifer swamps often develop on gentle slopes around lakes in association with other peatlands. They are commonly intermediate between uplands and peatlands / lakes / streams and can be found ringing lakes.

Black spruce swamps have the largest trees of any peatland type and are relatively common in Alberta

How Much: Wetland Cover in Alberta

Wetland area in Canada is approximately 127 M ha or 16% of Canada's total area (NAWCC 1993). Alberta has 11% of Canada's wetlands, totalling approximately 13,704,000 ha. This translates to 21% of the province (NAWCC 1993), although the most recent comprehensive wetland inventory in Alberta calculates wetland cover to be 18% with specific estimates by region (Vitt et al. 1996) (Figure 2.3). Wetland cover in Alberta increases from less than 5% in the southwest corner to over 65% the northeast corner (Figure 2.4).

Wetland area by wetland region and natural regions needs to be updated. Current estimates may not be far off and suggest that the vast majority of wetland cover in Alberta is peatland in the *Peatland Zone*, comprising approximately 93% of all wetlands in the province (AENV, Internet) (Figures 2.1, 2.3, and 2.4). Thus, peatlands are the main wetland types in 16 of Alberta's 20 natural subregions. Vitt et al. (2000) estimate that in the western boreal region the average peatland cover is 20%. About 64% of the peatland area is fen, comprised of 35% treed fens and 29% open fens. The remaining area is 36% bogs. Of the fens, approximately half are rich fens, primarily wooded; with current data wooded fens are likely be the dominant wetland type in Alberta.

The remaining 7% of the province's wetlands are mineral soil wetlands found in the *Mineral Soil Wetland Zone* (Figure 2.2). These are comprised primarily of marshes and shallow water wetlands with some shrub swamps in the northern part of the zone. While mineral soil wetlands are found in all of Alberta's natural regions, peatlands are not found in four of Alberta's natural subregions.

The area of wetland cover will be refined in 2011 as Alberta Environment is currently working on a wetland inventory that will provide more detailed information of wetland cover for 80 – 90% of Alberta (Spytzer, pers com.). Utilizing three different levels of resolution, it will provide a benchmark, allowing the monitoring of wetlands over time, assisting in industrial operational planning, and potentially guiding restoration efforts. At least sixteen of these inventories are compatible with the Canadian Wetland Inventory Project (CWI) and will be integrated into inventory data from the rest of Canada (CWI 2011).

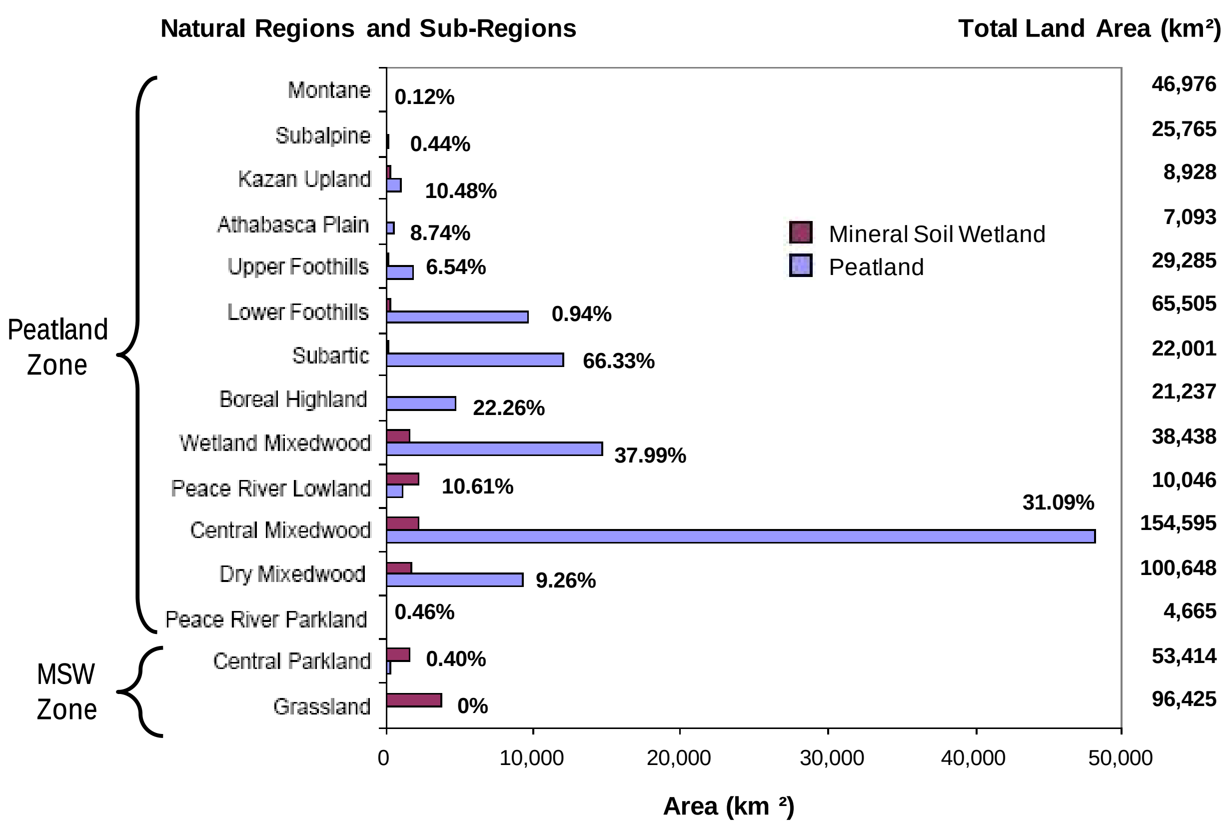


Figure 2.3. Peatland and mineral soil wetland area in Alberta by Natural Region (Grassland) and Subregion grouped by *Peatland Zone and Mineral Soil Wetland (MSW) Zone* in 1995. The Grassland Region is comprised of four subregions. Percents are total area of wetlands by Sub-regions/Region and total Subregion/Region are in km² on second y axis. Data from Vitt et al. (1996), except for Grassland Natural Region that was derived from Wilson et al. (2001). Figure adapted from Wilson et al. (2001).

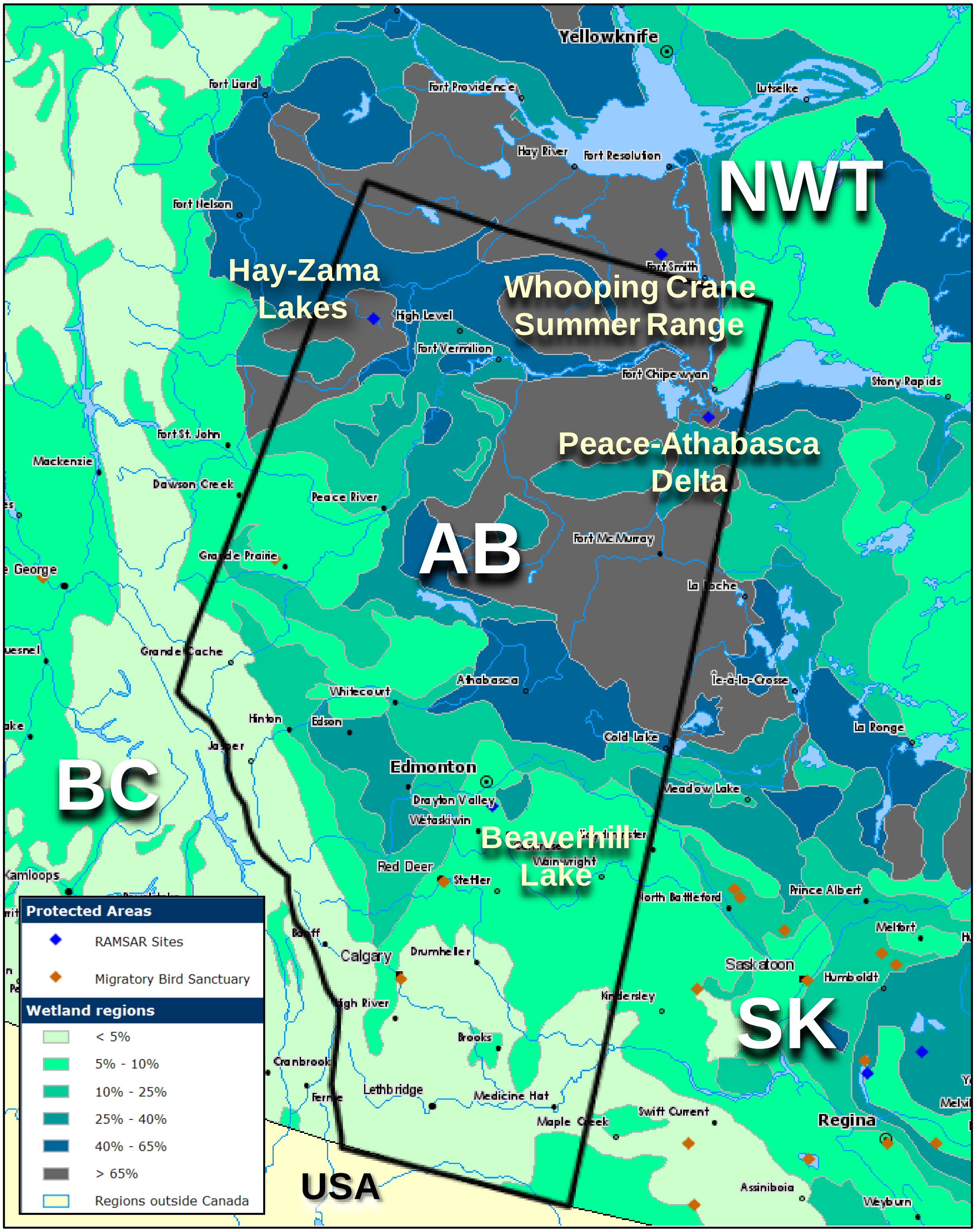


Figure 2.4. Wetland cover in Alberta (AB), with overlapping areas in the Northwest Territories (NWT), Saskatchewan (SK), and British Columbia (BC). Ramsar wetlands of international significance and migratory bird sanctuaries are identified. Modified from Natural Resources Canada (2003).

Summary

- **Wetlands are a distinct ecosystems**, not simply transitional landscape units found between terrestrial and aquatic ecosystems.
- **Two main wetland types exist in Alberta:** sloughs associated with the settled white area in the south and muskeg associated with the unsettled green area in the north.
- **Sloughs are mineral soil wetlands** (< 40 cm organic soil) that include marsh, shallow water wetland, and shrub swamp.
- **Muskeg are peatlands** (> 40 cm organic soil) that include bog, fen, and conifer swamp.
- **Fens can be divided** into poor, moderate-rich, and extreme-rich based on calciphile indicator plants and water chemistry factors.
- **Two wetland regions:** Based on soil, climatic data, and Alberta's natural regions it is intuitive to examine Alberta's wetlands based on the *Peatland Zone* and *Mineral Soil Zone* than the green and white areas, or Alberta as a single region.
- **Alberta has 11% of Canada's wetlands**, covering approximately 18% of the province.
- **Wetland cover in Alberta** increases from less than 5% in the southwest corner to over 65% the northeast corner.
- **Most of Alberta's wetlands are in the *Peatland Zone*** that includes 16 of Alberta's 20 natural subregions.
- **Most of Alberta's wetlands are peatlands**, with the most common type likely (wooded) moderate-rich fens. The remaining 7% of wetlands are mineral soil wetlands, mostly marshes and shallow water wetlands.
- **A made-in-Alberta wetland classification system** is required using the appropriate parts of various other classification schemes.
- **The Alberta Wetland Inventory** is a project inventorying 80-90% of the province's wetlands. When complete various components will be integrated into Canada's Wetland Inventory Project.

3. WETLAND FUNCTION, VALUE, AND KEYSTONE ECOSYSTEMS

Historically wetlands have been maligned and misunderstood. Shakespeare penned that some were to “as reek o’ the rotten fens...”. That wetlands may perform critical ecosystem functions, provide services, and have value are relatively recent concepts. It was not until the 1970’s that wetland scientists and conservationists began to convey the value of wetlands through demonstration of their measurable functions (Novitski et al. 1997).

Wetland function and value have been used interchangeably for various purposes over the last few decades (Kusler, Internet). Ambiguity between the two terms is partly attributed to the complex roles wetlands play in meeting society’s needs and lack of agreement upon what the roles wetlands play on the landscape and in society. A clear understanding of function and value help to determine the types of information required for assessment of wetlands. This is particularly critical when applying *no-net-loss* and other key wetland practices.

Function and value (ecosystem service) are often used to describe the worth, importance, significance, usefulness, and potential profit associated with wetlands. Generally, function encompasses the science-based ‘performance’ of a wetland whereas value includes a more socio-economic ‘usefulness’ factor. Thus, value is placed on function, introducing a degree of interchangeability.

Function encompasses the science-based ‘performance’ of a wetland whereas value includes a socio-economic ‘usefulness’ factor

To compare the terms, the function or the ability of a wetland to mitigate flooding can be measured and a dollar ‘value’ placed upon it. Many people living in the Mississippi Delta region of the Gulf Coast following Hurricane Katrina would likely be able to tell you that wetland losses have cost the economy dearly due to diminished natural flood protection. But values, particularly those that are monetary, are a human concept. The same degree of flood mitigation function performed by wetlands in an unpopulated region may be considered worthless to humans--despite the function providing immeasurable value to associated ecosystems.

While a function can be identified it may be difficult to apply a value to. For example, while it is generally acknowledged biodiversity is an important function, how does one place a measurable value on this? Irrespective of the difficulty and vagueness surrounding function and value, enough evidence exists to indicate that wetlands have high function and high value, inordinate to their size and location on the landscape. Such ecosystems are called keystone ecosystems, and wetlands are one of the best examples known.

Function vs. Value

When scientists first began to recognize important aspects of wetland function in the 1970's the role of wetlands in the hydrological cycle was the first to be identified (Novitski et al. 1997). The list of functions expanded until the present where we acknowledge a huge range of functions (Adamus and Stockwell 1983, Adamus et al. 1987, Wray and Bayley 2006), some of which are measured in dollars, (Costanza et al. 1997, Anielski and Wilson 2001) thus making them values.

Absolute values on various wetland functions, explicit (e.g., hydrology) or intrinsic (e.g., beauty) do not exist (Joosten and Clarke 2002). What is valuable in a wetland to one group may be less so to another. Explicit values, those most likely linked to function or a direct beneficial effect can be studied scientifically and are therefore more objective than intrinsic values. While intrinsic values may be independent from everything else, they deserve moral respect for their own sake, particularly when associated with culture. Adamus and Stockwell (1983) and Adamus et al. (1987) have provided a list of wetland functions which are of special interest not only because of a focus on functions that are important to humans, but also on the potential for human participation and developing a wise use of wetland practice. Similarly, the Ramsar (2010) Convention on wetlands categorizes wetland values as ecosystem services in a cogent manner:

Flood Control: Wetlands often play a crucial role in flood control. Loss of floodplains to agriculture and human habitation has reduced this capacity. Constructions of levees and dams on rivers to improve flood control have often had the reverse effect.

Groundwater Recharge: Many wetlands help replenish underground aquifers that store 97% of the world's unfrozen freshwater.

Shoreline Stabilization and Storm Protection: Coastal wetlands play a critical role in many parts of the world in protecting the land from storm surges and other weather events; they reduce wind, wave and current action, and coastal vegetation helps to hold sediment in place.

Sediment and Nutrient Retention, and Export: Wetlands slow the passage of water and encourage the deposition of nutrients and sediments carried in water. Nutrient retention in wetlands makes them among the most productive recorded, rivalling even intensive agricultural systems. Coastal deltas are dependent on riverine sediments and nutrients for their survival; engineered structures that interfere with the natural movement of sediments and nutrients can degrade deltas.

Climate Change Mitigation: Wetlands may store as much as 40% of global terrestrial carbon; peatlands and forested wetlands are particularly important carbon sinks.

Water Purification: Plants and soils in wetlands play a significant role in purifying water, removing high levels of nitrogen and phosphorous and, in some cases, removing toxic chemicals.

Reservoirs of Biodiversity: Freshwater wetlands hold more than 40% of the world's species and 12% of all animal species. Wetland biodiversity is a significant reservoir of genes that has considerable economic potential in the pharmaceutical industry and in commercial crop plants such as rice.

Wetland Products: The list of products from wetlands exploited by humans is immense. Exploitation is carried out at all levels from a commercial scale to cottage industries to subsistence levels. Two thirds of marine fish, for example, rely on coastal wetlands at some stage in their life cycle.

Recreation and Tourism: Many wetlands are prime locations for tourism; some of the finest are protected as National Parks, World Heritage Sites, Ramsar sites, or Biosphere Reserves. Recreational activities such as fishing, hunting and boating, etc., involve millions of people who spend billions of dollars on their activities. Wetlands offer ideal locations for involving the general public and schoolchildren in hands-on learning experiences, in an essentially recreational atmosphere, to raise awareness of environmental issues.

Cultural Value: Although largely an unexplored, poorly documented subject, wetlands are frequently of religious, historical, archaeological or other cultural significance at the local or national level.

Because wetlands vary greatly in form and location it is important to note that "not all wetlands perform all functions nor do they perform all functions equally well" (Novitski et al. 1997).

Not all wetlands perform all functions
nor do they perform all functions equally well

North America is second only to Australia in valuing its wetlands (Brander et al. 2006). However, incentives for wetland retention paid to landowners are not likely effective in conserving wetlands (Cortus et al. 2010). This suggests that some form of policy is required to effectively conserve wetlands.

The Temporal Aspect to Function and Value

Wetlands stakeholders vary widely on their views on what wetland legacy should be left for future generations (Joosten and Clarke 2002). This is risky given that the value of function may change over time and new values on latent functions may emerge with new information. Value judgements made on wetlands today may not reflect future values—in the same way value judgements on wetlands made in the past have not served us in the present. Lost wetlands represent a potential lost legacy of function and value.

Value judgements made on wetlands today
may not reflect future values, the same way that
past value judgements have not served us in the present

Alberta Wetlands: Some Functional Points

Wetlands in Alberta have elements of those functions and values listed above. Because they are divided broadly into mineral soil wetlands in the *Mineral Soil Wetland (MSW) Zone* and peatlands in the *Peatland Zone*, and because wetlands vary in which functions they perform and the efficacy of those functions, it is useful to highlight a few important insights specifically applicable to Alberta wetlands.

Ephemeral Wetlands
In much of the Alberta's *MSW Zone*, many areas in agricultural fields and native grassland take longer to dry during spring melt than the rest of the landscape. These are the ephemeral wetlands (Table 2.2) which form a significant and component of the Grassland and Parkland landscapes. While also present in Alberta's other biomes, they are comparatively less important.

Ephemeral wetlands are important and critical components of the landscape in many regions of the world (E.g., western North America, the Mediterranean region). For some organisms these marginal habitats are the only ones that they can exploit (Dodds and Whiles 2010). Emphemeral wetlands are particularly important to invertebrates and amphibians. They are one of the few habitats where amphibians may be top predators. Emphemeral wetlands link upland ecosystem processes and maintain biodiversity (Maine Audubon 2005) at the local and region levels. Migrating birds and mammals often use them.

Because emphemeral wetlands re-wet, these ecosystems have been and continue to be considered a nuisance by many farmers and government agencies. While the soils underlying ephemeral wetlands can often retain wetland plant diaspores for decades and appear fertile, recent research suggests that they may not be very suitable for crops (Bedard-Haughn 2010). The drainage process in these gleysolic soils (mineral wetland soils) may reduce soil viability, increase nutrient leaching through the binding of soil particles into larger aggregates, increase deposits of salts including calcium carbonate, and reduce absorption of herbicides, potentially contaminating ground water. Little is known about microbial community changes in these soils and they may be useful as carbon sinks, providing additional measureable value to Alberta's wetlands.

Given the ecological importance of ephemeral wetlands and the high losses of Alberta's mineral soil wetlands, ephemeral wetlands may well be excellent candidates for wetland restoration. They are an excellent example of how wetlands are always better as wetlands.

Wetlands are always better as wetlands

Wetlands Working Together: Complexes
Wetland complexes are comprised of a variety of wetland classes and types. In the *MSW Zone*, temporary and seasonal prairie wetlands (Table 2.2) provide an abundance of invertebrates for nesting waterfowl early in the breeding season. Later in the season when these more ephemeral wetlands are dry, semi-permanent and permanent wetlands are key habitat for waterfowl broods, moulting adults, and other wetland vertebrates with longer life cycles, such as amphibians. Wetland complexes support greater species diversity than isolated wetlands (Naugle et al. 1999) and the contribution of the complex of prairie wetlands to ecosystems goods and services has long been known (Brown and Dinsmore 1986, Fairbairn and Dinsmore 2001). The same principles apply to wetlands in the *Peatland Zone*.

Biodiversity
It is estimated that over 200 species of waterfowl, 16 species of mammals and 11 species of reptiles are directly dependent on wetlands in Alberta and countless others are indirectly dependent on wetlands for life support (Alberta Environmental Protection 1993).

Wetlands in the *MSW Zone* are particularly important for a large proportion of North America's waterfowl (NRCAN 2009). Based on critical water bird habitat, Alberta has three Ramsar internationally significant wetlands (Beaverhill Lake, Zama-Hay Lakes, and the Peace-Athabasca Delta) and shares the Whooping Crane Summer Range wetland complex Ramsar site with the Northwest Territories (Figure 2.4). It also has three migratory bird sanctuaries. Other animals that rely on Alberta's wetlands include up to 44 species of mammals, 15 species of herptiles (Locky 2004) and up to 22 species of fish (Alberta Environmental Protection 1993). Many other species utilize wetlands indirectly, including peregrine falcons, bald eagles, and carnivores (Locky 2003, 2004).

Wetlands in the *Peatland Zone* are important for biodiversity far beyond their borders (Locky 2010a). They maintain hydrological and microclimate features that provide temporary habitats or refuges for upland animals and plants. Plant species diversity may be lower in peatlands, but there is a higher proportion of species unique only to peatlands compared with terrestrial ecosystems. Peatlands are commonly the last remaining natural area in degraded landscapes and mitigate fragmentation. They may also provide habitat for species displaced by climate change. Of the peatland types in the western boreal region, plant species richness and rarity is highest in wooded moderate-rich fens (Locky and Bayley 2006), likely the most common wetland type in Alberta.

In addition to the high diversity of wetland plants and lichens, wetlands in Alberta also provide habitat for rare species, including orchids and sedges (Packer and Bradley 1984, Locky and Bayley 2006). Parkland and Grassland wetlands harbour more than 21 rare plant species.

Alternatively, low biodiversity does not always equate to low value. Some rare wetlands have low biodiversity (Locky and Bayley 2006, Locky unpublished). Wetlands with low diversity may be high value to wildlife. For example, marsh wrens are rare in some regions and are attracted to dense stands of cattails in marshes which, as monocultures, are not considered high biodiversity systems (Locky et al. 2005b).

Biodiversity at the Landscape Scale
Plant diversity and community composition are not similar in the same wetland type at the continental (multi-province) scale (Locky and Bayley 2010). Variability in plant community composition and species diversity has been found in western Canadian wooded fens. The patterns may be related, in part, to a gradient of precipitation and growing degree days, in addition to local scale factors. Thus, the suite of species in Alberta wooded fens are not likely to be similar to those observed in Saskatchewan or Manitoba and appropriate conservation plans must be developed to address this.

Wetlands are important for biodiversity far beyond their borders

Productivity
Wetlands have productivity similar to that of tropical forests with production up to 1000 gm / m^2 / per year (Whittaker 1975, Bradbury and Grace, 1983). They are among the world's most productive ecosystems (NRCAN 2009). Production in temperate wetlands, including shrub swamps and marshes, may be as high as 3500 gm / m^2 / per year (Bradbury and Grace, 1983), but boreal peatlands are likely closer to the overall wetland mean value of 1000 gm / m^2 / per year.

Water Storage and Flood Prevention
Landscape location is the principle consideration in determining the ability of a wetland to store water and prevent floods (Charman 2002). Wetlands that develop along watercourses or are associated with drainages may better mitigate flooding and potentially store water than isolated wetlands. However, mineral soil wetlands, due to their ability to withstand larger water table fluctuations than peatlands, generally perform far better than peatlands at storage and flood prevention. One of the largest misconceptions about peatlands is their ability to store large volumes of 'short-term' or 'temporary' water, from overland flow or flooding from water courses. As peatlands comprise approximately 93% of Alberta's wetland there is utility in further understanding their ability for water storage and flood prevention.

Peatlands hold vast quantities of water (Ingram 1983) and up to 95% of the peat may be saturated with water. Accordingly, a 1 ha peatland with a saturated peat depth of 2 m would contain 19,000 m^3 of water (Eggelsmann et al. 1993). However, only a very small proportion of the stored water in a peatland is part of the seasonal peatland to upland/water table water exchange. The key to understanding water table fluctuation and water budgets in peatlands is the hydrological nature of peat itself. The peat profile from surface to mineral soil is divided into two zones: the lowermost catotelm and thin upper acrotelm. The catotelm, or inert layer, is always saturated, anaerobic, and takes up all but a few centimetres of the peat profile. Here is most of the peatland's water storage. Above the catotolem is the acrotelm, only a few to perhaps 20 centimetres thick. This is the dynamic region of hydrologic change in peatlands where the peat is periodically aerated, the water table is present, and water content is highly variable (Ingram 1983, Eggelsmann et al. 1993). It is this thinness of the acrotelm in which the water table movement is confined that strongly suggests that most peatlands have a limited capacity to store or release water over the short term.

Terrestrial ecosystems and many mineral soil wetlands are likely better reservoirs for water storage than peatlands

There are situations where peatlands may function well at water storage and/or flood mitigation:

- Peatland complexes connected more broadly to a hydrological network may contribute to regional baseflow (Holden 2006). The size and the location of the peatland complex may allow for interception of catchment runoff and storage of some of the waters. This could reduce peak flows but is usually dependent on time of year (Ogawa and Male 1986) and peatland size and location relative to the regional drainage network (Heathwaite 1995). There may be less capacity for storage in the spring than summer.

- Peatlands with permafrost or impacted by beaver activity may exhibit even more lagged responses (Holden 2006).

- Forested boreal peatlands, which are a significant component of Alberta's peatlands (i.e., wooded moderate-rich fens), may have a significant impact on spring runoff peaks during years following drought (Hillman 1998, Woo and Young 1998).

Consequently, the proposal that peatlands are great at storing water (Ingram 1983) is incorrect in many cases. Terrestrial ecosystems, many mineral soil wetlands, and drained peatlands are likely better reservoirs for water storage than peatlands. The conservation of peatlands must then rest on other less conspicuous hydrological aspects such as water quality (Ingram 1983) and other values.

Water Quality

It is well known that many mineral soil wetlands, particularly marshes are excellent at improving water quality of sediment-laden, eutrophied, or polluted waters (Mitsch and Gosselink 2007). Many industries are now successfully using constructed treatment wetlands to treat industrial effluent. This includes the glycol treatment wetlands at Edmonton International and other airports. The role of peatlands and water quality is less known but includes the following from Charman (2002) and others:

- Increased suspended sediments in cases where erosion or disturbance is occurring (minor in undisturbed peatlands).

- Increased acidity where catchment have a high proportion of poor fens (and bogs).

- Increased dissolved carbon may change the colour of water and impact chemistry.

- Increased inputs of nutrients are likely from peatlands that have been disturbed. Undisturbed fens are known to act as nutrient sinks.

- Introduction of other chemicals including sulfate in oxidized (i.e., sites undergoing drought or artificial drawdown), mercury (promoted by industrial release of sulphate), particularly in shield-based peatlands in the eastern boreal region .

Peatlands and Carbon

Over the past 10,000 to 20,000 years a large proportion of the world's carbon, otherwise held in the atmosphere, has been stored in peat (Charman 2002). Peatlands represent a third to half of the global carbon pool, approximately equalling that in the global atmospheric carbon pool (Gorham 1991, Charman 2002). This is 350 to 535 Gt of carbon. Canadian peatlands store approximately 147 Gt, about 56% of our soil carbon. The amount of carbon estimated in Alberta's peatlands is 17 Gt (Anielski 1998). It has been calculated that Alberta's peatlands sequester more (56%) carbon than the province's forests. Peatlands thus take on a strategic importance with respect to the economic value of their carbon.

Peatlands release other greenhouse gases which must be factored into the carbon budget. Besides carbon dioxide (CO^2), methane (CH_4) and nitrous oxide (N_20) are produced through various internal processes. These gases add complexity to our understanding of peatlands and the carbon cycle. Perhaps the most important of these is CH_4, which is approximately 20 times more effective a greenhouse gas than CO^2. The amount of CH_4 released by wetlands of all types is roughly equivalent to that released by rice paddies and livestock. Fluxes of N_20 are generally considered to be low in undisturbed peatlands (Martikainen et al. 1993).

It is clear that peatlands play a key role in the global carbon cycle (Charman 2002), including those in Alberta. Any disturbances to peatlands, past, present, or planned necessitate tracking Alberta's carbon stores. To this end, Environment Canada has developed greenhouse gas monitoring stations in association with wetlands with two in Alberta: Lac Labiche and Esther (Environment Canada 2011).

Noteworthy is Ducks Unlimited Canada's peatland conservation strategy in Manitoba (DUC 2010). The program recognizes the significant role of peatlands in the global climate balance and seeks to preserve a number of key ecosystem services provided by peatlands.

Economic Values of Wetlands

Wetland functions and associated values have been translated into dollars in numerous ways. The exercise is not easy given that values and services vary widely, as do the methods of calculation, and knowledge of markets. Costanza et al. (1997) in their well-cited paper were one of the first provide some key insights the value of the earth's wetlands. Wetland values (ecosystem services) could include gas regulation, flood control, water supply, improved water quality, wildlife habitat, food production, and recreation For example, while inland wetlands (including all wetlands in Alberta) cover only 0.3% of the Earth's surface, they may contribute 10% of the annual ecosystem services. This translates into the highest total value per hectare of all the earth's ecosystems, $19,580/ha/year.

Wetlands are worth more per hectare than any other ecosystem type

Wetlands very well illustrate the type of goods and services that ecosystems can provide. Olewiler (2004) provides an interesting cross-section of values for various wetland functions:

- Biodiversity: Willingness to pay for hunting and fishing in Alberta averages $400/person/year.

- Biodiversity and beauty: Willingness to pay for fish and wildlife habitat by non-users in Alberta ranges from $267 to $453/person/year.
- Water filtration: Willingness to pay for water quality improvement provided by riparian wetlands in the U.S. Midwest ranges from $70 to $87/person/year.
- Water storage and filtration: Value/acre of flood control provided by wetlands in Massachusetts is $96,010, while that of nutrient filtering is $75,196 and water supply services is $291,357.

Alberta is one of three main provinces in Canada that produces horticultural peat. (Short 2010. Sun Gro Horticulture Inc and Premier Horticultural Inc produce up to 17% Canada's production. Annual sales exceed $69 M/year and 80% of this is exported to the US and Japan. This translates into 160 full-time and 70 seasonal positions in the province.

Cost of Wetland Losses

More recently and very importantly, the costs associated with wetland losses in Alberta from 1960 to 1999 have been calculated in 1998 – 1999 dollars (Wilson et al. 2001):

- Calculated annual economic benefit of wetlands remaining in Alberta has declined from $6.3B in 1961 to about $5.0B in 1999.
- Annual losses in value due to the estimated cumulative loss of 50 percent of Alberta's mineral soil wetlands by 1960 is to be estimated $6.4B (excludes shoreline protection services).
- Cumulative losses of mineral soil wetlands by 1999 are estimated to be 60.3% with a total annual cost of this loss at $7.7B.
- Adding shoreline function to the assumed 50% lost wetland area brings the losses to $15.5B in 1961 and $18.6B in 1999.
- Using value per hectare estimates of Constanza et al. (1997), the costs of losses then range from $38.0B in 1961 to $45.7B in 1999.

Wetlands, Alberta's Keystone Ecosystem

Some ecosystems have a positive impact on the landscape inordinate to their size or distribution. These are keystone ecosystems. The keystone ecosystem concept was first introduced by DeMaynadier and Hunter (1997) as a means to capture biotopes having greater importance to the biological structure and function than the average landscape unit. Keystone ecosystems sustain natural ecosystem process and scarce resources. They are the parts of the landscape that have high diversity, distinctive species compositions, and/or distinctive ecological processes that are beneficial to many other species and/or ecosystems (adapted from Stohlgren et al. 1997). Keystone ecosystems include coastal temperate rainforests (Moola et al. 2004), riparian areas, estuaries, some lakes and other aquatic ecosystems (Ocean Partners, Internet), mangroves (National Geographic 2001), and coral reefs. The presence and arrangement of keystone ecosystem types often determines the nutrient balance of a region (Blaschke 2005) in addition to a vast array of other functions and values.

Keystone ecosystems have an impact on the landscape inordinate to their size or distribution

Keystone ecosystems when mapped and identified can provide politicians, managers, planners, and the public useful information about critical ecosystem components (Stohlgren et al. 1997). It is here that ecology and management become one. The planning process can be fortified with knowledge of keystone ecosystems. Conversion and or loss of critical functions and values can thus be avoided, particularly for long-term planning.

Wetlands are Alberta's keystone ecosystem. In addition to functioning as distinct ecosystems unto themselves, wetlands are critical conduits between upland and aquatic ecosystems. Alberta's wetlands are found in all of the province's biomes and provide a wide range of ecosystem function and type. The health of Alberta's wetlands may well be a bellwether to the health of Alberta's water resources and the quality of life as we know it in the province. Protection of this valuable resource should be a provincial priority.

Alberta's wetlands will become increasingly important as development pressures increase and the climate changes. Wetlands are keystone ecosystems in the *Mineral Soil Wetland* and *Peatland Zone*s but key differences in type, function, losses, and pressures will necessitate that specific management policies and practices be developed and put into practice for each zone.

The health of Alberta's wetlands may well be a bellwether to the health of Alberta's water resources and the quality of life as we know it

Summary

- **Wetland Value and Function:** Function encompasses science-based 'performance' of wetlands whereas value includes socio-economic 'usefulness'; functions are valued.

- **Valued wetland functions** include flood control, groundwater recharge/discharge, sediment and nutrient retention, climate change mitigation, biodiversity reservoirs, wetland products, recreation and tourism, and cultural/heritage value.

- **Not all wetlands perform all functions** nor do they perform all functions equally well.

- **Today is Not Tomorrow:** Value judgements made on wetlands today may not reflect future values, the same way that past value judgements have not served us in the present. Lost wetlands represent a potential lost legacy.

- **Ephemeral wetlands** are critical ecological components of Alberta's *MSW Zone* and are likely more valuable functioning as wetlands than agricultural lands.

- **Wetland complexes** on the landscape are key to maintaining biodiversity and other functions. Wetlands are among the **most productive ecosystems in the world**.

- **Alberta has three Ramsar internationally significant wetlands**, shares one with NWT

- **The ability to store water and ameliorate floods** is likely higher in many mineral soil wetlands and terrestrial ecosystems than peatlands.

- **Many natural and constructed wetlands** are highly effective at removing sediments, excess nutrients, and pollution.

- **Alberta's peatlands hold 11% of Canada's soil carbon** and sequester more carbon than the forests. The value of this carbon is of strategic economic importance. Ducks Unlimited Canada is developing a unique **peatland conservation strategy** in Manitoba that focuses on peatland carbon storage.

- **Wetlands are worth more than any other of the earth's ecosystems**: $20,000/ha/year. The cumulative value of Alberta's lost wetlands was $45.7B in 1999.

- **Wetlands are Alberta's keystone ecosystem** and have a positive impact on the landscape inordinate to their size or distribution.

- **The health of Alberta's wetlands may well be a bellwether** to the health of Alberta's water resources and the quality of life as we know it.

4. LOSSES AND IMPACTS TO WETLANDS: MINERAL SOIL WETLAND AND PEATLAND ZONES

General Losses

Wetlands have been and continue to be impacted by great variety of disturbances in Canada. Most of these are anthropogenic but some are natural. Of the anthropogenic disturbances agriculture has caused more losses than any other activity. Since settlement by Europeans over 20 M ha of wetlands have been converted or drained. This represents 85% of all wetland losses in Canada (NRCAN 2009). The impacts have been widespread and regionally specific, including 80% of the Fraser River Delta, B.C. wetlands, 70% of southern Ontario wetlands, 65% of the Maritimes coastal marshes, and 70% of prairie province mineral soil wetlands. In Alberta, the settled or white area of Alberta had lost approximately 60% of its wetlands by 1996 (Wilson et al. 2001). Today wetland losses may be as high as 64%. This number must be taken into context; although less is known about wetland loss in Alberta's less settled green area this is where up to 93% of Alberta's wetlands are located.

Over 60% of Alberta's wetlands have been lost in the settled region but 93% of Alberta's wetlands are in the unsettled region

Wetlands in Alberta have begun to be extensively mapped, albeit at different resolutions. It is expected that most of the province will have been covered with mapping products available by in 2011 (Spytzer, pers com). The mapping will potentially provide the ability to adequately quantify new wetland losses in the *Mineral Soil Wetland (MSW) Zone* and parts of the *Peatland Zone*. As Natural Regions and Subregions are ecologically-based landscape units to calculation of wetland cover and loss by type would have utility from the perspective of wetland policy and practice in Alberta.

General Impacts

Impacts to wetlands are generally grouped into three categories:

- Complete loss (i.e., loss of wetland functions).
- Direct disturbance (leading to impairment of wetland functions).
- Indirect disturbance (resulting in impairment of wetland functions).

While impacts to wetlands, direct and indirect, are widespread throughout Alberta, finding appropriate methods to measure the impacts on associated functions is difficult. As noted previously, not only is wetland function variable by wetland type but it also differs within type under varying conditions.

Wetland impacts can also be divided into natural and anthropogenic disturbances. Natural disturbances include water level fluctuations, sediment deposition, fire (Niemi et al. 2004), and beaver activity (negative or positive). Anthropogenic disturbances may include changes due to development including drainage, fragmentation, nutrient input, and chemical input. Impacts may be as a result of a combination of natural and anthropogenic influences, with climate change being the most significant example (Niemi et al. 2004). Distinguishing between natural and anthropogenic disturbances and variation in wetland ecosystems is a primary challenge.

Only a few studies exist on Alberta wetlands in the Parkland Natural Region (Savard et al. 1994) and Central Mixedwood Subregion. Fewer yet are studies on sites in other Boreal Subregions, Foothills, and other Natural Regions (see review in Wray and Bayley 2006). Paucity on wetland data is not relegated to Alberta, but is also throughout much of North America (Amon et al. 2002). This hinders our capacity to not only understand Alberta wetlands, but identify effective indicators of wetland disturbance.

While loss of wetlands due to agriculture continues, new development pressures have arisen that are taking precedence in some regions of Alberta. Some of these pressures are related to urbanization, oil and gas development, oil sands activities, and logging. In Alberta differences in wetland type, cover, settlement patterns, population, and land uses necessitates an examination of impacts to wetlands by *MSW Zone* and the *Peatland Zone* (Figure 2.1).

Mineral Soil Wetland Zone

Agriculture: Direct Loss

As with the rest of Canada, wetland loss in Alberta's white area has historically been due primarily to agricultural activities. Much of this zone, as part of North America's prairie region, was once covered by 20 to 60% wetland (Turner et al. 1987). Over a century of agriculture had led to the majority (40-60%) of these wetlands being drained for croplands and greater than 90% being adversely affected by agriculture (and urban sprawl). At the northern edge of the white area, the Parkland Natural Region at has lost up to 60% of its wetlands. Here it is estimated that only 55% of pond margins (i.e., would include wetlands) and 51% of uplands have been untouched by cultivation in this region (Bjorge 1999)

Agriculture: Impairment

In Alberta has been the degradation of surface and groundwaters associated with agricultural activities has caused considerable impairment of wetland. This includes the application of fertilizers, pesticides, and herbicides (Miller et al. 1992, Greenlee et al. 2000, Anderson et al. 2002).

A study of 25 wetlands monitored over the course of a year by pesticides (Anderson et al. (2002) observed the following pesticides:

- Over 92% of wetlands contained measureable levels of pesticides and herbicides.
- Of the 42 compounds analyzed, wetland waters contained 16 and five were measured in precipitation and plankton.
- The compounds most frequently encountered were the herbicides 2, 4-D and MCPA but glyphosate and picloram occurred at higher concentrations.
- Of particular note is that 2,4-D, MCPA and glyphosate were measured frequently in precipitation samples (65%, 53% and 57%, respectively) and at concentrations higher than most other compounds. The likely pathway for these compounds is dry deposition related to wind and dust.

Research on eutrophication of groundwater related to agricultural activities in Alberta has revealed that 36% of samples exceeded water quality guidelines for at least one parameter (Forest et al. 2006). Nutrients are also tracked in Alberta's rivers and streams (AENV 2011). Of 28 monitoring stations reporting in 2008-2009, two reported excellent, four reported good, 19 reported fair, one reported marginal, and two reported poor. A high proportion of Alberta's lakes and wetlands are affected by agricultural and urban eutrophication. Further research is required to more closely monitoring eutrophication and pollution trends.

Urban Development

More recently, wetland loss due to urbanization has become the focus of larger centres in the province. Alberta's urban areas, most of which are in the *MSW Zone*, have fared far worse than agricultural areas. Wetland losses are up to 75% in Edmonton and 80-90% in Calgary (Parks Foundation Calgary 2005) and are due primarily to drainage for infrastructure and other development. Those wetlands that remain are often impaired by urban activities. Urban land uses have strong localized effects on water quality and aquatic biota (Paul and Meyer 2001), and increased stormwater flows to the wetlands include contaminants (Pettigrove and Hoffman 2005) which can decrease species richness (Findlay and Houlahan 1997).

Wetlands losses are high as 75% in Edmonton and 90% in Calgary

Climate Change

Wetlands in Alberta's *MSW Zone* are expected to experience significant changes in wet-dry cycles due to global climate change (Poiani et al. 1996, Johnson et al. 2005, Millett et al. 2009, Voldseth et al. 2009, Sorenson et al. 1998, Winter 2000). In particular, those in the western portion have been deemed the most susceptible (Johnson et al. 2010). Recently, departures from average precipitation have been high in western Alberta (Figure 4.1).

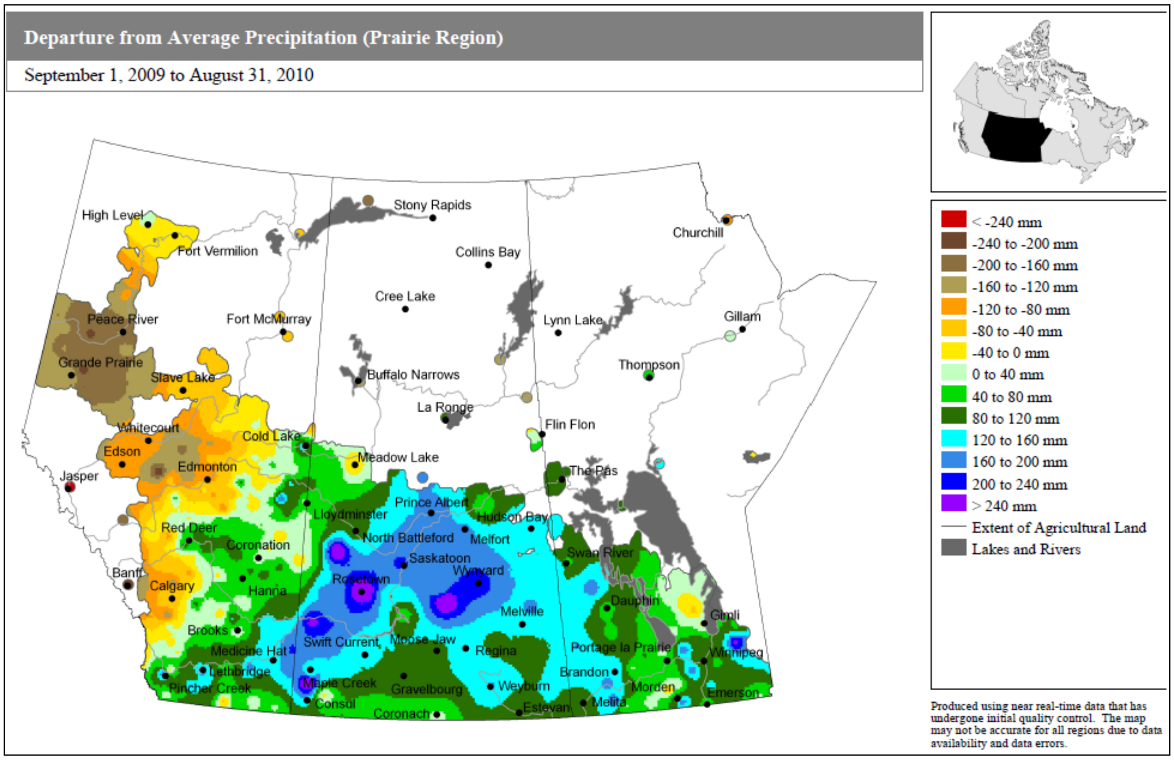


Figure 4.1. Precipitation departure from average in the agricultural regions of Alberta, September 1, 2009 to August 31, 2010. Source: Agriculture and Agri-Food Canada.

The most recent climate change modelling suggests that, under 2º C to 4º C mean temperature increase scenarios, without concomitant increases in precipitation of at least 5% vulnerability to drying increases in the following order: temporary wetlands, semipermanent wetlands, and seasonal wetlands (Johnson et al. 2010) (Table 2.2). The most dramatic results were for semi-permanent wetlands as a stable hydroperiod in those is critical for the survival of vertebrates with relatively long life cycles. Specifically, waterfowl populations may enter into an “ecological trap” whereby ponds that dry up early can no longer provide habitat and food for fledglings (Battin 2004). As occurred in the early 2000’s, waterfowl may compensate by shifting breeding activities north into the lower boreal region. Some estimates suggest that a doubling of carbon dioxide in the atmosphere would reduce the U.S. mid-west waterfowl population by half (Sorenson et al. 1998).

Prairie climate change research highlights include the following (Johnson et al. 2010):

- Prairie wetlands in general are highly sensitive to climate warming.
- Wetlands in the drier, western region (Alberta) are most vulnerable to climate warming.
- Members of the wetland complex will respond differently to climate change, and longer-hydroperiod wetlands are perhaps the most sensitive.

- Shortened wetland hydroperiods will severely affect vertebrates because of their longer life-cycle requirements.

- In a greenhouse climate, more of the prairies will be too dry or without functional wetlands and nesting habitat to support historic levels of waterfowl breeding.

- Adaptation of farming practices in wetland watersheds may buffer the effects of climate change on wetlands.

Wetlands in Alberta's Mineral Soil Wetland Zone are expected to experience significant changes to their hydrological cycles due to global climate change

Peatland Zone

Wetland loss and impairment in most Alberta's *Peatland Zone* is a relatively recent phenomenon. Only since the inception of grand scale oil and gas activity, oil sands development, and associated logging have the state of wetlands become an issue. Little is known of the true extent of wetland loss in this region. This is unfortunate as approximately 93 percent of Alberta's wetlands are located here. Given the rate of industrial activity in the region, cumulative impacts will be potentially high (Schneider and Dyer 2006).

Forestry

Forest fragmentation in uplands and wetlands in western Canada is attributed to not only forest harvest, but agriculture, and in Alberta, logging associated with oil and gas activity (Anielski and Wilson 2001, Lee et al. 2003). In fact, forest clearance associated with oil and gas exploration and operations accounts for approximately double the amount harvested during forestry (Anielski and Wilson 2001). Given that a significant proportion of the land base in the green area that is forested fen, this is a significant issue for wetlands. Unfortunately, most of the timber harvested is too far away from milled to be used and is left unused. Fortunately, some forestry companies are working with the oil sands industry on integrated operational plans to reduce areas cleared for facilities and roads and to coordinate movement of lumber on using well site roads (Schneider and Dyer 2006).

Many peatlands in the western boreal region contain forests with marketable timber but harvesting is generally limited to occasional strategic incidental harvest of softwood (Locky et al. 2007). This is in contrast to the granitic northwestern Ontario and Quebec where bogs and black spruce swamps are common and often logged with specific methods to minimize site disturbance (Locky 2010b). Logging in peatlands may become a more common source of fibre as pressure on timber resources in the southern western boreal region increases; ten years ago, less than 17% of the Boreal Plains Ecozone had intact contiguous forest and fragmentation continues (Lee et al. 2003). In Manitoba, research suggests that on logged peatlands black spruce regeneration is unaffected and nutrient flushes and watering up are temporary, but the peat surface becomes compromised (Locky and Bayley 2007). This has resulted in potential shifts in the plant community, loss of natural diversity, introduction of weedy species, and the establishment of stable shrub communities, which may be persistent and slow succession.

Drainage of peatlands as a means of increasing forest productivity is a common management technique in northern Europe. While demonstrated on an experimental scale in Alberta (Lieffers 1988, Silins and Rothwell 1998), the method will not likely be adopted in the near future. As peatland logging is a relatively new phenomenon in western Canada, equipment and expertise may need to be borrowed from eastern Canada (Locky 2010b).

Loss of forest cover on peatlands in Alberta's green area will continue as an artefact of associated oil and gas and some oil sands activities. The issue is particularly timely as 2011 is the International Year of Forests.

Conventional Oil and Gas Activity

Conventional oil and gas activities has impacted wetlands in the Mineral Soil Wetland and Peatland Zones, primarily through fragmentation related to seismic lines, pipelines, well site and upgrading facilities, and roads. The cumulative effects of conventional oil and gas activity are well-known and are discussed in the Forestry section. However, the extent of disturbance to wetlands is unknown.

Oil Sands Extraction

Oil sands extraction activities include mining and in-situ oil sands technologies. Both may impact wetlands through complete loss (particularly mining), directly by impairment of function, and indirectly by impairment of function.

Oil Sands Mining

For oil sands mining, drivers and their associated mechanisms that may lead to impairment include the following from CEMA's Framework for a regional monitoring program for wetland communities (CEMA 2011):

- **Aerial Deposition:** toxic metals, PAHs, dust and ash, sulphur, and nitrogen.
- **Surface Water Seepage and Runoff:** acidification, eutrophication, seepage of process-affected water, spills or releases, runoff from reclaimed areas.
- **Subsurface/Groundwater:** Basal aquifer depressurization, contamination via recharge through tailings, mobilization of natural PAHs, mobilization of naturally saline ground water.
- **Land Alterations:** habitat fragmentation, infrastructure development, land clearing, increased access via roads, etc., increase in impermeable land cover, end pit lake development.
- **Deep Groundwater Dewatering:** water withdrawal from tributaries and Athabasca River.

- **Surface and Shallow Groundwater Drainage Patterns Disruption:** peatland drainage, diversion/dispersion of natural drainage patterns, hydrologic isolation (closed circuit operation) of mines.

The stressors and response variables for this regional monitoring program are currently being developed but are focussed primarily on peatlands.

At the time of this writing eight approved oil sands surface mines covering approximately 1,500 km^2 have been approved (Cobbaert 2010). Another is close to approval and with the other proposed mines, an additional 700 km^2 of the region would be mined. Mines can access approximately 20% of the oil sands deposits (Oilsands Discovery Centre, Internet). The majority of the oil sands lease region will be disturbed and require reclamation. This region was 45-50% wetland pre-disturbance and thus the equivalent capability of wetland to be reclaimed is approximately 1000 km^2, assuming a 1:1 replacement ratio (Colbaert 2010). Here there is a high potential for economic benefits and environmental costs. The key challenge will be reclaiming wetlands similar to pre-disturbance, especially peat-forming wetlands.

In Situ Oil Sands Technologies

While oil sands mining is the most visible impact to the boreal landscape, approximately 80% of Alberta's oils sands deposits are buried too deep for conventional mining techniques (Oil Sands Discovery Centre, Internet). It is here that steam assisted gravity drainage (SAGD) and associated in situ technologies must be employed. These technologies are currently rivalling open pit mining in production and will inevitably replace mining as the principle means for oil extraction.

The technology is expensive and not without significant challenges. These include efficient recoveries, finding adequate water sources for the water used for steam to extract the bitumen, and dealing with waste products within the water. With respect to wetlands, sites in close proximity may be impacted by potential spills or changes to the ground water table. Levels of some salts may be significantly higher in surface waters of wooded fens within SAGD development compared with those of reference wetlands in the same watershed. However, these values are not more significant than the mean salt values in over 100 sites across the western boreal region from Manitoba to Alberta (Locky, unpublished). Fragmentation of wetlands and other ecosystem types may impact individual sites, with a primary emphasis on wildlife (Schneider and Dyer 2006).

Estimates of the areal extent of in situ oil sands development ranges from 13.8 M ha, an area the size of Florida (Schneider and Dyer 2006) to 1.9 M ha of recoverable deposits, plus another 1.7 M ha of unrecoverable deposits (Hornung 2010). Further research is required to determine the actual extents and potential impacts to wetlands from in situ oil recovery techniques. This is particularly important given that infrastructure, water and energy requirements, and wastes associated with in situ oil sands developments are much greater than those associated with conventional oil and gas developments (Schneider and Dyer 2006).

Groundwater
There is much to learn about the interactions between groundwater and surface water within the context of wetlands in the *Peatland Zone* (RSC 2010). Wetland may change from recharge to discharge seasonally, or can vary within the same wetland at the same time (Ferone and Devito 2004). Current research suggests that subsurface flows are a very important component of wetland hydrology in the boreal region near the oil sands leases (Ferone and Devito 2004, Smerdon et al. 2005, Smerdon et al. 2007, CEMA 2010). Regional groundwater modelling in the oil sands region is lacking, which has direct implications for the success of any wetland reclamation projects (RSC 2010). Dewatering activities before landscape clearing may result in modifications to groundwater regimes. This has the potential to reduce the proportion of wetlands that could occur on a fully reclaimed landscape (RSC 2010).

Climate Change
Worldwide discussion continues surrounding the reaction of peatlands to climate change (Charman 2002). Hydrology is a key aspect of the carbon cycle and, particularly, gas production in peatlands. Lowering of water tables in peatlands due to climate change may result in release of carbon, similar to that in peatlands drained for forestry (e.g., in Europe) or other purposes. However, responses of peatlands to climate change vary greatly among types and spatial scales (Moore et al. 1998). With respect to methane, any potential increase in production related rise in temperature will most likely be far exceeded by decreases related to lowered water tables in peatlands (Roulet et al. 1992). Predicted values may also be affected by colonization of trees to currently open peatlands, increasing the quotient of carbon stored in living biomass (Laine et al. 1996), and permafrost melting, which will increase soil water and potential releases of methane (Christenson and Cox 1995). As discussions on international greenhouse agreements continue, the role of carbon in peatlands will remain under the scrutiny of governments (Charman 2002).

Wetland frequency and position on the landscape is ultimately governed by climate (Winter 1988). Current climate change models and recent evidence in Alberta suggest that negative impacts will occur not only in the prairie and parkland regions but in the boreal region (Figure 4.2). This may be particularly important in the southern part of the region, given the proximity to the parkland and prairie regions (Kettles and Tarnocai 1999). Many of Alberta's peatlands initiated 6,000 years ago when the climate was much wetter (Zoltai and Vitt 1990) and their existence may be tenuous based on current climate projections.

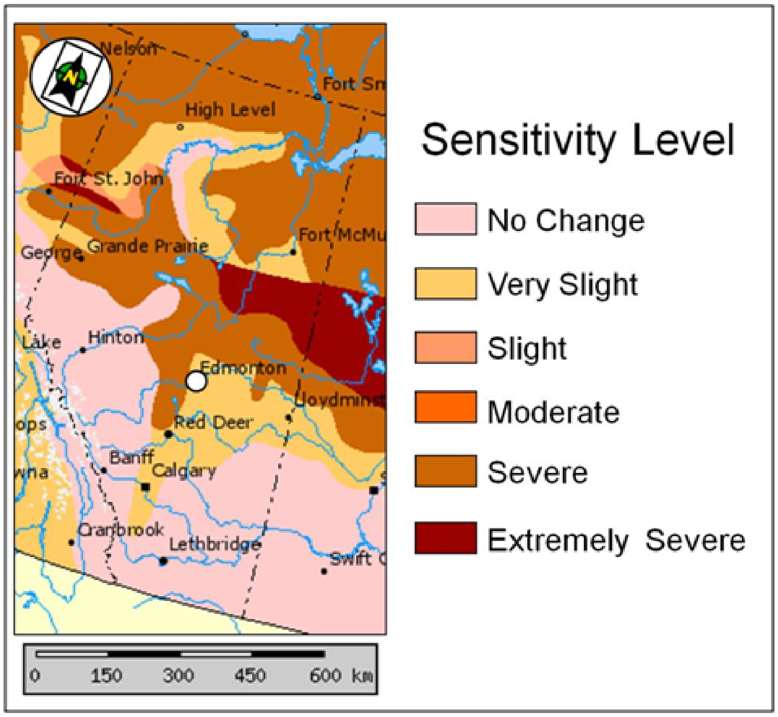


Figure 4.2. Peatland sensitivity to climate change in Alberta. Peatlands in the northern half of Alberta are predicted to experience severe to extremely severe impacts. Projection based on Tarnocai et al. 2000. Adapted from Natural Resources of Canada (Internet).

Many authors have posited that both prairie wetlands (Winter 2000) and peatlands (Ferone and Devito 2005) located in topographic lows are more highly connected to groundwater and are less susceptible to climate change. Wetland less connected would have reduced overall and ability to continue supporting high biodiversity and ecosystem services (Johnson et al. 2010). Regardless of hydrologic connection, without adequate precipitation to maintain surface water and groundwater connectivity, both peatlands and prairie wetlands may be susceptible to climate change (Covich et al. 1997, Ferone and Devito 2005).

Many of Alberta's peatlands initiated 6,000 years ago when the climate was much wetter -- their existence may be tenuous based on current climate projections

Summary

- **Agriculture has caused more losses to wetlands** than any other activity. Over 60% of Alberta's wetlands have been lost in the white area but only 7% Alberta's wetlands are here; 93% of Alberta's wetlands are in the green area where losses are unknown.
- **Eutrophication** from fertilizer and **pollution** from agricultural herbicides and pesticides are negatively impacting Alberta's wetlands, groundwater, and surface waters.
- **Alberta's wetland inventory project** may determine wetland loss by type over time. Calculation of by Natural Region would have utility for policy and practice in Alberta.
- **Wetland loss in Alberta's urban areas is up to 90%.**
- **Climate change will impact Alberta wetlands:** Models strongly suggest that wetlands in parts of the *Mineral Soil Wetland Zone* and *Peatland Zone* will be impacted.
- **Waterfowl breeding potential** in marshes and shallow water wetlands in parts of the *Mineral Soil Wetland Zone* may be compromised by climate change.
- **Peatland existence may be tenuous** given that many of Alberta's peatlands initiated 6,000 years ago when the climate was much wetter. **Carbon:** Wetlands in the *Peatland Zone* may experience shifts in the carbon budget related to drying.
- **Conventional oil and gas activities** have impacted wetlands in the *Mineral Soil Wetland* and *Peatland Zones* through fragmentation. The affects are additive with forestry operations, although companies are collaborating to reduce the footprint.
- **Over 2000 km^2 of oil sands surface mines** (20% of available deposits) may eventually be approved and impact wetlands directly and indirectly in the *Peatland Zone*.
- **In-situ oil sands technology will potentially impact** peatlands through fragmentation, surface and groundwater alteration, and spills of salt water. Up to 80% of Alberta's oil sands deposits in the *Peatland Zone*.
- **Forestry on peatlands** in Alberta is primarily a result of logging associated with oil and gas exploration. Planned logging on peatlands may become more viable in the future.
- **Research on the interactions between groundwater and surface water** for all wetland types is required to more fully understand the associated complex hydrology. This would include **province-wide monitoring programs**.

5. CAN WE BRING WETLANDS BACK? RESTORED AND CONSTRUCTED WETLANDS

The science of wetland restoration and wetland construction has reached a point where a high degree of success can be achieved through appropriate techniques and adequate investment (see review in Kadlec and Wallace 2009). Wetlands can be brought back from a degraded state or constructed from scratch to fulfil a number of human or natural roles. Wetland restoration is defined as "action(s) taken in a converted or degraded natural wetland that result in the reestablishment of ecological processes, functions, and biotic/abiotic linkages and lead to a persistent, resilient system integrated within its landscape" (SWS 2000). Ideally, the original wetland type is the end point but functional restoration may be more practical. Constructed wetlands are "designed and managed wetland systems of saturated substrates, wetland plants, microbial communities, and water that simulate the functioning of natural wetlands for human use and benefits" (Centre for Alternative Wastewater Treatment 2011). The term reclamation, "the process of recovering disturbed land to its former or other productive uses" (AENV 2002) will only be used more generally in this paper.

Wetland restoration and construction are becoming increasingly common in Alberta as part of compensation for loss and for treatment of various wastewaters. These efforts are focussed primarily on restoration or construction mineral soil wetlands in the *Mineral Soil Wetland Zone*. Successful examples of the restoration of peatlands after drainage for logging or peat harvest are known. While there are two fen construction projects currently underway in Alberta's *Peatland Zone*, there are no known examples of successfully constructed peatlands elsewhere in the world. Most of Alberta's wetlands are peatlands in the *Peatland Zone* where potentially extensive wetland loss may occur due to industrial activity. Successful restoration and construction efforts would likely be challenging, expensive but have high value.

There are no known examples of successfully constructed peatlands in the world

Mineral Soil Wetland Zone

Various wetland compensation cases have led to wetlands identified as degraded being restored as part of Alberta's past *no-net-loss* program. These wetlands are located primarily near urban centres where the original wetlands were removed for development. Figures on the total number of compensated wetlands were unavailable at the time of writing.

Constructed wetlands for human use are becoming more common in Alberta with a number of high profile cases. Edmonton International Airport spent $4.8M to develop 4.5 ha of subsurface wetlands for the treatment of toxic ethylene and propylene glycol used in aircraft deicing procedures and other toxins (EIA 2010). The City of Edmonton has a number of progressive treatment wetland projects including the award-winning $7.5M Kennedale Treatment Wetland (City of Edmonton, Internet). This wetland treats approximately 70% of the Kennedale stormwater flow, which collects runoff from 73 km² of urban area in the city. The City of Calgary is involved in wetland construction projects. The most high profile project is the Shepard Wetland, currently the largest constructed wetland in Canada (Chivers et al. 2011). This wetland treats the runoff of 62 km² of existing and future developments on the eastern edge of the city.

Peatland Zone

In Alberta's *Peatland* Zone, specifically the oil sands region, research suggests there are substantial challenges to restoration and/or construction of mineral soil wetlands and peatlands (see review in RSC 2010). Organisms, such as amphibians, will not survive in wetlands filled with oil sands process water (RSC 2010) though other studies suggest that some wetland plants will do well (Trites and Bayley 2009). Treatment wetlands have been considered an important part of any treatment plan for oil sand process water (Worley Parsons 2009) and some promise has been shown for the removal of ammonia and hydrocarbons (Bishay 1998).

There are ample biophysical studies on natural wetlands in the boreal region to provide benchmark systems for wetland restoration (RSC 2010). Currently, the standard reclamation guideline for oilsands reclamation is the Land Capability Classification for Forest Ecosystems (LCFS) (CEMA 2006). Unfortunately, use of the LCFS target, particularly from the perspective of soil, erosion, and growth, would severely diminish the value of wetlands in the region (RSC 2010). This is because wetlands in the oil sands region are predominately peatlands that are technically difficult to restore, let alone create. Recreating a forest viz-a-vis the LCFS is considered an achievable reclamation outcome with a reasonable time frame, whereas peatland creation is not (RSC 2010).

Reclamation of open pit mined wetlands is challenging. The original wetlands, the majority of which are peatlands, are upwards of 8,000 years old (Zoltai and Vitt 1990) and have been drained and excavated (RSC 2010). This completely removes all evidence of the original wetland. Various mineral soil wetlands have been constructed on sites where peatlands previously existed, with varying success (Trites and Bayley 2009). In addition, some mineral soil wetlands have formed naturally on post-reclamation sites (e.g., Suncor). To maintain ecosystem function and provide key anthropogenic value on the landscape peatlands are required.

To maintain ecosystem function and provide key anthropogenic value peatlands are required on the landscape

Salinity

Restored wetlands (and uplands) have surprised many by being able to exist on base materials more saline and sodic than earlier thought possible (see review in RSC 2010). Salt affects revegetation efforts by creating an osmotic barrier to plants accessing fresh water and may severely restrict community composition.

Construction of mineral soil wetlands, i.e., shallow water wetlands, marshes, and shrub swamps, currently shows the greatest promise of success in the oil sands region. Trites and Bayley (2009), Purdy et al. (2005), and others have demonstrated the existence of natural wetland analogues with similar levels of salinity that can be used as models for wetland reclamation. Species richness is low in both the natural analogues and industrial (i.e., constructed) wetlands, and although species composition differs, the industrial wetlands appear to be functioning systems.

Construction of mineral soil wetlands currently shows the greatest promise of success in the oil sands region

Key issues surrounding reclamation of wetlands in the oil sands include groundwater and salt movement. Current wetland reclamation research is laudable but there is room for significant improvement. These research initiatives appear to be initiated primarily by industry working with academic partners and there is an opportunity for involvement and support from the provincial (and potentially federal) government. It will not be possible to restore some wetlands in the same time frame in which they were destroyed or damaged.

Carbon

Reclaimed mineral soil wetlands are not currently considered as net carbon sinks (RSC 2010). Indeed, in many cases, particularly in sites with little vegetative cover, they are carbon sources. Bloise (2007) suggests that peatlands did not initiate by terrestrialization (i.e., water body infill) from mineral soil wetlands, such as marshes. Indeed, the majority of boreal peatlands have formed via paludification (initiation on uplands in presence of stable water source). Consequently, efforts aimed at reclaiming peatlands will likely have focus of paludification as a means of initiation.

Risk

With respect to risk, there is evidence that current Government of Alberta policy on financial security for reclamation liability leaves Albertans vulnerable to financial risks. This is likely more markedly pertinent to wetlands compared with uplands, due to the increased uncertainly associated with wetland reclamation (RSC 2010).

Oilsands Peatland Construction Projects

Although the successful re-establishment of hydrological and botanical aspects of cutover peatlands has been demonstrated (Boudreau and Rochefort 1999, Price et al. 1998, Ferland

and Rochefort 1997), these sites were located in their original place of development within a matrix of peatlands of various levels of disturbance, and had some semblance of remaining hydrologic connectivity. It is doubtful that conditions for peatlands can be recreated with similar ease from a clean slate of pure mineral soils and no pre-existing hydrological conduits as easily as they can for mineral soil wetlands. The cost to do so would also likely be comparatively high. The efforts at the Syncrude and Suncor fen reclamation sites hold promise, if only from the perspective of commitment to experimentation and science.

Syncrude Fen Construction Project

Syncrude's 50 ha Sandhill Fen Watershed project is a research initiative promoting the establishment of a fen on Syncrude's original east mine (Syncrude 2009). Slated for completion in 2012, development of the fen is focussed on transferral of live fen vegetation in its original peat matrix. This is essentially building a fen from a peat matrix derived from natural fens. Various treatments of varying depths of peat, water, and salinity, in addition to time of year when live fen vegetation is transplanted, will be tested over a 10 year period.

Suncor Fen Construction Project

Price et al. (2009) have developed a model under current experimentation that involves an artificial catchment approximately twice the size of the area of Syncrude's constructed fen. The engineered watershed has a 3% grade modelled to be adequate to supply growing season ground water under even drought conditions (E.g., sustain water for 176 days without precipitation) (Daly et al. 2010). Over the short there is emphasis on maintaining an average water table depth and range of fluctuations similar to undisturbed reference fens, and preserving the developed rooting zone below thresholds demonstrated to adversely affect key fen species. Long-term goals include a self-sustaining, carbon-accumulating ecosystem with representative biodiversity that can be used to test and refine techniques for future fen construction initiatives.

Natural peatland design

The Suncor fen construction projection may have the most effective design; a reliable source of water is the key to wetland formation, by humans or by nature. Peatlands may initiate naturally on oil sands reclaimed lands through the process of paludification. Paludification is the blanketing of terrestrial systems (often forests) by the overgrowth of peatland vegetation. Moss spores blown in from adjacent peatlands often provide the initiation stock. Paludification is the most common means of peatland formation in the boreal region. Research into natural peatland dynamics may provide insight into creative reclamation designs that would facilitate natural paludification, i.e., passive wetland construction.

Marshes

While marshes are not functionally similar to peatlands, their construction in the *Peatland Zone*, as part of an oil sands reclamation program, would be very beneficial. In addition to being highly productive, marshes are among the rarest wetland types in all of boreal Canada (NWWG 1988). Research demonstrates that constructed marshes and shallow water wetlands in the boreal region attract rare breeding birds and other wildlife (Locky et al. 2005b).

Summary

- **The science of wetland restoration and construction** has reached a point of high success with appropriate techniques and adequate investment.

- **Wetland restoration** is any action taken in a converted or degraded natural wetland that results in reestablishment of ecological processes, functions, and biotic-abiotic linkages leading to a persistent, resilient system, within its landscape.

- **Wetland construction** is design and management of wetland systems of saturated substrates, wetland plants, microbial communities, and water that simulate the functioning of natural wetlands for human use and benefits.

- **Wetland reclamation** is the process of recovering disturbed land to its former or other productive uses.

- **Wetland compensation projects** in the *Mineral Soil Wetland Zone* have been used to restore degraded wetlands as part of Alberta's past *no-net-loss* program.

- **Wetland constructions project** in the *Mineral Soil Wetland Zone* have been used for the effective treatment of urban and industrial effluents including Edmonton's Kennedale Treatment Wetlands, Edmonton International Airports Glycol Subsurface Treatment Wetland, and the City of Calgary's Shepard Wetland, currently the largest constructed wetland in Canada.

- **Wetland restoration and construction challenges** in the oil sands region include hydrology, salinity, representative vegetation, and loss of carbon sink.

- **Construction of mineral soil wetlands** in the oil sands region of *Peatland Zone* show the greatest promise of success.

- **Two peatland (fen) construction projects** are currently in development at Suncor and Syncrude using different techniques. Reclamation projects focussing on providing conditions for **natural peatland paludification** may have the highest chance at success.

- **No known successful peatland construction projects exist**. The high cost and technical challenges suggest that constructed peatlands the oil sands region is an unlikely scenario.

- **Peatlands are dominant** in the *Peatland Zone*, which adds technical uncertainty and financial risk associated with wetland loss in the region.

6. THE EVOLUTION OF WETLAND POLICY AND PRACTICE IN ALBERTA

Wetland policy in Alberta is applied at the federal, provincial, and municipal levels. The development of provincial wetland policy and practice spans the early 1990's to the present. During this period Alberta went from a province with virtually no policy, to a national leader on policy (Rubec and Hanson 2009), to, at present, a province with potentially diminished wetland protection (Calgary Herald 2010, Renner and Allard 2010, Sierra Club of Canada 2010). The evolution of Alberta wetland policy development and practice is outlined below.

Federal

Alberta wetlands on federal lands are covered by Canada's *no-net-loss* wetland policy (Government of Canada 1991) which applies to 10.6% of the province (Canadian Encyclopedia, Internet). It includes wetlands in national parks, First Nations reserves, and on military bases and installations (ASRD 2004).

Provincial

To understand wetland policy development in Alberta (and most jurisdictions) one must start with water ownership. In Alberta, all water is owned by the province, i.e., the Crown (Kwasiniak 2001). This includes water in wetlands irrespective of permanence. The Crown may choose to divert or disturb these waters. While the water is owned by the Crown, the surrounding land and the bed and shores of non-natural or non-permanent wetlands may be privately owned. Thus, the coexistence of the public's interest in wetland protection and private property rights must considered, particularly in the white area. Here lies some difficulty with application of wetland policy; many agricultural land owners do not recognize that water bodies, including wetlands, are crown land (Clare et al. 2011). Most land in the south is privately owned whereas most land in the green area is Crown land (60%) (ASRD 2004).

Pre-1990s: No Wetland Policy

Before the 1990's Alberta had no wetland policy. In many jurisdictions wetland drainage and filling was encouraged. Issues surrounding wetlands generally fell under the Alberta's Municipal Government Act, Public Lands Act, and/or Water Act. All of these policies still exist and are utilized.

1993: Draft Wetland Policy

Recall that most land in Alberta is owned by the Crown, including wetlands. By the early 1990's the Alberta government had developed two draft wetland policies that signalled a new era of wetland conservation in the province: the 1993 Wetland Management in the Settled Area - An Interim Policy (GoA 1993a, Internet) and Beyond Prairie Potholes - A Draft Policy for

Managing Alberta's Peatland and Non-Settled Area Wetlands (GoA 1993b, Internet). These draft policies were considered relatively progressive for the time.

2004-2005: Interim Wetland Policy and Compensation Plan – No-Net-Loss

The Wetland Management in the Settled Area - An Interim Policy (GoA 1993a) turned out to be a workable model for the white area of Alberta. Here, wetland losses were high (~64%), remaining wetlands were relatively small, and private land ownership common (excluding wetlands), making the process palatable. In 2004 Alberta's Water for Life program instituted a goal to develop wetland policy and In 2005 Alberta Environment (AENV) in partnership with the North American Waterfowl Management Plan (NAWMP) released a draft Alberta Wetland Restoration/Compensation guide (AENV and NAWMP 2005a,b). These guidelines were strongly based on the *no-net-loss* concept used in many jurisdictions in the United States (USEPA 2002) and was lauded by wetland experts (Rubec and Hanson 2009).

Primarily for use in the white area, here the mitigation sequence was a hierarchical concept of mitigation *avoid impacts first*, *mitigate (minimize) unavoidable impacts second*, and *compensate for irreducible impacts third*. Compensation was integrated into a base 3:1 ratio for replaced wetlands, with a sliding scale (e.g., 4:1, 5:1,...10:1) for restorations taking place further away from the lost natural wetland. Any compensation would be applied primarily towards the restoration of local disturbed wetlands (AENV and NAWMP 2005a,b) as identified by Ducks Unlimited, the wetland agency. Wetland construction was not officially considered at that time. Those qualified to work with wetlands were considered Qualified Wetland Aquatic Environment Specialists (QWAES). However, there is no certification program or guidelines for use of this designation.

In 2005 Alberta's Water for Life Strategy (GoA 2009a) short-term goal of wetland policy development and implementation plan by 2007 led to a Wetland Policy Project Team being formed. Extensive consultations with 25 stakeholders began and would carry on for three years (AWC 2010). Two years later the 2005 draft restoration/compensation guide was updated and revised (AENV and NAWMP 2007). Alberta's Provincial Wetland Restoration/Compensation guide was now being selectively used in primarily urban (e.g., Edmonton and Calgary) but also rural situations where wetlands were impacted by development.

The Efficacy of Avoidance as Compensation

Recently a reversal of the mitigation sequence has led to avoidance being chosen last as a viable option in the U.S. (Krogman 1999) and Alberta (Clare et al. 2011). This reversal disregards the spirit of the mitigation sequence and fosters the loss of natural wetlands. Central to the failure of decision-makers to prioritize avoidance over mitigation and compensation were the following key factors (Clare et al. 2011):

1. Lack of agreement on what constitutes avoidance.

2. Current approaches to land-use planning do not identify high-priority wetlands in advance of development.

3. Wetlands are economically undervalued.

4. "Techno-arrogance" associated with wetland creation and restoration resulting in increased wetland loss.

5. Compensation requirements are inadequately enforced.

2007: Suggested Policy Revision

In 2007 Alberta Infrastructure and Transportation (AIT) released a Proposed Revision to the Provincial Wetland Restoration/Compensation Guide AENV and NAWMP 2005a,b for internal and external review (AIT 2007). The revision focussed primarily on the construction of new wetlands as part of compensation. AIT commonly creates wetlands as an artefact of transportation construction and improvement initiatives and was seeking to have these wetlands included as compensation measures to AENV to meet guidelines.

2008-2009: Wetland Policy Consultations

In 2008, results from the extensive stakeholder consultations revealed that of the 590 stakeholders, 90 per cent of respondents agreed that the policy goal should be to maintain or increase wetland area. It is worth noting that 145 of the respondents were from industry and that there were concerns expressed regarding the feasibility and desirability of increasing wetland area.

Later in 2008 after three years of consultations, two resource-based members of the 25 stakeholder groups declined to ratify the final recommendations after some members of their sectors dissented after consultation. The dissenting organizations sent a letter to the AWC outlining their objections and provided alternatives. A number of the remaining stakeholder groups submitted their own letter announcing frustration and dissatisfaction with the dissenting factions. A wetland package was assembled by the AWC's Board of Directors and submitted to the Minister for guidance (AWC 2010).

In 2008 the Alberta Water Research Institute initiated a three year wetland policy implementation study entitled, Wetland Health, Challenges and Opportunities in Implementing Alberta's wetland policy (AWRI, Internet). This research is currently assessing the ecological and social challenges related to implementation of the forthcoming Alberta wetland policy. It is uncertain if the recent potential change in direction on wetland policy, i.e., loss of *no-net-loss*, will affect the study's outcomes.

In 2009, AENV announced a new timeline for the completion of the province-wide wetland policy and implementation plan: policy in 2012; Alberta wetlands inventory, 2015 and; Application of research and knowledge to develop and model indicators of wetland health, 2015 (GoA 2009a).

2010: Wetland Compensation Assessment, Proposed New Policy Discussions

Alberta's Auditor General released a report in April, 2010 indicating that the government had deficiencies with the wetland compensation program (AGA 2010). Recommendation No. 6 stated that "We recommend that the Department of Environment formalize its wetland compensation relationships and control procedures". This stemmed from the fact that while Ducks Unlimited Canada (DUC) is listed as Alberta's wetland restoration agency and has been working with the province on compensation since 2005, no agreements were in place. It was noted that the government and DUC did not follow guidelines in AENV (2007) nor did the government enforce the guidelines in other jurisdictions such as Calgary, which have developed their own guides (see below). Additionally no individual in the government was responsible for monitoring DUC's work or reviews its financial summaries; compensation money from the Alberta government is one of DUC's most significant revenue streams (AGA 2010).

Early in 2010 a Draft Alberta Wetland Policy Briefing Note was posted online (Sierra Club Canada 2010). The change from a strong *no-net-loss* recommendation (AENV and NAWMP 2005a,b, AENV and NAWMP 2007, AWC 2008) and a weak redirection to saving only those wetlands deemed rare resulted in a flurry of opinion-editorial articles in the major newspapers and blogs within and outside of Alberta.

In November 2010, the Alberta government announced that it would not follow the non-consensus items in the Alberta Water Council's (2008) wetland policy recommendations (Calgary Herald 2010, Renner and Allard 2010). The government indicated that the new policy would be released by late 2011 or 2012 (Calgary Herald 2010). The province will now have a system where wetlands are rated for their importance based on factors such as location or biodiversity. Once importance is determined then creative penalties or exchanges can be made. Wetlands would be restored but there would be options for wetland creation or a university could receive a major grant to conduct wetlands research.

The government stated that wetlands are not the same in terms of functionality and should be treated differently (Renner and Allard 2010, Calgary Herald 2010). Wetlands would then be protected based on the value of the function. There has been no official announcement on development of a wetland functional assessment with associated valuation.

Alberta's Land Use Framework

Alberta's Land Use Framework (LUF) is being designed to balance development and conservation (GoA 2010). Boundaries for the seven regional land-use plans are based partly on watersheds and partly on land use type. In 2010 a new information and data-sharing agreement was signed by DUC and various Alberta government departments to facilitate and support wetland management. The LUF boundaries do not follow all watershed boundaries and land-use decisions will be different between provincial and municipal decision-makers. It is unclear how the LUF will affect wetland policy and practice in Alberta.

Municipalities

Alberta municipalities have developed their own wetland conservation strategies and policies. Novel wetland development and mitigation projects by municipalities are good examples of the importance given to wetlands in areas where losses have been historically high. They also provide examples of creative options potentially useful for the development of provincial wetland policy.

Edmonton

The City of Edmonton has worked closely with developers, environmental consultants, and the province to conserve and mitigate wetland loss within the city. It does not have an *a priori* wetland policy like Calgary's. Instead, the City follows the Natural Areas Policy (City of Edmonton 2007), which outlines how it "will lead by example – engaging the public in natural area issues, and encouraging businesses, residents, and the community to secure new natural area systems and steward what we have effectively." Wetlands have specific mention in this document.

Calgary

In 1994 Calgary adopted a Wetland Conservation Plan (City of Calgary 2004), the first of its kind for a major North American city. A key principle is *no-net-loss* and the program also utilizes natural wetlands for some stormwater management. The City works closely with developers and associated environmental consulting firms to develop novel solutions to wetland mitigation and compensation challenges.

The program states an adherence to provincial and federal laws and policies. However, it is unknown if the *no-net-loss* concept will be followed if the province does not continue to maintain a similar precedent.

Summary

- **Federal *no-net-loss* wetland policy** applies to 10.6% of Alberta's land base including wetlands in national parks, First Nations reserves, and military bases.

- **All water in Alberta** on provincial lands is owned by the Crown, including wetlands, irrespective of permanence. Only the Crown may divert or disturb these waters, but in practice many agricultural and other land owners do not recognize this.

- **Pre-Wetland Policy:** In the 1990s, Alberta had no wetland policy and wetland drainage and filling was encouraged. Issues surrounding wetlands fell under the Municipal Government Act, Public Lands Act, and/or the Water Act, which are still utilized.

- **Draft Policies:** In 1993 Alberta released two draft policies based on the north and south, signalling a new era of wetland conservation in the province. The version for the settled south, Alberta's white area, was used as a workable model for interim policy.

- **Interim Policy and Compensation:** In 2004 Alberta released Draft Wetland Restoration/Compensation guide based on a *no-net-loss* concept: avoidance first, mitigation second, compensation last, with a 3:1 compensation ratio. Application on mineral soil wetlands in white area. Research suggests that avoidance is not considered or enforced as an option. QWAES professionals without certification.

- **Water for Life and Wetlands:** Alberta's Water for Life Strategy includes wetlands as a key provincial resource and Wetland Policy Project Team formed. Updated in 2005.

- **Wetland Policy Consultations** with 25 stakeholder groups that began in 2005 were completed in 2008 with two of the resource-based groups declining to ratify the final recommendations. Deemed unacceptable by the remaining stakeholders, the government was consulted for guidance.

- **Wetland Compensation Assessment** by the Auditor General in early 2010 strongly recommended formalization of wetland compensation relationships and control procedures to address lack of agreements and fiscal accountability.

- **New Wetland Policy** announced as forthcoming in 2011-12 indicated that *no-net-loss* concept would no longer be followed. Wetlands would be rated on importance using location or biodiversity, with creative penalties or exchanges potentially made.

- **Land Use Framework** information and data-sharing agreement renewed in 2010 to facilitate and support wetland management. It is unclear how development of the land-use regions will affect wetland policy and practice in Alberta.

7. WHAT ARE OTHERS DOING? POLICY VIEW OUTSIDE THE PROVINCE

Worldwide, there is striking similarity in the diversity and wealth of wetlands (Smardon 2009). Most jurisdictions acknowledge, to some degree, the significance of wetland losses and the importance of maintaining wetlands. However, there is tremendous variation in wetland policy and practice, particularly between North America and Europe and developing countries. Select aspects of wetland policy and practice in other jurisdictions are outlined below with relevant commentary and application to Alberta.

Canada

Wetlands in Canada are protected by The Federal Policy on Wetland Conservation that includes *no-net-loss* of wetlands on all federal lands since the early 1990s (GoC 1991). Four percent of Canada's provinces are considered federal land. Canada's federal wetland policy provided inspiration for some provinces to develop their own policy, particularly with respect to *no-net-loss*. See details below for wetland policy in the Maritime Provinces, Ontario, Manitoba, Saskatchewan, British Columbia.

Prior to the federal policy on *no-net-loss*, Canada's Department of Fisheries and Oceans issued a *no-net-loss* policy for fish-bearing wetlands and other fish habitat in 1986. Additionally, the Fisheries Act, Policy for Fisheries Management protects fish habitat in federal waters (Rubec and Hanson 2009), including those that are classified as wetlands. Many of Alberta's grand scale projects are cross-jurisdictional, with federal and provincial responsibilities sometimes overlapping. Some aspects are in fact, quite interlinked; pollution generated on provincial lands eventually migrates to waters under federal jurisdiction.

New Brunswick

New Brunswick is currently developing operational guidelines to improve the efficacy of its wetland conservation policy (Water Canada 2010[b]) that was first rolled out in 2002. Acting on public feedback indicating that current policy and guidelines were too complex, the government will release new guidelines in 2011 intended to make decision-making on wetland development and management more consistent and predictable. Overall policy objectives that include a *no-net-loss* policy will remain intact. This includes two level policy: *no- net-loss* of provincially significant wetlands and *no-net-loss* of function for other wetlands.

In concert with the augmented policy, the N.B. government will launch a 2011 online mapping service allowing the public to better identify the location of wetlands in the province (Water Canada 2010[b]). See GeoNB (2010) for current mapping products at 50 m resolution.

Since N.B.'s wetland policy was rolled out in 2002, developers have expressed frustration with the policy, noting that they often had to move or change their plans after the municipality provided project approval. The new guidelines will provide clarity for future development initiatives. These two aspects of a *no-net-loss* policy are good examples of the creative thinking that can support wetland conservation and may provide some vision for Alberta policy-developers.

Prince Edward Island

Prince Edward Island has adapted a *no-net-loss* wetland policy (P.E.I. Internet). The policy was designed to complement the existing P.E.I. Environmental Protection Act. *No-net-loss* is a progressive concept in the province. It includes wetland area and function, and mitigation includes avoidance, minimization of negative impacts, and compensation for lost area and function.

Nova Scotia

Nova Scotia's wetland policy is currently under development pending review of 2009 stakeholder comments (GoNS 2009). The overarching theme includes *no-net-loss*, specifically no loss of provincially significant wetlands and prevention of net loss and function for other wetlands. Significant policy objectives include the promotion of long-term net gain in wetland types that have experienced historically high losses, alignment of policy with New Brunswick and Prince Edward Island, and application to wetlands as small as 100 m^2 in area. Nova Scotia's wetland policy is being supported by a wetland inventory that was completed in 2002 and is available to the public, similar to that now being developed in New Brunswick.

Newfoundland and Labrador

Activities in wetlands in Newfoundland and Labrador are guided by the province's Policy Directive for Development in Wetlands (Rubec and Hanson 2009). This includes activities that may impair hydrological, recreational, and natural function in wetlands.

Ontario

In Ontario the provincial government promotes development of local wetland policies that align with provincial wetland policy in protecting provincially significant wetlands. The overarching provincial policy is Provincial Policy Statement on Natural Heritage which includes all wetlands regardless of ownership or size (Rubec and Hanson 2009). With this policy all coastal wetlands are protected and the province is divided into the south and north for specific protection objectives.

Management decisions in wetlands within each of the two sections of the province are guided by separate Ontario Wetland Evaluation Systems (OMNR 1994). The Southern Manual encompasses the southern edge of the Canadian Shield and the Northern Manual encompasses all parts north of this line. Both manuals evaluate wetlands based on a numerical scale with 250 points for each of four sections: Biological, Social, Hydrological, and Special Features. Wetlands with a score of 600 or more overall or with 200 or more points in either the Biological or Special Features components are considered provincially significant and protected.

Wetlands falling beneath this designation are still considered to have value, societal and intrinsic, and their conservation is encouraged. Municipalities may deem that these wetlands are significant at the "local scale" and protect them (OMNR 1994). In particular, these could include wetlands identified as having value in ground water discharge, societal values (e.g., education or recreation), or aboriginal/cultural heritage. There may be aspects of these evaluations that would be useful in developing a made in Alberta wetland evaluation system.

However, Ontario's wetland policy is not without its problems. The province may propose that wetlands be deemed significant but the associated municipality must designate the wetland in its official plan. Failure to do so by a municipality has lead to significant wetlands being altered beyond the original state (Water Canada 2010[a]). It is important that various levels of government work together as a means of creating an effective wetland policy, including within Alberta.

Saskatchewan

The government of Saskatchewan first developed a wetland policy in 1995 but moved to the Saskatchewan Watershed Authority in 2002 (SWA 2002). The spirit of the policy is to implement sustainable management of wetlands, to maintain numbers, diversity and productive capacity (Rubec and Hanson 2009). However, the policy is significantly geared towards agricultural wetlands (SWA 2002). This would appear to be unfortunate, as most of Saskatchewan's wetlands are in their boreal zone. Alberta shares its border with Saskatchewan and there are similar, if not emerging, issues surrounding development and wetland types common to both provinces. At some point it may be important and strategic to develop a relationship at the policy level with Saskatchewan.

British Columbia

British Columbia has recently release a Wetland Action Plan which will assist in developing policy (BC Wetlands 2010). The three overarching directives include a) Clear and Comprehensive Information (wetland information and education), b) Effective Legal and Planning Tools (enhance legal protection and enforcement, integrate wetland protection into strategic planning), and c) Effect Actions and Incentives for Wetland Protection (secure protection of priority wetlands and improve coordination among partners). Although the *no-net-loss* has been discussed publicly, there is not net consideration as policy (REF).

B.C.'s Water Resources Act identifies that wetlands are 'bodies of water' and that the property and the right to the use water, in a body of water in the province are for all purposes vested in the Crown. Thus, the Act's identification of wetlands as bodies of water effectively permits the provincial government to assert property rights over water in any wetland, regardless of whether that wetland lies on public, private, incorporated or unincorporated land (Rubec and Hanson 2009). There is merit to this strategy, given the highly-connected nature of some wetlands. Alberta shares wetland complexes with BC in the northwestern corner (Figure 6.1). There would be utility in coordinating wetland policy between the two provinces.

Northern Territories

Canada's northern territories include the Yukon, Northwest Territories (NWT), and Nunavut. The federal government retains a significant proportion of responsibilities for land use planning in these lands. In the NWT, wetlands requiring a high level of protection by classification are included in the Key Migratory Sites in the Northwest Territories policy (Environment Canada 1991). Here the focus is on avoidance. In other areas, land claim settlements and the development of protected areas have been the leading components in ecosystem conservation initiatives (Rubec and Hanson 2009). Alberta shares its northern border with the NWT, including significant wetland area; 51 – 100% of the border is wetland (Figure 2.3). The Whooping Crane Summer Range Ramsar wetland of international significance lies over the border of Alberta and NWT. Ramsar wetlands of international significance in Alberta close to the NWT border include the Hay-Zama Lakes and Peace-Athabasca Delta.

Given the transboundary wetland of international significance shared between Alberta and NWT and wetlands of international significance in proximity of the border, in a addition to the important shared watersheds (Mackenzie River, Hay River), there is high utility in the two jurisdictions communicating on wetland issues and policy. This is irrespective of any federal jurisdication.

United States

In the United States the evolution of wetland policy has evolved markedly from that of destruction to protection – in many cases within the same agency. Since the 1970's the U.S. Army Core of Engineers, the Soil Conservation Service, and Bureau of Reclamation have refined their policies to reflect wetland protection. The U.S. Department of the Interior's Fish and Wildlife Service always encouraged their protection (World Wildlife Fund 1992, Smardon 2009).

By 1987, at the U.S. Environmental Protection Agency's request, a National Wetlands Policy Consortium recommended a *no-net-loss* policy, which was soon adopted by the U.S. government (The Conservation Foundation 1988). Currently most U.S. states explicitly or implicitly apply a *no-net-loss* aspect in all or some of their programs, including Minnesota, Maryland, Illinois, Vermont, Maine, and Pennsylvania (Kusler 1992). Similarly, maintenance of particular functions has been adopted by Oregon and New Jersey. More locally, over 5,000 local governments have integrated wetland regulations into their policies, including various states that require local governments to legislate wetland protection. Of particular interest is Minnesota where enforcement of statewide wetlands protection is currently in place (Connolly 2005). This has particular application for isolated wetlands.

In 1989 the North American Wetlands Conservation Council (NAWCC) Act was passed into council by the U.S. government to aid in the conservation of wetlands in North America (NAWCC 1993). Funds generated by the council can be used by Mexico, the U.S., or Canada on project that secure, restore, enhance, and/or manage wetlands. In March 2010, President Obama signed into law a bill to allow for Canadian-raised funds Canada to become eligible to match for NAWCC projects funded for Canada (NAWMP 2010).

Europe

In Europe, the most current and interesting developments around wetland policy include the following recognized needs gleaned from Matlby (1986) and Williams (1990): recognition of small wetlands (particularly marshes); further wetland inventory (specifically small wetlands); cooperation among farmers, recreationalists, and other participants to ensure that conservation of small wetlands is viable, and law for the protection of national wetlands.

Of the European nations, the Netherlands has a high relative proportion of wetlands and some successes with policy. Outcomes include distributing the benefits or maintaining wetlands among recreationalists and farmers, and reducing the conversion of existing wetlands to farmland (Leander and de Mare 1994).

In Ireland, despite centuries of wetland conversion and drainage, the Irish Peat Board considers the ecological damage brought on by peat mining a fair trade for improved standard of living and reduced energy import bills (Smardon 2009). One is reminded of similar trade-offs for lost peatlands as a current cost of doing business currently in Alberta's oil sands.

Central and South America

In Central and South America lack of effective wetland policy and associated instruments has led to the hope that ecotourism-generated revenues funnelled back to communities to divert land use activities deleterious to wetlands to those used to maintain wetland-dependent livelihoods (Smardon 2009).

The effectiveness of ecotourism and its role in wetland conservation remains to be seen in Central and South America. However, the Pantanal wetland complex is the world's sixth largest wetland complexes (Fraser and Keddy 2005), a UNESCO world heritage site, and Ramsar wetland of international significance. Plans to decrease the upper half of the wetland for development initiatives have given the region international recognition as a place for conservation.

The Peace Athabasca Delta, also a Ramsar wetland and part of a UNESCO world heritage site, is one of the worlds' largest inland deltas. It is also part of the Mackenzie river basin, the fifth largest wetland complex in the world (Fraser and Keddy 2005). Alberta shares the delta with the Northwest Territories and this is a transboundary issue between them. One wonders of the potential conservation and tourism opportunities for Alberta and NWT that would be encouraged with maintenance of healthy wetlands and other resources in the region.

Summary

- **Canada has a *no-net-loss* policy for wetlands**, which applies to 10.6% of the federal lands in Alberta. Further collaboration between federal and provincial agencies on wetland issues would be beneficial in the oil sands region.

- ***No-net-loss*** is utilized in some form in most wetland policies in the United States.

- ***No-net-loss*** concept is being developed or utilized in Nova Scotia, Prince Edward Island, New Brunswick wetland policy.

- **Wetlands as small as 1 ha** are included in wetland policies in Nova Scotia, New Brunswick, and Ontario.

- **The significance of small wetlands** is also acknowledged by the Netherlands through including detailed wetland inventories.

- **Detailed wetland inventories,** as being developed in New Brunswick, Nova Scotia, and Alberta, would be useful in identifying high-priority wetlands before development and significantly advance the planning process.

- **Wetland mitigation policies** are in place in the Maritimes.

- **Development of two wetland evaluation systems** is required in Alberta for the *Peatland* and *Mineral Soil Wetland Zones*. Ideally, they would utilize broad-based indicators including hydrological, biological, social, and rarity-based aspects.

- **Alberta shares borders** with British Columbia, Saskatchewan, and the NWT and some degree of collaboration on wetland policy would have high efficacy in wetland management. This would be particularly important between Alberta and NWT.

- **Integrating Alberta's wetland inventory** into wetland inventories in the NWT, Saskatchewan, and British Columbia (e.g., the Canadian Wetland Inventory) would markedly increase the ability to manage wetlands at the landscape scale.

- **The efficacy of stakeholders** communicating and working together to reduce wetland losses is demonstrated in European Nations, particularly the Netherlands.

- **Integration of tourism and indigenous peoples** may raise the profile of wetland conservation and provide opportunities in the Peace-Athabasca Delta region where there are internationally significant wetlands, and a UNESCO World Heritage Centre.

8. FINAL CONCLUSIONS:
OBSERVATIONS AND INSIGHTS ON WETLANDS IN ALBERTA

1. Wetlands as Alberta's Keystone Ecosystem

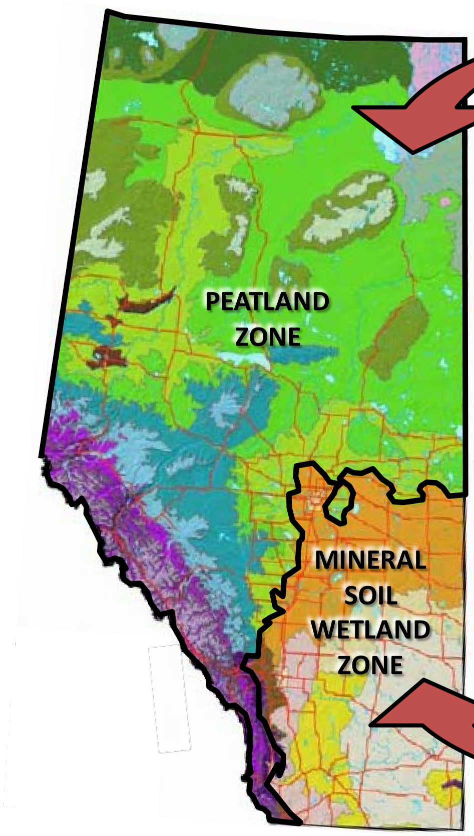
Wetlands need to be recognized as Alberta's keystone ecosystem and resource. They are worth more than any other of the earth's ecosystems. Found in all provincial biomes, they are inextricably linked to Alberta's aquatic and terrestrial ecosystems, having an impact inordinate to their size or distribution on the landscape. Wetlands provide a wide range of functions and values, and will become increasingly important with forthcoming industrial development and climate change. The state of Alberta's wetlands may be a bellwether for the state of the province's aquatic resources.

2. Two Types, Two Regions, Two Strategies

Alberta has two primary wetland types in two different regions that require two different management strategies (Figure 8.1). The great majority of Alberta's wetlands are peatlands (bogs, fens, conifer swamps) located in the *Peatland Zone*, a region that coincides with, but is larger than, the green area. The remaining wetlands are mineral soil wetlands (marshes, shallow water wetlands, and shrub swamps) that are found in the province's *Mineral Soil Wetland Zone*. This zone approximates but is smaller than the white area. The two regions differ significantly by wetland type, area, land ownership, population, land use pressure, and authority to set regulations. Boundaries around the green and white zones are based on settlement and land use patterns and subject to change over time. Use of *Peatland* and *Mineral Soil Wetland Zones* based on the province's Natural Regions and Subregions would be a more appropriate means to identify, monitor, and manage Alberta's wetlands. Completion of the Alberta Wetland Inventory could facilitate fine-tuning of wetland region boundaries.

3. Alberta's Wetland Inventory

The government of Alberta's Alberta Wetland Inventory Project will provide wetland cover for 80-90% of the province in 2011. Although at three different resolutions, the initiative is excellent and will have utility for planning to restoration initiatives. The utility of this inventory would be enhanced significantly when available online to the public. It is anticipated that Alberta's inventory will be part of the Canadian Wetland Inventory. Integration with inventories in Saskatchewan, British Columbia, and the Northwest Territories would go far in enhancing wetland management at the landscape scale. This would provide the base for wetlands monitoring programs.



Attribute	Peatland Zone	MSW Zone
Area of Province	78%	22%
Proportion of Provincial Wetland Area*	~93%	~7%
Proportional Wetland Area by Region	20 - 80%	<5 - 10%
Dominant Wetland Types	bog, fen, conifer swamp	marsh, SWW, shrub swamp
Wetland Function	Variable	Variable
Wetland Losses to Date	Low	+60%
Principal Ownership	Mostly Crown	Mostly Private
Comparative Population	Low	High
Land Use	Foresty, oil & gas, oil sands, coal	Settlements, agriculture, oil & gas
Development Pressure Past	Low	High
Development Pressure Current	Moderate	High
Development Pressure Future	Moderate-High	High
Potential for Climate Change Impacts	Moderate-High	Moderate-High
Authority for Regulations and Decisions	Province	Mostly Municipal

Figure 8.1. Comparison of selected wetland, geographical, and societal attributes between the *Peatland Zone and Mineral Soil Wetland Zone* in Alberta. SWW is shallow water wetland class. See figure 2.1 for details on the Natural Regions and Sub-regions. Map adapted from AENV (2005).

4. Made-in-Alberta Wetland Classification

The large number of individual wetland classifications used in Alberta has been problematic from the perspective of mapping, inventorying, developing policy, and compensation initiatives. The proposed effort to develop an Alberta Wetland Classification System shows promise of consolidating key wetland classifications for a made-in-Alberta tool with high efficacy.

5. Alberta's Wetland Policy: An Opportunity for Leadership

Alberta was recently considered a leader in Canada and other jurisdictions on wetland policy and practice, specifically *no-net-loss* compensation. Now is the time for Alberta to continue the leadership charge for the rest of Canada in wetland policy and practice. The spectre of potential diminishment of wetland protection and loss of a region-specific wetland policy in the province is unfortunate. Examples of wetland policy and practice from other provinces and countries may provide a model for policy and wetland evaluation development in Alberta.

No-Net- Loss
A policy of *no-net-loss* of wetlands recognizes the need to maintain a critical amount of wetlands to sustain not only local but regional ecosystem services. There are many successful examples of the application of *no-net-loss* policy on mineral soil wetlands in the *Mineral Soil Wetland Zone* of Alberta. The application of *no-net-loss* in the *Peatland Zone* requires further thought. This should not hold up *no-net-loss* in the *Mineral Soil Wetland Zone*. Thus, application of *no-net-loss* in the *Mineral Soil Wetland Zone* is low hanging fruit; this policy is easy to implement, relatively effective, publically visible, cost-effective, and the benefits easily seen. Disentangling Alberta's two natural wetland zones by developing dual policies will allow wetland conservation to be served at two levels. While congruence on policy between the two regions may never be achieved, effective wetland conservation can continue in Alberta.

Policy development in the *Peatland Zone* will be more challenging and will require extensive consultation, resources, funding, and research. Time is of the essence. Nothing less should be acceptable given that most of Alberta's wetlands are in this region and development plans are ambitious. Until the requirements are known and the policy developed, in the interim the priority should be given to conserving wetlands in the region. The opportunity for Alberta to be among those jurisdictions that play a key leadership role in the development of novel and effective wetland policy and practice is particularly evident within this realm.

Consideration for those peatlands found in the *Mineral Soil Wetland Zone* and those mineral soil wetlands in the *Peatland Zone* could be integrated into the individual wetland policies and evaluations. This would to ensure that value is captured and not lost, and in many cases, that increased value be given.

Wetland Avoidance, Mitigation, and Compensation
Research in Alberta has demonstrated unequivocally that the mitigation sequence of avoid impacts first, mitigate (minimize) unavoidable impacts second, and compensate for irreducible impacts third has been reversed. This reversal of the mitigation sequence disregards the spirit of the mitigation sequence and fosters the loss of natural wetlands. The sequence needs to be reset back to avoidance-mitigation-compensation.

The standardized 3:1 compensation ratio with a sliding scale for distance from original wetland is useful replacement for lost wetland function and value in lieu of a standardized wetland evaluation system (see below).

Land Use Framework and Wetlands
Clear integration of Alberta wetland policy into the Land Use Framework will facilitate effective management of wetlands at the landscape scale.

6. Two Wetland Evaluation Systems

Two wetland evaluation systems are required in Alberta to address the myriad of differences in the *Peatland* and *Mineral Soil Wetland Zones*. Ideally, they would utilize holistic broad-based indicators including hydrological, biological, social, and rarity-based aspects. Wetlands in both zones are fundamentally different in many functions, their area of cover, have different land use pressures, and ultimately different values. The proposed evaluation systems would be directly applicable to the wetland mitigation sequence and have high utility in determining wetland restoration and wetland construction end points. One model for consideration is Ontario's Northern and Southern Wetland Evaluation Systems, which have been in use since the 1980's. Less expensive and more efficient versions could be developed for Alberta.

7. Conservation: Function, Value, and Rarity

Wetland conservation involves decision-making related to measureable function and estimated value. Values of functions are generally anthropogenic constructs. Rarity is often used as means of valuing an ecosystem. Wetlands may be considered rare based on a number of factors, including type, percent cover on the landscape, proximity to urban area, habitat for rare species, or other factors. Often rarity is a useful measure. However, rarity is independent of function and value as much as function may be independent of value (Figure 8.2).

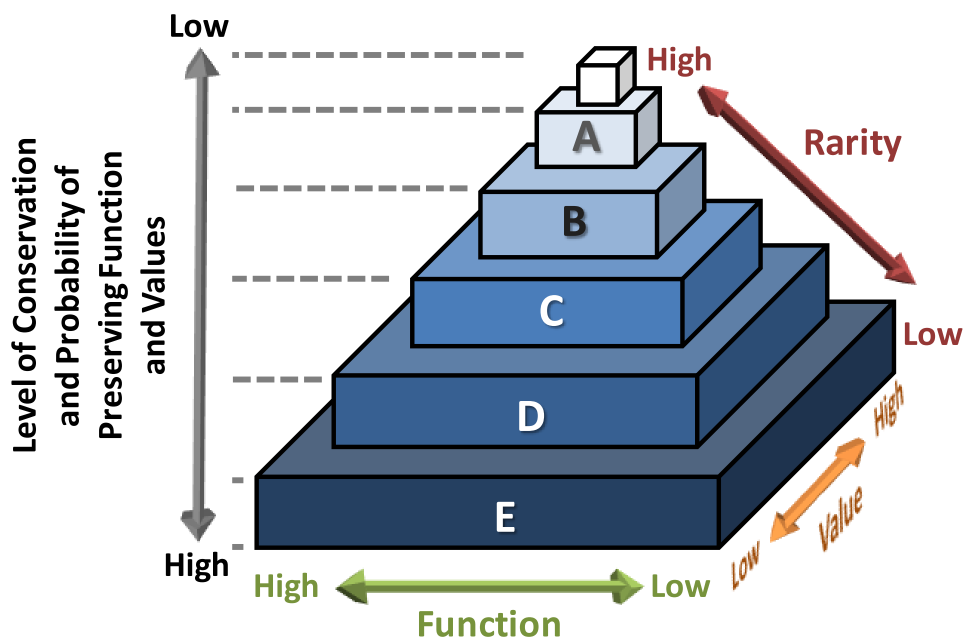


Figure 8.2. Level of wetland conservation and probability of preserving function and values. A to E represents increasing percent cover on landscape or local to landscape scale. Rarity is independent of function and value. Function and value range from high to low independent of level of rarity. Level of conservation relates to degree retention of function and value from landscape to local levels.

Functions are scientific measures such as hydrology and biological aspects whereas values are more socio-economic. Function and value can range from high to low, independent of level of rarity. Rarity, function, and value are scale-dependent. Figure 8.2 illustrates how the level of conservation relates to degree retention of function and value at landscape to local levels. Thus, rarity or "importance" must not be used at the cost of lost function and value found in more 'common' wetland types that are considered expendable.

Biodiversity is a key component in any ecosystem. However, low biodiversity does not always equate to low value. Some rare wetlands have comparatively low biodiversity. Wetlands with low diversity may have high value for some wildlife. For example, marsh wrens are rare in some regions and are attracted to dense stands of cattails which, as monocultures, are not considered high biodiversity systems.

There is an important temporal aspect to value. Today is not tomorrow and value judgements made on wetlands in the present may not translate into the same values in the future. This is no different than value judgements made in the past have not served us in the present. Lost wetlands represent a potential lost legacy.

8. Restored and Constructed Wetlands

Our knowledge on the restoration and reclamation of mineral soil wetlands, particularly marshes and shallow water wetlands is advanced. Ducks Unlimited and other agencies have been actively developing successful projects in Alberta for several years. Continued development and application of a *no-net-loss* wetland policy with progressive compensation will maintain momentum in refining restoration and construction techniques.

Natural peatland design

Paludification is the means that peatlands most commonly form in the boreal region. It is the blanketing of terrestrial systems (often forests) by the overgrowth of peatland vegetation. Peatlands may initiate naturally on oil sands reclaimed lands through this process of paludification. Healthy peatlands in the vicinity would potentially provide the moss spores for peatland initiation stock. Research into the dynamics of natural peatland may help to develop creative reclamation designs that facilitate natural paludification. Provision of a naturally-occurring, reliable source of water is key.

Marshes

Marshes are not functionally similar to peatlands but their construction in the *Peatland Zone* as part of an oil sands reclamation program could be very beneficial. Marshes are highly productive but also are among the rarest wetland types in the boreal region. Construction of marshes and shallow water wetland complexes may play a role in supporting avian and other biodiversity in the oil sands region.

9. Qualified Wetland Aquatic Environment Specialists

A rigorous protocol must be developed in order to validate the knowledge, ability, and experience of those seeking Qualified Wetland Aquatic Environment Specialists (QWAES) status. Certification can be done through other organizations. This could include international professional organizations specializing in wetlands such as the Society of Wetland Scientists Professional Certification Program (SWS, Internet). Wetland workers in many U.S. jurisdictions are required to have Professional Wetland Scientist specialization through the SWS. Alternatively and perhaps preferably, arrangements could be made for a wetland specialist certification program through Alberta's local professional organizations. This could include the Alberta Institute of Agrologists (AIA, Internet) and/or the Alberta Society of Professional Biologists (ASPB, Internet).

10. Qualified Wetland Agencies

Consider expanding the pool of agencies qualified to work in wetland restoration and construction in the province reach and maintain the critical mass of skilled workers required to effectively address wetland issues. Workers in the agencies would preferably be accredited as Qualified Wetland Aquatic Environment Specialists.

11. Wetland Monitoring Programs and Protocols

Consider developing sophisticated wetland monitoring programs and programs to track and models changes in area, nutrients, pollutants, and climate change aspects including carbon.

12. Recognize Ephemeral Wetlands

Ephemeral wetlands are often left out of the policy equation due to their small size, temporary nature, and lack of understanding of function and value. However, emphemeral wetlands are particularly important as keystone ecosystems, fueling upland ecosystem processes and maintaining biodiversity. Ephemeral wetlands are particularly essential in regions with low wetland cover, as exists in the *Mineral Soil Wetland Zone*. Recent research suggests that conversion of emphemeral wetlands to agriculture during dry periods represents low value compared with maintaining full wetland function.

13. Carbon as a Resource

Carbon stores in Alberta's peatlands may become valuable in future global carbon credit scenarios. Peatlands play a dominant role in the global carbon cycle, including those in Alberta. Disturbances to peatlands, past, present, or planned necessitate tracking Alberta's carbon stores. Development of a peatland conservation initiative in Alberta, not unlike what DU is proposing for Manitoba, would go a long way to preserving a number of key ecosystem services provided by peatlands, including carbon storage.

14. Alberta: Centre of World Class Wetland Research

There exists an opportunity for Alberta to become a centre for world class wetland research. Wetland research has been conducted in the province for over 30 years and continues to grow with researchers taking advantage of emerging challenges related to wetlands. Exceptional wetland expertise inside and outside the province exists and there are many well-equipped academic and industrial laboratories in Alberta. There needs to be a means to consolidate research expertise and resources and increased collaborative opportunities. The province, industry, and academic institutions must consider fostering the development of a research centre of excellence, a Western Canada Wetlands Research Centre. A funded Endowed Chair in Applied Wetland Research in an Alberta university would facilitate the initiative and provide high dividends. New technologies could be developed and marketed. Current climate change models forecast a general movement of development northwards into peatland-rich areas of Canada. Alberta has a unique opportunity to develop leading edge wetland-related technology that can be exported world-wide. Potential but not exhaustive research topics could include the following:

- Conservation and biodiversity
- Policy and practice
- Carbon cycling, horticultural peat, peatland forestry
- Wetland restoration
- Wetland construction, particularly treatment wetlands for weather performance
- Peatland restoration and construction techniques in the oil sands
- Wetland mapping, remote sensing
- Wetland monitoring protocols for area change, nutrients, pollutants
- Hydrological and hydrogeological modelling and mapping
- Climate change modelling
- Exporting critical knowledge and skills, training, business opportunities

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