Guiding Principles for Wetland Stewardship and Forest Management

PRACTITIONER GUIDE

A product of the Forest Management Wetland Stewardship Initiative (FMWSI)
First Edition | December 2018

Photo courtesy of Millar Western.

FIRST EDITION
ISBN 978-0-9812303-7-5
December 2018

PRACTITIONER GUIDE

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ABOUT THIS GUIDE

This guide was developed as part of the Forest Management and Wetland Stewardship Initiative (FMWSI)

A visionary initiative to share knowledge and resources to advance sustainable forest management and wetland stewardship in the boreal forest.

In 2016, Ducks Unlimited Canada (DUC) launched the FMWSI, a three-year partnership between DUC and the forest products industry, including, Alberta-Pacific Forest Industries Inc., Canfor, the Forest Products Association of Canada (FPAC), Millar Western Forest Products Ltd., Tolko Industries Ltd., West Fraser, and Weyerhaeuser Company. The FMWSI is an innovative collaboration that aims to share knowledge and resources to advance sustainable forest management and wetland stewardship in the boreal forest.

Three projects of mutual interest were selected to be completed over a three year term, including:

1. **Forestry and Waterfowl: Assessing and Mitigating Risk**
2. **Guiding Principles for Wetland Stewardship and Forest Management**
3. **Guide to Wetland BMPs for Forest Management – Planning and Operating Practices**

The objective of these projects is to advance sustainable forest management with a specific focus on establishing guiding principles and best management practices to:

- conserve wetlands and waterfowl in forest management planning and operations
- complement provincial forest management planning requirements and forest certification program needs

DUC would like to thank member companies and their representatives for contributing significant time, expertise, and resources to this initiative.

Terms and Conditions

FMWSI members support the contents of this report. However, members are not required to implement the practices and recommendations discussed in this report. Some of the principles and practices may already be in place by member companies, some may be adopted over time, or may not be an appropriate fit for a particular company based on current practices and approaches, geographic location, and other factors.

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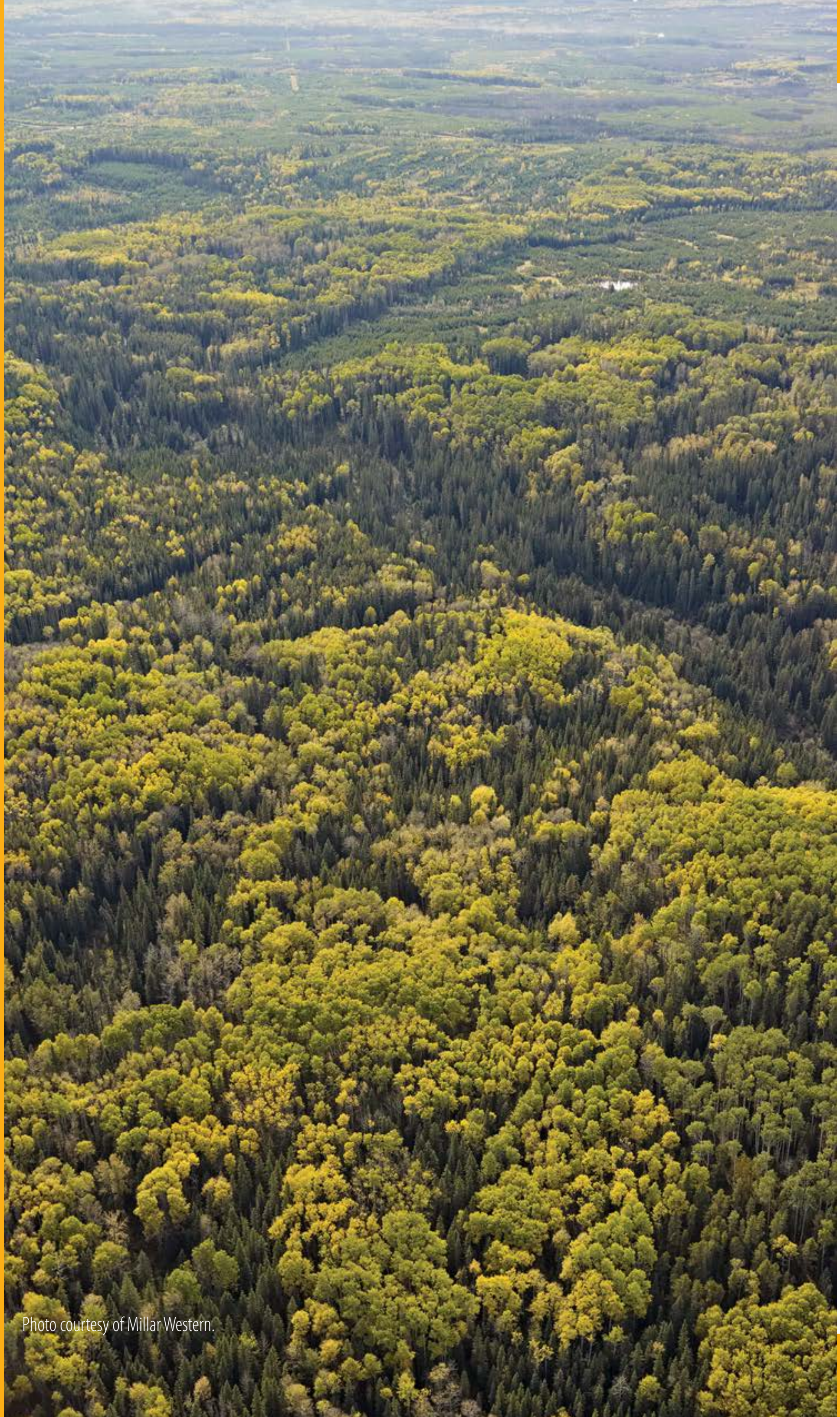

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CHAPTER 1: INTRODUCTION

More than two-thirds of Canada's boreal forest is covered by aquatic ecosystems including wetlands, lakes, rivers and streams. Boreal wetlands provide a wealth of ecological, social, and economic benefits that are important to society as a whole as well as the forest industry.

There is increasing evidence that wetlands and upland forests are interdependent. Because of these connections, sustainable forest management is key to sustaining healthy wetland habitats, and healthy wetlands are key to sustaining productive upland forests.

This practitioner guide provides an introduction to boreal wetlands, identifies key links between boreal wetlands and forest management, and outlines four guiding principles for wetland stewardship along with objectives and planning considerations that can be applied to meet these principles.

For in-depth information and supporting literature on the topics covered in this guide, refer to the accompanying Guiding Principles for Forest Management and Wetland Stewardship Technical Report.

WHO IS THIS PRACTITIONER GUIDE FOR?

This guide is aimed at forestry professionals involved in forest management planning at the strategic level, but may also be applicable to other forestry professionals in a range of positions. The information in this guide is intended to assist forest managers in achieving improved wetland stewardship by:

1. Building an enhanced understanding of wetlands in the Canadian boreal plains ecozone and their value to the forest sector and society as a whole

2. Describing the interactions between wetlands, upland forests, and forest management
3. Establishing wetland stewardship principles, objectives, and planning considerations that will result in positive environmental outcomes
4. Providing practices and tools to consider during forest management planning to help avoid or minimize adverse effects to wetlands
5. Identifying knowledge gaps and providing recommendations to fill those gaps

WHY DID WE DEVELOP THIS GUIDE?

Wetlands are increasingly a part of legal requirements, certification standards, and social license expectations. A better understanding of wetlands and the intersection between wetland stewardship and forest management will help forest managers meet these needs.

For example, the Alberta Wetland Policy applies to all wetlands in Alberta, and while most other jurisdictions in Canada do not yet have a wetland policy in place, all have some legal requirements or recommended guidance relating to wetlands, water and watershed conservation.

In addition to legislative requirements, all three forest certification systems followed in Canada (Sustainable Forestry Initiative, SFI; Canadian Standards Association, CSA, Sustainable Forest Management Standard; and the Forest Stewardship Council, FSC) include elements of wetland stewardship within their forest management standards.

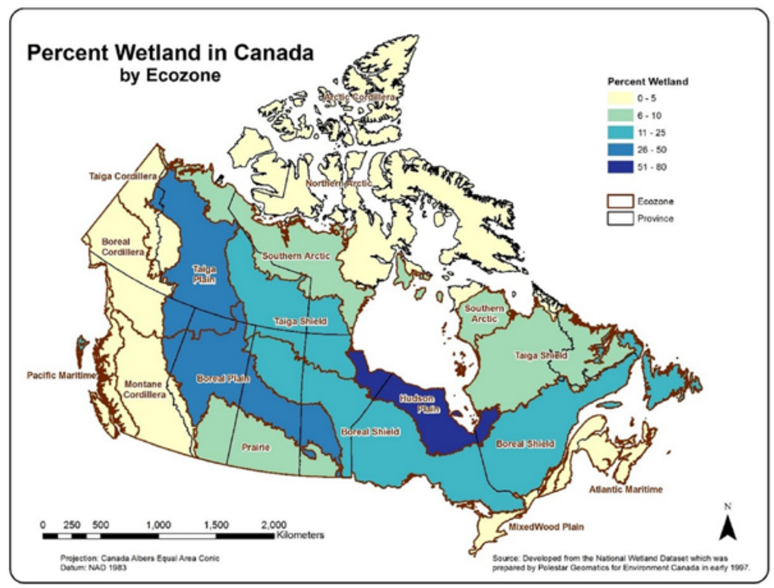
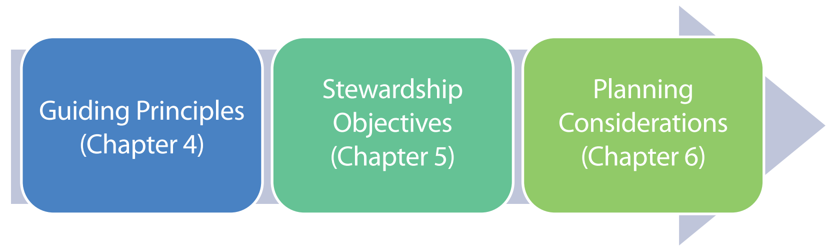


FIGURE 1. *Percent of Ecozone land base that is wetland habitat in Canada.*

INTRODUCTION

OVERVIEW

Chapters One, Two and Three introduce boreal wetlands and describe the intersection of wetlands and forest management. Chapters Four, Five and Six identify wetland stewardship guiding principles (Chapter 4), objectives (Chapter 5), and avoidance and minimization planning considerations (Chapter 6).



WHAT ISN'T COVERED

There are topics that are not addressed in this guide, but that are important to acknowledge.

- Climate change will affect Canada's boreal in ways we are only beginning to understand. Understanding how wetlands and upland forests will change is a gap that presents a high level of uncertainty making it challenging to plan around. This guide does not directly address climate change, but we encourage users to consider how a changing climate may influence their decision-making with respect to planning and operations.
- Harvesting treed wetlands is not a common practice in western Canada, but may occur in cases where wetlands, particularly conifer swamps, are not properly identified and/ or contain merchantable wood.. This guide does not address the potential effects of harvesting treed wetlands.

The focus of this guide is on planning practices, operational practices will be addressed in a separate guide, *Guide to wetland best management practices for forest management – planning and operating practices*.

DISCLAIMER

This guide presents principles, tools, and resources for avoiding or minimizing potential adverse effects to wetlands during forest management operations. Readers are cautioned that this document is a guide that contains selective information based on the best information available at the time of writing. The practices described should not be considered exhaustive or restrictive. Forest managers should select practices and tools to avoid or minimize adverse effects on the basis of the unique, site-specific, on-the-ground conditions and on the feasibility of successful implementation to achieve desired results. Information in this document is subject to change as new practices are developed and evaluated. This document should not be taken as legal advice and where the document differs in any way from applicable legislation, the legislation prevails.

CHAPTER 2: WETLANDS OF THE BOREAL FOREST

Often when one thinks of a wetland, they picture a shallow, open waterbody surrounded or interspersed with emergent vegetation such as cattail or bulrush. Wetlands that match this description can be found in the boreal forest; however, other wetland types are also abundant. Boreal wetlands are diverse in form and function. Some, such as treed swamps, can be mistaken for uplands, particularly during dry periods. Wetlands have distinguishing features that can assist with their identification, including:

1. **water present above, at, or below the surface**
2. **poorly drained soils**
3. **organisms adapted to living in wet conditions**

While there is no single, legally recognized wetland definition that is applicable across all municipal, provincial, and federal jurisdiction in Canada, the Canadian Wetland Classification System's (National Wetlands Working Group 1997) definition is widely accepted.

"... land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment..."

WETLANDS | **UPLANDS**

FIGURE 2. *Example of wetland terrain*

FIGURE 3. *Example of upland terrain*

FIGURE 4. *Example of wetland soil*

FIGURE 5. *Example of upland soil*

FIGURE 6. *Example of wetland vegetation*

FIGURE 7. *Example of upland vegetation*

WETLAND ECOLOGY

Wetlands can form wherever soil is saturated with water for extended periods of time. Climate, geology, and topography interact to create these saturated conditions. How water moves within and between wetlands, wetlands and uplands, and wetlands and the atmosphere, is influenced by soil type, texture, depth to impermeable layer, underlying geological material, topography, drainage network, and local and regional climate conditions (Devito et al. 2005).

These factors also influence wetland abiotic (chemical and physical) and biotic (microbes, plants and animals) ecological functions. Wetlands perform a range of ecological functions that can be grouped into: hydrology, biogeochemical cycling, climate regulation, and habitat.

FIGURE 8. *Boreal wetlands frequently occur as parts of large wetland complexes, such as those depicted in the photos above. Note the variation of wetland types over relatively small geographic extents.*

WETLAND TYPES

Organic wetlands

Includes bogs and fens. Organic wetlands are typically located on flat, poorly drained terrain and are characterized by organic deposits greater than 40cm deep that build up slowly due to wet, cool, low oxygen conditions.

Bogs

- nutrient poor, relatively low plant diversity
- receive water through precipitation
- often characterized as "stagnant" (no to gradual water movement) under average climatic conditions
- have the potential to move water and during wet periods can act as important water sources to adjacent wetlands and uplands
- Can be treed, shrubby, or open

WETLANDS OF THE BOREAL FOREST

Fens

- receive water through a combination of precipitation, surface runoff and groundwater sources
- can be nutrient rich or nutrient poor depending on water sources and nutrient availability/input
- tend to be more nutrient rich than bogs and as a result have greater plant species diversity
- Can be treed, shrubby, or graminoid

Mineral wetlands

Includes swamps, marshes and shallow open water wetlands. Mineral wetlands are characterized by shallow organic deposits less than 40cm deep and nutrient rich soils and water. They are a diverse group of wetlands with dynamic water regimes.

Swamps

- mineral wetlands although may have deeper (greater than 40cm) peat soils
- diverse and are sometimes referred to as lowland forests, forested wetlands, treed swamp forests, wooded swamps, or shrub swamps
- commonly recognized as shoreline areas of streams, lakes and floodplains
- receive water from run-off, precipitation and groundwater sources
- water movement regimes range from slow gradual movement to more frequent, larger, and quicker movement
- All swamps are treed, with the exception of shrub swamps

Marshes

- sometimes called reed swamps or sedge meadows, marshes are often transition zones between open water and shorelines
- receive water from precipitation, run-off, groundwater, and streams
- water levels fluctuate seasonally allowing them to dry out periodically, exposing soils to oxygen, and resulting in a nutrient rich soil substrate that supports the germination of water tolerant emergent plants (e.g., sedges, grasses, rushes, reeds, and cattail)

Shallow open waters

- often called ponds or sloughs, have a water depth of less than two meters
- receive water from precipitation, run-off, groundwater, and streams
- look like shallow lakes and may have pond-lily or submerged aquatic vegetation in more nutrient rich settings, but are too deep for emergent plants such as cattail and rushes to establish
- are generally permanently flooded but water levels may fluctuate seasonally resulting in exposed mudflats

Seeps, springs, ephemeral draws are valuable hydrologic features that may be permanently or seasonally connected to wetlands and which are common features within the boreal forest.

Vernal or woodland pools develop in relatively small depressions that temporarily fill with water following spring snowmelt, heavy rainfall or as a result of a high water table.

These are important features to maintain because of their biodiversity values and connections to wetlands.

WETLAND FLOW CHARACTERISTICS

Understanding the primary factors influencing water movement in forested environments and how to characterize water movement can provide valuable information for planning and operational practices.

In the Boreal Plains, wetland hydrology is influenced by climate, bedrock geology, surficial geology, soil type and depth, and topography and drainage (Figure 9). Outside of the Boreal Plains, the relative importance of these factors may differ. For example, in the Montane Cordillera ecozone, topography is a more significant driver of wetland hydrology.

FIGURE 9. *Primary factors influence water flow in forested environments.*

Photo courtesy of Millar Western.

WETLANDS OF THE BOREAL FOREST

TABLE 1. *Wetland hydrological groupings and their features. Groupings are appropriate during average climatic conditions. All boreal wetland types are likely to be connected under high precipitation conditions. Flow in most wetland types is likely to be affected by the amount of precipitation, more precipitation leading to increased flow. Under dry conditions, connectivity and flow rates are likely to be lower.*

HYDROLOGIC GROUP	WATER SOURCE	HYDROLOGIC CONNECTIONS	SOILS	WETLAND TYPES	OTHER
STAGNANT	Precipitation	May be isolated with water at or below the surface; however, stagnant wetlands are often connected to adjacent wetlands and uplands. Stagnant wetlands are not completely without movement (e.g., can be water sources following high precipitation events)	Deep organic layers	Treed bog, shrubby bog, open bog, conifer swamp, and treed poor fens	Unlikely to be near a defined peat channel Little discernable water movement
SLOW LATERAL-FLOW	Precipitation, runoff and groundwater	Typically connected to adjacent wetlands with slow water movement at or below the surface	Deep organic layers	Treed rich fen, shrubby rich fen, graminoid rich fen, shrubby poor fen, and graminoid poor fen	Less likely to freeze because of surface and subsurface water movement year round
SEASONALLY FLUCTUATING	Precipitation, runoff and groundwater	Often part of a flowing system with slow water movements at or below the surface and periodic lowering of the water table	Typically woody organic layers over mineral soils	Mixedwood swamp, hardwood swamp, shrub swamp, and tamarack swamp	May be obvious water movement
INUNDATED/ FLOODED	Precipitation, runoff and groundwater	Can be isolated or connected to flowing systems with seasonal or annual water fluctuations	Mineral soils	Emergent marsh, meadow marsh, open water, and aquatic bed	Often transitional zone between deep lakes and adjacent swamps or uplands

BENEFITS OF WETLANDS

Wetlands provide a wide range of regulating, provisioning, cultural, and supporting services, examples of these services are provided in Table 2. These services are important for the economic benefits and social values they support, their role in global or landscape scale processes and disturbances such as climate change and wildfire, and their contribution to ecosystem functioning.

TABLE 2. *Examples of regulating, provisioning, cultural and supporting ecosystem services provided by wetlands.*

ECOSYSTEM SERVICE CATEGORIES	EXAMPLES OF SERVICES PROVIDED BY BOREAL WETLANDS
REGULATING	• Regional and global climate • Hydrology
PROVISIONING	• Supplying fresh water • Replenishing ground water • Providing wild game and foods • Wood fuel and commercial wood fibre • Supporting fur-bearer resources for trappers • Pollination • Medicinal plants
CULTURAL	• Spiritual • Hunting • Canoeing • Hiking • Trapping • Bird watching • Gathering food and medicine
SUPPORTING	• Habitat for flora and fauna • Supporting biodiversity including listed and culturally significant species

CHAPTER 3: FOREST MANAGEMENT AND WETLAND STEWARDSHIP

Wetlands are a very important component of boreal forest ecosystems and intersect forest management activities in a number of ways.

WETLANDS SUPPORT UPLAND FORESTS

Wetlands support upland forests by contributing to forest productivity and resiliency, mitigating effects of upland harvest on waterbodies, potentially protecting against wildfires, and mitigating effects of climate change.

Contributing to forest productivity and resiliency

- Wetlands and uplands are often connected through groundwater or lateral surface or near surface runoff.
- During drought cycles and dry periods, wetlands in the boreal plains store and redistribute water across the landscape.
- During wet cycles or periods, wetlands in the boreal plains are capable of buffering and slowly moving large amounts of water through the landscape, potentially mitigating flood events.

Wetlands as a source of water for regenerating upland forest stands

- Upland forests and open waterbodies often act as sinks while vegetated wetlands tend to act as sources
- Sources can contribute to increased forest productivity in upland habitats, influencing vegetation cover, growth and yield recovery
- Following harvest, regenerating aspen stands may use water resources from adjacent wetlands by sending suckers from upland forests, through riparian zones, to wetlands

Mitigating the effects of upland harvest

- Runoff from roads and harvested areas can result in erosion and sedimentation into wetlands and waterbodies.
- Wetlands can play an important role in mitigating the effects of forest harvest on water yield and water quality by reducing or slowing runoff.

Protecting against wildfires

- Wildfires are one of the largest disturbances affecting the boreal forest and can pose a risk to forest resources and management activities.
- When undisturbed, peatland vegetation, soils, and water regimes limit wildfire frequency and inhibit deep burning under most fire weather conditions.

Mitigating effects of climate change

- The same mechanisms that help peatlands control vulnerability to wildfires (i.e. hydrological feedbacks, wet soils, low evapotranspiration, high water retention), can also play an important role in peatland response to climate change.
- If precipitation inputs follow current projections, boreal peatlands may exhibit considerable resilience to climate change.
- Peatland persistence and capacity to retain water in a changing climate may benefit uplands, and particularly aspen uplands, by supplying these forests with water resources.

Photo courtesy of Millar Western.

CHALLENGES OF CONDUCTING FOREST MANAGEMENT ACTIVITIES IN AND AROUND WETLANDS

Wetlands can be challenging to work in and around, especially if they are not identified early or addressed as part of the planning process.

Because of high water tables, weak organic soils, and other hydrological and ecological properties, planning, building and maintaining infrastructure in and around wetlands often requires additional considerations, time, and cost (Figure 10).

FIGURE 10. *Example of wetland road challenges clockwise from top left: perched culvert, sunken culvert, blocked flow, and road compaction.*

FOREST MANAGEMENT AND WETLAND STEWARDSHIP

Understanding wetland type is important for worker and equipment safety

Areas with flowing subsurface water movement, as is often found in fens, can require additional work to freeze down to create a safe surface for transport and operations. These areas can present safety concerns for workers operating equipment, and can make retrieving equipment more challenging, time consuming, and expensive.

FIGURE 11. *Example of equipment submerged in a peatland. Understanding wetland type can provide information about potential peat depth and subsurface water flow, important considerations for making safe decisions when operating in and around wetlands. Photo courtesy of Millar Western.*

FOREST MANAGEMENT ACTIVITIES CAN EFFECT WETLANDS

Forest management activities can have potential adverse effects to wetlands including wetland loss, changes to natural hydrology, and lowered water quality.

Wetland loss

Wetlands are typically avoided during forest harvest as they are often viewed as 'unproductive' areas. However, wetlands are often crossed to gain access to harvest areas and they may be used for landings.

Wetland hydrology

Common forest management activities such as building and maintaining resource roads, skidding or transporting felled timber within a harvest block, and building landing sites, camps, and equipment storage areas have the potential to disrupt the natural hydrology by altering the flow of surface or subsurface water.

Wetland quality

Soil

- Wetland soils are wet, loose, and have weak bearing capacity, making them especially prone to rutting, compaction, and erosion particularly during frost-free periods.
- Wetland road crossings can cause soil compaction and soil disturbance.
- Heavy equipment operating on skid trails or landings in or near wetlands can cause soil compaction, rutting and ponding of water.

FIGURE 12. *Example of soil rutting and compaction*

Water quality

- Forest management activities can result in sedimentation, mechanical leaks and spills, and vegetation management inputs (e.g., herbicides), all of which can affect wetland water quality.
- Activities that expose soils, such as road and trail construction and use, may cause erosion.
- Increased turbidity levels from suspended sediment can reduce light penetration, increase water temperatures, reduce plant growth, and reduce visibility for fish and other species.

Vegetation

- Wetland vegetation acts as a filtration system, stabilizes soil, and creates habitat for a variety of wetland dependant species.
- Disturbing wetland vegetation can result in the loss or alteration of these ecosystem services and alter or remove rare ecological communities and rare plant habitats.
- Removing wetland vegetation can expose soil to erosion and sedimentation which can decrease water filtration capacity.

Invasive species

- The introduction and spread of invasive species has the potential to affect wetland quality.
- Outside of their native habitat, these species may have no natural controls and may replace valuable native species.
- Equipment may facilitate the spread of invasive species if not properly cleaned.

SUSTAINABLE FOREST MANAGEMENT SUPPORTS WETLAND STEWARDSHIP

Managing timber harvest sustainably supports wetland stewardship. In Canada, the forest industry has demonstrated a commitment to Sustainable Forest Management and/ or Ecosystem Based Management (EBM) that embraces a balance between ecological, economic and social values.

Canadian forest managers are responsible for managing public land in a way that ensures the long term productivity and sustainability of the land base.

Forest management strategies are designed to maintain variability in forest patterns and forest structure, similar to patterns resulting from natural disturbances. The goal is to maintain forest conditions within the range of natural variability.

This long term investment in sustainable development means that forest managers must work with other stakeholders (e.g., public, Indigenous Peoples, other industries) to maintain healthy systems and achieve multiple objectives.

Forest managers can influence behavior within their companies, and externally, to promote wetland stewardship by implementing best management practices (BMPs) that minimize adverse effects.

Ecosystem Based Management (EBM) means taking a holistic view of environmental management. Considerations include:

- Landscape and local biodiversity
- Water quantity and quality
- Soil productivity
- Local, regional and global climate and nutrient cycling

When applied, EBM can help support the long term health of forest systems and the wetlands within.

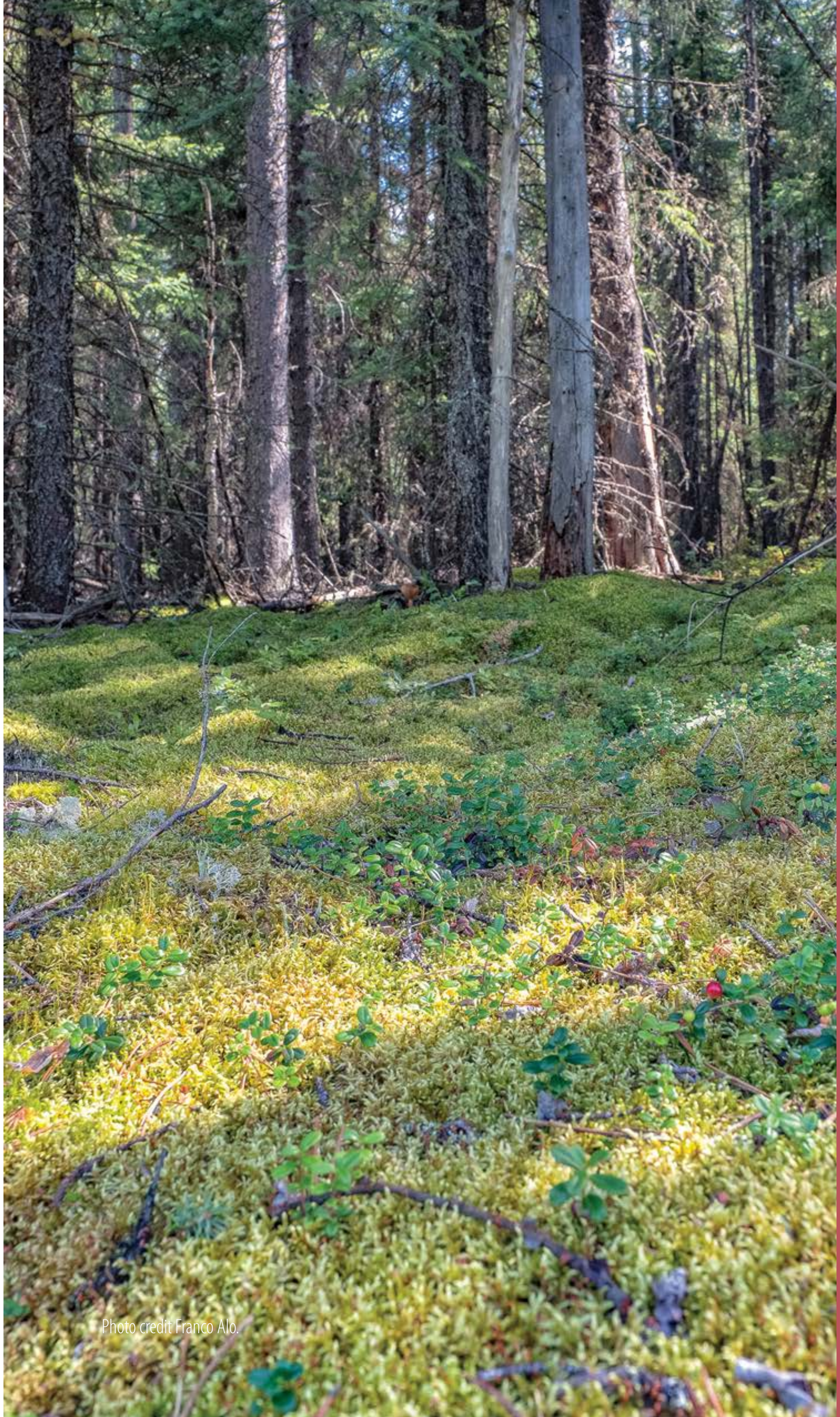
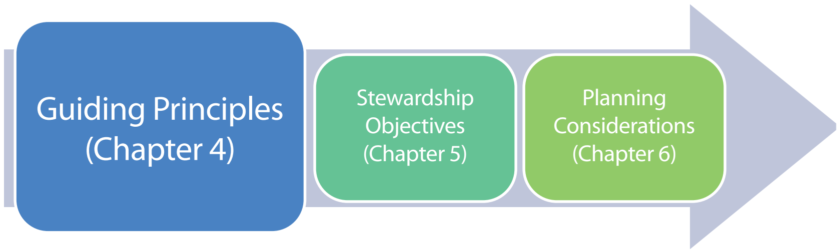


Photo credit Franco Alo.



CHAPTER 4: GUIDING PRINCIPLES

This Chapter describes four guiding principles for wetland stewardship and forest management:

- **maintain wetland quantity**
- **maintain wetland quality**
- **maintain hydrologic processes**
- **maintain hydrologic connectivity**

Working to achieve these principles will support other related values identified under government or certification requirements such as biodiversity, riparian habitats, invasive species control, forest health and productivity, and soil productivity.

GUIDING PRINCIPLES

MAINTAIN WETLAND QUANTITY

Where feasible, avoiding wetlands is the best approach to maintaining wetland quantity. Avoidance is typically at the top of policy, regulatory, and voluntary wetland mitigation hierarchies.

Depending on the extent, wetland loss can result in:

- loss of habitat
- loss of plant and animal diversity or shifts in dominance
- degraded water quality
- reduced productivity in connected upland forests
- changed hydraulic regimes
- reduced water supply and potentially water shortages
- loss of flood plain land and flood plain protection
- reduced recreational opportunities
- loss of aesthetic values
- reduced groundwater recharge
- increased risk of wildfire

Maintain redundancy and diversity of wetland types

It is important to maintain ecosystem diversity at the landscape scale by maintaining the variety of communities and ecosystems that occur naturally within that landscape. For a forest manager, this means maintaining the communities and ecosystems that occur within the area they manage.

Different wetland types provide different ecosystem goods and services. Maintaining redundancy and diversity of wetland types can help ensure that the full suite of goods and services are maintained.

MAINTAIN WETLAND QUALITY

Maintaining wetland quality requires maintaining water quality, soil integrity and quality, and wetland biogeochemistry.

Alterations to *water quality*, including the introduction of pollutants, sediment, or nutrients, can compromise water quality and influence species composition including vegetation and other wetland biota.

Wetland soils are the location of many of the chemical transformations that take place in wetlands as well as where the chemicals that support most wetland plants are stored. Activities can alter wetland soil:

- bulk density and porosity
- hydraulic conductivity
- nutrient availability
- cation exchange capacity

Maintaining wetland biogeochemistry is about maintaining the natural transport and transformation of chemicals in wetlands.

MAINTAIN HYDROLOGIC PROCESSES

Hydrology is the most important determinant of a wetlands' structure and function is a function of climate and the shape and properties of the wetland basin. Wetland hydrology refers to changes to things such as water level, flow, and frequency of flow. These changes can modify nutrient availability, oxygen availability, pH, and toxicity.

The main wetland hydrologic processes that can be adversely affected by forest management activities include:

- hydroperiod – seasonal pattern of flooding duration, frequency, and water depth
- water budgets – changes in water volume from precipitation, streamflow, and groundwater
- water storage potential

These processes are responsible for the transport of sediments, nutrients, species (e.g., plant, fish, amphibian), and toxic substances into and out of wetlands. Alterations can significantly influence vegetation, microbe, and other species composition.

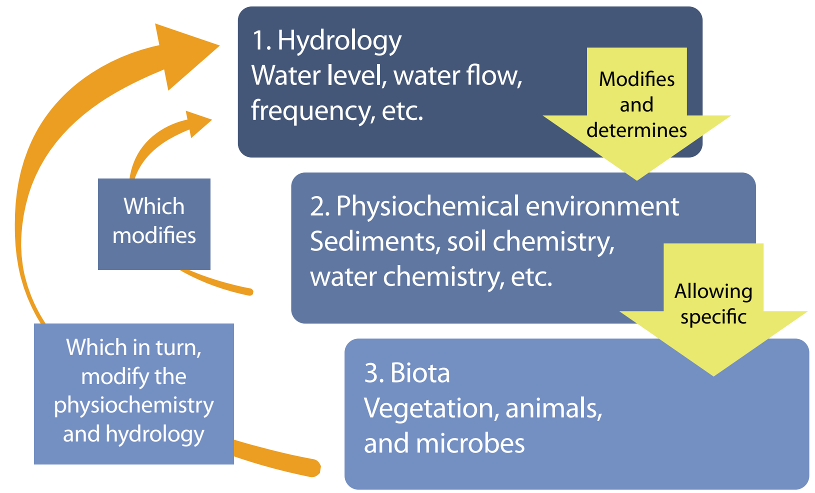


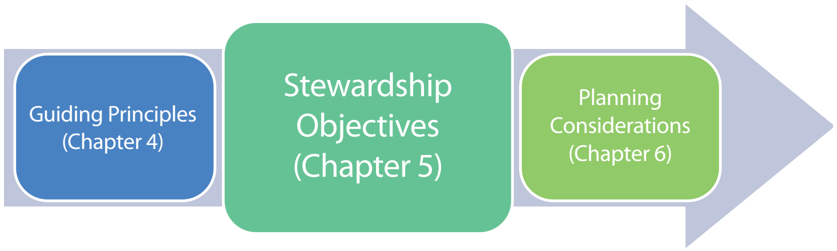
FIGURE 13. *Conceptual diagram of the relationships between wetland hydrology, physiochemical environment, and biota. Demonstrates the effects of hydrology on wetland function and the feedbacks that can affect wetland hydrology. Adapted from Mitch and Gosselink (2015).*

MAINTAIN HYDROLOGIC CONNECTIVITY

Wetland hydrologic connectivity refers to how surface, shallow sub-surface and ground water are connected. These connections may not be obvious, nor are they often well understood, but changes can have significant effects that may not be immediately apparent.

Hydrologic connectivity plays an important role in transporting matter, energy, and organisms. Blocking flow can alter water chemistry and ecological communities by stopping water from flowing into an area and preventing the accompanying transport of organic material and nutrients.

Depending on the position of the wetland within the watershed and whether it is isolated or connected, blocking flow can directly affect a specific wetland or have implications for hydrologic connectivity at the regional or landscape scale(s).



CHAPTER 5: STEWARDSHIP OBJECTIVES

This Chapter describes several wetland stewardship objectives that support the guiding principles. We developed the objectives to address potential adverse effects of forest management activities to wetlands and aligned objectives with current mandatory and/ or voluntary forest management requirements where applicable.

TABLE 3. *Relationships between Guiding Principles described in Chapter 4 and Stewardship Objectives described in this chapter.*

OBJECTIVES	GUIDING PRINCIPLE(S) THE OBJECTIVE SUPPORTS
Maintain wetland surface and subsurface water flow	• Maintain wetland quantity • Maintain wetland quality • Maintain wetland hydrologic processes • Maintain regional hydrologic connectivity
Avoid or minimize soil compaction	• Maintain wetland quality • Maintain wetland hydrologic processes • Maintain regional hydrologic connectivity
Avoid or minimize soil layer disturbance	• Maintain wetland quality • Maintain wetland hydrologic processes • Maintain regional hydrologic connectivity
Maintain structure and function of riparian and wetland vegetation	• Maintain wetland quality • Maintain regional hydrologic connectivity
Avoid or minimize site level run-off and erosion	• Maintain wetland quality • Maintain wetland hydrologic processes
Prevent sediment and pollutants from entering the wetland	• Maintain wetland quality • Maintain wetland hydrologic processes
Avoid or minimize invasive species introduction and/ or spread	• Maintain wetland quality • Maintain wetland hydrologic processes

MAINTAIN WETLAND SURFACE AND SUBSURFACE WATER FLOW

Blocking or disrupting wetland surface and subsurface flows can result in flooding upstream of the blockage and drying downstream of the blockage. Roads, trails, landings, and stockpile sites all have the potential to alter wetland hydrology.

Altering flow can disrupt wetland interconnectedness, and changes to the quality and quantity of downstream water flows have the potential to alter plant and animal communities.

Failing to consider wetlands as part of forest harvest access planning, design and construction can result in altered water flow if the wetland crossing design and hydrologic conditions don't match. This can lead to maintenance issues and higher long-term road costs.

Example wetland water flow may be impeded if road crossing design and construction fail to provide sufficient water conduits to accommodate water flow. Upstream flooding and downstream drying can result in a shift in the ecological communities, with woody vegetation dying off upstream and increased vigour downstream.

AVOID OR MINIMIZE SOIL COMPACTION

Wetland soils are typically saturated and have weak bearing capacity, characteristics that makes them especially prone to rutting, erosion, and compaction. Because of this, wetlands have a greater potential for damage compared to upland sites. Increased risk of compaction typically occurs in:

- Wet compared to dry conditions
- Unfrozen compared to frozen conditions
- Organic compared to mineral soils

Soil compaction results in denser soils with fewer spaces between soil particles (increased bulk density, decreased porosity). As a result fluids, such as water, face greater resistance moving through the soil (decreased hydraulic conductivity).

Activities resulting in soil compaction may also increase the potential for soil erosion and lead to changes in landscape hydrology, such as enhanced overland flow and raised water tables. These changes can make it more difficult for vegetation to establish as the same changes that make it difficult for water to move through the soil also make it difficult for roots to penetrate.

FIGURE 14. *Examples of soil compaction and rutting from off road vehicles along powerline right-of-way near Grande Prairie, Alberta (left) and from highway vehicles on access road near Wabasca, Alberta (right).*

AVOID OR MINIMIZE SOIL LAYER DISTURBANCE

Soil is the main source of nutrients for all plant species, supports above and below ground animal biodiversity, and transmits water across the landscape. Different soil layers have different physical and biogeochemical properties that support different processes and functions.

Disturbing soil layers, such as by mixing, can have potential negative implications for plant growth. Mixing soil layers can be especially damaging in organic wetlands (bogs and fens) where it may compromise the unique properties of peat, altering hydrology and vegetation growth.

MAINTAIN STRUCTURE AND FUNCTION OF RIPARIAN AND WETLAND VEGETATION

Vegetation is a defining feature of wetlands and riparian areas. Vegetation supports important ecosystem services such as water filtration, soil stabilization, and habitat provisioning for a variety of wetland dependent species. Removing or altering wetland vegetation can result in:

- exposed banks vulnerable to erosion and sedimentation
- loss or alteration of the ecosystem services provided by wetland vegetation
- sedimentation
- decreased water holding capacity
- damage to rare and/ or sensitive ecological communities and species

Photo courtesy of Alberta-Pacific Forest Industries Inc.

AVOID OR MINIMIZE EROSION AND SEDIMENTATION

Vegetation clearing and construction activities may result in the exposure and erosion of upland soils and transportation of sediments into wetlands and other water bodies. Locating roads or skid trails through wetlands, streams, or other wet areas and operating harvesting equipment in or near wetlands may result in soil disturbance and subsequent erosion and sedimentation.

Erosion can affect soil quality, structure, stability, and texture making it more difficult for:

- plants to establish due to loss of nutrients and organic matter
- soils to retain moisture due to loss of surface permeability and changes to soil texture that affect water holding capacity

FIGURE 15. *Example of soil erosion at wetland crossing*

PREVENT POLLUTANTS FROM ENTERING THE WETLAND

Equipment and vehicles are potential sources of spills of oil, gas and other fuels. If a spill occurs, the extent of wetland contamination will depend on the amount and type of product spilled, wetland connectivity, and rate and direction (vertical vs. horizontal) of water movement.

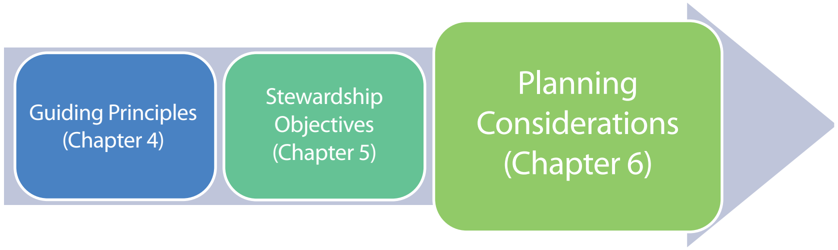
AVOID OR MINIMIZE INVASIVE SPECIES INTRODUCTION AND/ OR SPREAD

Invasive species are non-native species that once introduced are able to spread and often cause socio-cultural, economic, or environmental harm. Disturbing wetland vegetation and exposing wetland soils may facilitate the spread of invasive species. Industry equipment and recreational vehicles have the potential to introduce and spread invasive species if users don't take measures to minimize risk.

TABLE 4. *Invasive species that may be of concern to forest managers working in Canada's western boreal forest. Table is not exhaustive, but identifies key species of concern.*

INSECTS	PATHOGENS	PLANTS	AQUATIC
Pine shoot beetle	Scleroderris canker	Garlic mustard	Faucet snail
European pine sawfly	White pine blister	Common toadflax, Dalmatian toadflax, Yellow toadflax	Zebra & quagga mussel
Bark beetle	Dogwood anthracnose	Tall buttercup	Phragmites
Mountain pine beetle (native to Canada, but expanded beyond historic range)	Dothichiza canker of poplar	Oxeye daisy	Variable-leaf watermilfoil
Larch sawfly	European larch canker	Giant hogweed	Curly leaf pondweed
Rusty tussock moth	Poplar leaf rust	Wild parsnip	Spiny waterflea
European spruce sawfly	Willow scab	Perennial sow thistle, Nodding thistle, Bull thistle	Hydrilla
Balsam woolly adelgid	Dutch elm disease	Purple loosestrife	Salt cedar
European gypsy moth		Canada Thistle	European frog-bit
Ambermarked birch leafminer		Spotted knapweed	Yellow flag iris
Birch leafminer		Scentless chamomile	Flowering rush
Emerald ash borer		Common tansy	Himalayan balsam
		European buckthorn	Reed canary grass
		Japanese brome, Downy brome	Water hyacinth
		St. John's wort	Narrow leaved & hybrid cattail
			Rusty crayfish
			Elodea
			Water soldier

FIGURE 16. *Examples of terrestrial and aquatic invasive species clockwise from top left: purple loosestrife, faucet snail, giant hogweed, leafy spurge, invasive phragmites, and flowering rush.*



CHAPTER 6: PLANNING CONSIDERATIONS

Chapter Six describes avoidance and minimization planning considerations that support the stewardship objectives and guiding principles. The key decisions for successful forest management are made in the planning phases. This guide provides brief descriptions of several avoidance and minimization practices.

Detailed descriptions of the practices including evidence of effectiveness and supporting information can be found in the technical report.

BRINGING TOGETHER GUIDING PRINCIPLES, STEWARDSHIP OBJECTIVES, AND PLANNING CONSIDERATIONS

Many of the planning considerations discussed in this Chapter support all principles and objectives. In particular, considerations that result in activities avoiding wetlands will in most cases meet all objectives and principles. Considerations that result in activities minimizing adverse effects to wetlands will help meet some objectives and principles depending on minimization approaches. Table 5 links the planning considerations covered in this Chapter to the objectives and principles that they support.


Photo courtesy of Millar Western.

TABLE 5. *Summary of planning considerations, objectives the planning considerations supports, and principle(s) the planning considerations support including avoidance and minimization considerations.*

PLANNING CONSIDERATIONS	OBJECTIVE(S) THE PLANNING CONSIDERATIONS SUPPORT	PRINCIPLE(S) THE PLANNING CONSIDERATIONS SUPPORT
Avoidance considerations		
Map the distribution of wetlands on the landscape by type Avoid new disturbances to wetlands by participating in integrated land management planning Avoid new disturbances to wetlands by locating new infrastructure near or on existing disturbances and by planning access routes to accommodate future development needs Prioritize avoidance of wetland types based on ecological, social, and economic criteria	Supports all objectives: • Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Maintain structure and function of riparian and wetland vegetation • Avoid or minimize site level run-off and erosion • Prevent sediment and pollutants from entering the wetland • Avoid or minimize invasive species introduction and/ or spread	Supports all principles: • Maintain wetland quantity • Maintain wetland quality • Maintain hydrologic processes • Maintain hydrologic connectivity
Minimization considerations		
Consider timing, location and equipment when working in or near wetlands in relation to the following: • Climate • Bedrock and surficial geology, soils • Topography and drainage network	Supports all objectives	Supports all principles, particularly: • Maintain hydrologic connectivity
Consider the location of planned access, harvest, and renewal activities in relation to wetlands and the following: • key attributes and flow characteristics • position of wetland in the watershed • wetland connectivity	Supports all objectives, particularly: • Avoid or minimize blockage or disruption of wetland surface and subsurface water flow	Supports all principles, particularly: • Maintain hydrologic connectivity
Locate wetland crossings to minimize disturbance	Supports all objectives	Supports all principles
Consider the wetland type when choosing the wetland crossing	Supports all objectives, particularly: • Avoid or minimize blockage or disruption of wetland surface and subsurface water flow	• Maintain hydrologic connectivity
Schedule activities to occur during favourable weather conditions (e.g. winter operations, shutting down operations during spring runoff or heavy rain events)	• Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Prevent sediment and pollutants from entering the wetland • Avoid or minimize blockage or disruption of wetland surface and subsurface water flow	• Maintain wetland quality, maintain hydrologic processes, maintain hydrologic connectivity
Establish vegetated zones around wetlands	• Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Prevent sediment and pollutants from entering the wetland	• Maintain wetland quality
Establish storage sites and recovery plans for petroleum products and other pollutants	• Prevent sediment and pollutants from entering the wetland	• Maintain wetland quality
Plan to minimize invasive species introductions and spread	• Avoid or minimize invasive species introduction and/ or spread	• Maintain wetland quality

PLANNING CONSIDERATIONS

PLANNING TO AVOID

Avoidance is first stage of many environmental mitigation strategies and is the preferred response to achieving wetland stewardship objectives. Generally, with the exception of merchantable treed swamps, forest managers avoid wetlands where possible because of potential cost and safety issues, regulatory or certification requirements, and additional logistical considerations. However, lack of awareness and understanding of boreal wetlands may result in some wetland types being avoided more than others.

Avoidance is typically achieved at the planning stage by determining the abundance, type, and location of wetlands within the area of interest and then choosing locations for access and timber harvesting to avoid or minimize adverse effects to these areas. Planning to avoid is done remotely at the landscape planning level and later through ground-truthing and operational practices.

Map the distribution of wetlands on the landscape by type

Knowing where wetlands are located on the landbase is critical to the planning process. An accurate understanding of wetland locations allows forest managers to make effective decisions on if, how, and when to avoid wetlands.

Different boreal wetland types have different ecological characteristics that can present different types of challenges. Maps identifying wetlands by type can be used to help prioritize wetland avoidance, determine appropriate minimization techniques if wetlands can't be avoided, and identify and potentially prioritize areas for wetland restoration or reclamation.

Application: Wetlands can be mapped or delineated using aerial photography, satellite imagery, modeling, or through on the ground field data collection. For example:

- Aerial photography has been used to map wetlands in Canada (Murphy et al. 2007, Watmough and Schmoll 2007).
- The Canadian Wetland Inventory (Ducks Unlimited Canada 2016), DUC's Enhanced Wetland Classification (Smith et al. 2007a) was developed using multi-spectral remotely sensed imagery.
- The Alberta Merged Wetland Inventory (Government of Alberta 2017) is a compilation of different wetland inventories developed for different regions of the province. The EWC at the five class level covers the province's Green Zone.
- LiDAR has be used in Wet Areas Mapping projects in a number of locations across Canada (Forest Watershed Research Center 2017). While not a wetland inventory per se; wet areas mapping helps to more accurately delineate wetlands from uplands (Murphy et al. 2008).

Avoid new disturbances to wetlands by participating in integrated land management (ILM) planning

Working with other land users can help avoid or minimize the extent and duration of legacy disturbances. ILM includes coordinating activities such as:

- site selection
- design, planning, construction and use of new development
- maintenance and use of existing developments
- remediation or restoration of decommissioned areas

Sharing infrastructure can reduce construction, maintenance and decommissioning costs.

Application: To be effective, ILM should include planning over space and time. Planning should incorporate current and future needs and consider a range of potential future situations. ILM should be done at the forest management plan level and at larger landscape level if appropriate. Planning should identify:

- Activities taking place on the landbase
- Companies, organizations and individuals working on the landbase
- Where and when there is the need to collaborate

Collaboration should consider how the existing footprint is used, future footprint needs, opportunities to remove or reduce the footprint, and ways to coordinate activities and infrastructure.

Photo courtesy of Millar Western.

Avoid new disturbances to wetlands by locating new infrastructure projects near or on existing disturbances and by planning to accommodate future development needs

New disturbances to wetlands can be avoided by using existing infrastructure or disturbed sites. For example, disturbance may be reduced by locating camps and other facilities near existing access roads or other industrial developments. Planning access routing to accommodate future development needs will ensure that existing infrastructure can be used or reused, reducing the need for further disturbance on the landscape.

Application: Like ILM, utilizing existing infrastructure and disturbances requires planning over large space and lengths of time to be effective. This practice requires quality information about the location and type of disturbance on the landbase, generally in the form of maps that can be incorporated into desktop planning. There are times where re-using existing infrastructure and disturbances may not be the preferred option, this may include:

- original infrastructure was poorly sites and/ or constructed
- there are safety concerns with existing disturbance or infrastructure

Prioritize wetlands for avoidance

If having to choose which wetlands to avoid and which to potentially adversely affect, consider prioritizing avoidance according to what is of interest or high conservation priority for the forest company.

For example, planners may want to prioritize avoiding wetlands that are habitat for species of conservation concern (e.g., caribou, yellow rail) or wetlands identified as valuable by government policy and/or legislation (e.g., Provincially Significant Wetlands in Ontario, "A" valued wetlands in Alberta).

Application: Prioritizing wetlands for avoidance can be challenging due to local and regional variation, developing a decision framework based local and regional needs, taking into consideration the values listed in Table 6, will help determine priorities.

TABLE 6. *Recommended considerations regarding prioritizing wetlands for avoidance.*

WETLAND VALUES TO CONSIDER	REASONS FOR IMPORTANCE
Complexes	• In areas with low topographic relief, wetlands are often highly connected resulting in a large complexes of several wetlands transitioning from one wetland type to another across the landscape. • Several wetland classes can be associated with an open water pond or stream or adjacent to upland sites. These wetland riparian areas are typically defined as transition areas between open water and uplands. Soil moisture and other properties are expected to change across a transition area reflecting several wetland types. • Wetland complexes are high in biodiversity. • Because boreal wetland complexes contain a number of wetland types they can encompass all of the considerations below. As a result, wetland complexes could be prioritized highest for avoidance.
Rarity	• To maintain the diversity of habitat types on the landscape, special effort may be needed to retain rare wetland types. • In Canada's boreal shallow open water and marsh wetlands tend to be rare compared to other wetland types. • Rarity should be determined by calculating wetland type coverage using tools such as wetland maps. • Rarity may depend on the scale (FMU, FMA, landscape, etc.) at which it is assessed.
Waterfowl abundance	• Waterfowl are an important part of wetland ecosystems and areas with high waterfowl abundance can often indicate good habitat for other aquatic species. • Waterfowl are more likely to be found in or near open water and marsh wetlands, but may nest in a variety of wetland types. • Waterfowl distribution maps such as those described in Barker et al. 2014 or DUC 2014 can be used to identify areas of predicted high waterfowl abundance.
Species of special consideration	• Wetlands that provide important habitat for species of interest, particularly for subsistence species, rare species, species at risk, species of cultural value to Indigenous peoples, and species identified either through legal or certification requirements. • Examples of potential species of interest include caribou, yellow rail, black tern, trumpeter swans, and moose.
Reclamation	• Some wetland types are more challenging than others to reclaim. • Peatland (bog and fen) reclamation is still in the early stages of research. • Reclaiming peatlands, as may be required following road decommissioning, generally requires more time, money, and expertise compared to restoring mineral wetlands due to the complex hydrology and specially adapted vegetation communities.

TABLE 6 (cont'd). *Recommended considerations regarding prioritizing wetlands for avoidance.*

WETLAND VALUES TO CONSIDER	REASONS FOR IMPORTANCE
Government policy and/ or legislation value	• In some jurisdictions governments have prioritized wetlands or defined criteria for valuing wetlands (e.g., Ontario significant wetlands, Alberta Wetland Policy wetland valuation). • Provincial recovery plans for species of special consideration, such as caribou, may identify valuable wetlands.
Hydrologic function	• Many boreal wetlands are important to the hydrologic functioning of the watershed by acting as water source areas. • Bogs, fens, and swamps are important water sources that can help support upland forests, particularly in dry years. • These wetlands can contribute to forest productivity.
Hydrologic impairment	• All wetland types, including those referred to as 'stagnant' have the potential to move water and are at risk of hydrologic impairment. • Because of the dynamic water movement in fens (laterally flowing) and swamps (seasonal fluctuations and potential for lateral flow), these wetland types may be at greater risk of hydrologic impairment compared to other wetland types.
Carbon storage potential	• Peatlands, bogs and fens, can store significant amounts of carbon. • Boreal peatlands typically have peat depths between 40cm and up to several meters. • Compared to other wetland types, disturbing bogs and fens has a greater potential to adversely affect carbon stores and future storage potential.

TABLE 7. *Checklist identifying ecological, economic, and social considerations for the five major wetland classes. This information can be used when prioritizing wetlands for avoidance; however, it is up to users to determine how to apply this information. Additional information about species of concern and subsistence or cultural species can be found in Table 8.*

WETLAND TYPE	ECOLOGICAL								ECONOMIC	SOCIAL
	High biodiversity	Potential habitat for species of concern (Table 8)	Potential waterfowl feeding habitat	High carbon storage/ sequestration	Important water source	Risk of hydro- logical impairment	Rare Wetland type	Challenge to build	Challenge to restore/ reclaim	Subsistence or cultural species (Table 8)
Wetland complex	X	X	X	X	X	X		X	X	X
Shallow open water	X[1]	X	X				X	X		X High value[1]
Marsh	X[1,2]	X	X				X	X		X High value[1]
Swamp	X[1,4]	X			X	X		X	X	X Highest ranking[1]
Fen	X[1,3,4,5]	X	X	X	X	X		X	X	X High to moderate ranking[1]
Bog	X[1,3,4,5]	X		X	X			X	X	X Low - moderate ranking[1]

TABLE 8. *Species of concern and species of cultural importance for major and minor boreal wetland classes. The presence of species of concern and species of cultural importance can be considered when prioritizing wetlands for avoidance.*

WETLAND TYPE	SPECIES OF CONCERN								SPECIES OF CULTURAL IMPORTANCE				
	Black tern	Horned grebe	Canada warbler	Rusty black bird	Olive sided flycatcher	Yellow rail	Woodland caribou	Western toad	Beaver	Muskrat	Moose	Fisher	Mink
Shallow open water		X		X					X	X			X
Marsh	X			X				Breeding	X	X	X		X
Swamp			X	X	X	X			X			X	X
Hardwood			X		X			X	High value[1]				
Mixedwood			X	X	X				High value[1]				
Shrub			X	X		X			Highest value[1]				
Tamarack			X	X	X				High value[1]				
Conifer			X	X	X		X		High value[1]				
Fen			X	X	X	X	X		X		X	X	X
Treed rich			X	X	X	X	X		Low value[1]				
Shrubby rich			X	X	X	X			Moderate value[1]				
Graminoid rich						X			Highest value[1]				
Treed poor			X	X	X	X	X		Low value[1]				
Shrubby poor			X	X	X				Moderate value[1]				
Graminoid poor									Low value[1]				
Bog			X	X	X		X	Wintering			X	X	
Treed			X	X	X		X		Moderate value[1]				
Shrubby			X	X	X		X		Low value[1]				
Open									Low value[1]				

Previous page:

[1] Ducks Unlimited Canada. 2014. Ranking Vertebrate Biodiversity in Boreal Wetland Habitats of Alberta using the Enhanced Wetland Classification System – Version 2.1. Ducks Unlimited Canada, Edmonton, Alberta.

[2] Bright, D.A. 2011. Vegetative and soil mesofaunal changes at boreal peatland field sites from produced water spills: Implications for the environmental assessment and remediation of upstream oil and gas sites. Prepared by AECOM, Victoria, BC. Accessed February 16 2018 from <http://auprf.ptac.org/wp-content/uploads/2016/04/2011-AECOM_EcologicalEffects-of-Salt-Releases-to-Boreal-Peatlands.pdf >

[3] Locky, D.A. and S.E. Bayley. 2005 Plant diversity, composition, and rarity in the southern boreal peatlands of Manitoba, Canada. Canadian Journal of Botany. 84: 940-955.

[4] Locky, D.A, Bayley, S.E, and D.H. Vitt. 2005. The vegetational ecology of black spruce swamps, fens and bogs in southern boreal Manitoba, Canada. Wetlands. 25(3): 564-582.

[5] Warner, B.G., and T. Asado. 2006. Biological diversity of peatlands in Canada. Aquatic Sciences. 68: 240-25

PLANNING TO MINIMIZE

Avoidance in the boreal forest is often difficult to achieve due to the high density and distribution of wetlands. As a result, forest managers should plan to minimize potential adverse effects of forest operations on wetlands.

Careful up-front planning can minimize the adverse effects of road infrastructure, forest harvest, and forest renewal while helping to reduce maintenance, decommissioning, and reclamation/restoration requirements.

Incorporating wetlands in strategic and operational planning can help reduce the duration, size, intensity, and/ or frequency of potential negative effects in or near wetlands. The following section describes planning considerations to minimize adverse effects to wetlands during forest management operations.

Consider timing and location when working in or near wetlands in relation to:

- Climate
- Bedrock and surficial geology, soils
- Topography and drainage network

Wetlands in forests are influenced by a number of factors including climate, bedrock and surficial geology, soil type and depth, and topography and drainage network. Understanding these factors will assist forestry professionals in determining where, when and how to work in or near wetlands to reduce potential adverse effects.

Application: Climate information can be used to identify times in the year when conditions are typically wetter or drier to help minimize challenges associated with working in wetlands during wet periods. In addition, climate information can be used to identify periods when the ground is expected to be frozen.

- Historical climate data can be found on the Government of Canada website, and other provincial sources of climate information.
- Surficial geology maps are not always available for all areas; however, they can be a useful tool for better understanding the landscape.
- Topography maps can be used to identify areas with steep relief that may present operational challenges.

Mapping by wetland type can provide some insight related to geology and soils. Local knowledge and experience can be used to direct and interpret wetland maps.

Location of planned access and harvest activities in relation to wetlands and the following:

- key attributes and functions of different wetland types (e.g., water flow, deep organic vs. shallow organic soils)
- position of wetlands in the watershed
- wetland connectivity

Considering key wetland attributes and functions by wetland type, position in the watershed, and connectivity can help minimize adverse effects to wetlands. Different wetland types have different ecological characteristics. Being able to classify wetlands and understanding some key characteristics will help forestry professionals make decisions to minimize potential adverse effects.

Application: A number of tools and approaches can be used to collect information on key wetland attributes and functions, including:

- wetland inventory maps with wetlands classified to at least the five major classes (bogs, fens, swamps, marshes, and shallow open waters)
- hyrography maps for landscape position
- LiDAR or derived tools, such as wet areas mapping, for understanding connectivity and amount of moisture

Mapping wetlands within the context of watershed boundaries can provide insight into water yield and fluctuations and the associated potential implications for planning wetland crossing locations.

- Anticipate increased water yield and water level fluctuations lower in the watershed, and accommodate anticipated fluctuations when designing and constructing crossings.

Understanding whether wetlands are isolated or connected and the degree of connectivity will provide will provide valuable insight into anticipated water yield. Connected wetlands typically have greater water movement and potentially greater water fluctuations compared to isolated wetlands.

- Consider wetland extent and connectivity when developing planned road corridors and harvest block locations

Locate wetland crossings to minimize disturbance:

A carefully chosen crossing location can minimize potential adverse effects to wetlands. A well positioned crossing location can also decrease the likelihood of road degradation over time and could help reduce maintenance and/ or restoration costs.

Application: When crossing wetlands cannot be avoided, often the narrowest point offers the least amount of habitat disturbance and loss. However, other factors such as slope, soil stability, hydrologic flow, and wildlife features (e.g., bird nests, fish habitat) should also be considered when choosing wetland crossing locations.

For example, crossing at the narrowest point of slow flowing wetlands may result in "pinch points" where surface and subsurface flow maybe concentrated (Ducks Unlimited Canada 2014, Partington et al. 2016). Narrow wetland crossings could become problem areas for water flow blockage because of storm water debris or beavers.

Consider the wetland type when choosing the wetland crossing

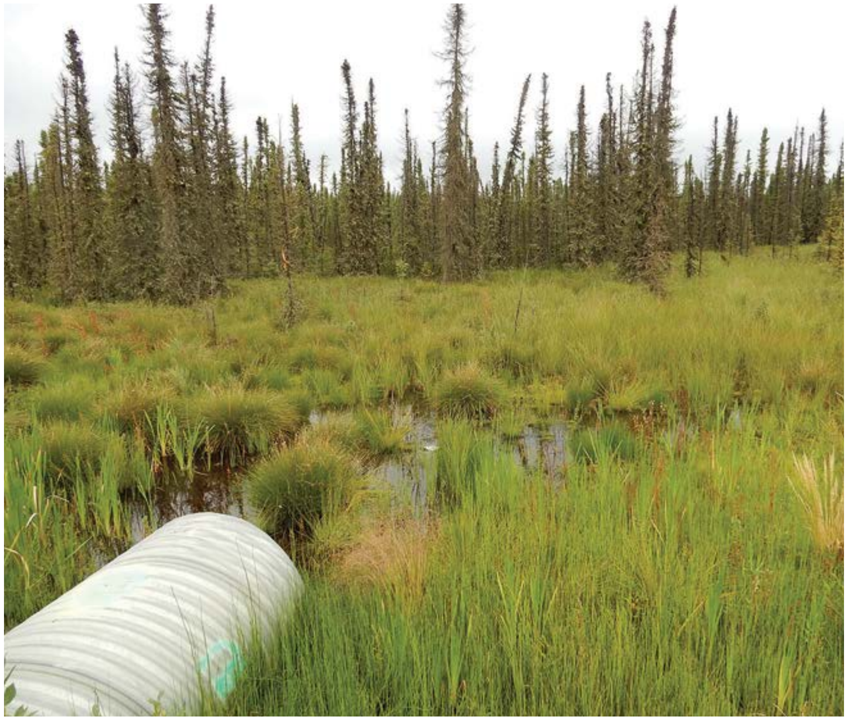
When planning a wetland crossing, identifying wetland type can provide insight into ecological characteristics such as permanency, amount and type of water flow, and soil characteristics. Information about wetland type and location can help inform this process, consider the following:

- Wetland types present and their ecological and hydrological characteristics
- Maps of wetland distribution
- Location of a crossing within a watershed
- Extent and connectivity of the wetland(s) being crossed to other wetlands
- Predicted water flow

Application: The tools described on page 60 can be used to identify wetland type and location. To assist with predicting water flow, wetlands can be grouped into four categories that describe water flow under average climatic conditions:

1. Stagnant – no to gradual flow
2. Moving – slow lateral flow
3. Moving – seasonally fluctuating
4. Inundated/Flooded

Refer to pages 15 and 16 or to the Technical Report for additional information on wetland flow types.



PLANNING CONSIDERATIONS

Schedule activities to occur during favorable weather conditions

Wetland soils are sensitive and prone to rutting and compaction. Schedule activities to occur when the ground is expected to be frozen or dry to minimize adverse effects to wetland soils.

Application: At the planning stage it is important to understand the scope of operations and determine what can be accomplished during favourable weather conditions. Identifying what activities may need to occur when the ground is not frozen will be important for identifying operational BMPs to minimize potential adverse effects to wetlands. This information can also be used to avoid higher risk wetlands during the times of year when safety risks are highest, such as during spring break up.

Establish vegetated zones around wetlands

Where appropriate, consider establishing vegetated zones around wetlands where activities are not allowed or are limited. Leaving vegetated zones around wetlands within harvest blocks could be considered avoidance or minimization depending on the width of the zone and the activities allowed within. Vegetated zones may include or be referred to as buffers or setbacks.

Application:

- The width of the vegetated zone will largely depend on regulation and conservation goal
- Most jurisdictions have no legal requirements for buffers
- Generally, buffers are applied to open water and marsh habitats, it can be more challenging to apply buffers to vegetated wetlands and to wetland complexes
- Typically no buffers are required around fens, bogs, or swamps

Establish storage sites and recovery plans for petroleum products and other pollutants

While there are potential negative effects of pollutants entering a wetland, most forest management activities are low risk for release of pollutants. The most likely would be a release of petroleum product from vehicles or equipment.

Application: Minimize risk by planning ahead:

- Location of storage sites
- Setbacks from wetlands for certain types of materials or certain activities where there is the potential for leaks or spills
- Clean up and/ or recovery plans for different material types with potential to spill

Minimize invasive species introduction and spread

Managing the introduction and spread of invasive species is an important component of sustainable forest management. Invasive species have the potential to adversely affect wetlands as well as upland forests. Wetland invasive species can change the composition of plants and animals which can in turn affect wetland function including hydrologic processes (e.g., nutrient cycling).

Preventing the introduction of invasive species into wetlands is the easiest way to minimize adverse effects. Once introduced, control of many species is challenging and often costly.

Application:

- Identify invasive species that are known to occur within the management area and those with future invasive potential within the management area.
- Consider both aquatic and terrestrial invasive species. Aquatic invasive species pose less of a risk to forest resources, but are important to manage to achieve wetland stewardship objectives.
- Companies may develop protocols to monitor and track known invasive species, this information can be used at the planning stage to identify risks and approaches to minimize risks.
- Consider the relevant provincial or territorial legislation and responsibilities under that legislation. For example, in Alberta invasive species under legislative control are listed as noxious or prohibited noxious, with different requirements for the two groups.

ENHANCING KNOWLEDGE AND AWARENESS

Targeted off-highway vehicle recreation

Traversing wetlands can be an entertaining challenge for off-highway recreational vehicle (OHV) users. However, wetland soils, vegetation, and water can be seriously damaged by OHV users.

Using wetland inventory maps, forest managers can help plan to avoid/minimize the use of wetlands by OHV users and can aid in recovery of damaged wetlands.

Application:

- Using wetland inventory maps, work with local recreation associations to create trails in areas where wetland density is low and/ or that avoid wetlands.
- Where wetlands have been degraded by OHV use, explore options to reroute existing trails through wetlands to non-sensitive upland sites to minimize further wetland degradation and promote recovery.
- Wetland degradation from OHV trails can be identified remotely using wetland inventory maps and/or satellite imagery.
- Consider using avoidance considerations described in Tables 6, 7, and 8 to help prioritize wetlands that are expected to be most sensitive to OHV use for avoidance and recovery.
- Access barriers, signage, and education materials can help prevent access and use of wetlands by OHV users, consider these proactive approaches where possible.
- Develop a plan to monitor and evaluate the effectiveness of minimization activities (e.g., putting up signage or barriers).

Reclamation

Requirements for restoring temporary features (e.g., temporary roads). Wetlands are often sensitive habitats, and may not recover naturally following removal of the disturbance. As a result, foresters may have to assist with the recovery of damaged wetlands. Planning to reclaim wetlands can include identifying damaged areas, determining what functions need to be restored, determining best methods for reclaiming, implementing those methods, and monitoring results.

Planning ahead can help minimize the extent of wetland reclamation required. For example, prioritizing wetlands that are challenging to reclaim (e.g., those with deep peat soils) for avoidance or using minimization practices at the construction stage, may improve reclamation outcomes and/ or reduce the amount of time, expense, and effort required to reclaim.

Application:

- Use wetland inventory maps to work with local recreation associations to plan and create new trails in areas where wetland density is low.
- Where wetlands have been degraded by OHV use, explore options to reroute existing trails through wetlands to non-sensitive upland sites to minimize further wetland degradation and promote recovery

Introductory wetland training

Raising awareness and understanding of boreal wetlands is necessary for wetland stewardship. Without an understanding of the importance, types, and functions of wetlands it is impossible for those working on the landscape to act as stewards of these habitats. Wetland training can:

- Provide insight into the environmental, social, and economic values wetlands provide
- Build an awareness of why to avoid, minimize, or improve wetlands
- Improve awareness and understanding of how wetlands may affect forest operations and economic reasons for avoiding, minimizing, and improving wetlands

Application:

Wetlands training can come in a variety of formats, in the field, course-based, online or a combination of multiple approaches. Availability and applicability of training varies based on location and focus. Wetlands training includes:

- DUC provides wetlands training to companies that can be tailored to specific company needs
- Companies may develop their own in-house wetland training programs

Universities and colleges may offer wetlands training through their continuing education departments, these courses are unlikely to be industry specific but may provide an introduction to wetland basics relevant to the area they are offered.

Best management practices training

Learning about practices that can be applied to avoid or minimize adverse effects to wetlands from forest industry activities can help improve outcomes for wetlands. Building on an introductory understanding of wetlands acquired from wetlands training or similar, BMP training can provide information and guidance about how to apply knowledge of wetland types when carrying out forest industry activities.

For example, information about hydrologic characteristics of various wetland types can be applied to road building. This type of training can increase awareness of considerations to minimize adverse effects and practices that may be applied to do so.

Application:

- In 2016 FPInnovations (FPI) and DUC released the *Resource roads and wetlands: A guide for planning, construction and maintenance*. Following the release, FPI and DUC hosted a series of workshops in Alberta, Saskatchewan, Manitoba, and Quebec. These workshops provided an opportunity to share wetland and resource road BMP information from the guide with practitioners in a field setting.
- Consider carrying out internal field or classroom training to discuss challenges relating to working in and around wetlands and potential solutions. Consider bringing in outside expertise where appropriate.

TOOLS

There are a variety of tools available to assist with applying planning considerations is included in this guide. For complete descriptions, refer to the technical report.

Forest Vegetation Inventories

Forest vegetation inventories can be used to help map wetland locations within forest management areas. Each provincial government establishes their own vegetation inventory standard that requires the identification of the type, extent and condition of vegetation mapped, for example:

- British Columbia Vegetation Resources Inventory,
- Alberta Vegetation Inventory,
- Saskatchewan Forest Vegetation Inventory,
- Manitoba Forest Land Inventory

Generally, wetlands are considered as "non-contributing", "non-productive", and sometimes "non-vegetated" within these inventories. While these inventories are widely available and applied, they often do a poor job of mapping wetlands. Vegetation inventories are best applied in conjunction with wetland specific tools.

Hybrid Wetland Layer (HWL)

The HWL is a Canada wide land-based wetland map that categorizes the landscape into three general classes of wetland, upland and water. The HWL can be used to fill gaps where more detailed wetland inventories (such as the EWC) are not available. It is recommended that the HWL be used for regional and national use of open water and general wetland/ upland cover.

Canadian Wetland Inventory (Ducks Unlimited Canada 2016)

Based on The Canadian Wetland Classification System, the Canadian Wetland Inventory data model divides wetlands into shallow open water, marsh, swamp, fen, and bog.

The CWI Progress Map displays wetlands across Canada that have been mapped to date. This interactive map displays CWI-compatible wetland inventory areas that have been completed or are in progress across Canada.

DUC's Enhanced Wetland Classification

The EWC is a detailed, 19-class wetland classification of the boreal plains (Figure 17).

The EWC data model divides the Canadian Wetland Classification System (CWCS) 5 major classes into 19 minor wetland classes.

The classification scheme of the EWC allows inferred products to be developed that map the distribution of hydrodynamics, soil moisture, and relative nutrient based on wetland classes.

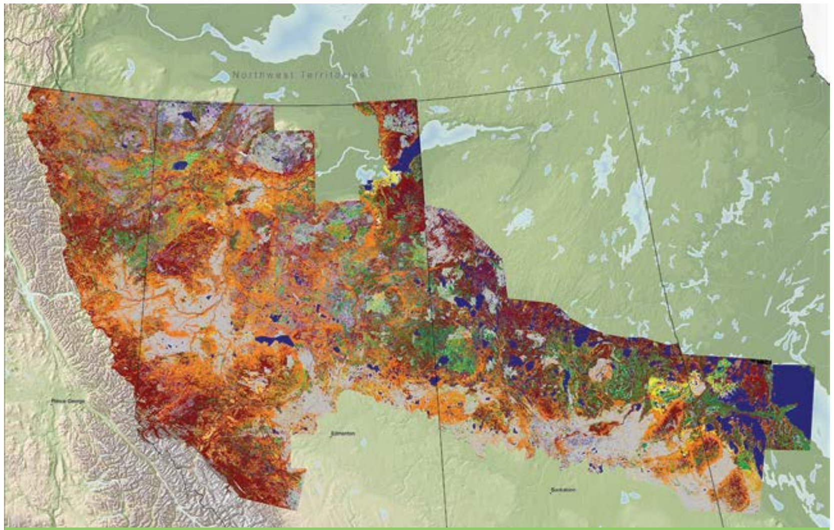


FIGURE 17. *DUC's EWC coverage of the boreal plains ecozone. Wetlands are classified into five major and 19 minor classes.*

Alberta Merged Wetland Inventory (AMWI)

The AMWI spatially depicts wetlands within the province of Alberta, Canada from the period of 1998 to 2015. This inventory is classified to the five major wetland classes of the Canadian Wetland Classification System (CWCS), including bog, fen, marsh, swamp and shallow open water.

The AMWI is made up of 33 individual wetland inventory components which have been developed utilizing different types of source data from different years, different data capture specifications and different classification systems. As a result, there is high variability in terms of level of detail and accuracy within the AMWI.

Wet Areas Mapping (WAM)

This GIS-based product spatially depicts wet areas derived from one meter spatial resolution digital terrain models, which were interpolated from LiDAR point cloud ground returns.

The purpose of WAM is to provide high-resolution flow-channel and wet-area maps that can be used for forest planning and operations. WAM data estimate depth to water. WAM is widely used by forest planners for harvest design, layout and road locations.

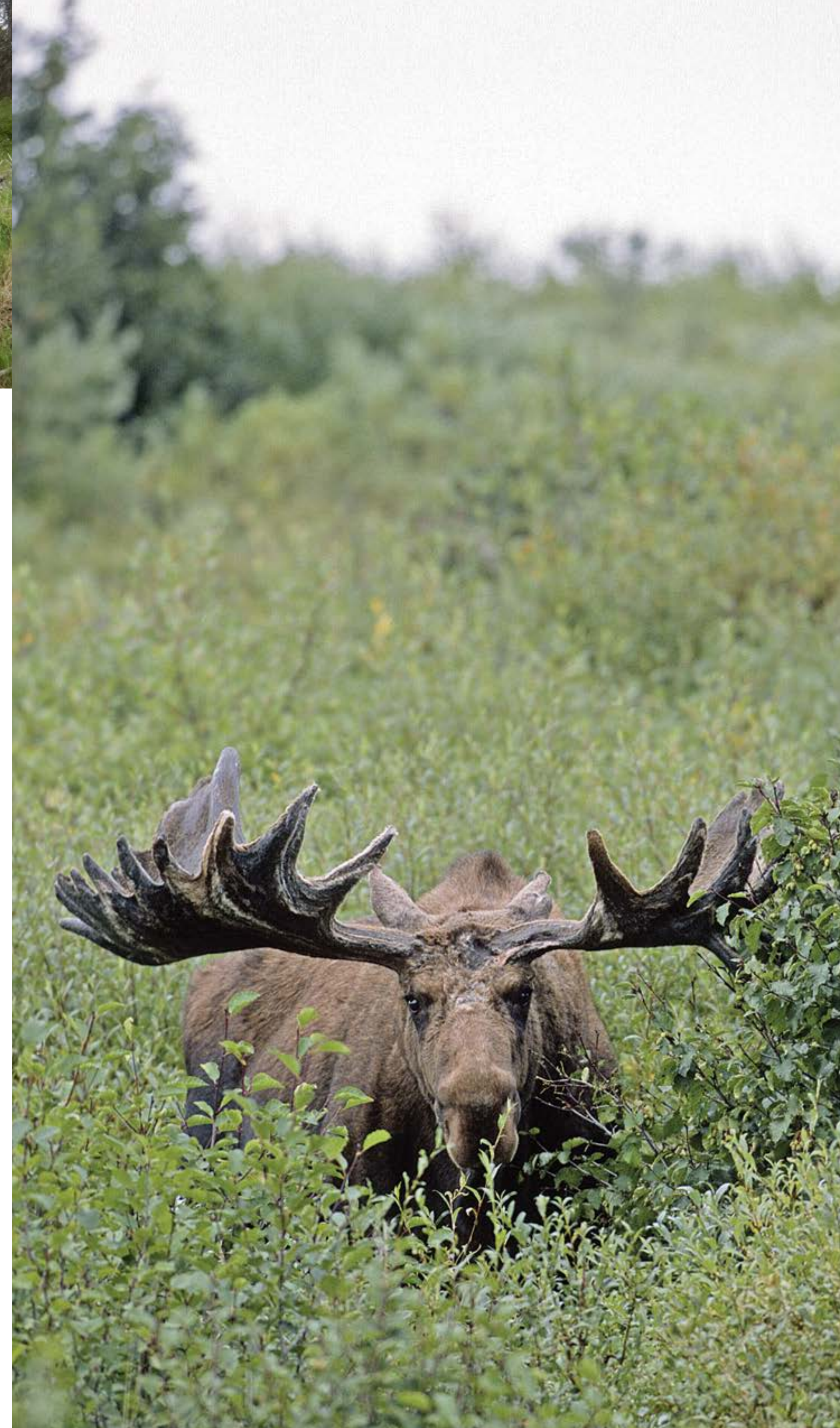
CHAPTER 7: GAPS AND RECOMMENDATIONS

Boreal wetlands, potential adverse effects, and practices to avoid and minimize adverse effects are still poorly understood compared to many other fields of study. This report is based on the best available information, but we recognize that there are a number of knowledge gaps. As more information becomes available, recommendations made in this report may change.

Some topics that will benefit from continued research include:

- Successional dynamics over space and time given historical landscape conditions and projected conditions
- Wetlands and forest fire
- Vegetation regeneration success – e.g., road crossing reclamation
- Wetland hydrologic connectivity
- Wetland hydrologic processes
- Wetland greenhouse gas dynamics
- Wetland carbon storage and sequestration
- Relative value of wetland types
- Effectiveness of minimization strategies

For more detailed descriptions of the topics of further research, knowledge gaps, and recommendations to fill the gaps relating to forest management and wetland stewardship, refer to the Technical Report.



RESOURCES

Guiding Principles for Wetland Stewardship and Forest Management Technical Report

Alberta Environment and Parks, Government of Alberta. 2017. Alberta Merged Wetland Inventory. Available at: http://aep.alberta.ca/forms-maps-services/maps/resource-data-product-catalogue/biophysical.aspx.

Alberta Environment and Sustainable Resource Development (AESRD). 2015. Alberta Wetland Classification System. Water Policy Branch, Policy Division, Edmonton, Alberta.

Creed, I., Sass, G., Beall, F., Buttle, J., Moore, D., and M. Donnelly. 2011. Hydrological principles for conservation of water resources within a changing forested landscape. Sustainable Forest Management Network, Edmonton, Alberta. Pg. 80.

Ducks Unlimited Canada. 2014. Operational guide: Forest road wetland crossings Version 1.0. Ducks Unlimited Canada. Edmonton, Alberta.

Ducks Unlimited Canada. 2015. Field Guide - Boreal Wetland Classes in the Boreal Plains Ecozone of Canada. Version 1.2. ISBN 978-0-9812303-2-0

Ducks Unlimited Canada. 2016. Canadian Wetland Inventory. Accessed March 22, 2017 from <http://www.ducks.ca/initiatives/canadian-wetland-inventory/>

Forest Watershed Research Center. 2017. Wet Areas Mapping. Accessed March 22 2017 <http://watershed.for.unb.ca/research/wet-areas-mapping/ >

Government of Alberta. 2017. Alberta Merged Wetland Inventory. Alberta Environment and Parks. Accessed March 22, 2017 <http://aep.alberta.ca/forms-maps-services/maps/resource-data-product-catalogue/biophysical.aspx>

National Wetlands Working Group. 1997. The Canadian Wetland Classification System, 2nd Edition. Warner, B.G. and C.D.A. Rubec (eds.), Wetlands Research Centre, University of Waterloo, Waterloo, ON, Canada. 68 p.

Partington, M., Gillies, C., Gingras, B., Smith, C. and Morissette, J. 2016. Resource roads and wetlands: a guide for planning, construction and maintenance. (Special Publication SP-530E) Pointe-Claire, QC: FPInnovation.. p. 86.

Smith, K.B., C.E. Smith, S.F. Forest, and A.J. Richard. 2007a. A Field Guide to the Wetlands of the Boreal Plains Ecozone of Canada. Ducks Unlimited Canada, Western Boreal Office: Edmonton, Alberta. 98 pp.

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FIRST EDITION
ISBN 978-0-9812303-7-5

First Printing - December 2018

Copies available from
Ducks Unlimited Canada

Guiding Principles for Wetland Stewardship and Forest Management

PRACTITIONER GUIDE

This guide was developed as part of the
Forest Management and Wetland Stewardship Initiative
(FMWSI)

ISBN 978-0-9812303-7-5