How does the Healthy Landscape Program Define a Landscape?

A WHOLE LANDSCAPE APPROACH TO ECOSYSTEM-BASED MANAGEMENT: PART 1

fRI Research
Informing Land & Resource Management

Ducks Unlimited Canada

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INTRODUCTION

Project Background

The Healthy Landscapes Program (HLP) is a forest land management research partnership based at fRI Research. The HLP brings together researchers and practitioners from industry, government, non-profit, academia, and other organizations to advance ecosystem-based management principles focusing on forest dynamics and disturbance in Canada's boreal region. The HLP started in 1996 and has contributed to numerous studies, education, and outreach products.

Over its history, the HLP has been primarily comprised of partner members from forest industry and government forestry divisions. While the HLP is open to members from other sectors, its priorities, projects, and internal language have reflected the needs of the forest management sector with a focus on upland forests. However, there is a growing recognition within the HLP team of the interconnectedness of all boreal forest ecosystems, the complexity of contemporary threats such as climate change and biodiversity loss, and the need for diverse perspectives to develop solutions to these challenges.

The Healthy Landscape Program defines Ecosystem Based Management (EBM) as:

"A collaborative, integrated, science-based approach to the natural management of resourses that foceuses on the health and resilience of entire ecisystems, while allowing for sustainable use by humans of the goods and services they provide." (Andison, 2020)

Managing the whole landscape begins with the recognition that all parts of the landscape are valuable and collectively contribute to the health and resilience of entire ecosystems. The value (e.g., relative value, perceived value) of different landscape components will change over time and space and will differ by stakeholder group. Perhaps the most significant shift in taking a whole landscape approach is welcoming the input of stakeholders who hold different values and perspectives. Creating standardized terminology helps bring together stakeholders under a common understanding. This more inclusive approach is also necessary to achieve the HLP's definition of EBM that focuses on the health and resilience of entire ecosystems.

To support a whole landscape approach to forest land management, the HLP recognizes the need to develop a standardized, neutral, and universal way of describing and classifying all parts of a landscape. The purpose of this document is to propose:

1. **A definition of "Whole Landscape".**
2. **A high-level landbase classification system for use by the HLP.**

These two outcomes will introduce a standardized and neutral terminology to describe the landbase. The goal of this is to shift the terminology used, change the focus on how the landscape is viewed, and achieve the HLP's approach to EBM: to be more inclusive of different perspectives and to capture the full suite of values provided by the entire landscape.

Landscapes can be parsed through the lens of climatic, geological, hydrological, ecological, pedological, cultural, social, political, or economic criteria. Current approaches to adopting EBM as a forest management paradigm in the boreal forest have focused almost entirely on the forested portion of the whole landscape. These areas are often referred to as 'upland', 'contributing', 'productive', 'active' or 'working' landbase. The counterpart to these areas is typically referred to as the 'lowland', 'non-contributing', 'non-productive' or 'passive' parts of the landscape. These are often 'white space'.

This language can reflect a prioritization of values based on the groups involved. For example, 'productive' versus 'non-productive' is defined through a timber management lens, which is neither neutral nor universal. Areas labeled 'non-productive' timber are often productive for other ecological goods and services such as wildlife habitat, water filtration, etc.

Considerations for Landscape Classifications

There are three important considerations that bring additional complexity to a whole landscape approach:

1. Administrative Boundaries

Administrative boundaries do not necessarily reflect ecological boundaries and have been and continue to be a significant barrier to achieving have a whole landscape approach to EBM. Some of these boundaries may factor into an ecological land classification (e.g., agricultural land), others may guide what is of interest to a group (e.g., 'conservation area') without referencing the underlying ecological classification of the area within the boundary. Administrative boundaries to consider including:

- Parks and protected areas at all levels (e.g., National parks, Provincial parks, ecological reserves, recreation areas, etc.)
- Private land (including agricultural land)
- Government boundaries at all levels (federal, provincial, municipal)
- Indigenous and traditional land users (traditional territories, treaty lands, reserve lands, and harvest areas)
- Forest management boundaries (FMAs, FMUs, operational areas, polygons, etc.)
- Other industry leases, licenses, rights-of-way, and dispositions (e.g., mining, oil and gas, utilities, peat harvesting)
- Regulated environmental (ecoregions, watersheds, wetland boundaries, etc.)

Administrative boundaries can be porous to many processes that impact the landscape. Climatic effects such as drought or heatwaves, wildfires, and forest diseases do not recognize administrative lines. It is therefore important to recognize that administrative boundaries exist and to understand the differences in land management across different administrative regions. The existence and breadth of administrative boundaries

highlights the need to bring together diverse groups when taking an EBM approach.

2. Anthropogenic Activities or Modifiers

Anthropogenic activities and modifiers are an important consideration for a whole landscape classification, but it can be a challenge to integrate this information depending on the scope and scale of the activity (e.g., a mine site vs. a linear disturbance), changes to the activity footprint over time (e.g., vegetation regeneration), overlapping activities (e.g., harvest area and seismic line), and availability of spatial information (e.g., maps of active and decommissioned roads). While most landscape classification systems include anthropogenic categories (with varying levels of detail), anthropogenic boundaries add a layer of complexity on top of administrative and ecological boundaries that needs to be considered as part of a whole landscape approach to EBM.

3. Dynamic vs. Static Classifications

We now recognize that landscape components change over time and space and that landscape classifications can be static (conducted at one point in time; past, present, or future) or dynamic (representing a range of conditions reflecting the past, present and/or future). When producing static classifications, it is helpful to consider what is the most relevant timeline for landscape classification.

Ecosystems or values may move around the landbase over time. For example, over many decades in a fire-driven ecosystem, a single patch may burn, then go through several stages of growth, before burning again. Over time the values that patch provides will change and these changes may or may not be captured in a classification depending on the time frame and whether it is static or dynamic. As well, pressure to maintain certain ecosystem types or values (e.g., old forest) in a specific place can present a challenge for a whole landscape approach.

FOREST MANAGEMENT AREA AND PARK BOUNDARY: A CASE STUDY ON ADMINISTRATIVE BOUNDARIES

Contained within Manitoba's Duck Mountain Provincial Forest is the Duck Mountain Provincial Park. The Park has three different land use categories: backcountry, recreation, and resource use. Each of these park administrative boundaries have very different land uses and could divide the overall landscape potentially blocking ecosystem-based management. An ecological inventory was created for the entire landscape that transcended administrative boundaries. This benefited ecosystem-based management and strategic planning by accounting for all wildlife habitat in the Duck Mountain, both FMA and Park area.

Defining the Whole Landscape

The boreal forest is a mosaic of upland and wetland ecosystems. Although some wetland ecosystems are not traditionally considered in an industry context, functioning wetlands benefit upland forests by contributing to forest productivity and resiliency, mitigating the effects of upland harvest on streams and waterbodies, influencing wildfire behaviour and patterns, and mitigating the effects of climate change through carbon storage and sequestration (DUC, 2018).

Historically, forestry was concerned only with productive forested land base. However, as knowledge systems progressed and EBM became more prominent as a management paradigm, our language has not necessarily evolved. The goal in defining the whole landscape and setting a whole landscape approach is to recognize that ecosystems are highly interconnected and to move away from management approaches that may not include the unproductive landbase. In removing certain areas from forest management, land managers do not fully capture the value (or risks) that these areas contribute. By including these areas, managers are practicing an approach to EBM that "**focuses on the health and resilience of entire ecosystems.**" (Andison, 2020)

For the purpose of this document, the HLP developed the following whole landscape definition:

The collection of all landforms within an area from hills and rivers to wetlands and forests. A whole landscape approach considers all landscape components, recognizes the interconnectedness of these components, and values the perspectives of diverse stakeholders.

We recognize that this definition represents a western science perspective and view it as a first step towards the goal of developing a holistic definition of the whole landscape. Indigenous ways of knowing offer valuable perspectives on a whole landscape approach but have not been extensively explored as part in this document. Incorporating these perspectives will require meaningful engagement with Indigenous Peoples and we consider this the next step in continuing to define whole landscape in a way that reflects diverse backgrounds and perspectives.

Creating a standardized terminology can help bring together diverse stakeholders under a common understanding; however, to do so the terminology itself needs to be inclusive of different perspectives and knowledge systems. Principles have been established to help different stakeholders reach compromise on whole landscape management.

Principles for bringing together diverse stakeholders to achieve whole landscape management:

1. Continual learning and adaptive management: acknowledgment that landscape processes are dynamic and our knowledge of them is incomplete.
2. Common concern entry points: what are shared interests and challenges?
3. Multiple scales: being aware of higher/lower level processes can influence local interventions.
4. Multi functionality: landscapes and their components have multiple uses, valued in different ways by different stakeholders.
5. Multiple stakeholders: Recognize all stakeholders, but may be differences in concerns, aspirations, and contribution to decision-making.
6. Negotiated and transparent change logic: trust is needed between stakeholders and transparency is the basis of trust.
7. Clarification of rights and responsibilities: rules on resource access and land use, rights of all actors need to be clear and accepted by all stakeholders.
8. Participatory and user-friendly monitoring: information from multiple sources, widely accessible, and integrate different kinds of information.
9. Resilience: active recognition of threats and vulnerabilities, particularly through local learning.
10. Strengthened stakeholder capacity: effective participation by stakeholders requires certain skills.

More information on the principles can be found in here: Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses

Whole Landscape Classification System

Here we take a first attempt at an objective, universal, hierarchical classification system for defining all the components of a whole landscape. The purpose of developing a classification hierarchy is to provide a common neutral language and approach for HLP members and future HLP projects. The HLP spans jurisdictions and sectors and members may be required or prefer to use a different classification system in their work. The purpose of the classification system presented here is not to replace classification systems already in use, but to identify (where possible) the common denominators. For this reason, the classification system is high level and does not go to the level of detail found in many regional classification systems.

The classification system is intended to apply across all areas that the HLP works, with a specific focus on the boreal. However, to identify common denominators and develop the classification system we reviewed land classification systems from British Columbia, Alberta, Saskatchewan, and Manitoba (Appendix 1), which encompass areas that are outside of the HLP's areas of focus.

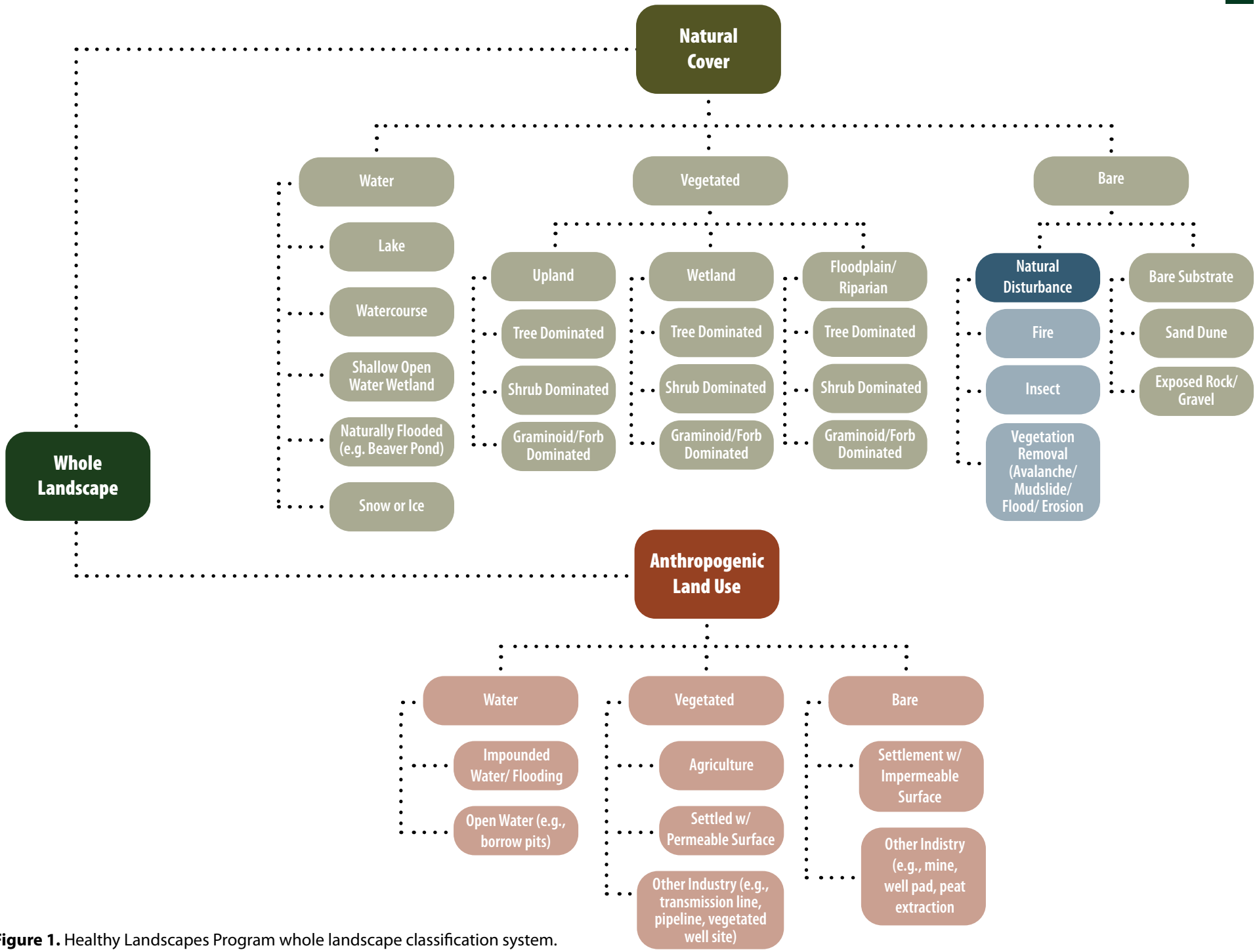

Figure 1. Healthy Landscapes Program whole landscape classification system.

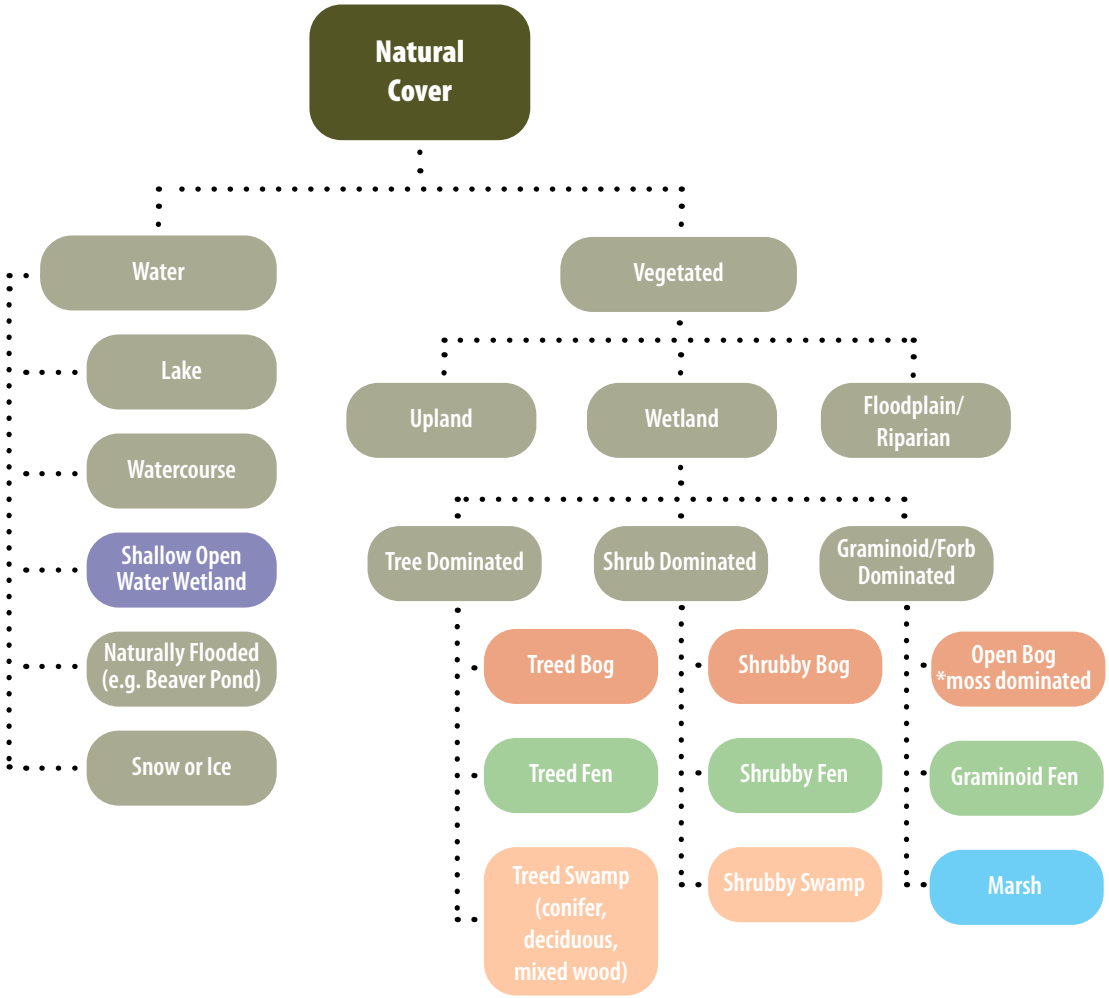

Figure 2. Alignment of the Healthy Landscape Program's whole landscape classification system with the five major wetland classes — shallow open water, marsh, swamp, fen and bog.

Anthropogenic Land Use

Anthropogenic land use refers to areas where humans have significantly influenced the land cover and is broken down into water, vegetated, and bare.

Anthropogenic Water

Water features that have been influenced by humans, for example storm water ponds, hydroelectric reservoirs, or dugouts.

Anthropogenic Vegetated

Vegetated land where the vegetation has been influenced by humans, this can include cultivated areas (agriculture), settlements (e.g., city parks, lawns), and other human land uses that heavily influence vegetation. In this classification system, linear clearings with vegetation remaining (e.g., pipelines, seismic lines, transmission lines) are captured under this category; however, some provincial land classification systems may put them in their own category (e.g., Government of Alberta 2022).

Anthropogenic Bare

Land area with minimal vegetation cover where the lack of vegetation is a result of human activity (e.g., agricultural areas during non-growing season, impermeable surfaces in settlements, industrial sites (e.g., facilities, mines, non-vegetated well pads, gravel pits), linear clearing with vegetation removed (e.g., roads), and other human land uses that result in bare land. Different thresholds exist, typically between 5 – 10%. For example, Alberta Vegetation Inventory Standard sets the threshold as below 6% (Government of Alberta, 2022).

Natural Cover

Water

Water categories encompass areas that consistently have open water and includes lakes, watercourses, and shallow open water wetlands. These categories are generally well-defined as part of provincial or territorial land or waterbody classification systems (***Appendix 1.0*** & ***Appendix 2.0***), though there are differences in definitions and classifications amongst jurisdictions. Categories in the HLP whole landscape classification include:

- **Lake:** Naturally occurring body of water that is greater than 2 meters deep in some portion.
- **Watercourse:** Rivers or streams, formed when water flows between two definable banks.
- **Shallow Open Water Wetland:** Mineral wetland (less than 40cm organic soils) dominated by open water that is less than 2 meters deep.
- **Flooded:** Permanently (longer than seasonally) inundated areas, such as areas affected by beaver activity.
- **Snow or Ice:** Areas covered in snow or ice year-round.

Vegetated - Upland

Most jurisdictions in the western boreal forest have a land classification, ecological classification, or vegetation inventory standard that describes vegetated ecosystems, typically with a focus on upland forested ecosystems developed for the purpose of forest management (***Appendix 1.0***). Examples of relevant resources by jurisdiction include:

- **British Columbia** – British Columbia Land Cover Classification Scheme (Government of British Columbia, 2018)
- **Alberta** - Alberta Vegetation Inventory Standard (Government of Alberta, 2022)
- **Saskatchewan** – Saskatchewan Forest Resource Inventory (Government of Saskatchewan, 2020a)
- **Manitoba** – Forest Lands Inventory (Forestry Corp., 2004)

Categories in the HLP whole landscape classification include:

- **Tree dominated:** Forested classes are commonly defined as having 6% to 100% tree crown closure with the lower end of the threshold varying slightly across different land classification systems (e.g., Alberta Vegetation Inventory 6% vs. BC Land Classification System 10%). Classes within the tree dominated category can vary greatly in detail and type based on jurisdiction, but typically include coniferous, deciduous, and mixed classes. As these classes are often a target of land inventories (or forest inventories) detailed information such as moisture regime, crown closure, height, species composition, productivity information, and more are often included.
- **Shrub dominated:** Shrubs are evergreen or deciduous multi-stemmed perennial plants. Shrub classes may be upland areas that could grow trees, but only have shrubs (e.g., due to natural disturbance such as fire or beaver) or upland areas with limited capacity to support trees (e.g., rocky slopes). Thresholds for shrub classes vary across classification systems, but typically need to meet requirements for overall vegetation cover, low tree crown cover, and ~30+% of vegetation composed of shrubs.
- **Grass dominated:** Naturally vegetated grass classes, referred to as grassland ecosystems, are often intermixed with forested areas in the western boreal forest. Typically, grasslands occur on very coarse sandy soils or gravel deposits that are too dry to sustain trees. Grasslands harbor a diversity of plant and animal species. Their deep root systems store carbon that won't be consumed and released during a wildfire.

Vegetated - Wetland

Wetlands are an essential part of Canada's boreal forest, covering over 1 million km2, or more than 35% of the landbase. Boreal wetlands are ecologically diverse and encompass open, shrubby, and treed classes. The Canadian Wetland Classification System and most jurisdictional classification systems (e.g., Alberta Wetland Classification System, Yukon Wetland Classification System) include five major wetland classes – shallow open waters, marshes, swamps, bogs and fens.

Provincial land classification systems in the western boreal forest capture wetlands in varying ways, but most do not directly include the five classes. For example:

- Saskatchewan Forest Resource Inventory (2020a) includes categories for treed, shrubby, open wetlands.
- British Columbia Land Cover Classification Scheme (2002) first divides the landscape into treed vs. non-treed, then by landscape position (upland, wetland, alpine). Wetlands are captured under both treed and non-treed categories.
- Alberta Vegetation Inventory Standard (2022) Doesn't specifically identify wetlands in the classification schema (except under non-forest bryophytes and lichens).

Because wetlands are often captured in different categories under land classification schemes and these categories often don't directly align with the widely accepted five major wetland classes, wetlands can be missed or mis-interpreted when land management relies on these classifications. For example, there can be discrepancies between provincial or territorial wetland classification systems (where they exist), land classification systems, waterbody classification systems, and land and water requirements in (e.g., timber harvest ground rules). In the HLP Whole Landscape Classification wetlands are captured under "**Natural Cover – Water"** and **"Natural cover – Vegetated – Wetland"** (*Figure 1*). **"Natural Cover – Vegetated – Wetland"** is then divided into treed, shrub, and open like the divisions for upland and floodplain/ riparian. ***Figure 2*** demonstrated how the classes in the HLP Whole Landscape Classification align with the five major wetland classes.

Vegetated – Floodplain and Riparian Areas

Floodplain and riparian areas are areas adjacent to rivers or streams. They are transitions between upland and aquatic ecosystems and may be seasonally flooded. Riparian areas are often, but not always wetlands and there can be significant overlap between these classes. Land classification systems from British Columbia, Alberta, Saskatchewan, and Manitoba do not have a specific category for floodplain and riparian areas. However, they are and important landscape class and typically captured under aquatic and riparian protections (e.g., Alberta timber harvest planning and operating ground rules, 2024).

Natural Cover - Bare

Areas under the natural cover – bare class can include natural disturbances (e.g., recent burn) and non-vegetated substrates (e.g., sand dune, rock, gravel).

Appendix 1.0 Overview of Landscape Classification Systems

Existing Landscape Classification Schema Summaries

Schema	Scale	Basis of Classification	Hierarchical Divisions
National Ecological Framework (Marshall et al. 1999)	National	Soils	Ecozone Ecoregion Ecodistrict
Canadian National Vegetation Classification (classification) and Vegetation Zones of Canada: A Biogeoclimatic Perspective (map) (Curtis et al. 2013)	National	Ecological (vegetation-based), recognizing that ecological zones are modified by climate and geology	Class Subclass Formation Division Macrogroup Group Alliance Association
Natural Regions and Subregions of Alberta (Alberta Parks, 2005)	Provincial		Natural Regions Natural Subregions
Alberta Vegetation Inventory (Government of Alberta, 2024)	Provincial		Moisture Regime Dominant species composition
BC Vegetation Resource Inventory (Government of British Columbia, 2018)	Provincial		Land cover type Landscape position Vegetated Type Density Classes
Saskatchewan Forest Resource Inventory (Government of Saskatchewan, 2020)	Provincial		
BC Biogeoclimatic Ecosystem Classification Program (Baldwin, 2020)	Provincial		Zones Subzones Variants

Canadian Wetland Classification System (National Wetlands Working Group, 1997) and the Canadian Wetland Inventory (in development)	National	Ecological (wetland vegetation-based)	Classes Forms Types
Alberta Wetland Classification System (Alberta Environment and Sustainable Resource Development, 2005) and the Alberta Wetland Inventory	Provincial		Classes Forms Types
Ducks Unlimited Canada's Enhanced Wetland Classification System for the Boreal Plains Ecozone (Ducks Unlimited Canada, 2014)	Regional		Major Classes Minor Classes Types
Wetlands of British Columbia: A Guide to Identification (MacKenzie and Moran, 2004)	Provincial		Site Classes Site Associations

Appendix 2.0 Wetland & Wetland Related Classification Systems

Overview of wetland and wetland related classification systems by jurisdiction.

Jurisdiction	Resource
Canada	- Canadian wetland classification system - Stewart & Kantrud Classification System (for the prairie pothole region) - Cowardin Classification System (could only be applied to BC)
BC	- Riparian Management Area Guidebook (expanding the headers will show you the classifications) - A Classification Framework for Wetlands and Related Ecosystems in British Columbia - Oil and gas commission Environmental Protection and Management Guideline (Chapter 5) and Riparian Classification (part 4) - Wetlands of British Columbia - Compendium of Forest Hydrology and Geomorphology in British Columbia Pages 482(121) - 495 (134)
Alberta	- Alberta Wetland classification system - Alberta timber harvest planning and operating ground rules (2024) - EAP Approval Standards Appendix A: Provincial watercourse and water body descriptions
Saskatchewan	- FRI: Land class - generalized - The forest operating standards
Manitoba	- Field Guide boreal wetland classes in the Boreal Plains Ecozone of Canada (DUC, 2014) - Wetland Classification Key - DUC Manitoba Prairie Wetland Classification Guide

Literature Cited

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

Alberta Parks. (2005). Natural subregions of Alberta [PDF]. https://albertaparks.ca/media/442827/nsr2005_final_letter.pdf

Andison, D. (2020). EBM is a journey review. fRI Research Healthy Landscapes Program.

Baldwin, K. A. (2020). Vegetation zones of Canada: A biogeoclimatic perspective. Natural Resources Canada = Ressources naturelles Canada.

Biogeoclimatic Ecosystem Classification (BEC) and Ecology Research Program. (2023). BECWeb. Forest Service British Columbia - Research Branch. https://www.for.gov.bc.ca/hre/becweb/

British Columbia. (2010). Environmental Management Act: Part 4. https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/200_2010#part4

British Columbia Energy Regulator. (2024). Environmental protection and management guideline (Chapter 5). https://www.bc-er.ca/files/operations-documentation/Environmental-Management/Environmental-Protection-and-Management-Guideline.pdf

British Columbia Ministry of Forests. (2004). Riparian management area guidebook. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/silvicultural-systems/silviculture-guidebooks/riparian-management-area-guidebook

Cowardin, L. M., Carter, V., Golet, F. C., & LaRoe, E. T. (1979). Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page.

Curtis, S., Meades, B., Baldwin, K., Faber-Langendoen, D., Harcombe, A., McLennan, D., Lautenschlager, R. A., & Hendrickson, O. (2013). Canadian National Vegetation Classification (CNVC). http://cnvc-cnvc.ca/index.cfm

Ducks Unlimited Canada. (2014). Boreal wetland classes in the boreal plains ecozone of Canada: Field guide.

Ducks Unlimited Canada. (2015). Operational guide for forest road wetland crossings. Ducks Unlimited Canada.

Ducks Unlimited Canada. (2019). The Manitoba Wetland Classification Guide. Native Plant Solutions. Winnipeg, MB.

Forest Management and Wetland Stewardship Initiative (FMWSI). (2018). Guiding principles for wetland stewardship and forest management: Technical report. Ducks Unlimited Canada.

Government of Alberta. (2013). Enhanced approval process (EAP): Integrated standards guide (Appendix D: Provincial watercourse and water body descriptions). https://open.alberta.ca/dataset/633dc6c2-8b96-4602-bbf0-f1bd40437ae9/resource/feddfcb8-d81d-4011-8247-59b1f5b162c6/download/2013-enhanced-approval-process-eap-integrated-standards-guide-2013-12-01.pdf

Government of Alberta. (2022). Alberta vegetation inventory standards Version 2.1.5. Government of Alberta, AB. https://open.alberta.ca/dataset/a35dcb86-eaa2-492f-9541-93d35174ee06/resource/5124f3e7-05d7-4d88-b489-252d749e81a8/download/afred-alberta-vegetation-inventory-standards-version-2-1-5.pdf

Government of Alberta. (2024). Timber harvest planning and operating ground rules (FPT). https://open.alberta.ca/dataset/0df77414-cdb6-4e34-8972-2e422bbeaafc/resource/66326942-a29c-43fc-80d9-af29c73c5804/download/fp-timber-harvest-planning-and-ogr-2024.pdf

Government of Alberta. (2024). Alberta Vegetation Inventory [database]. https://open.canada.ca/data/en/dataset/64b0e73a-da5f-4f7f-bca1-b656b6e86c94

Government of British Columbia. (2002). Vegetation Resource Inventory [electronic resource]: the B.C. land cover classification scheme – Version 1.3. Government of British Columbia. BC.

Government of British Columbia. (2018). Forest inventory [database]. Government of British Columbia. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory

Government of Manitoba. (n.d.). Wetlands classification key. Manitoba Conservation and Climate, and Manitoba Agriculture and Resource Development. https://www.gov.mb.ca/sd/pubs/water/water_rights/mb_wetlands_classification_key.pdf

Government of Saskatchewan. (2020a). Forest inventory standard. Government of Saskatchewan. https://publications.saskatchewan.ca/#/products/110320

Government of Saskatchewan. (2020b). Forest resource inventory [database]. Government of Saskatchewan. https://environment-saskatchewan.hub.arcgis.com/pages/forest_resource_inventory#FRIABO

Government of Saskatchewan. (2021). Saskatchewan land cover 2021 [database]. Government of Saskatchewan. https://saskatchewan.maps.arcgis.com/home/item.html?id=fa9d70da3ec64dd393d01b6ce28c6a98

MacKenzie, W., & Banner, A. (2001). A classification framework for wetlands and related ecosystems in British Columbia: Third approximation. British Columbia Ministry of Environment, Lands and Parks. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/ecosystems/bec/wrec20classification20framework20jan202001.pdf

MacKenzie, W. H., & Moran, J. R. (2004). Wetlands of British Columbia: A guide to identification. Res. Br., B.C. Min. For., Victoria, B.C. Land Manage. Handb. No. 52.

Marshall, I. B., Schut, P. H., & Ballard, M. (1999). A national ecological framework for Canada: Attribute data. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research, and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull.

National Wetlands Working Group, Canada Committee on Ecological Land Classification. (1997). The Canadian wetland classification system (B. G. Warner & C. D. A. Rubec, Eds.). Wetlands Research Branch, University of Waterloo.

Pike, R. G., Redding, T. E., Moore, R. D., Winker, R. D., & Bladon, K. D. (Eds.). (2010). Compendium of forest hydrology and geomorphology in British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. and FORREX Forum for Research and Extension in Natural Resources, Kamloops, B.C. Land Manag. Handb. 66. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66.htm

Rempel, R. S. (2022). Canada warbler resource selection function (RSF) Bayesian model: Methods and performance summary. FERIT Environmental Consulting.

Sakaw 1st Nation. (2020, July 8). Forest operations standard. https://www.sakaw.ca/government_documents/2021/Forest%20Operations%20Standard%20-%2008July2020.pdf

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., Venter, M., Boedhihartono, A. K., Day, M., Garcia, C., van Oosten, C., & Buck, L. E. (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proceedings of the National Academy of Sciences, 110(21), 8349–8356. https://doi.org/10.1073/pnas.1210595110

Stewart, R. E., & Kantrud, H. A. (1971). Classification of natural ponds and lakes in the glaciated prairie region. Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C., USA. Resource Publication 92.

The Forestry Corp. (2004). Forest lands inventory user guide. Prepared for Louisiana-Pacific Canada Ltd. and Manitoba Conservation.