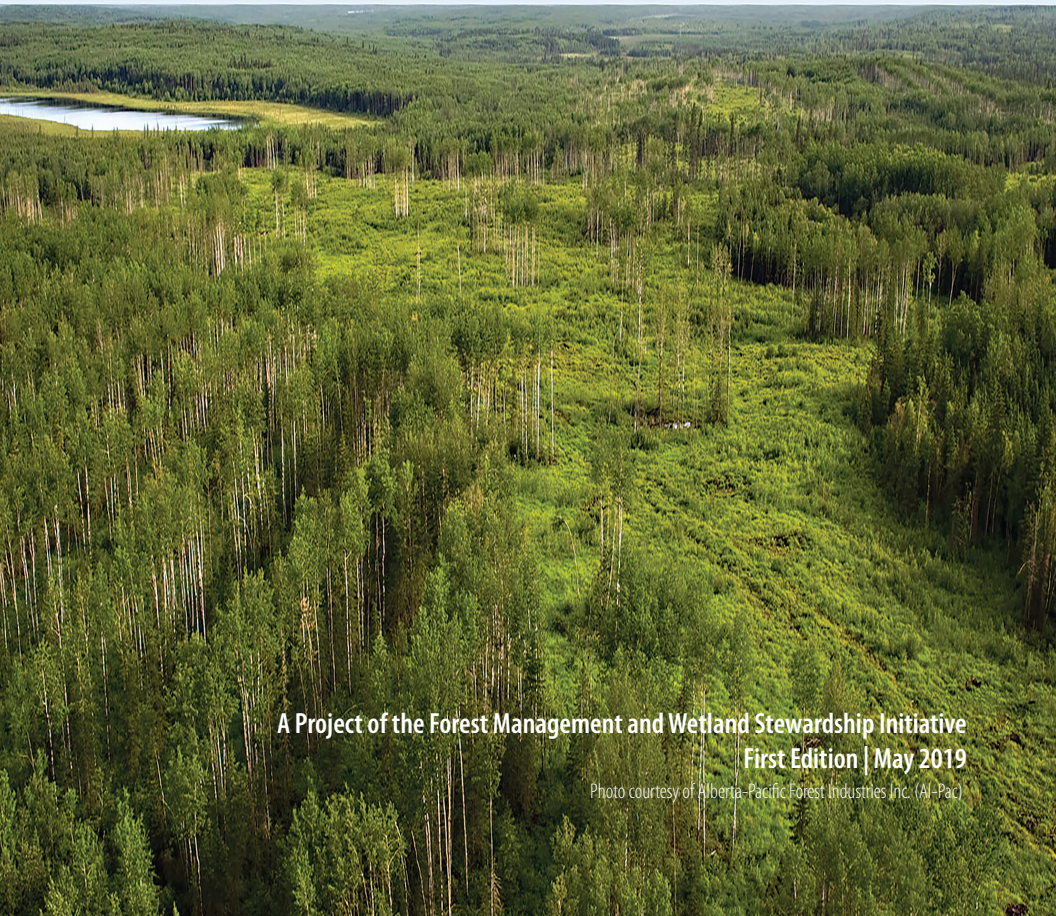
PRACTITIONER GUIDE

WETLAND BEST MANAGEMENT PRACTICES FOR

Forest Management Planning & Operations



A Project of the Forest Management and Wetland Stewardship Initiative

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Photo courtesy of Alberta-Pacific Forest Industries Inc. (Al-Pac)

Practitioner Guide
Wetland Best Management Practices for Forest Management Planning and Operations

FIRST EDITION
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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
- Forest Products Association of Canada (FPAC)
- Millar Western Forest Products Ltd.
- Tolko Industries Ltd.
- West Fraser
- Weyerhaeuser Company

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. **Wetland Best Management Practices for Forest Management Planning and Operations** (this guide)

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 and are strongly encouraged to implement the best management practices (BMPs) described in this guide. Some of the BMPs 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. The BMPs described in this guide are not intended to be prescriptive and users are expected to apply their professional judgment when deciding what guidance and practices apply to their situation.

Photo courtesy of Canfor

CONTENTS

ABOUT THIS GUIDE

Wetlands are an important part of Canada's boreal forest and provide ecological, social and economic benefits. Ecological benefits include filtering and storing water, providing habitat for Canada's plants and animals, and storing and sequestering carbon. Wetlands are important places for recreational, cultural, and spiritual activities, while also providing economic benefits, such as those that come from natural resource industries.

Canada's upland boreal forests are linked to boreal wetlands through multiple pathways including surface and sub-surface water flow. Functioning wetlands are important for maintaining healthy forests and sustainable forest management is important for maintaining functioning wetlands.

Despite these important connections, boreal wetlands often present challenges for practitioners tasked with managing Canada's forest resources. Wetlands can be difficult to work in and around due to weak organic soils and water saturated conditions. Forest management practices that work well in uplands can have unexpected and undesired outcomes when applied to wetlands. In addition, most of Canada's boreal wetlands are vegetated, and many are treed, increasing the difficulty of identification.

Boreal wetlands are sensitive systems, but careful planning and practices by forest practitioners can avoid or minimize adverse effects and operational challenges associated with forest management activities.

PURPOSE OF THIS GUIDE

The purpose of this guide is to build on the framework described in the **Guiding Principles for Forest Management and Wetland Stewardship** (**Guiding Principles**) and identify planning and operating ***best management practices*** (BMPs) for forest management that support wetland stewardship.

The FMWSI **Guiding Principles** ***Technical Report*** and ***Practitioner Guide*** provide detailed information at the strategic planning level about the links between boreal wetlands and uplands, links between wetlands and forest industry activities, and guiding principles, objectives, and planning considerations for avoiding and minimizing adverse effects to wetlands.

For detailed strategic planning level information please refer to:

Guiding Principles for Forest Management and Wetland Stewardship:

- Technical Report (FMWSI 2018a)
- Practioner Guide (FMWSI 2018a)

Photo courtesy of Al-Pac

HOW TO USE THIS GUIDE

This guide provides direction on how to approach forest management planning and operating when working in and around boreal wetlands. This guide describes BMPs for avoiding and minimizing adverse effects to boreal wetlands.

Information in this guide may be used to support or complement environmental systems, certification standards, or other requirements that forestry companies currently follow.

For example, information on wetland BMPs for planning and operating can support:

- **Forest Management Standards** (e.g., Forest Stewardship Council, Sustainable Forestry Initiative, or Canada Standards Association);
- **Environmental Management Systems** (e.g., ISO 14001:2015); or
- **Provincial or territorial operational guidelines** (e.g., Alberta Timber Harvest Planning and Operating Ground Rules).

Incorporating information from this guide into current processes (e.g., operating ground rules, standard operating procedures) can help strengthen these processes with respect to wetlands. Many of the practices in this guide are already in use by many companies, and this guide can be used to highlight current practices that promote wetland stewardship.

The BMPs described are not intended to be prescriptive and users are expected to apply their professional judgment when deciding what guidance and practices apply to their situation. This is not a legal document and does not replace applicable legislation and regulations. Users should be aware and informed of their legal requirements.

INTENDED USERS

Intended users include forest practitioners involved in operational planning and on-the-ground activities. The focus of the Guide is on Canada's boreal plains ecozone, but the guidance may also apply to wetlands outside this region.

Wetlands make up over 30% of Canada's boreal plains ecozone, and in some management areas they can be over half of the land base. As a result, all forest practitioners from planners to road construction teams have a role to play in wetland stewardship.

WHAT ARE WETLAND BMPs?

In this guide, BMPs refer to practices that can be applied to avoid or minimize adverse effects to wetlands and that represent the best current knowledge and methods. BMPs are recommendations that are intended to support key environmental values.
BMPs are not rules or requirements but, applied in conjunction with relevant Acts and Regulations, BMPs can help forest practitioners maintain environmental values. Adopting wetland BMPs is one way of demonstrating corporate commitment to wetland stewardship by demonstrating a willingness to go above regulatory requirements.

Practices may be site or circumstance specific, and what is a best practice in one location or at a certain time of year, may not be the best option during different circumstances.

The wetland BMPs described in this guide are intended to support the **four guiding principles** *(detailed within the **Guiding Principles** - see page 8)*:

- Maintain water quantity
- Maintain water quality
- Maintain hydrologic processes
- Maintain hydrologic connectivity

And the **six stewardship objectives** *(detailed within the **Guiding Principles** - see page 8)*:

- Maintain surface and subsurface water flow
- Avoid or minimize soil compaction
- Avoid or minimize soil layer disturbance
- Maintain structure and function of riparian vegetation
- Avoid or minimize site level run-off and erosion
- Prevent pollutants from entering the wetland
- Avoid or minimize invasive species introduction and/or spread

Meeting these guiding principles and stewardship objectives will also support a range of other objectives including: conserving species and habitat, maintaining and enhancing forest ecosystem condition and productivity, conserving soil resources, and maintaining benefits to society.

Links between the guiding principles, stewardship objectives, and the planning, operating, renewal, and other outcomes described in this guide can be found in Appendix 1.

GEOGRAPHIC SCOPE AND SCALE

BMPs may apply at the landscape, regional, or local scale. Strategic planning activities typically cover whole forest management units or tenures and may also include regional plans at the scale of areas defined by biological, physical or other characteristics. For example, larger watersheds, natural regions, or species at risk (e.g., caribou ranges).

This guide primarily focuses on:

- Landscape (compartment, smaller watershed) and local (harvest area or groups of harvest areas, local roads) scales.
- Canada's boreal plains ecozone.

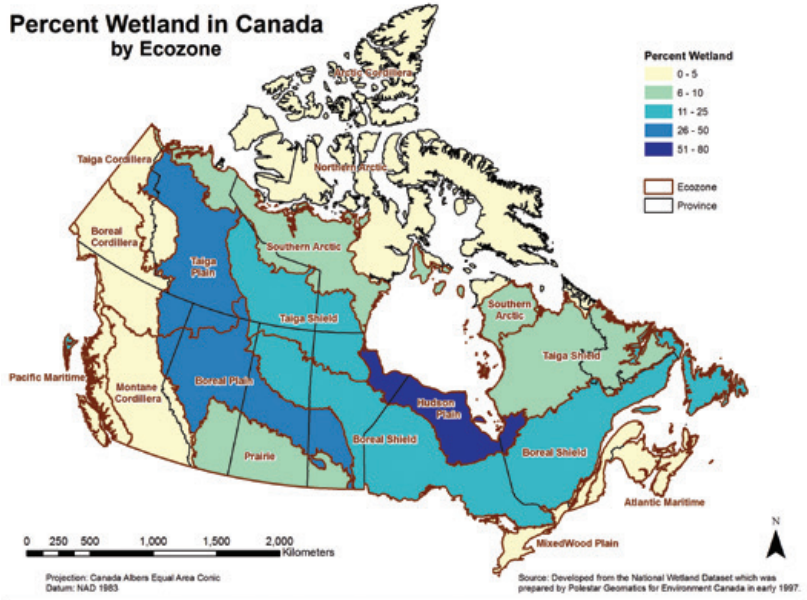


Figure 1. Percent of ecozone land base that is wetland habitat in Canada.

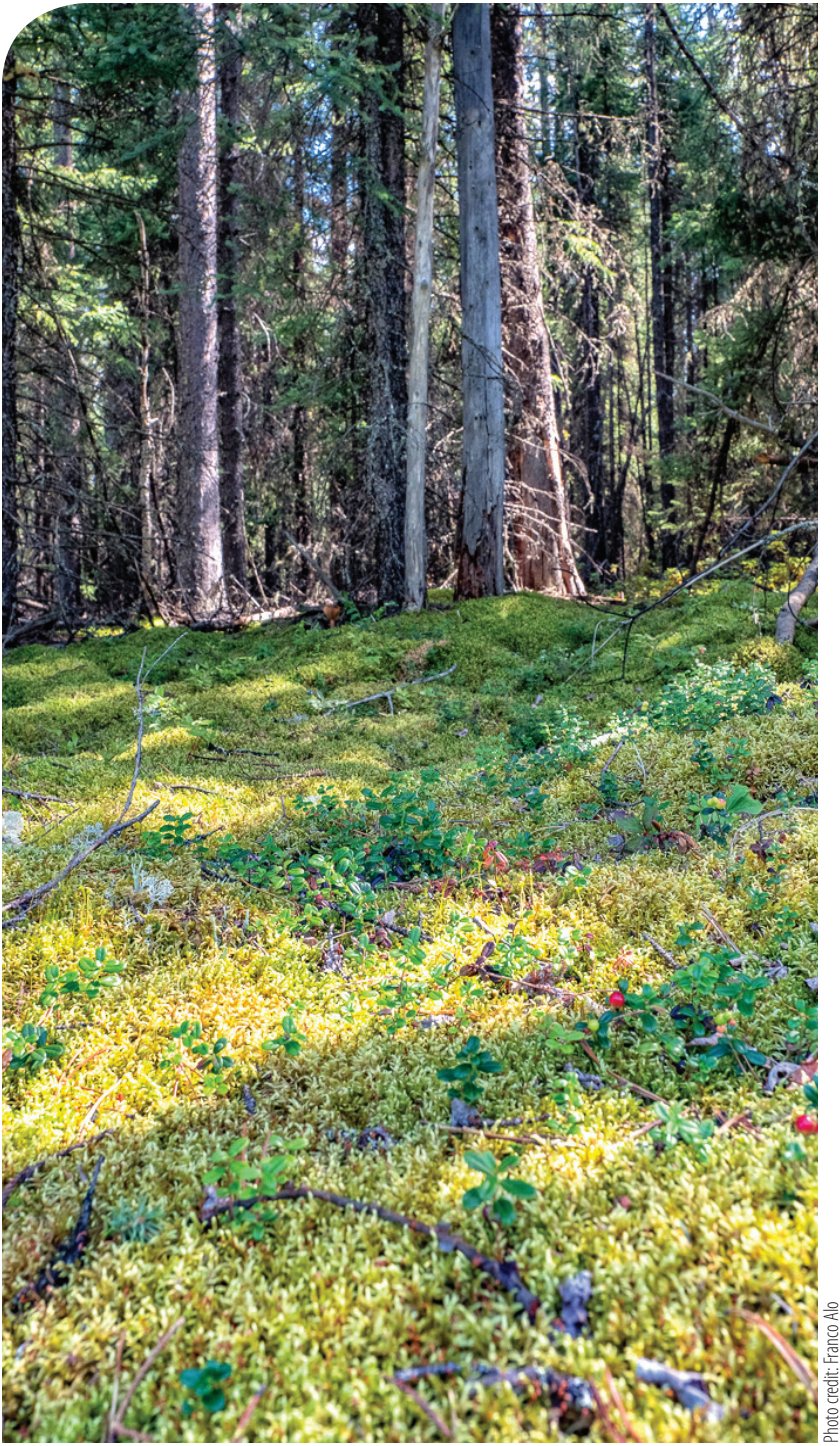


Photo credit: Franco Alo

WETLAND IDENTIFICATION

Boreal wetlands are diverse in form and function and a basic understanding of wetland identification and wetland function is needed to apply the information covered in this guide. An overview of the five major wetland types according to the **Canadian Wetland Classification System** (CWCS) is provided on the following pages.

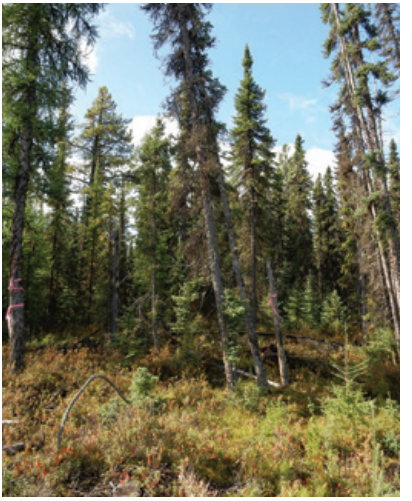
Most wetlands in Canada's boreal are vegetated, and over 50% of the wetlands are peatlands. Some wetland classes, such as treed swamps, can easily be mistaken for uplands, particularly during dry periods or years.

Regardless of how they look, wetlands are defined by the following features:

- Poorly drained soils
- Water tolerant vegetation
- Biological activity adapted to wet conditions

For more information about boreal wetland classification in the boreal plains ecozone of Canada refer to:

- Field Guide Boreal Wetland Classes in the Boreal Plains Ecozone of Canada (DUC 2015)



Examples of treed wetlands in Canada's boreal plains. Conifer swamps, such as the ones shown here, may contain merchantable trees and can difficult to identify as wetlands.

Boreal wetlands tend to occur as part of larger wetland complexes where the transition between one wetland type and another, or wetland and upland, is not always clear.

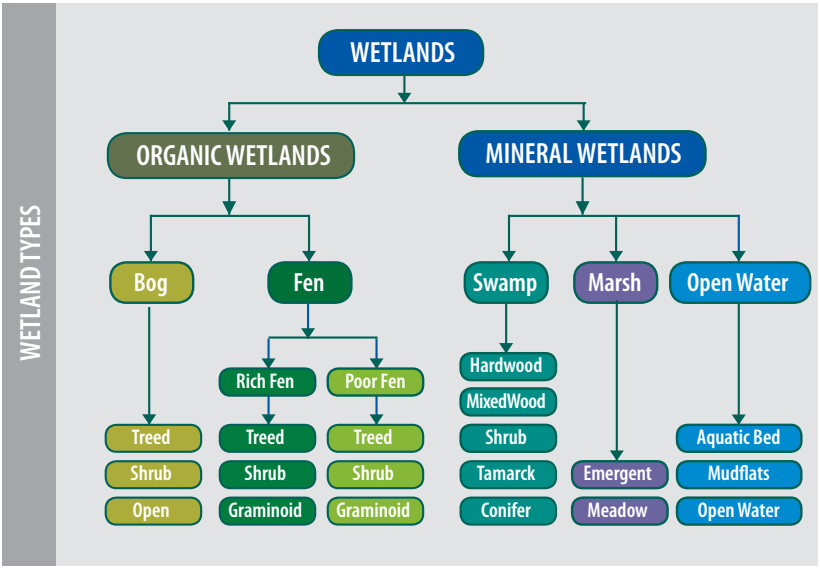
Photo courtesy of Millar Western

Example of a boreal wetland complex.

WETLAND TYPES OVERVIEW

According to the CWCS, there are five major classes of wetlands found in the boreal forest: bog, fen, swamp, marsh and shallow open water. These wetlands are grouped into two categories based on soil type: organic wetlands and mineral wetlands.

The five major wetland classes can be further broken down and, depending on the classification system, these may be called 'minor classes' or 'types'.



The DUC Enhanced Wetland Classification (EWC) system shown here is an example of a detailed wetland classification system. The classification includes the five major wetland classes, which are further broken down into 19 minor wetland types.

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

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

Organic Wetlands

Bogs:

- Nutrient poor, relatively low plant diversity
- Receive water through precipitation
- Often characterized as "stagnant" (little water movement) under average climatic conditions
- Have the potential to store water and can act as important water sources to adjacent wetlands and uplands - during wet or especially during dry/drought periods

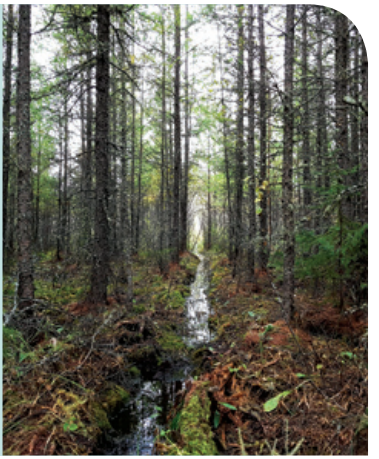
Fens:

- 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

Mineral Wetlands

Swamps:

- Mineral wetlands but may have deeper (e.g., greater than 40 centimetres) organic soils
- Diverse and are sometimes referred to as lowland forests, forested wetlands, treed swamp forests, wooded swamps, or shrub swamps
- Commonly recognized as shoreline or riparian areas of streams, lakes and floodplains
- Receive water from run-off, precipitation and groundwater sources
- Water movement regimes range from stagnant to dynamic



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, allowing for seasonal dry periods with oxygenated and resultant nutrient-rich soils supporting germination of emergent plant species (e.g., sedges, grasses, rushes, reeds, and cattail)

Shallow open waters:

- Often called ponds or sloughs, have a water depth of less than 2 metres
- 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

Users of this guide should seek out more detailed information on wetland identification and use resources relevant to their geographic area.
Resources to assist with identification include:

- DUC Field Guide to the Boreal Plains (DUC 2015)
- Alberta Wetland Classification System (Government of Alberta, 2015)
- Wetlands of British Columbia: A Guide to Identification (Mackenzie and Moran 2004)
- Terrestrial and Wetland Ecosites of Northwestern Ontario (Racey et al. 1996)
- Forest Ecosystem Classification for Northwestern Ontario (Sims et al. 1989)
- Canadian Wetland Classification System (National Wetlands Working Group 1997)

GENERAL WETLAND BMPs

The practices in this section apply throughout the forest management life cycle from strategic planning, to operational planning, to operations. In this guide, practices for wetland training, soil conservation, invasive species, spills, and recreational access are addressed up front as they relate to sections in both the planning and operations wetland BMP chapters.

Photo courtesy of Millar Western

Participants taking part in introductory wetlands field training to learn how to classify boreal wetlands in the field based on vegetation, soil, and water indicators.

WETLAND TRAINING

To effectively implement the practices described in this guide, staff and contractors require, at a minimum, introductory training on boreal wetland types, functions, and values. Staff and contractors should participate in wetland training and, where possible, training should include a field component.

Wetland training can enhance awareness and understanding of boreal wetlands, their functions and values, and lead to an improved understanding of how wetlands can affect forest industry activities and how forest industry activities can affect wetlands. This information can be applied to help meet environmental and operational objectives relating to wetlands.

DUC and Alberta Pacific Forest Industries Inc. (Al-Pac) visiting wetland crossings on the Al-Pac Forest Management Area to share information about wetland types, challenges with crossings, and BMPs for wetland road crossings.

Outcome: Staff and contractors are informed about boreal wetlands and boreal wetland BMPs as they relate to their roles and responsibilities.

Wetland Training BMPs:

- Awareness and understanding of wetland classes with an emphasis on boreal wetlands, their functions, and wetland ecosystem services.
  - Awareness and understanding of the types and location of wetlands within the company's management area.
  - Understanding of how to apply knowledge of wetlands to avoid or minimize potential adverse effects of forest activities on wetlands (e.g., understanding why it is important to consider the type of water flow when designing a road through a wetland).
  - Understanding of how to use wetland classification system(s) relevant to the region in the field. For example, in the Boreal Plains this could be learning to apply the DUC Field Guide: Boreal Wetland Classes in the Boreal Plains Ecozone of Canada.

- Incorporate wetland training into orientation training for new staff and contractors.
- Incorporate wetland training into regular staff and contractor training schedules.
- Provide staff and contractors whose jobs interact with wetlands with role or task specific wetland BMP 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, wetland BMP training can provide information and guidance about how to apply knowledge of wetland types when carrying out forest industry activities.

Wetland training should cover information about vegetation, soil, and water indicators that can be used to identify wetlands. Species present, soil and water pH, and organic soil depth can provide important information about wetland type.

SOIL CONSERVATION

Soil Moisture Conditions

Outcomes: Soil moisture conditions are considered when planning operations activities to:

- *Minimize adverse environmental effects to wetlands including rutting and compaction, vegetation damage, and impeded water movement.*
- *Minimize safety risks to equipment and people. Some wetland types, particularly those with deep peat and subsurface flows, can pose a safety risk to equipment and workers if they don't freeze down.*

Soil Moisture Conditions BMPs:

- Match the activity and site conditions to the most appropriate time of year.
  - For many activities taking place in peatlands, the frozen season is the best time to operate because frozen soils provide a more stable surface to work on.
  - For some activities it may be advantageous to operate during dry non-frozen conditions so that operators can see what they are doing. For example, monitor erosion and install effective erosion control during a stream crossing installation.
- Prioritize operations during frozen conditions in the wetland types that will be the most challenging to operate in during non-frozen conditions (e.g., graminoid fens). Look for:
  - Organic wetlands with deep peat deposits.
  - Wetland classes associated with sub-surface groundwater flow.
- If operating during non-frozen conditions, avoid rutting or churning soils. Suspend or limit operations when soils are saturated and rutting occurs.
  - Follow government requirements and guidelines related to rutting.
- Match the type of equipment to the activity, site, and time of year.
  - During the non-frozen season consider using low ground pressure equipment.
- Consider equipment availability and cost when deciding the time of year to operate.
  - Low ground pressure equipment is often more expensive and harder to obtain.
  - Wet conditions can result in potential work delays (e.g., needing to stop machinery until a site dries out due to rutting concerns).
- Avoid operating in wetlands during spring break-up.
  - This is a very challenging time of year with significant safety concerns and high potential to damage wetland soils.

In many parts of the country the frozen season is changing. On average, winters are becoming shorter and less predictable. As the climate continues to change, these trends are likely to become more pronounced. Tracking how the frozen season changes over time can help inform planning for future years. For example, record:

- Date operations under frozen conditions were able to start
- Period where freeze down for roads could occur
- Dates of mid-season thaws
- Spring break up date

Equipment

Outcome: Equipment for all activities (e.g., harvest, road construction) is chosen to minimize adverse effects to wetlands.

Equipment BMPs:

- Avoid using heavy equipment in wetlands and wet areas during non-frozen conditions.

- If operating in wet areas during non-frozen conditions, consider using lower impact equipment:
  - Low ground pressure vehicles.
  - Amphibious vehicles/ high flotation equipment.
  - Tracked equipment.
  - Smaller and lighter equipment.
- Organic wetlands with saturated soils are particularly susceptible to compaction and rutting.
- If lower impact equipment is not feasible, consider using corduroy or access mats to support traffic. This could be particularly useful if any wetland areas will be subjected to high traffic (e.g., ephemeral drainage crossing).
- Compact snow to promote frost penetration on frozen surfaces, this will help to minimize the damage to wetland soils, roots and vegetation.

Erosion and Sedimentation

Example of poorly installed sediment fencing (left) and well installed sediment fencing (right) to control erosion and sedimentation.

Outcome: Soil erosion and soil displacement from wetlands is minimized. Sedimentation into wetlands and other waterbodies is avoided or minimized.

Erosion and Sedimentation BMPs:

- To the extent possible, leave ground vegetation intact to minimize soil disturbance and minimize erosion potential.
- Install and maintain erosion control measures to prevent sediment from being transported into the wetland. This may include:
  - Erosion control measures along the edges of the road or applying mulch or fibre mats on exposed soils.
  - Installing silt fence at edges of landing or other active areas to prevent sediment from moving off site.
- If appropriate, use slash or logs to prevent sediment from moving off site.

INVASIVE SPECIES

Examples of boreal invasive species - phragmites (left) and purple loosestrife (right).

Wetland invasive species can alter native wetland biodiversity which can in turn affect wetland function (e.g., nutrient cycling). Invasive species tend to be adapted to disturbed habitats and activities that alter natural wetlands can make them more vulnerable to invasion.

Outcome: Introduction and spread of invasive species to wetlands is avoided, minimized, and managed.

Invasive Species BMPs:

- Refer to relevant regulations for your jurisdictions. Depending on the requirements, some of the BMPs described below may not apply.
- Be aware of wetland invasive species that could affect your region.
- Develop a protocol for identifying the presence of invasive species.
- If an issue exists, prepare a plan to reduce the risk of new introductions. The plan should be designed to meet government and other requirements (e.g., certification), it could include:
  - Wear clothing/ footwear which are not seed friendly.
  - Inspect equipment and clothing for invasive species prior to activity.
  - Scrape, brush, and clean equipment when entering and exiting sites.
  - Ensure construction mats, especially timber mats, are free of invasive species.
  - Properly dispose of invasive species on site.
  - Avoid unnecessary soil and vegetation disturbance.
  - Use weed free material for erosion control and soil stabilization.
  - Promote the establishment of native vegetation.
- Where possible utilize native species for erosion control and revegetation projects.
- Create a monitoring program for sites under management.
- Maintain records of all activities done to control invasive species.

SPILLS

Improper storage and handling of oil products, fuel, and chemicals (e.g., herbicides, pesticides, fertilizers) can result in spills or releases with potential adverse effects to water quality, soils, plants, and wildlife. The surface and sub-surface water flow in wetlands can transport spilled materials from the release location.

Outcome: All potential deleterious substances (e.g., oil products, fuel, herbicides, pesticides, fertilizers) are stored and handled to minimize the likelihood and consequences of a spill. Established procedures are followed in the case of a spill to minimize adverse environmental effects to wetlands.

Spills BMPs:

- Refer to relevant regulations for your jurisdictions. Depending on the requirements, some of the BMPs described below may not apply.
- Develop a spill contingency plan that identifies storage, transport, handling, and clean up procedures of hazardous substances.
- Provide training to staff and contractors on the content and process to enact all components of the contingency plan.
- Designate areas for storing petroleum products that are a minimum of 100 metres from wetlands and waterbodies.
- Avoid equipment maintenance and fueling in wetlands.
- Maintain equipment regularly to reduce risk of failure.
- Designate areas for equipment maintenance, ensure that the sites are a minimum of 100 metres from wetlands.
- Keep spill containment and clean up materials on site.
- Safely clean up and or contain spills and releases immediately.
- Properly dispose of containers, used oil, and other refuse.

RECREATIONAL ACCESS

Forestry roads and harvest areas can open access to areas that were previously inaccessible. This can lead to increased recreational traffic and associated adverse environmental effects.

Traversing wetlands can be an entertaining challenge for recreational off highway vehicle (OHV) users. However, OHV activity can significantly damage wetland soils, vegetation, and water quality. While forestry companies are not responsible for managing OHV access and use, there are some actions companies can take to positively contribute to managing recreational access.

OHV tracks through a graminoid fen in northern Alberta.

Example of fencing used for OHV control. Fencing did not effectively control access.

Outcome: Use of recreational vehicles in sensitive wetlands is avoided, minimized, and managed.

Recreational Access BMPs:

- Participate in coordinated access planning with other land users, and where feasible consider opportunities to limit recreational access to sensitive sites as part of planning activities.
- Where members of local recreational vehicle clubs are part of company Public Advisory Committees (or similar), engage members to help with education about safe and environmentally responsible OHV use.
- Consider using 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 less 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.
- 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).

Including Wetlands in Strategic Planning Supports Operational Planning for Wetlands

IDENTIFY WETLANDS
Identify wetlands using digital inventories.

PRELIMINARY DECISION
Allocate wetlands for harvest or no harvest.

NO HARVEST

HARVEST

Consider ecological and economical costs and benefits, for example:
- Harvest system to minimize disturbance.
-Regeneration practices to promote tree growth on wet sites.

REASSESS

Reassess whether to keep treed wetlands as part of harvest areas based on cost-benefit assessment.

Develop a preliminary harvest rate and schedule for treed wetlands to be harvested.

Operational Planning
Additional digital and on-the-ground information will be used to help make decisions at the operational level and identify further opportunities for wetland stewardship.

FOREST MANAGEMENT PLANNING BMPs

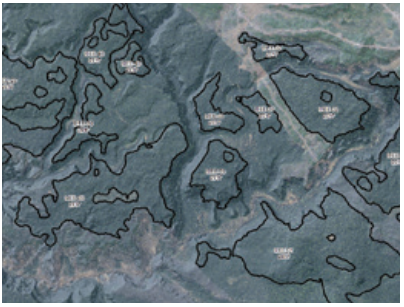
Photo courtesy of AL-Pac

STRATEGIC PLANNING

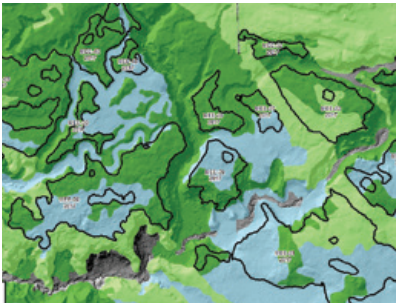
Operational plans can fit into the overarching framework for wetland stewardship and forest management provided within the **Guiding Principles** (see page 8). Some aspects of strategic planning (see chart page 28) that assist with operational planning around wetlands include:

- Digital wetlands inventory (e.g., DUC Enhanced Wetland Classification) or interpreting wetlands from digital forest cover inventories (e.g., Alberta Vegetation Inventory).
- Allocating wetlands to be part of, or removed from, the harvested landbase based on government requirements/company criteria (e.g., amount of merchantable time, cost to harvest and reforest).
- Identifying broad-scale silvicultural prescriptions including assigning a harvest system (e.g., variable retention, partial-cut), regeneration method (e.g., natural or planted and additional treatment prescriptions), and tree growth rates (yield curves) to each yield class used in the timber supply analysis.
- Planning harvest rate and schedule. Depending on the jurisdiction, the government may require spatial identification of the first 5-20 years of future harvest areas as part of strategic planning.
- Identifying wetland stewardship activities, if any exist, that do not relate to future access and harvest (e.g., restoring previously harvested wetlands, deactivating and reclaiming unsuitable or unneeded wetland road).
- Links to other environmental values such as watershed-based targets and plans for water quantity and quality.

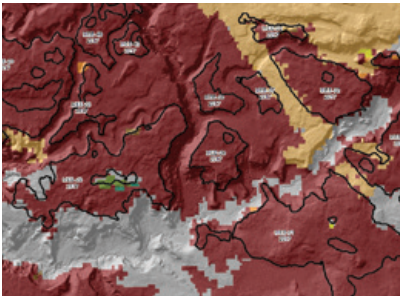
This guide describes specific approaches and practices to incorporate wetlands into operational forest management planning.



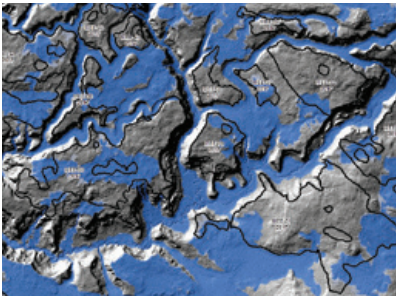
A. Aerial imagery of harvest areas (outline in black) pre-harvest.



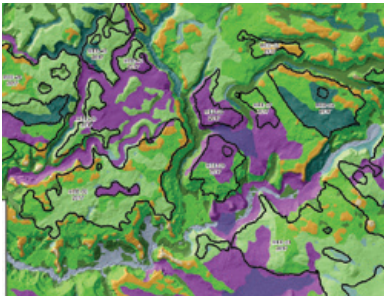
B. Vegetation inventories, such as the Alberta Vegetation Inventory, can provide information about vegetation communities. In this example, lowland black spruce (blue), pine (pale green), and spruce/ pine/ fir mix (dark green) dominate.



C. Wetland inventories, such as DUC's Enhanced Wetland Classification (EWC), can identify wetland types and locations. In this example, most of the area is classified as upland conifer (maroon), with small pockets of treed fen (dark green), shrubby fen (light green), and graminoid fen (light green).



D. Hydrology models, such as wet areas mapping with Soils Data influence, can predict areas of elevated soil moisture conditions. In this example, areas identified as uplands using the EWC may still have high moisture levels (blue).



E. Ecosite mapping, such as the Alberta Derived Ecosite Phase (DEP), can provide information about groupings by ecological sites which can help with understanding of ecosystems function. Sites represented by blue and purple tones represent hydric (wet) ecosite types.

F. Aerial imagery of harvest areas (outlined in black) post-harvest.

Images courtesy of Millar Western.

Digital inventories and information can be used to identify wetlands as part of forest management planning. Not all information provided in the example above will be available or applicable to all areas. This example illustrates the types of digital information that can be used to inform wetland identification.

WETLAND IDENTIFICATION

The first step to incorporating wetland stewardship into forest management is to identify wetlands within the planning area. Ideally wetlands are identified as part of strategic planning, and wetland information can be confirmed and augmented as part of operational planning.

Information about the location and type of wetlands within the planning area can be applied to a range of planning decisions from identifying merchantable areas to laying out road networks.

Outcome: Wetland locations and types are accurately identified and located to inform all stages of planning and operating.

Wetland Identification BMPs:

- Obtain and use available digital inventories for strategic planning and improve them continually throughout the planning and operating phases.
  - Refine information about wetland types and locations derived from digital maps and inventories such as wetland inventories (DUC's EWC inventory), vegetation inventories, LiDAR derived products (see example (A-F, page 30) which illustrates wet areas mapping), aerial photos, and others.
  - Identify major and minor wetland classes to provide a more detailed understanding of soil type, water permanence, and water movement. Identifying to minor class will provide better information (refer to page 15 for examples of major and minor wetland classes).
  - Conifer swamps may contain merchantable trees and may be allocated to harvest using desktop mapping tools. Wetland maps can help inform whether harvesting should proceed in these areas; however, the best way to verify is with on the ground surveys during snow-free seasons.
- Confirm and refine wetland inventory.
  - Confirm wetland classification and boundaries for wetlands in or bordering proposed roads and harvest areas.
  - Include streams and other waterbodies.
- Augment wetland inventory using additional tools or on-the-ground information.
  - Identify wetlands not captured in inventories (e.g., wetland pockets, vernal pools, ephemeral drainages).
  - Identify special features not captured in inventories (e.g., rare species, cultural sites, springs and seeps, mineral licks, rookeries, beaver influenced areas).

Tools that can help forestry professionals better plan for wetlands include:

- Wetland maps, aerial imagery, or LiDAR derived products such as wet areas mapping and digital elevation models
- Waterbody and stream maps
- Topography and vegetation maps
- Surficial geology maps
- Other relevant hydrologic models

RIPARIAN AREA IDENTIFICATION

Riparian areas are terrestrial areas where the vegetation and microclimate conditions are products of the combined presence and influence of perennial or intermittent water, associated with high water tables and soils that exhibit some wetness characteristics. Riparian areas are often associated with wetlands and other waterbodies.

Riparian areas are influenced by, and exert an influence on, the associated aquatic ecosystem. Riparian areas are important because they can reduce erosion into waterbodies, provide shade, provide a source of woody debris, supply nutrients, and help to regulate water levels.

Outcome: Riparian areas are identified and located to inform all stages of planning and operating.

Riparian Area Identification BMPs:

- Classify and map all riparian areas in or adjacent to proposed operating areas (e.g., harvest areas and access roads).
  - Use digital inventories to conduct preliminary identification of riparian areas.
  - Mark riparian areas on operational maps.
  - Confirm location of riparian areas during on-the-ground surveys.
  - Mark riparian areas identified in the field, either flagging their location or recording and digitizing on operational maps.
- Use wetland inventories to enhance the identification of riparian areas that are not covered by existing regulatory criteria.

WETLAND AVOIDANCE

Forest industry activities including forest harvest, road construction and use, and other associated activities should avoid wetlands where feasible. However, because of the high density of wetlands in Canada's boreal, wetland avoidance is not always possible.

When avoidance isn't feasible, consider prioritizing wetlands for avoidance based on ecological, social and economic criteria. The most relevant and high priority criteria will vary by company based on geographic location, species and features of concern, and other factors.

Wetlands with deep organic soils (e.g., peat core left) or wildlife features (e.g., beaver dam right) may be prioritized for avoidance.

Outcome: Wetlands are prioritized for avoidance based on ecological, social, and economic criteria.

Wetland Avoidance BMPs:

- Treed wetlands that are allocated to be harvested can be prioritized for avoidance using the criteria below, along with operational criteria such as ease, cost, and effectiveness of forest harvest and renewal activities.
- Mark the boundaries of wetlands that are allocated for harvest on harvest area maps and identify specific silvicultural prescriptions to be followed.
- Avoid non-merchantable wetlands as much as possible. Where avoidance is not possible:
  - When roads intersect wetlands, identify wetlands on operational maps and apply practices to avoid or minimize adverse effects.
  - When conducting activities outside of wetlands, but with the potential to affect adjacent wetlands, apply practices to avoid or minimize adverse effects (e.g., wetland border areas).

Certain wetland types may be more challenging to work in, more sensitive to disturbance, or more valued for a variety of reasons.

- Consider the following criteria to prioritize certain wetlands or wetland types for avoidance. For detailed information about factors to consider when prioritizing wetlands for avoidance, refer to the **Guiding Principles -Technical Report** (see page 8). Examples of factors to consider include:
  - Uncommon wetlands (e.g., marshes and shallow open waters tend to be less common in the boreal compared to other wetland types).
  - Wetlands with the potential for water flow to be blocked (e.g., surface or sub-surface water movement in fens).
  - Wetland complexes.
  - Wetlands that have a high likelihood of use by known uncommon species or species of concern (e.g., trumpeter swan, boreal woodland caribou).
  - Wetlands that have high carbon store values (e.g., peatlands).
  - Wetlands that have a high likelihood of adverse effects from adjacent activities (e.g., sedimentation).
  - Other wetland properties valued by the company or stakeholders (e.g., cultural or spiritual uses, habitat for species of interest, rarity).

WETLAND ROAD CROSSINGS

Permanent and temporary resource roads are needed to access harvest areas, move within harvest areas, and transport forest products from harvest areas to the mill. The lifespan of temporary roads can range from a single season (e.g., winter roads or roads within the harvest area) to a few years, while permanent roads should be designed and maintained to last many years.

With the high density of wetlands in the boreal, it is often not possible to completely avoid crossing wetlands when constructing a new road. Incorporating wetlands into road design, construction, and maintenance plans can maximize the quality, lifespan, and life cycle cost of a road while minimizing adverse effect to wetlands.

Outcomes: Effective road planning and wetland crossing design include:

- *Maintaining water quality and flow*
- *Minimizing disturbance to the organic soil layer*
- *Conserving the ecological integrity of wetland environments*
- *Enhancing road and operator safety*

To learn more about wetland road crossing BMPs refer to:

- Resource Roads and Wetlands: A Guide for Planning, Construction, and Maintenance (Partington et al. 2016)
- Operational Guide: Forest Road Wetland Crossings (DUC 2014)
- COSIA In-Situ Oil Sands Shared Practices for Working in and Around Wetlands (Osko et al. 2018)

When a road is not designed, constructed, or maintained to accommodate water flow, the road may act as a dam resulting in pooling water upstream and drying downstream. Vegetation can be an indicator of this damming effect; upstream wetland vegetation tends to die off and downstream vegetation tends to grow more vigorously.

Road blocking water movement across a treed fen. Vigorous growth is visible on the downstream side (left) which has dried out and tree die-back (right) is visible on the upstream side where water has ponded.

Blocking wetland flow can affect the quality and safety of the crossing. For example, water may flood a crossing or may saturate the crossing resulting in rutting, compaction, and potential for erosion and sedimentation. Or water may overtop the crossing resulting in safety concerns and limited access.

Road Routing

Outcome: Roads are planned to avoid wetland crossings where feasible and minimize the number, length, and sensitivity of wetland crossings for all road types including seasonal roads.

Road Routing BMPs:

- Use wetland inventories and other applicable inventories and information to identify the location of wetlands and other features of interest, such as soil types or peat depths.
- Use existing access points or existing roads where available and appropriate.
  - Where it makes sense to do so, use existing roads and other linear features (e.g., transmission lines, seismic lines) to minimize new disturbance on the landscape. If existing corridors are poorly placed, consider developing new access routes or re-routing portions of existing corridors to minimize wetland crossings.
  - If using existing roads, plan to remediate problems associated with stream and wetland crossings.

Use existing access points or linear features including seismic lines (left) and roads used by other industries (right).

- Plan roads as part of a road system to meet long-range objectives as opposed to simply accessing individual sites.
  - Where feasible lead or participate in the development of coordinated access plans with other land users to minimize new disturbance on the landscape.
  - Consider road life cycle as part of any road system planning to assist with design of new roads and management of existing roads.
- Plan new routes to minimize the number of wetland crossings required.
- Where wetland crossings cannot be avoided, consider:
  - Wetland connectivity – crossing a wetland that is part of a wetland complex will have a greater risk of disruption compared to crossing isolated wetlands.
  - Crossing location – where possible, locate new crossings at the narrowest point of the wetland or wetland complex to minimize the length of the crossing.
  - Position in the landscape – wetlands in the upper watershed can typically be expected to transport less water than wetlands in the lower watershed.
  - Road direction – orient the road parallel to the direction of flow to minimize the risk of hydrologic impairment.

- Soil conditions – wetland soils, particularly the organic soils found in bogs and fens, can have poor bearing capacity. Identify and avoid locations where soil properties (e.g., peat depth and strength) will increase the difficulty and cost of road construction and maintenance.
- Other hydrologic factors – depth to water table and amount, speed, and direction of flow can influence the difficulty and cost of road construction and maintenance.
- Challenges and costs associated with reclaiming wetland crossings at the end of their life cycle. □

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

Crossing at the narrowest point of slow flowing wetlands may result in "pinch points" where surface and subsurface flow may become concentrated. Narrow wetland crossings could become problem areas by blocking water flows (e.g., from storm water debris or beavers). Designing crossings to accommodate peak flows and beaver activity can mitigate these concerns.

- Use topographic maps and other available tools to avoid steep slopes or steep approaches to wetland crossings to increase safety and minimize runoff and erosion into the wetland.
- Confirm the results of desktop planning during road layout and surveying. Desktop tools can be extremely helpful for planning across large areas; however, on-the-ground surveys are important for verifying this information.
  - Collect information on wetland type(s), soil depth, and water flow (surface water and shallow groundwater levels, flow direction and rates).
  - Better understand how the wetland is connected to the landscape.
  - Identify and flag sensitive habitats or important features for avoidance.
  - Confirm the best placement of crossing location.
  - Identify any features that need to be considered as part of road design that were missed as part of the desktop analysis.

Wetland Crossing Design

Depending on the type of wetland, connectivity to other wetlands and uplands, specific water and soil characteristics, and other factors, a wide range of crossing structures can be appropriate including bridges, culverts, corduroy and geotextiles.

Different types of wetland crossings (clockwise from top left): geogrid and geotextile, corduroy and culverts, winter bridge structure, and culverts only.

Outcome: Wetland crossings are designed to accommodate flow and minimize adverse environmental effects while meeting operational, cost, and safety needs.

Wetland Crossing Design BMPs:

- Use maps, modeling tools, and field data to identify the wetland type(s) present at the proposed crossing location and consider the following site information when choosing a wetland and designing a wetland crossing:
  - Length of crossing required, including identifying the narrowest point and determining whether this is a suitable crossing location.
  - Soil properties (e.g., soil type, peat depth, peat strength and stability).
  - Surficial geology, soil types underlaying the road can affect drainage. For example, fine-textured silts and clay soils require more extensive drainage control measures as less water will infiltrate the soil.
  - Hydrologic regime (e.g., water table level, amount of flow, direction of flow).
  - Wildlife features (e.g., fish and migratory bird habitat).
  - Crossing approach, consider the steepness and other features of the approach that could contribute to erosion and sedimentation into the wetland.
- Use the above information to determine expected water passage requirements.
  - Water moves differently in different wetland types, this can help inform passage requirements.

- Design the wetland crossing to account for maximum expected flow events based on the expected lifespan of the road and the type of wetland(s) crossed. For longer-term roads, consider climate variability as part of the road design.

- Identify the type of fill needed and where it will be sourced from. To minimize adverse effects to wetlands, fill material should be sourced from outside of the wetland boundaries and beyond the slope leading to the wetland.
- Consider the lifespan of the road and crossing when determining the construction materials:
  - Short-term crossings can use materials with a shorter lifespan, such as biodegradable geotextiles.
  - Longer-term crossings should use materials that will perform over the expected lifespan of the road.
- Use corduroy, geotextiles, or rig mats to increase the soil bearing capacity, maintain water movement through the road and reduce the amount of fill required.
- Consider the construction season, depending on the wetland type, winter road construction may be strongly preferred.
- Once wetland crossings are designed, plan to ensure that materials (e.g., geotextile, culverts) and equipment (e.g., low ground pressure vehicles) will be available at the time of construction.
- Once a wetland crossing is designed, identify maps, plans, and practices necessary to minimize adverse effects. For example, crossing type, sensitive areas, timing restrictions, and all other requirements for operations to follow.

Example of a flooded boreal wetland crossing in the spring.

For detailed BMPs for wetland crossing designs and accommodating different water flow regimes refer to:

- Resource Roads and Wetlands: A Guide for Planning, Construction, and Maintenance (Partington et al. 2016)
- Operational Guide: Forest Road Wetland Crossings (DUC 2014)

FOREST HARVEST AREA

Outcome: Wetland avoidance is prioritized during harvest area layout and preliminary silvicultural prescriptions are identified for wetlands to be harvested.

Management Area Terminology

Different operating practices are expected to apply when conducting forest harvest or other operations in or near wetlands compared to uplands.

Some companies may use specific terminology to describe areas that are managed differently, including **Special Management Areas** (SMAs), **Management Zones**, or other terms. These terms aren't exclusive to wetlands and wetland associated areas and they often have different meanings depending on the company or jurisdiction.

This guide focuses on BMPs that can be incorporated into a range of existing workflows. For example, a company may decide to incorporate BMPs for harvesting treed wetlands and wetland transition zones into current SMA identification and practices.

Forest Harvest Area BMPs:

- Consider the location and type of wetlands present when laying out harvest areas and determining access routes to the harvest areas. Integrate wetlands into the design of all harvest areas.
- Confirm wetland classification and boundaries first using desktop approaches then on-the-ground approaches.
- Identify smaller wetlands, ephemeral drainages, seeps and springs, and vernal pools not already mapped and include them on maps and in planning.
- Determine appropriate boundaries between harvest areas and bordering wetlands, including wetlands located within harvest areas.
- Identify treed wetlands that are to be harvested and prescribe harvest and forest renewal practices.
- Identify areas for retention or selective harvesting. For example:
  - Retention around wetlands, riparian areas, vernal pools, seeps, springs, and other wet areas.
  - Selective harvesting in treed wetlands, transitions between wetlands and uplands with merchantable timber, or uplands adjacent to sensitive wetlands.
- Verify and augment desktop plans using on-the-ground fieldwork.
  - Treed wetlands can be difficult to identify in the winter. Time pre-harvest visits to sites suspected to be wetlands (e.g., based on desktop planning) to occur when there is no snow on the ground to ensure accurate classification and verification.
- Use desktop information and on-the-ground fieldwork to determine the time of year of operations and equipment needed.
- Mark boundaries of areas for retention or alternative harvest approaches either on-the-ground or on digital maps that will be used by operators.

Treed wetlands with merchantable trees (e.g., conifer swamps) can be challenging areas to identify and may not be classified as wetlands. Treed wetlands are often not well captured in desktop tools, such as forest inventories. As well, these wetland classes can be difficult to identify on-the-ground during winter or dry periods. As a result, wetlands with merchantable trees may be inadvertently classified as uplands and included in harvest areas.

Example of a wetland within a harvest area in Canada's boreal. Planning for tree retention around wetlands can help minimize adverse effects to wetlands from harvest activities.

FOREST RENEWAL

Outcome: Forest renewal prescriptions that will promote the return of the site to its pre-harvest condition are identified for forested wetlands designated to be harvested. Or, if effective renewal prescriptions are too costly or operationally challenging, these sites are removed from harvest.

Successfully regenerating a harvest area is a legal requirement and an important component of sustainable forest management. However, re-establishing trees in wetlands is significantly more challenging, compared to establishing trees in most upland sites and the additional challenges and costs should be considered early in the planning stage.

Forest renewal in wetlands typically requires different approaches and techniques. For example, harvesting a conifer swamp is likely to raise the water table and therefore reforestation activities should be planned to accommodate the higher water table.

Forest Renewal BMPs:

- Follow applicable government forest renewal requirements. Depending on the jurisdiction, requirements can be very prescriptive and some of the recommendations in this section may not be feasible or applicable.

- Identify preliminary prescriptions prior to harvest and plan to develop more detailed renewal following harvest.
  - Recognizing that these may be carried out by different staff, ensure preliminary prescriptions are shared with staff developing detailed strategies.
- Consider inherent productivity of forested wetlands (e.g., site index). If it takes a very long time to produce a merchantable stand it may not be possible to meet legal tree establishment and growth requirements.
  - Approaches to harvest and forest renewal for low productivity stands may include partial harvest, natural and active regeneration approaches, and extended rotation length.
- Consider forest renewal activities when planning harvest areas. Establishing trees in wetlands is typically more challenging, time consuming, and costly compared to uplands.
  - For wetlands that are part of proposed harvest areas consider the feasibility and cost of renewal when making the final decision of whether to harvest.
- Use information about the site collected during pre-harvest surveys or any time prior to harvest to understand pre-disturbance site characteristics (e.g., wetland types, soil type and depth, vegetation, water level, flow and direction).
- Renewal techniques for treed wetlands, particularly if deeper peat is present, will likely require different equipment and methods. For example, mounding to provide dry microsites for planting or natural seeding.
  - Consider the needs of the species being planted relative to the site conditions.
  - Plan for equipment and materials to be available when needed.

Example of a mounding trial for a linear feature through a treed wetland. Mounding can be used to promote the establishment of woody vegetation on wet sites and can serve as a deterrent to OHV users. However, mounding can be expensive and the cost should be considered as part of forest renewal planning.

FOREST MANAGEMENT OPERATIONS BMPS

Photo courtesy of Millar Western

WETLAND ROAD CROSSING CONSTRUCTION

Outcome: Wetland crossings are constructed to minimize adverse effects to the wetland during construction and crossings are constructed to accommodate wetland flow.

Wetland Road Crossing Construction BMPs:

- Planners and operators should be involved in developing work plans to ensure everyone has a clear understanding of the objectives of the wetland crossing including environmental performance, operational, and safety objectives. The division of road planning and design responsibilities between planners and operators may differ depending on the company.
- If possible, build non-seasonal roads far enough in advance of use to allow natural settlement.
- If field conditions or operational constraints require deviations from the planned crossing design, ensure that changes to the plan accommodate wetland flow and minimize wetland disturbance.
- When clearing the road right-of-way minimize vegetation disturbance. Consider:
  - Removing vegetation during frozen conditions.
  - Leaving surface vegetation, including root mats, intact.
- Ensure proper placement of conduit (e.g., culverts or corduroy) to maintain water flow based on wetland type.

- Engineer road surfaces to direct surface run-off into drainage structures and away from wetlands and waterbodies.

Geotextile used as a separation layer.

Culvert crossing.

Use of biodegradable geotextile is suitable for temporary crossings.

Photo courtesy of Louisiana Pacific

Winter Road Construction

Winter roads can provide an alternative access solution in wet areas for activities that can occur over the winter (e.g., some harvest, but not most silviculture activities). Compared to all-season roads, winter roads can help minimize adverse effects to wetlands and can help save costs. Winter roads are constructed using a base of ice or snow and can be constructed through uplands, wetlands or waterbodies. Freezing down into the soils for a seasonal road can increase the bearing capacity of wetland soils, minimize adverse effects to vegetation and soils, and reduce alterations to wetland hydrology and connectivity. Winter crossings include ice bridges, snow fills, log fill, and others.

There can be a substantial amount of sub-surface water movement in certain wetland types, even under frozen surface conditions. If not well understood, these wetlands, typically peatlands, can present safety risks to workers and equipment.

The practices described below provide an overview of how to approach winter wetland road crossings, for more detailed information refer to:

- Resource Roads and Wetlands: A Guide for Planning, Construction, and Maintenance (Partington et al. 2016)

Outcome: Winter roads are constructed to minimize adverse effects to wetlands while meeting operational, cost, and safety needs.

Winter Road Construction BMPs:

- Classify the wetlands present at the crossing location to their minor classification (e.g., graminoid rich fen). Use knowledge of wetland types along with any field data or desktop information, to infer the expected hydrologic regime.
  - Systems with little water movement, such as bogs or treed poor fens, are expected to be lower risk (e.g., more likely to freeze).
  - Systems with significant subsurface water movement, such as rich fens, are expected to be higher risk (e.g., less likely to freeze).
- Winter snow and ice crossings are recommended for crossing inundated or flooded wetland types.
- Bridges are recommended for crossing moving lateral wetlands, if winter crossings are required. Before deciding on the type of crossing for these systems, consider:
  - Depth of peat – peat is an excellent water conduit and wetlands with deep peat can (but don't necessarily) have sub-surface water movement that can inhibit freeze-down
- Water movement (direction, speed, depth of water).
- Remove surface snow cover to promote greater frost penetration.
  - Maintain surface vegetation when removing snow cover. Removing surface vegetation can lead to ponding following spring melt and challenges revegetating the road.

- If not removing snow cover, consider the temperature. Very cold temperatures create sugary, less compactable snow which can lead to less stable winter roads.

- During construction, minimize disturbance to soils underlying the road to help maintain hydrologic connectivity when the crossing thaws. This is especially important when working on peat soils.
- Use clean snow to construct wetland crossings; winter road crossings will melt in the spring and sediment or other material in the snow will enter the wetland.
  - If clean snow isn't available remove contaminated snow prior to spring break-up.
- Avoid using materials with the potential to contaminate the wetland (e.g., shavings or sawdust). While these materials have been used to extend the life of snow and ice crossings, they can be extremely challenging to remove, particularly once melt has started.
- Design winter crossings to accommodate spring melt and plan where the water is going, expected volume and timing, and potential for erosion or sedimentation.
- Ensure operations cease when the road begins to thaw or visible rutting occurs. Ensure the road surface is clean and free of debris prior to road decommissioning or thaw.

Some wetland types have sub-surface water movement year-round and do not completely freeze in the winter. Some of the fen classes (e.g., graminoid fens) tend to have deep peat deposits and significant sub-surface water flows, making them challenging systems to work in. Where feasible, these systems should be avoided because of the challenges and safety considerations associated with freezing down. If they cannot be avoided, then plan for additional time and resources to freeze down winter crossings.

While winter wetland crossings tend to be lower impact compared to all-season wetland crossings, there is still potential for adverse effects to wetlands as well as safety risks if equipment goes through ice or frozen peat.

Photo credit: FPInnovations

Snow and ice crossings are ideal when crossing inundated/flooded wetlands.

Access Mat Use

Access mats can provide temporary, lower impact access into water saturated areas, such as wetlands. When used effectively, access mats minimize ground disturbance by spreading the equipment weight over a larger surface, in turn reducing ground disturbance. Mats can be made from a variety of materials including wood, bamboo, rubber, fibreglass and other reinforced materials and come in a variety of weights and strength ratings and lifespans.

Example of wood access mat.

Access mats are not widely used by the forest industry, but there may be opportunities for increased use as climate change continues to reduce the length and predictability of frozen winter conditions.

There is little research or long-term studies on the effectiveness of access mats and the potential impacts of long-term use in boreal wetlands. **Use mats with caution and closely monitor for any signs of ground disturbance.**

Outcome: Access mats are used where appropriate to minimize adverse effects to wetland soils and vegetation.

Access Mat Use BMPs:

- Minimize the number and length of access mats used while ensuring that wetlands are adequately covered or that alternate practices are applied to minimize disturbance.
- Clear vegetation during frozen season where feasible and leave as much ground cover and root mat as possible.
- Use clean mats to avoid contamination or introduction of invasive species.
- Ensure that access mats do not impede surface or sub-surface water movement.
  - Access mats are designed to specific strength ratings, use mats according to these specifications to reduce the risk of mats sinking into the soil.
  - Do not layer mats if mats start to sink into the soil and are no longer passable. Layering mats can compact soil and impede sub-surface water movement.
- Remove access mats when work is complete.
- Remove mats by backing out of the site, removing one mat at a time, and taking care not to move equipment and vehicles across areas.

Road Reclamation

Outcome: Following deactivation, wetland road crossings are reclaimed to the pre-disturbance wetland type or are on a successional trajectory towards the pre-disturbance wetland type (e.g., for treed wetlands).

Road Reclamation BMPs:

- Wetland road crossings are removed to minimize vegetation and soil disturbance. Measures to prevent and control erosion and sedimentation are applied.
- Wetland crossings through marsh and shallow open water wetlands tend to be rare in the boreal and often use crossing structures or take advantage of frozen conditions.
  - Minimize disturbance when removing crossing structures (e.g., bridges).
  - Where needed, re-establish vegetation to reflect the wetland type.
- Wetland crossings through swamp, bog, and fen wetlands include both frozen season crossings and a variety of crossing structures for all-season roads (e.g., corduroy, culverts, geotextiles, etc.).
  - Minimize disturbance when removing crossing materials and consider the time of year and equipment needed.
  - Re-establish the natural hydrology of the site, this may include restoring microtopography, decompressing soils, and other techniques.
  - Where feasible, re-establish the appropriate soil type for the wetland type being reclaimed (e.g., peat forming vegetation can establish on clay soils but it is preferable to use peat as the substrate).
  - Re-establish vegetation to reflect the wetland type being restored. Consider whether vegetation will re-establish naturally or whether planting is needed. (e.g., peat forming species may need to be planted to ensure a reclaimed peatland road crossing is on the trajectory towards a peat forming system).

There are opportunities to enhance current knowledge and practices relating to wetland road crossings, particularly for crossings located in swamp, bog, and fen wetland types.

Aerial view of a successful reclamation of a wetland crossing. The culvert was removed, and the stream bed was restored.

Monitoring Road Performance

Monitoring road performance and potential adverse effects on wetlands is critical for effectively managing wetland road crossings.

Outcome: A road monitoring program is developed to ensure wetland road crossings meet operational, environmental, and safety needs throughout their operating lifespan.

Monitoring Road Performance BMPs:

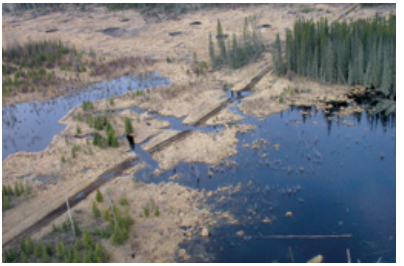
- Provide staff conducting road inspections with training:
  - Introductory wetlands training, including field wetland identification training.
  - Training to identify common wetland road crossing problems.
- Maintain detailed records of wetland road crossing locations, crossing properties (e.g., wetland type, crossing design), identified problems (e.g., blocked culverts, water ponding, rutting or compaction on the road), and dates of inspections and repairs.
- Conduct regularly scheduled inspections including drainage evaluations, ground disturbance evaluations, and ground disturbance. Look for signs of culverts that aren't functioning as they should, visible changes to wetland hydrology, and changes to vegetation communities on either side of the road.
- If there are too many wetland crossings to inspect regularly, develop protocols to prioritize crossings for inspection and repair based on risk (likelihood of impaired hydrology and consequence of impaired hydrology).
- When evaluating drainage structures at wetland crossings, look for ponded water on the side of the road that may indicate a blocked culvert or the need for additional culverts or water passage method.
- Monitor culverts for signs that they are not functioning as intended (e.g., sunken, perched, blocked, or banana'd). Due to the weak bearing capacity of wetland soils culverts may not function as intended. These problems may indicate a need for road maintenance or improvements.
- Maintain road surfaces to direct surface run-off into drainage structures away from the wetland.
- Clean roads and drainage structures following forest management activities, particularly harvesting and subsequent log hauling, to maintain adequate drainage.
- Where it makes sense, manage road access to minimize unnecessary traffic.

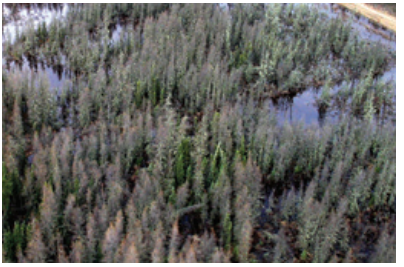
For detailed information on indicators of hydrologic effects refer to:

- Resource Roads and Wetlands: A Guide for Planning, Construction, and Maintenance (Partington et al. 2016)




Examples of challenges with culverts that may impeded water or fish passage. (clockwise from top left): banana'd culvert due to road settling, sunken culvert likely due to road settling, perched culvert, and blocked culvert.






Examples of roads blocking natural wetland hydrology. Consequences included inundated roads, water level rises upstream, drying downstream, and ecological changes resulting from altered soil moisture conditions *(die-off of upstream vegetation and vigorous growth of downstream vegetation)*.

HARVEST ACTIVITIES

Forest harvest can adversely effect wetlands directly when treed wetlands or wetland transition zones are harvested, or indirectly when wetlands are within or adjacent to harvest areas. Harvesting treed wetlands varies across the country and by company.

This section covers wetland BMPs for a range of harvest activities (e.g., harvesting, landings and storage sites, skidding), that have the potential to affect wetland quantity, wetland quality, hydrologic processes, and hydrologic connectivity. This section also covers BMPs for operating near other water features (e.g., riparian areas, vernal pools, seeps and springs).

Harvesting Treed Wetlands

Treed wetlands, particularly conifer swamps, can contain merchantable wood and may be targeted for harvest. Harvesting these wetland types can be challenging because of deep organic soils and the presence of water close to the surface. This can result in site conditions that are susceptible to rutting and forest renewal challenges when water pools at the surface after harvest.

Outcome: Treed wetlands are harvested using techniques that minimize adverse environmental effects and that promote forest renewal to pre-harvest conditions.

Harvesting Treed Wetlands BMPs:

- Use information about wetland type and location collected as part of desktop and on-the-ground planning activities to inform the timing of harvest, harvest area configuration, and wetland stewardship measures.
- Schedule harvesting during frozen or dry conditions. If harvesting during non-frozen conditions, take precautions to minimize adverse effects to wetland soils.
- Consider lower-impact harvesting techniques to minimize adverse effects to wetlands being harvested and to promote regeneration following harvest (page 52).
- Minimize damage to understory vegetation, retain unmerchantable timber and advanced growth.
  - Conserves organic material and nutrients.
  - Promotes site recovery which can be particularly challenging in wetlands.
- Ensure structure retention requirements are met and identify opportunities to protect wetlands as part of meeting requirements. Some areas may be identified for retention as part of the planning process, while others may be left to the discretion of operators.
  - Consider using wetlands as anchors for retention patches. Include trees that border open areas, especially if they are deciduous in conifer stands or have growth forms influenced by the opening.

- Consider leaving a variable-width retention around the wetland using ecological or topographical features to locate boundaries.
- Follow provincial retention requirements where applicable.

➔ Ensure the harvest area boundary is clearly marked from adjacent non-harvest areas including within-area reserves.

- Marking can be carried out by accurately GPS-ing boundaries and features and loading digital maps onto GPS-equipped machinery. The benefit to this approach is that operators can add more features to the maps as they encounter them.
- Flagging or paint can be used to mark boundaries in the field. The benefit to marking in the field is that it requires a site visit to confirm what should be done and that marking can be done to an individual tree level.

➔ Review the harvest area plan with operations staff or contractors to ensure wetland conservation measures are clearly understood.

Low Impact Forest Harvest Techniques

Low impact forest harvest techniques may be applicable in some situations to reduce adverse effects to wetlands. The applicability of these techniques will depend on tree species, stand age and density, windthrow risk and other factors.

Careful logging around advanced growth – Involves restricting equipment to parallel trails and harvesting in a way that preserves advanced growth.

Small area clearcuts and strip cuts – These techniques may have the benefit of improved regeneration by natural seeding while also reducing exposure, desiccation, and run-off. These techniques can also benefit biodiversity by maintaining habitat for flora and fauna. Draw-backs include contributing to forest fragmentation and potential associated adverse effects on biodiversity and species dispersal.

Partial harvest techniques – Involves maintaining some tree cover on site and provides a mixed forest structure. This can help minimize adverse environmental effects and support biodiversity. However, this practice favours shade tolerant species.

Image courtesy of Weyerhauser

Image courtesy of Millar Western

Examples of forest harvest in areas with wetlands present on the landbase.

Harvesting Wetland Transition Zones

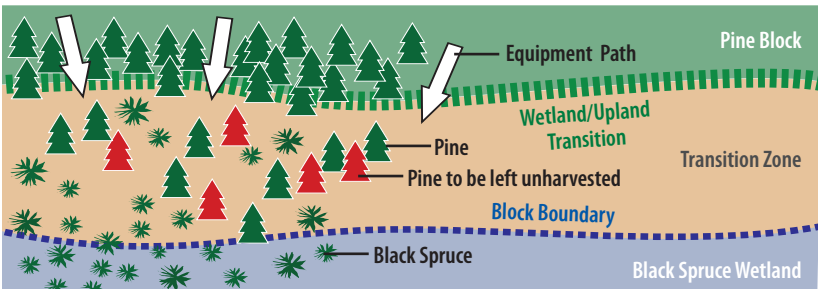
Transition zones between merchantable stands and wetlands or riparian areas may contain some merchantable timber. For example, in parts of the boreal plains it is common to have an upland portion of a harvest area with trees such as lodgepole or jack pine transitioning to wetland species like black spruce.

Transition zones may also be between areas of a wetland with merchantable timber and areas without; however, in cases where treed wetlands are harvested low impact harvest techniques should be considered throughout the harvest area.

Outcome: Wetland transition zones are managed to minimize adverse effects including effects to wetland quantity, wetland quality (soils, vegetation, and water quality), hydrologic processes, and hydrologic connectivity.

Harvesting Wetland Transition Zones BMPs:

- Use wetland/upland boundaries or merchantable/non-merchantable *(if the whole area is a wetland)* boundaries identified at the planning stage. Ensure these boundaries are marked, either on-the-ground and/ or on digital maps of the harvest area.
- Use desktop imagery and on-the-ground surveys to determine whether merchantable trees are present within the transition zone. If merchantable trees are present, avoid harvesting if feasible.
- If merchantable trees are present in the transition zone and will be harvested:
  - Use low impact harvest techniques to remove merchantable trees while minimizing ground and vegetation disturbance, and maintaining natural site contours (e.g., reaching into the transition zone to remove individual tress or techniques described on Page 52).
  - Consider removing only 50% of merchantable trees.
  - Leave merchantable trees with poor form or that lean towards the wetland or riparian area.
  - Harvest during frozen or dry conditions. If this is not possible use machine-free practices or low-ground-pressure equipment to avoid rutting and erosion in the transition zone and sedimentation into the wetland or riparian area.



Example of low impact harvest approaches to harvesting pine in the transition between a pine block and a black spruce wetland. Within the transition zone, equipment enters along specific pathways to minimize disturbance.

Harvesting Adjacent to Wetlands

Outcome: When harvesting adjacent to wetlands where no or minimal transition zone exists, adverse effects (e.g., erosion, sedimentation) to the adjacent wetland are avoided or minimized.

Harvesting Adjacent to Wetlands BMPs:

- Identify and mark (on-the-ground or digitally) wetland boundaries prior to harvesting.
- If there is no, or minimal, transition zone between the wetland and harvest area, consider retaining merchantable trees on the fringes. Even a small number of retained trees can help minimize erosion and sedimentation into the adjacent wetland.
  - If retention isn't feasible around all wetlands within/outside of the block or around all sides of large in-block wetlands, prioritize areas that are most sensitive to disturbance or most at risk of adverse effects for retention.
- Consider using low impact forest harvest techniques in areas adjacent to wetlands.
- Use felling techniques to keep excessive woody debris out of adjacent wetlands.

Photo courtesy of Weyerhauser

Photo courtesy of West Fraser

Harvesting Near Vernal Pools

Vernal pools are seasonal wetlands found in depressions covered by shallow water. Water levels change throughout the year with the highest water levels typically in spring, and vernal pools maybe completely dry for most of the summer and fall.

Despite their ephemeral nature, vernal pools provide important habitat for several plant and animal species (e.g., frogs and salamanders) and the surrounding forest is important for maintaining these functions. Surrounding trees, shrubs and other vegetation contribute nutrients to the pools, help to regulate hydrology, and provide shade.

Outcome: Vernal pools are avoided during harvest and vegetation is retained around vernal pools.

Harvesting Near Vernal Pools BMPs:

- Identify and mark the boundaries of vernal pools prior to harvest operations. Vernal pools are easiest to identify in the spring but can be identified in any snow-free season based on the presence of water, the absence of vegetation, or the presence of wetland vegetation.
- Follow retention plans around vernal pools to leave undisturbed vegetation and trees around pools. Ideally these will be identified as part of planning, but retention decisions around the pool may be left up to the operator.
- Use felling techniques to keep excessive woody debris out of vernal pools.
    - Some woody debris may be desirable depending on the natural state of the vernal pool. For example, if there is woody debris in the pool it may be beneficial to carefully place a few non-merchantable trees in the pool or leave nearby standing trees that are close enough to fall into the pool.

Example of a vernal pool.

Harvesting Near Seeps, Springs and Ephemeral Drainages

A spring is a place where water from an aquifer reaches the earth's surface. Depending on the volume of water that reaches the surface, a spring may result in flow beyond the location where the water surfaces. Seeps typically have insufficient water volume to flow beyond their above-ground location. Springs typically emerge from a single point, while seeps tend to emerge over a larger area with no well-defined origin. An ephemeral drainage is often a linear depressional or gully feature within a harvest area that has no defined channel or perennial surface water and is typically but not always indicated by wetland plants. Seeps and springs can result in an ephemeral drainage.

Photo courtesy of West Fraser

Outcome: Seeps, springs, and ephemeral draws are avoided during harvest and vegetation is retained around vernal pools.

Harvesting Near Seeps, Springs and Ephemeral Drainages BMPs:

- Identify the location and/or boundaries of these features within harvest areas or near the boundary of harvest areas. To identify these areas consider:
  - Using LiDAR and digital elevation model tools.
  - Conducting field surveys in the winter or spring time looking for areas where water is unfrozen/flowing even under cold or frozen conditions.
  - Looking for wetland indicator plants in places that you would not typically expect to see them (e.g., on hillslopes).
- Where seeps, springs and ephemeral drains have not been identified, inform harvest operators on how to identify such features.
- Avoid machine activity in seeps and springs and maintain vegetated areas around these features
  - If treed areas around these features are to be harvested, consider using selection harvesting practices.
- Avoid disturbing the ground upslope of seeps and springs.
- Avoid skidding through or along ephemeral drains. If this cannot be accommodated, minimize the number of skid trails, subject to potential rutting effects.

Skid Trails

Skid trails (either drag skidding or forwarding) are necessary to move trees with branches and processed logs from the stump to a landing where they can be processed and loaded onto trucks.

Outcome: Rutting, erosion, sedimentation and other adverse effects to wetlands resulting from the use of skid trails are minimized.

Skid Trail BMPs:

- Locate skid trails to avoid or minimize impacts to wetlands, small streams, or other wet areas including ephemeral drainages.
  - Minimize and plan wetland and drainage crossings.
  - Cross under frozen or dry conditions when possible.
  - Snow fill can be used for winter crossings.
  - If crossing a wet area that conveys water during the unfrozen period, use skid bridges or log corduroy to distribute equipment weight and maintain natural water flow.
  - Depending on the equipment used, avoid placing skid trails parallel to drainage paths and perpendicular to slopes, this can channel water and potential sediment into wetlands and other water areas.
  - Minimize skid trails that concentrate runoff into wetlands or other drainages.
  - Consider area skidding instead of trail skidding in sensitive areas. One or two passes over large areas instead of multiple passes along trails can be beneficial for sites with soils that are easily rutted or eroded.
- Use low ground pressure equipment when operating in wetlands during non-frozen conditions to minimize the risk of rutting.
  - Where appropriate, consider placing tops and branches on skid trails to minimize soil disturbance and disperse the load.
- Adapt to weather conditions, stop skidding during wet periods.

Photo courtesy of West Fraser

Examples of using cordoroy, geotextile, and culverts to reinforce skid trails across wet areas to minimize soil disturbance.

Landings, Storage, Work Sites and Camps

Areas may be cleared for landings, timber storage, equipment storage, work sites and camps. These activities typically involve removing vegetation to clear an area and create a level surface for equipment/material storage or a work site.

Outcome: Landings, storage, work sites and camps are planned, constructed, and used to minimize adverse effects to wetland vegetation, soils, and water quality.

Landings, Storage, Work Sites and Camp BMPs:

- Avoid placing landings, storage, work sites, and camps in or beside wetlands, seeps, springs, vernal pools, or other wet areas.
- Plan sites in advance of road construction and consider the location relative to the road network, harvest areas, and environmental features including wetlands.
- Where applicable, locate sites to minimize wetland crossings by skid trails and resource roads.
- Sites should be located on well-drained gently sloping sites. This will help with shedding water and keeping equipment on firm ground.
- Sites with greater than 5% slopes may require additional erosion control measures. Install necessary erosion controls concurrently with landing construction.
- Strip and store surface soils and organic matter to use in landing restoration.
- Where applicable, locate debris piles and log storage decks (particularly aspen) away from drainages where runoff may wash leachates into streams, lakes or other waterbodies.
- Site petroleum storage and maintenance locations to avoid potential for spills to enter water bodies and use containment systems to prevent and catch spills.
- Stabilize areas where heavy equipment is parked to minimize the risk of rutting, compaction, and erosion.
- Upon completion prepare sites for forest renewal activities (de-compact if necessary, restore natural drainage paths, spread soil and organic debris).

Photo courtesy of Al-Pac

Photos courtesy of Millar Western

Depending on the company or jurisdiction, landings may not be a common practice and timber may be primarily stored and processed at roadside sites. If this is the case, avoid locating roadside storage sites in wetlands. Use digital wetland mapping products to identify potential storage locations before going into the field. When in the field, confirm that locations for roadside timber storage are not in wetlands.

Monitoring Harvest Activities

Outcome: Harvest activities are monitored to document the application of wetland BMPs and where it can be determined the preliminary effectiveness of those BMPs.

Monitoring Harvest Activities BMPs:

- Monitor the on-the-ground implementation of the harvest plan to ensure BMPs to promote wetland stewardship are applied.
  - Review of the harvest area plan with the contractor prior to activities to ensure proposed activities are discussed.
  - During the harvest operation, periodically review progress of activities relative to wetland protection as outlined in the harvest area plan.
  - Any documentation of on-site meetings with contractors and/or government related to activities and criteria associated with wetland and waterfowl stewardship.
  - Complete final inspection reports.
- Incorporate wetland-specific aspects into existing monitoring plans (e.g., monitoring plans for Environmental Management Systems):
  - Mapped and marked (digitally or physically) access road layout avoids wetlands.
  - Wetland crossings accommodate anticipated hydrology.
  - Mapped and marked harvest area layout reflects wetland protection.
  - Silviculture prescription that includes road reclamation.

FOREST RENEWAL

Forest renewal of treed wetlands by Canada's forest sector is limited in Canada's boreal plains ecozone because forest harvest of treed wetlands is uncommon. However, where harvesting does occur, forest renewal can be challenging because of deep organic soils and the presence of water close to or above the surface.

Because forest renewal requirements can be strict and vary by jurisdiction, this section provides only a high level overview of practices and resources to consider and resources to consider.

Outcome: Wetland species on harvested treed wetlands are re-established.

Forest Renewal BMPs:

- Refer to jurisdictional requirements to ensure that applicable forest renewal requirements are met. BMPs described in this section may not be relevant depending on the requirements of your jurisdiction.
- When mechanical site preparation is required, undertake these operations during the winter months where possible to minimize soil disturbance and protect existing vegetation and ground cover as much as possible.

- When working in or near wetlands:
  - Conduct mechanical site preparation parallel to the slopes leading to the wetland to reduce the potential for sedimentation into the wetland.
  - Consider establishing a "no site preparation" zone in harvest areas adjacent to wetlands if needed to prevent erosion into a wetland.
  - Do not use herbicides within wetlands. Where herbicides are used to control unwanted vegetation, follow regulatory criteria and ensure herbicides do not enter water bodies.
- Ensure that soil and hydrology conditions are suitable for re-establishing vegetation. For example, harvest in treed wetlands may raise the water table and site preparation may be needed to provide dry planting sites for woody vegetation.
  - Site preparation, such as mounding, may be needed to re-establish site microtopography.
  - Standard mounding (soil placed next to excavated hole) or rough and loose mounding (soil placed partially in excavated hole) can help with soil decompaction on wet sites.
- Re-establish wetland species on harvested wetlands, consider:
  - In cases where vegetation disturbance is minimized during harvest, natural re-establishment may be more successful.
  - Consider planting techniques and planting locations (relative to mounds) depending on the moisture conditions of the site.
  - Seeding is less reliable than planting, but it may be a suitable regeneration method on some sites.

Image courtesy of West Fraser

Mounding site preparation in a boreal wetland.

Forest Renewal Resources for Wet Sites:

- Silviculture Toolkit - covers techniques for wet and dry sites. Developed to share silvicultural knowledge with the oil and gas industry. Includes knowledge extension tools (factsheets and videos) and has applications to a range of industries including forest renewal and resource road reclamation.
- NAIT Centre for Boreal Research Technical Resources - include information about reclamation techniques and field trials.

GLOSSARY

Clearcut: A silvicultural practice where an entire area is harvested uniformly, and no retention of marketable timber occurs.

Deleterious substance: Section 34(1) of the Fisheries Act defines "deleterious substance" as:

a. Any substance that, if added to water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or

b. Any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water. (GoA 2016)

Ephemeral drain: A linear feature within a harvest area that is typically vegetated by willow and alder species. Seeps and Springs can result in an ephemeral drainage feature.

Felling: The processing of cutting down trees by either machinery or by hand.

Landing: Areas that are cleared for processing and staking logs before they are loaded onto a log truck. Landings may also serve as an area to store machinery.

Partial harvest: A silvicultural practice that maintains varying amounts of standing trees to provide a mixed forest structure and enhance environmental values. Trees may be maintained in patches or as individual trees across the harvest area.

Peatland: A grouping of wetlands characterized by organic soils greater than 40 centimetres deep. Peatlands include bogs and fens (CWCS).

Riparian area: Terrestrial areas where the vegetation complex and microclimate conditions are products of the combined presence and influence of perennial and/or intermittent water, associated high water tables and soils that exhibit some wetness characteristics. Normally used to refer to the zone within which plants grow rooted in the water table of these rivers, streams, lakes, ponds, reservoirs, springs, marshes, seeps, bogs and wet meadows. The riparian zone is influenced by, and exerts an influence on, the associated aquatic ecosystem (GoA 2016).

Seep: A place where water, typically from an underground aquifer, reaches the earth's surface resulting in a wet place. Seeps usually emerge over a large area with no defined origin and do not produce enough water to leave the site.

Selection harvesting: A silvicultural system used to create or maintain uneven aged stands. Usually accomplished through the periodic removal of groups of trees or individual trees, while full residual stand growth rates are maintained and natural regeneration from overstory trees is encouraged. Not to be confused with selective harvesting, or high-grading, where trees are selected and removed periodically based

solely on economic criteria. Selective harvest is not designed to improve the growing conditions of the remaining crop trees as Selection harvest is. (GoA 2016)

Sensitive sites: Sites that have soil, water, slope, aesthetic, vegetation or wildlife characteristics that require special protection beyond the normal precautions required in the relevant jurisdiction.

Silviculture: The theory and practice of controlling the establishment, composition, health, structure and growth of forests in order to achieve specified management objectives (GoA 2016).

Site preparation: Any action taken in conjunction with a reforestation effort (natural or artificial) to create an environment favourable for survival of suitable trees during the first growing season. Altering the ground cover, soil or microsite conditions can create this environment; using biological, mechanical or manual clearing; prescribed burns; herbicides or a combination of methods. (GoA 2016)

Skid trail: An unimproved temporary forest trail suitable for use by equipment such as bulldozers and skidders in bringing trees or logs to a landing or road.

Spring: A place where water, typically from an underground aquifer reaches the earth's surface. Springs usually originate from a single point and produce enough water to flow beyond the location where the water surfaces.

Structure retention: A partial harvesting technique that results in patches of unharvested trees that can serve to maintain structural diversity, wind buffering and environmental values. Retention may include single trees or patches and can take different patterns or forms.

Strip cut: A silvicultural practice where the harvest area is divided into equal width strips and every other strip is harvested.

Vernal pool: Ephemeral depressions covered by shallow water. Vernal pools may be completely dry for most of the summer.

Wetland: Lands saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophilic vegetation, and various kinds of biological activities that are adapted to the wet environment (National Wetlands Working Group, 1997).

Watershed: An area of land that separates water flowing to different rivers, streams or waterbodies.

Wildlife tree: Any tree, dead or alive, that provides valuable habitat for the conservation or enhancement of wildlife.

Photo courtesy of Millar Western

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APPENDIX 1

LINKS BETWEEN OUTCOMES, STEWARDSHIP OBJECTIVES AND GUIDING PRINCIPLES

The following chart illustrates the relationship between planning, operating and other outcomes described in this guide and the stewardship objectives and guiding principles as described in the **Guiding Principles for Wetland Stewardship and Forest Management Technical Report and Practitioner Guide** (FMWSI 2018) (see page 8).

Outcome	Stewardship Objectives	Guiding Principles
General Wetland BMPs		
Wetland Training (page 20)		
Staff and contractors are informed about boreal wetlands and boreal wetland BMPs as they relate to their roles and responsibilities. Where appropriate, staff and contractors have training on wetland best management practices.	Supports all objectives	Supports all principles
Soil Conservation (page 21)		
Soil Moisture Conditions Soil moisture conditions are considered when planning operations activities to: • Minimize adverse environmental effects to wetlands including rutting and compaction, vegetation damage, and impeded water movement. • Minimize safety risks to equipment and people. Some wetland types, particularly those with deep peat and subsurface flows, can pose a safety risk to equipment and workers if they don't freeze down.	• Maintain surface and subsurface water and flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles. Particularly: • Maintain wetland quality

Outcome	Stewardship Objectives	Guiding Principles
Equipment Equipment for all activities (e.g., harvest, road construction) is chosen to minimize adverse effects to wetlands.	• Maintain surface and subsurface water and flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles. Particularly: • Maintain wetland quality
Erosion and Sedimentation Soil erosion and soil displacement from wetlands is minimized. Sedimentation into wetlands and other waterbodies is avoided or minimized.	• Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles. Particularly: • Maintain wetland quality
Invasive Species (page 24)		
Introduction and spread of invasive species to wetlands is avoided, minimized, and managed.	• Avoid or minimize invasive species introduction and/ or spread	Supports all principles. Particularly: • Maintain wetland quality
Spills (page 25)		
All potential deleterious substances (e.g., oil products, fuel, herbicides, pesticides, fertilizers) are stored and handled to minimize the likelihood and consequences of a spill. Established procedures are followed in the case of a spill to minimize adverse environmental effects to wetlands.	• Prevent pollutants from entering the wetland	Supports all principles. Particularly: • Maintain wetland quality
Recreational Access (page 25)		
Use of recreational vehicles in sensitive wetlands is avoided, minimized, and managed.	Supports all objectives	Supports all principles

Outcome	Stewardship Objectives	Guiding Principles
Forest Management Planning BMPs		
Wetland Identification (page 31)		
Wetland locations and types are accurately identified and located to inform all stages of planning and operating.	Supports all objectives: • Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion • Prevent 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
Riparian Area Identification (page 32)		
Riparian areas are identified and located to inform all stages of planning and operating.	Supports all objectives	Supports all principles
Wetland Avoidance (page 33)		
Wetlands are prioritized for avoidance based on ecological, social, and economic criteria.	Supports all objectives	Supports all principles
Wetland Road Crossings (page 34)		
Road Routing Roads are planned to avoid wetland crossings where feasible and minimize the number, length, and sensitivity of wetland crossings for all road types including seasonal roads.	Supports all objectives. Particularly: • Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles, particularly: • Maintain hydrologic connectivity

Outcome	Stewardship Objectives	Guiding Principles
Wetland Crossing Design Wetland crossings are designed to accommodate flow and minimize adverse environmental effects while meeting operational, cost, and safety needs.	Supports all objectives. Particularly: • Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles, particularly: • Maintain hydrologic connectivity
Forest Harvest Area (page 40)		
Wetland avoidance is prioritized during harvest area layout and preliminary silvicultural prescriptions are identified for wetlands to be harvested	Supports all objectives	Supports all principles
Forest Renewal (page 41)		
Forest renewal prescriptions that will promote the return of the site to its pre-harvest condition are identified for forested wetlands designated to be harvested. Or, if effective renewal prescriptions are too costly or operationally challenging, these sites are removed from harvest.	Supports all objectives	Supports all principles. Particularly: • Maintain wetland quality
Forest Management Operations BMPs		
Wetland Road Crossing Construction (page 43)		
Wetland crossings are constructed to minimize adverse effects to the wetland during construction and crossings are constructed to accommodate wetland flow.	Supports all objectives	Supports all principles, particularly: • Maintain hydrologic connectivity
Winter Road Construction Winter roads are constructed to minimize adverse effects to wetlands while meeting operational, cost, and safety needs.	Supports all objectives. Particularly • Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance	Supports all principles, particularly: • Maintain hydrologic connectivity

Outcome	Stewardship Objectives	Guiding Principles
Access Mat Use Access mats are used where appropriate to minimize adverse effects to wetland soils and vegetation.	• Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	• Maintain wetland quality • Maintain hydrologic processes • Maintain hydrologic connectivity
Road Reclamation Following deactivation, wetland road crossings are reclaimed to the pre-disturbance wetland type or are on a successional trajectory towards the pre-disturbance wetland type (e.g., for treed wetlands).	• Maintain surface and subsurface water flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles
Monitoring Road Performance A road monitoring program is developed to ensure wetland road crossings meet operational, environmental, and safety needs throughout their operating lifespan.	• Maintain surface and subsurface water flow	Supports all principles
Harvest Activities (page 51)		
Harvesting Treed Wetlands Treed wetlands are harvested using techniques that minimize adverse environmental effects and that promote forest renewal to pre-harvest conditions.	Supports all objectives	Supports all principles. Particularly: • Maintain wetland quality • Maintain hydrologic processes
Harvesting Wetland Transition Zones Wetland transition zones are managed to minimize adverse effects including effects to wetland quantity, wetland quality (soils, vegetation, and water quality), hydrologic processes, and hydrologic connectivity.	Supports all objectives	Supports all principles. Particularly: • Maintain wetland quality • Maintain hydrologic processes

Outcome	Stewardship Objectives	Guiding Principles
Harvesting Adjacent to Wetlands When harvesting adjacent to wetlands where no or minimal transition zone exists, adverse effects (e.g., erosion, sedimentation) to the adjacent wetland are avoided or minimized.	Supports all objectives	Supports all principles. Particularly: • Maintain wetland quality • Maintain hydrologic processes
Harvesting Near Vernal Pools Vernal pools are avoided during harvest and vegetation is retained around vernal pools.	• Maintain surface and subsurface water and flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles
Harvesting Near Seeps, Springs and Ephemeral Drainages Seeps, springs, and ephemeral draws are avoided during harvest and vegetation is retained around vernal pools.	• Maintain surface and subsurface water and flow • Avoid or minimize soil compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles
Skid Trails Rutting, erosion, sedimentation and other adverse effects to wetlands resulting from the use of skid trails are minimized.	• Avoid or minimize soil rutting and compaction • Avoid or minimize soil layer disturbance • Avoid or minimize site level run-off and erosion	Supports all principles. Particularly: • Maintain wetland quality
Landings, Storage, Work Sites and Camps Landings, storage, work sites and camps are planned, constructed, and used to minimize adverse effects to wetland vegetation, soils, and water quality.	Supports all objectives	Supports all principles. Particularly: • Maintain wetland quality
Monitoring Harvest Activities Harvest activities are monitored to document the application of wetland BMPs and where it can be determined the preliminary effectiveness of those BMPs.	Supports all objectives	Supports all principles
Forest Renewal (page 60)		
Wetland species on harvested treed wetlands are re-established.		

PRACTITIONER GUIDE

WETLAND BEST MANAGEMENT PRACTICES FOR

Forest Management Planning & Operations

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