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Yukon Ecological and Landscape Classification (ELC) Guidelines Version 1.0

By

Ecological and Landscape Classification Program

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MERG is a cooperative working group made up of the Federal and Yukon Governments, Yukon First Nations, mining companies, and non-government organizations for the promotion of research into mining and environmental issues in Yukon.

July 16, 2013

Letter of Introduction: Ecosystem and Landscape Classification and Mapping Guidelines

On behalf of the Ecological and Landscape Classification (ELC) Program, I am pleased to submit our *Ecosystem and Landscape Classification and Mapping Guidelines*. Guidelines provided in this document are best practices for collecting, creating and applying ecological data and mapping in environment assessments and resource plans in Yukon. To develop these guidelines, we consulted with experts within Yukon government, Yukon Environment and Socioeconomic Assessment Board, and the private sector - both within and outside Yukon.

The report is divided into six sections, as follows:

- Background about the purpose of and need for Ecosystem and Landscape Classification and Mapping guidelines is provided in Section 1.0
- A brief overview of the Yukon ELC Program is provided in Section 2.0
- An overview of the Yukon ELC Frameworks and their intended applications is discussed in Section 3.0
- Technical aspects of the Yukon Bioclimate Framework mapping guidelines are described in Section 4.0, including a background on mapping concepts
- Information management is discussed in Section 5.0
- Steps for conducting an ELC project are outlined in Section 6.0

As ecological classification and mapping standards are published they will be incorporated into the *Ecosystem and Landscape Classification and Mapping Guidelines.* The draft "Yukon Ecosystem and Landscape Classification (ELC) Framework: Overview and Concepts (released for review Feb 2011) will be revised to provide technical background for classification concepts not covered in the ELC Guidelines report. ELC practitioners, who require an in-depth treatment of ecological and landscape classification concepts, are encouraged to contact the ELC Coordinator to inquire about training opportunities and background material.

Readers interested in learning more about the strategic direction of the ELC Program can review our Five-Year Strategic Plan downloadable from our our projects and initiatives page **www.env.gov.yk.ca/elc.**

To everyone who reviewed drafts of the report and contributed to the development of its content, I extend my deep gratitude.

Sincerely, on behalf of the ELC Program

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This report would have been significantly more difficult to produce without the benefit of research and standards reports produced and made accessible by the ecological and landscape classification community. In particular, we have borrowed and referenced material produced over the years by the B.C. Ministry of Forests and Range, Research Branch.

Financial assistance for preparing this report was provided by Yukon Environment, Policy and Planning Branch and Mining and Petroleum Environmental Research Group (MPERG).

1.0 INTRODUCTION

BACKGROUND

Ecological classification and mapping refers to an integrated approach to mapping and classifying units of land according to their ecological similarity (Rowe 1979). The aim of ecosystem classification and mapping is to provide information on the biological and physical characteristics of landscapes in order to facilitate a range of natural resource management interpretations (Rowe and Sheard 1981).

Vegetation and ecological classification and mapping have a long history of practice in the Yukon. Through early federal initiatives, Oswald and Senyk (1977) completed the initial *Ecoregions of the Yukon* mapping and, shortly after, Wiken et al. (1981) conducted ecological land surveys in northern Yukon. In the 1980s the Yukon Department of Renewable Resources initiated vegetation and ecological inventory programs for the Southern Lakes (Davies et al. 1982) and Macmillan Pass (Davies et al. 1983) areas. Also in the 1980s and 1990s, the Department of Indian and Northern Affairs completed forest inventory mapping for much of southern Yukon. The first iteration of soil landscape mapping was completed by White et al. (1992) and also around this time, a draft forest ecosystem classification was developed for southeast Yukon (Zoladeski et al. 1996). More recently, as part of the National Ecological Framework of Canada (ESWG 1995), Yukon's terrestrial ecozones and ecoregions were updated and described by a Yukon working group, resulting in the widely-used publication *Ecoregions of Yukon* (Smith et al. 2004).

In 2002 a multi-agency biophysical technical working group was established to advance ecological classification and mapping concepts. Over a period of ten years, the efforts and contributions of this group led to the establishment of a formal Yukon Ecological and Landscape Classification (ELC) Program (Yukon ELC Program) within Environment Yukon. In spring of 2013, the Yukon ELC Program released a 5-year Strategic Plan to develop and distribute ecological classification and mapping information for Yukon.

PURPOSE

Development of a standardized ecosystem classification and mapping framework is intended to facilitate improved land and resource management decisions and foster improved coordination between Yukon resource sectors and managers. While ELC is not currently a mandated activity in Yukon, it supports multiple management activities by providing consistent, integrated base mapping from which different environmental and landscape interpretations can be developed. ELC mapping supports environmental and cumulative effects assessment, land use and conservation planning, wildlife habitat management, forest management, and integrated resource management. Standards and guidelines are needed to ensure consistency in how ecological classification and mapping is developed and used.

This document, *Yukon ELC Guidelines*, has been developed for a variety of audiences who require an understanding of, and guidance on, the use and application of ecological classification and mapping products. A key audience is Yukon's land and resource development sectors, including mining, oil and gas, forestry, infrastructure development, and municipal development and planning. This document provides guidance on the following topics:

- What type of ELC product should be used for specific applications;
- What mapping scale and level of accuracy is desired for different applications; and
- Suggested methods and considerations for conducting ELC.

The value of ELC as a tool in environmental assessment and resource planning and management is provided through a number of case studies. This document also serves to inform Yukon land and resource practitioners about the Yukon ELC Program and provides an overview of the Yukon ELC Frameworks. Information on important ELC classification and mapping concepts is also included.

This document is the first iteration of ELC *Standards* for Yukon. As the Yukon ELC Program evolves, changes to the *Guidelines* and more detailed technical standards will be produced. Until these Yukon products are completed, guidelines and standards from other jurisdictions are referenced for use in Yukon. Efforts to produce standardized ecological classifications and ecosystem guidebooks for different areas of the territory are ongoing.

HOW TO USE THESE GUIDELINES

Users are directed to the following sections:

- A brief overview of the Yukon ELC Program is provided in Section 2.0;
- An overview of the Yukon ELC Frameworks and their ecological concepts and intended applications is discussed in Section 3.0;
- Technical aspects of the Yukon Bioclimate Framework mapping guidelines are described in Section 4.0, including a background on mapping concepts;
- Information management is discussed in Section 5.0; and
- Suggested steps for conducting an ELC project are outlined in Section 6.0.

2.0 ABOUT THE YUKON ELC PROGRAM

The Yukon ELC Program has a mandate to develop and deliver an ecological classification and mapping system for Yukon on behalf of Yukon Government and its project partners. It will conduct territory-wide ecological classification and mapping activities that provides expert knowledge of Yukon landscapes and accessible map products. This knowledge is a foundation for responsible resource planning and management. Two Yukon Government departments, Environment and Energy, Mines and Resources, are working collaboratively to promote and conduct ELC activities.

Administered from Environment Yukon's Policy and Planning Branch, the Yukon ELC Program has its own budget and **ELC Coordinator**. The Yukon ELC Program is managed by an **ELC Supervisory Committee** of senior staff from Environment and Yukon Energy, Mines and Resources. Additional program oversight includes interdepartmental and external stakeholders, so it can be adapted to meet evolving needs. This structure encourages input and guidance from a variety of sources. An **ELC Technical Working Group (TWG)** contributes technical expertise to the Yukon ELC Program and to the development of specific products or technical methods. The TWG includes representatives of government and non-government groups.

A five-year Strategic Plan (2012-2017) outlines the goals and major tasks for the Yukon ELC Program. Three priority areas have been identified:

- **Yukon ELC Frameworks:** Develop a uniform approach to Yukon ecological and landscape classification and mapping that facilitates the integration and exchange of ecosystem knowledge across multiple disciplines;

- **Yukon ELC Standards:** Ensure the ELC products are developed from a set of defined, consistent, and coordinated standards. These products will provide foundational ecological information for sustainable resource planning and management; and
- **Yukon ELC Program Services:** Enhance understanding of Yukon's landscapes by integrating ecological knowledge into decision-making across government. This understanding will enhance our policy and decision-making to sustainably manage Yukon's landscapes and ecosystems.

3.0 YUKON ELC CONCEPTS AND FRAMEWORKS

Two ecological frameworks are currently recognized in Yukon:

1) **Yukon Bioclimate Framework**; and
2) **National Ecological Framework of Canada**

The two frameworks are based on different ecological concepts and have different applications but are intended to be used together in a complementary manner. The Yukon Bioclimate Framework (YBF) is generally modeled after the *Biogeoclimatic Ecosystem Classification System of British Columbia* (Pojar et al. 1987; Meidinger and Pojar 1991). The YBF has both a climate and site-level classification but considers climate to be the primary influence on ecosystem development and distribution. The YBF is being designed to provide detailed site-level ecological mapping and interpretations required by some resource sectors. Efforts to develop detailed site-level units are ongoing.

The National Ecological Framework of Canada (NEF) identifies and describes the biophysical properties of large land units based on ecological similarity (ESWG 1995). The NEF subdivides Canada into ecologically similar areas based on the integration of climate, physiography, landform, and vegetation. The NEF is a well-developed system that has supported many Yukon land and resource management activities. In Yukon it is best represented by the *Ecoregions of Yukon* (Smith et al. 2004). While the NEF supports a range of regional interpretations, it is less suited to the detailed mapping requirements of some resource sectors.

Each framework is discussed below.

YUKON BIOCLIMATE FRAMEWORK

3.1.1 Overview

Bioclimate classification is an approach to understanding and classifying ecosystems that considers climate to be the primary influence on regional vegetation and ecosystem development and distribution. Differences in climate—most importantly temperature and precipitation—create different growing conditions which influence vegetation species composition, structure and growth, resulting in different ecosystems. While other factors such as landforms and soil influence local vegetation and ecosystem distribution, climate differences are considered to be most important.

Climate differences can occur at different spatial scales such as sub-continental (e.g., northern versus southern Yukon) or sub-regional due to the effects of elevation (e.g., low elevation valley bottoms versus high elevation alpine areas). The orientation of mountain ranges and distance from major water bodies, most importantly the Pacific and Arctic Oceans, also affect temperature and precipitation patterns. All of these factors—latitude, elevation, physiography and landform—interact at different scales, creating differences between geographic areas that are characterized by warmer, cooler, wetter or drier climates. Bioclimate classification attempts to categorize the different areas of Yukon according to these climate characteristics, and identifies representative mature vegetation growing on ‘reference sites’ that can be used to characterize each climatic area along with climate data.

3.1.1.1 Classification

The YBF incorporates a bioclimate and site classification organized into different levels, based on the influence of ecological factors and scale. A bioclimate classification describes regional and sub-regional climatic patterns while the site classification is used to describe local site and vegetation conditions. The YBF is hierarchical in organization; the local site-level classification is nested within the broad bioclimate areas. The bioclimate and site classifications are as follows:

1. Bioclimate Classification

Bioclimate Zone

Within Yukon’s broad climatic regions (e.g., subarctic, boreal), **bioclimate zones** are areas with similar climate that support a reference ecological community—termed a **reference ecosite**. The reference ecosite occurs on gentle slopes with typical soil conditions (e.g., medium textured soils with moderate drainage) where local site factors such as soil and landscape position are less important than climatic influences. Seven bioclimate zones are currently recognized in Yukon (Table 1).

Bioclimate Subzone

Bioclimate subzones are more detailed divisions of bioclimate zones. For example, the Boreal Low bioclimate zone may have different characteristics depending on whether it occurs in southwest Yukon (cooler and drier) or southeast Yukon (warmer and wetter). The same general ecological community will characterize both the bioclimate zone and subzone it occurs within, but subzone reference ecosites may have different productivity or slightly different vegetation characteristics. At this time, bioclimate subzones have not been identified for all areas of Yukon.

Table 1. Overview of Yukon bioclimate zones.

Bioclimate Zone	Code	Description
BOREAL BIOCLIMATE ZONES (SOUTHERN YUKON)		
Boreal Low	**BOL**	Continuously forested areas at low to middle elevations, below the BOH of all mountain valley and plateau regions of southern and central Yukon. Winters are long and cold, with short, cool and dry summers. Forests are generally mixedwood (lodgepole pine, white spruce and aspen) with moderately developed understories. Wetlands are common.
Boreal High	**BOH**	Middle to upper elevations of forested areas in all mountain valley and plateau regions of southern and central Yukon. Found above the BOL in large valleys. Characterized by steep slopes in southern mountainous regions and gentle rolling plateaus in the central regions. Summers are brief, cool and moist, with long cold winters. Forests are dominated by white spruce, lodgepole pine, and subalpine fir.
Subalpine	**SUB**	Sparsely forested areas at moderate to higher elevations on steep slopes above the BOH (or BOL). Subalpine areas form a transitional zone between forested Boreal and the higher elevation non-forested, Alpine bioclimate zones. Open canopy conifer forests (tree cover < 20%) and tall shrub communities are characteristic vegetation conditions. Depending on the geographic area, either subalpine fir or white spruce are the predominant tree species. Winters are long and cold, while summers are short, cool and moist.
TAIGA AND ARCTIC BIOCLIMATE ZONES (NORTHERN YUKON)		
Taiga Wooded	**TAW**	Coniferous or mixedwood forested areas with an open canopy in northern Yukon. Taiga Wooded generally occurs in valley bottoms and lower slopes of mountain valleys, or on plateaus and plains. Slope position, aspect and the distribution and depth of permafrost are major influences on vegetation distribution and dynamics. In steep terrain, active slope processes (rock slides, slumps, talus cones) play a major role in the distribution of forests.
Taiga Shrub	**TAS**	High elevation Taiga Shrub replaces the term 'Subalpine' in northern Yukon. These areas are tall or low shrub-dominated, with sparse or sporadic tree cover. Taiga Shrub generally occurs at high elevations in northern mountain systems. However, the distribution of Taiga Shrub in some areas of northern Yukon appears to be influenced by arctic weather systems this situation may require a different bioclimate zone designation similar to BOH and BOL.
Arctic	**ARC**	High latitude areas along the Arctic Ocean in northern Yukon above the arctic tree line. Dwarf shrubs, tussock tundra, herb/cryptograms and low-growing and scattered krummholtz trees are the predominant vegetation condition.
ALPINE BIOCLIMATE ZONE (all of Yukon)		
Alpine	**ALP**	High elevations associated with mountainous conditions throughout Yukon. Dwarf shrubs, herb/cryptograms and low-growing and scattered krummholtz trees are the predominant vegetation condition. In very high elevation areas, bare rock, colluvium or ice/snow may be the dominant conditions.

2. Site Classification

Ecosite

Ecosites are the detailed site-level 'building blocks' of the YBF and are interpreted within the context of the bioclimate zone or subzone in which they occur. Ecosites are relatively stable enduring features defined by characteristic site conditions (soil moisture and nutrient regime) and landscape positions. Conceptually, ecosites may be organized along a landscape profile—called a **toposequence**—where certain ecosites are associated with different areas of the landscape based on moisture, nutrients and other factors (Figure 1). An **edatopic grid** is used to show the relative moisture and nutrient conditions associated with ecosites, and how different ecosites are organized in relation to each other (Figure 2). Within a bioclimate zone or subzone, the location of ecosites in the landscape is expected to be relatively predictable. Ecosites have characteristic vegetation associations that are described based on their mature or relatively stable phase.

Ecosite Phase

Ecosite phase is a more detailed level of the ecosite classification. While ecosites represent vegetation potential, ecosite phase describes the current vegetation characteristics of the ecosite. In a disturbance dominated landscape like Yukon's boreal forest, where much of the landscape may be in a young post-fire condition, describing the current vegetation characteristics of ecosites is required. Ecosite phase describes either the successional stage (either the seral or structural condition) of the current vegetation growing on a specified ecosite. The Canadian National Vegetation Classification (CNVC) (http://cnvc-cnvc.ca) is being used to identify and describe the vegetation associations that will form the different vegetation phases of ecosites. Ecosite phase is interpreted within the context of the bioclimate zone or subzone it occurs within.

Status of YBF Site-level Classification in Yukon

The Yukon ELC Program has partnered with the Yukon Environment Habitat Unit to describe vegetation associations for treed, shrub, grassland and wetland communities across Yukon. This project, initiated by the Habitat Unit in 2004 in partnership with the Canadian Forest Service, has produced a preliminary ecological classification for the arctic region of Canada (including Yukon). A preliminary version of the treed ecological associations for Yukon is anticipated in 2013. These ecological or vegetation associations will be organized within an edatopic grid, and used to describe ecosites along generalized toposequences for different bioclimate zones and subzones. For those interested in further information about the Yukon Vegetation Project please contact Catherine Kennedy, Yukon Environment Vegetation Ecologist. For more information about how the Yukon Vegetation Project is being incorporated into the YBF ecosystem classification please contact the ELC Coordinator (contact information is provided in Section 0).

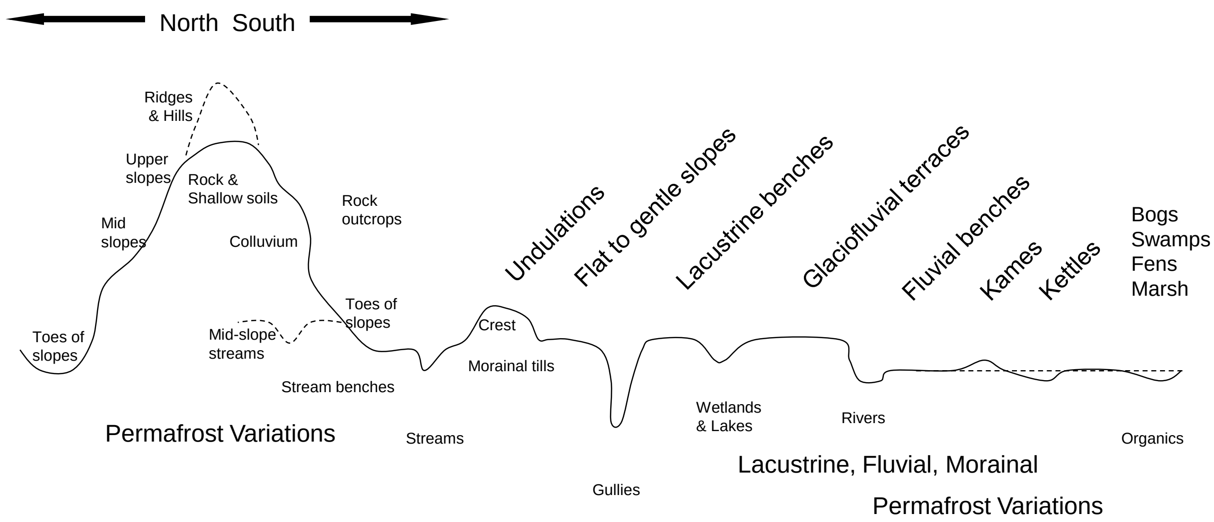

Figure 1. Example toposequence illustrating different landscape positions and other factors that influence the distribution of ecosites.

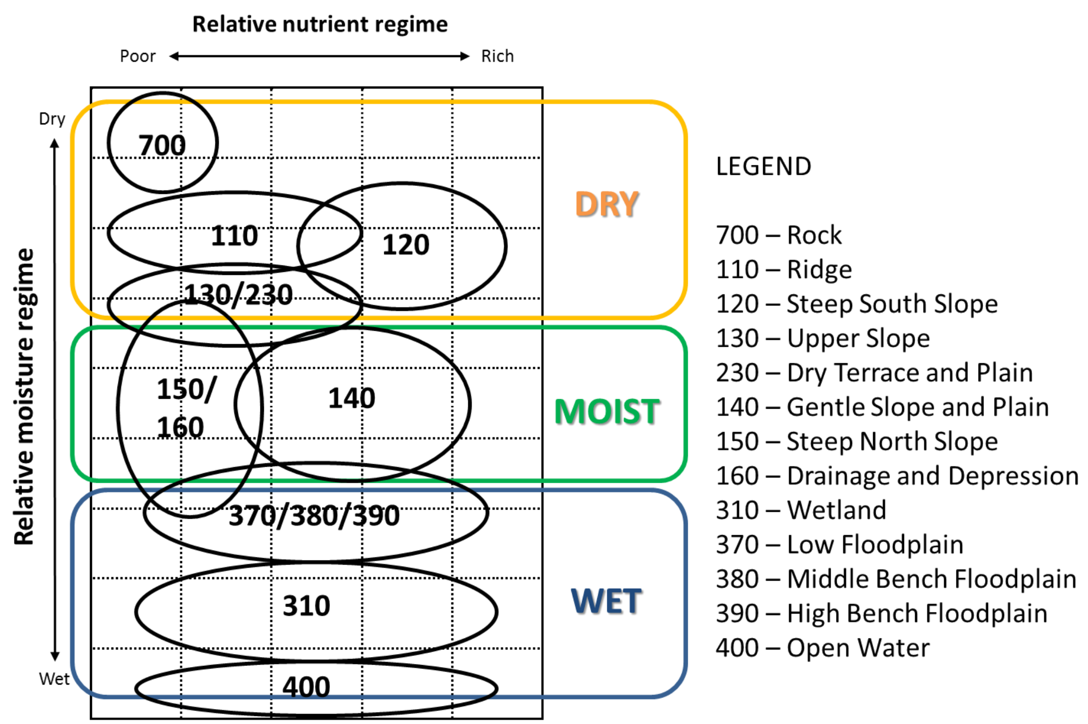

Figure 2. Example edatopic grid illustrating relative moisture and nutrient position of different broad ecosystem types in east-central Yukon. Source: *Regional Ecosystems of East-Central Yukon* (Makonis 2012b).

3.1.1.2 Mapping

The YBF has three mapping levels. From the most generalized to the most detailed they are:

1. Bioclimate Zones and Subzones

Bioclimate zones and subzones are relatively large areas with similar climatic conditions. They are characterized by reference ecosites. Draft mapping of Yukon's bioclimate zones has been completed (Figure 3). Bioclimate zone or subzone mapping shows the major ecological patterns across Yukon and is intended for regional applications (1:100,000 to 1:1,000,000 scale). This mapping is used to establish ecological context for broad or local ecosystems, and can be combined with other map information such as ecoregions or Yukon Vegetation Inventory (forest inventory) to produce required interpretations. As of the date of this publication, bioclimate subzone mapping has not been finalized for Yukon. A draft version of bioclimate subzones however is being assessed using climate data and distribution of vegetation associations on reference and non-reference ecosites. For more information about Yukon bioclimate zones and subzones please contact the ELC Coordinator (section 6.1).

2. Broad Ecosystems

Broad ecosystems are generalized ecosites. Broad ecosystems of a mapping level of the bioclimate ecosystem classification framework, not a formal part of the classification. This mapping level is included in the YBF to provide basic ecosystem information for large geographic areas in a rapid and cost effective manner. Broad ecosystems are designed to be mapped and interpreted at scales relevant for regional applications (1:50,000 to 1:250,000), including regional land use planning, wildlife management and cumulative effects assessment. Broad ecosystem mapping has been completed for approximately half of the Yukon (North Yukon, Peel Watershed and Dawson planning regions, and Ross River area).

Broad ecosystems are usually mapped using predictive ecosystem mapping methods through the use of GIS, satellite imagery or other landcover information, surficial geology and elevation model analysis. These data are combined in different ways depending on available information and knowledge of ecosystems within a project area. As with local ecosystems, broad ecosystem units (BEUs) include a 'site' and 'phase' component – these are termed **BEU type** and **BEU phase**, respectively. The BEU phase in this context describes the generalized vegetation condition occurring on a site (e.g., deciduous versus coniferous forest). BEUs are intended to be interpreted within the context of bioclimate zones or subzones.

3. Local Ecosystems

Local ecosystem mapping is the most detailed mapping level of the YBF. Local ecosystems are intended to be mapped and interpreted at large scales (1:10,000 to 1:50,000). This mapping is usually completed using manual mapping methods in areas where higher levels of detail and accuracy are required, such as for transportation corridor planning, or environmental assessment to support mining, oil and gas, forest harvest planning, or municipal development activities. Local ecosystem mapping consists of **ecosite** and **ecosite phase** mapping. A number of local ecosystem mapping projects using different methods and terminology have been completed throughout Yukon.

Table 2 shows the organizational hierarchy of YBF classification and associated map products.

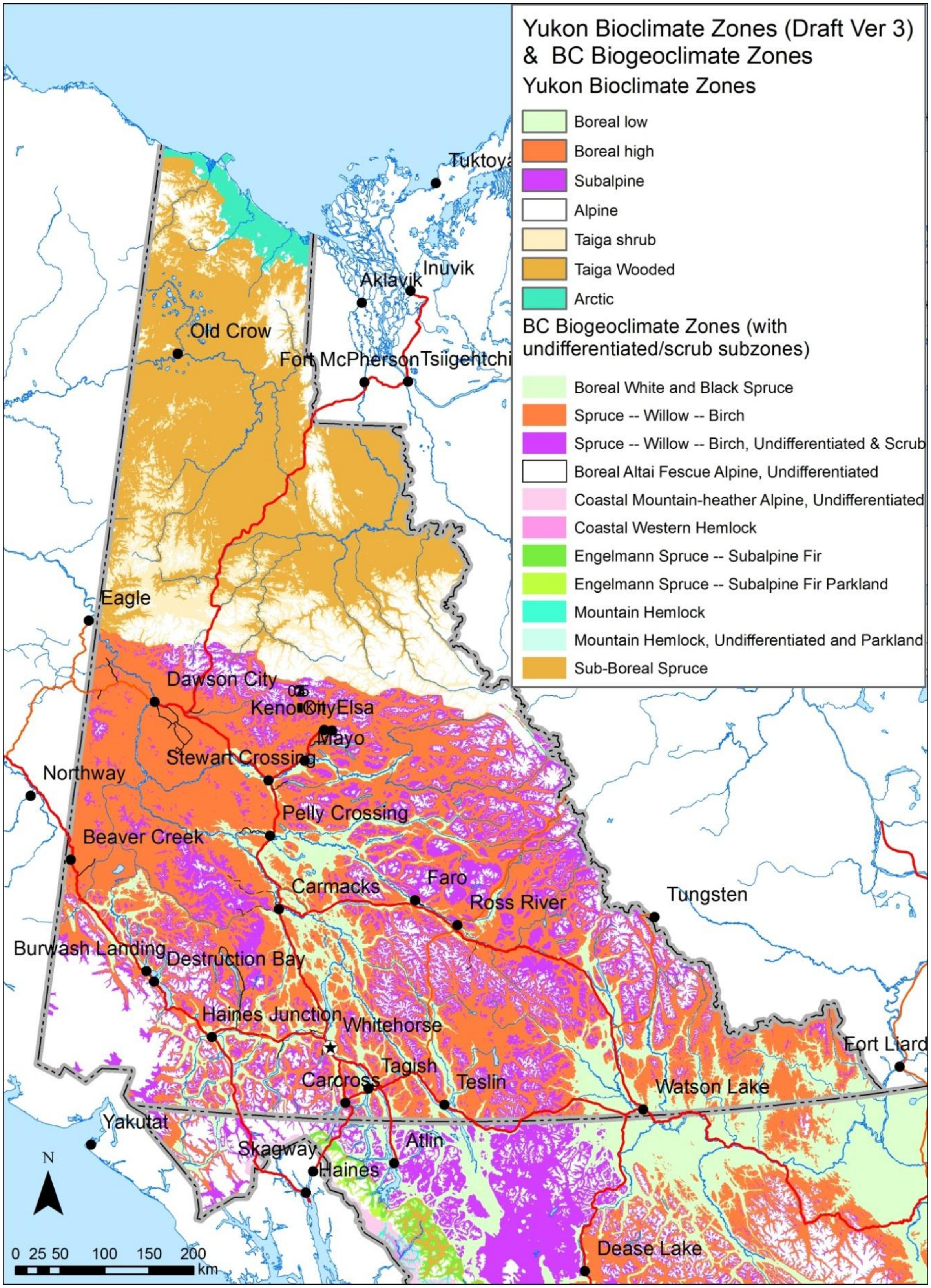

Figure 3. Yukon bioclimate zones (version 3.0 interim release, December 2012) and adjacent biogeoclimatic zones in British Columbia (version 8.0 release Feb 2012).

Table 2. Spatial hierarchy of Yukon Bioclimate Framework classification and mapping levels.

YBF Classification Level	YBF Mapping Level		Example
BIOCLIMATE	**Bioclimate** (1:100,000 to 1:1,000,000 scale)	Zone	Boreal Low
		Subzone	Southern Lakes
SITE	**Broad Ecosystems** (1:50,000 to 1:250,000 scale)	Type	Dry Terrace and Plain
		Phase	Coniferous
	Local Ecosystems (1:10,000 to 1:50,000 scale)	Ecosite	Lodgepole Pine-Spruce-Grass-Lichen
		Phase	Lodgepole Pine-Lichen / young-seral

Regional
SCALE
Local

3.1.2 Management Applications

The broad ecosystem and local ecosystem (ecosite) mapping levels are well suited to identifying and describing ecosystems at scales required by many resource management activities. Bioclimate zones and subzones establish the appropriate ecological context in which to interpret broad and local ecosystem mapping. Management applications of the different YBF mapping levels are listed in Table 3. Case study examples are provided to illustrate how different mapping products have been used to support different Yukon land and resource management initiatives. Many YBF mapping products have been used for multiple applications.

Table 3. Management applications of the Yukon Bioclimate Framework mapping levels.

YBF Mapping Level	Management Applications
Bioclimate (1:100,000 to 1:1,000,000 scale)	• Forest management • Conservation area planning and representation • Climate change studies • Regional land use planning • State of Environment reporting
Broad Ecosystems (1:50,000 to 1:250,000 scale)	• Wildlife and habitat management • Cumulative effects assessment and management • Regional land use planning • Conservation area planning and representation • Mineral exploration planning • Oil and gas exploration and development • Sensitive or rare ecosystem mapping • Land capability (e.g., agriculture, aggregate) • Cultural use
Local Ecosystems (1:10,000 to 1:50,000 scale)	• Transportation and infrastructure planning (transportation corridors and other industrial infrastructure) • Municipal and local area planning (urban and rural residential) • Project-level environmental impact assessment (e.g., fish and wildlife values, environmental sensitivity, etc.) • Sensitive or rare ecosystem mapping • Watershed planning and effects modeling • Mineral development planning (mine sites) • Oil and gas exploration and development • Land reclamation (e.g. mining, gravel pits) • Forest management

NATIONAL ECOLOGICAL FRAMEWORK OF CANADA

3.1.3 Overview

The NEF uses a divisional approach to classifying and mapping ecological areas to identify land units with similar biophysical properties at different scales (ESWG 1995). The system is hierarchical, with more detailed units being divisions of broader scale units. The NEF has a strong focus on physiography and landscape patterns but also considers climate and vegetation. At the continental scale, ecological units are subdivisions of major climatic zones and broad physiographic regions (e.g., Boreal Cordillera, Taiga Cordillera, etc.) Within these broad **ecozones**, smaller geographic areas—**ecoregions** and **ecodistricts**—are identified with an increasing emphasis on similar landforms, climate and vegetation patterns. In the NEF, each area can be viewed as a discrete system resulting from the interactions of geology, landform, soil, vegetation, climate, wildlife and human factors (Smith et al. 2004).

Three levels of the NEF are used in Yukon. From the most generalized to the most detailed they are:

1. Ecozones

Ecozones are areas of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting abiotic factors. Five ecozones are recognized in Yukon, with the Boreal and Taiga cordillera being the largest units.

2. Ecoregions

Ecoregions represent smaller areas of ecozones characterized by distinctive physiography and ecological responses to climate as expressed by the development of vegetation, soil, water and fauna. Ecoregions have formed an important reporting framework for many Yukon management initiatives and processes.

3. Ecodistricts

Ecodistricts are parts of ecoregions characterized by distinctive assemblages of relief, geology, landforms, soils and vegetation. Ecodistricts are the most detailed level of the National Ecological Framework used in Yukon, and have been used as reporting units and inputs to other mapping.

Soil landscape units of the Soil Landscapes of Canada (SLC) database are large-scale (detailed) physiographic units. The SLC database, developed and maintained by Agriculture and Agri-food Canada, is the foundational linework upon which ecodistricts, ecoregions and ecozones are developed. Updated soil landscape unit mapping has been completed for all of Yukon at a map scale of 1:250,000.

Status of NEF in Yukon

The Yukon ELC Program has formed a working group to refine currently published (ESWG 1995; Smith et al. 2004) ecoregion linework and classification concepts (Figure 4). Until this new product is adopted, *Ecoregions of Yukon* (Smith et al. 2004) should be used as the primary source of ecoregion descriptions and mapping. Revisions will reflect current understanding of glacial history and boreal vegetation characteristics, and incorporate advances in digital base data and relief mapping. Ecoregion boundaries have been correlated with adjacent jurisdictions (Alaska, NWT and British Columbia). A case study describing the new ecoregion updates is provided.

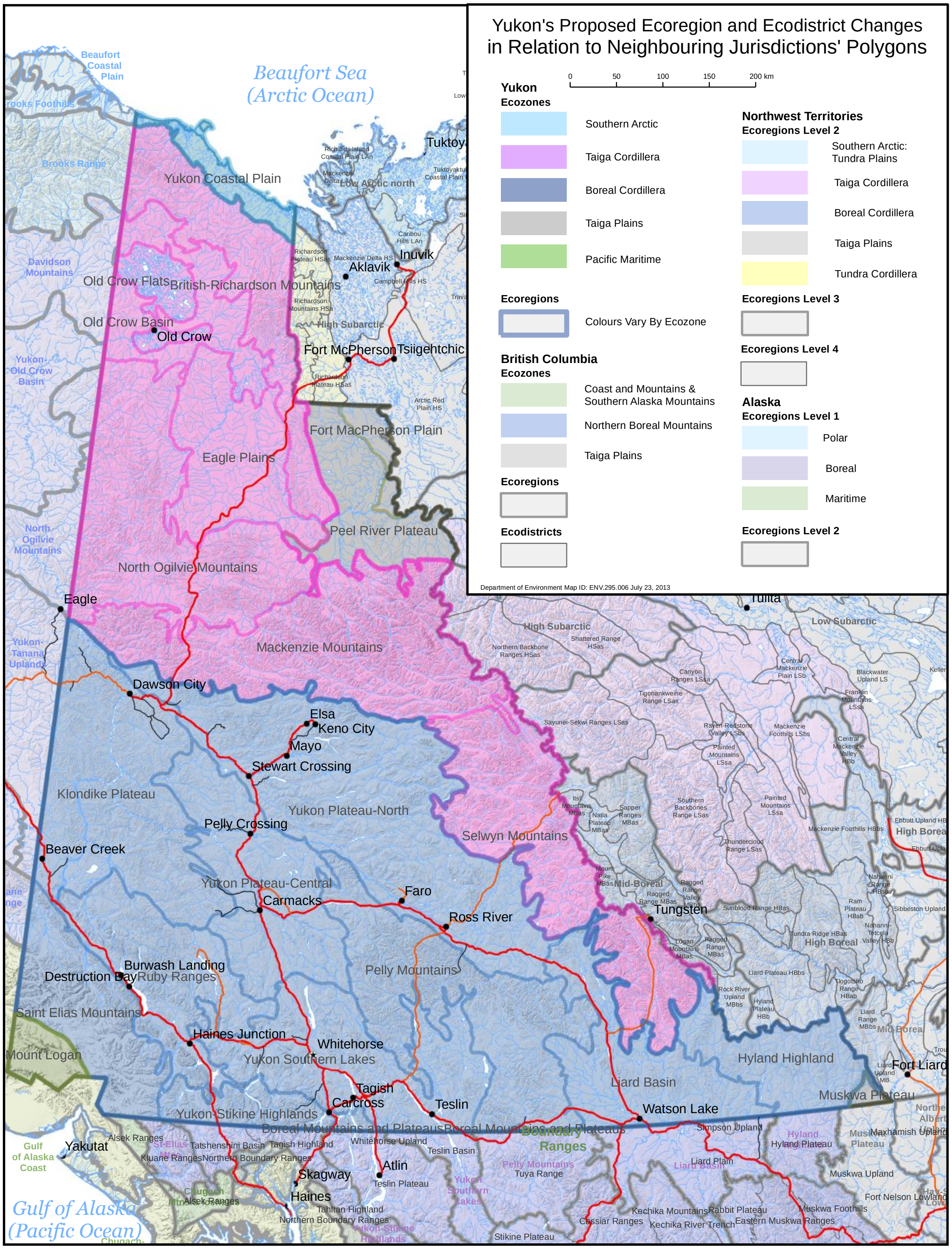

Figure 4. Yukon ecoregions (National Ecological Framework of Canada – Ecological Stratification Working Group 1995).

3.1.4 Management Applications

The ecoregions, ecodistricts and soil landscape units mapped as part of the NEF have received wide use in Yukon land and resource management. These units were originally mapped at a 1:1,000,000 scale. Their utility for land management applications has been enhanced recently by updating to a map scale of 1:250,000. New mapping criteria have also been introduced to ensure that ecological units, such as valley systems, are kept intact. Ecoregions and ecodistricts form logical management or planning units as they are intended to identify ecologically distinctive areas of Yukon. While ecoregions and ecodistricts do not provide the detailed site-level mapping required by some resource sectors, they should be used as a complementary product to interpret more detailed mapping such as the bioclimate, broad and local ecosystem mapping of the YBF. Ecodistricts and soil landscape units have also been used as important inputs to ecosystem modeling. Management applications of the NEF mapping levels are listed in Table 4.

Table 4. Management applications for Yukon ecoregions, ecodistricts and soil landscapes.

National Ecological Framework Mapping Level	Management Applications
Ecoregions (1:250,000 scale)	• Conservation area planning and representation • Regional land use planning • State of Environment reporting
Ecodistricts (1:250,000 scale)	• Regional land use planning (planning units) • Conservation area planning and representation • Inputs to predictive ecosystem mapping • Cultural use
Soil Landscape Units (1:250,000 scale)	• Inputs to predictive ecosystem mapping • Inputs to ecodistrict and ecoregion mapping • Cultural use

4.0 YUKON BIOCLIMATE FRAMEWORK MAPPING GUIDELINES

Ecosystem mapping is the stratification of a landscape into map units (ecosystem units) representing single or multiple ecosystems. Broad and local ecosystem units are identified through the integration of different ecological factors, including climate, physiography, geology, surficial material, and surface expression, as well as vegetation type and successional stage. For many land and resource managers, ELC maps will be their most frequently used ELC product. The broad and local ecosystem mapping of the YBF is expected to be completed by ELC practitioners in support of project-specific requirements. Guidelines for conducting broad and local ecosystem mapping, and an introduction to ELC mapping concepts, is provided below.

The Yukon ELC Program anticipates that it will remain responsible for internally completing bioclimate zone and subzone mapping, and for producing and distributing Ecoregions of Yukon updates using the NEF. Mapping guidelines for these products have therefore not been included in this document.

MAPPING METHODS

4.1.1 Types of Ecosystem Maps

In general, ecosystem mapping may be conducted using one of three methods:

1. a manual process where aerial photographs or satellite images are visually interpreted to identify and delineate ecosystems and their attributes;
2. a GIS modeling, or 'predictive' approach, where knowledge of ecosystem patterns and relationships is used to predict the locations of ecosystems on the landscape; and
3. a 'hybrid' approach where manual methods are used to supplement, or increase the accuracy of, certain features within a GIS modeled map.

Each method is described below.

4.1.1.1 Manual Ecosystem Mapping

Manual ecosystem mapping is the process of mappers examining and interpreting aerial photographs, satellite imagery, or similar information, and then delineating ecosystem units manually (e.g., drawing polygons on aerial photographs or digitizing polygons in GIS). Prior to the development of advanced GIS and the availability of digital spatial data such as elevation models, land cover and soil mapping, most ecosystem mapping was conducted using the manual interpretation process. Today, manual mapping methods are generally used for detailed (local) ecosystem mapping where higher map resolution and accuracy is required, or for creating map products that are difficult to model, such as wetlands, through to units with a strong conceptual components such as ecoregions of the NEF.

Producing manual ecosystem maps requires base feature mapping of a matching scale (e.g., waterbodies, rivers, topography, etc.). In most areas of Yukon, outside of communities, specific project areas, and major transportation corridors, 1:50,000 scale base feature mapping is the most detailed scale available. Detailed, manually derived ecosystem mapping products can be more costly to produce than modeled ELC products, and so are used for specific applications where a higher level of detail and map resolution is required. These include environmental impact assessment for transportation and industrial infrastructure development; transportation, municipal, and forestry site planning; and sensitive feature mapping. The City of Whitehorse, Southern Lakes and Selwyn Baseline case studies are examples of manually created, local-scale ecosystem mapping.

4.1.1.2 Ecosystem Modeling

Ecosystem modeling is the use of knowledge-based computer models and GIS-based approaches for developing ecosystem maps. This approach is also termed 'predictive ecosystem mapping' (PEM). Modeling approaches are typically used to provide basic ecological information across large geographic areas, and are therefore well suited to support regional planning, wildlife and habitat management, regional cumulative effects assessment and management, and similar applications. For many of these management activities, detailed mapping may not be required, and would be costly to develop. Ecosystem modeling makes it possible to map ecosystems across large geographic areas in a rapid and cost effective manner when compared to manual mapping methods. Ecosystem modeling creates a single, consistent coverage at one point in time and at a uniform map scale—something that is often not possible through detailed manual mapping methods. Regional ecosystem mapping in the Peel Watershed (Meikle and Waterreus 2008), the Dawson Planning Region (Makonis et al. 2012a) and Ross River area (Makonis et al. 2012b) provide examples of Yukon PEM methods and applications.

Ecosystem modeling requires an assessment of the input spatial and thematic source data used for modeling. Assessing the relative accuracy of spatial data inputs determines where classification errors are likely to occur, helps establish the level of confidence of the resultant mapping, and also guides the mapping process and modeling effort.

While modeling ecosystems can be cost effective and efficient, it is important to recognize that the ability to produce modeled ecosystem maps, and the quality of the output, relies heavily on both the availability and quality of input digital GIS information, and an adequate knowledge of ecosystems within an area. There will remain a need to create detailed, manually-created ELC products to support site-specific management activities.

4.1.1.3 Hybrid Ecosystem Mapping

Hybrid ecosystem mapping combines manual interpretation methods with modeling to create a single, integrated product. A common example of this approach is to conduct ecosystem modeling across a large geographic area, and then use manual interpretation to better delineate and classify ecosystems of limited spatial extent, such as wetlands, grasslands or alpine areas. In this manner, hybrid products can deliver general, consistent ecosystem information for large geographic areas, while providing additional detail for ecosystems of management interest or concern than entirely interpreted products. Understanding the objectives and intended uses of an ecosystem mapping exercise is important to the success of hybrid mapping projects. A hybrid approach was used to map ecosystems along the proposed Alaska Highway Pipeline corridor.

4.1.2 Mapping Scale and Intended Use

Map **scale** refers to the ratio between the size of the feature on a map and the size of a feature in the real world. For example, a map scale of 1:50,000 means one unit on the map relates to 50,000 units in the real world. Large-scale mapping is generally considered to be less than 1:50,000 scale (e.g., 1:10,000 scale). Maps created at scales of 1:100,000 or greater (e.g. 1:250,000) are considered to be small-scale maps. As map scale decreases (e.g., 1:10,000 scale), map features can more closely approximate those features in the real world; features can be represented with higher resolution and with greater levels of detail.

Different applications require different scales and types of ecosystem mapping. The mapping objectives are therefore important considerations when beginning a mapping project. Selecting the appropriate map scale and product for the intended application (objectives) will ensure the mapping fulfills end user requirements. Different map products will also have different costs. To illustrate this further, Figure 5 shows the general relationship between map scale, cost and intended management applications, and the most appropriate Yukon ELC Framework map product for that application. More detailed local ecosystem mapping is required for some applications (e.g., infrastructure corridor planning) while more generalized mapping may be appropriate for other applications (e.g., regional land use planning). Local ecosystem maps generally cost more per unit area to complete than smaller scale (lower detail) mapping.

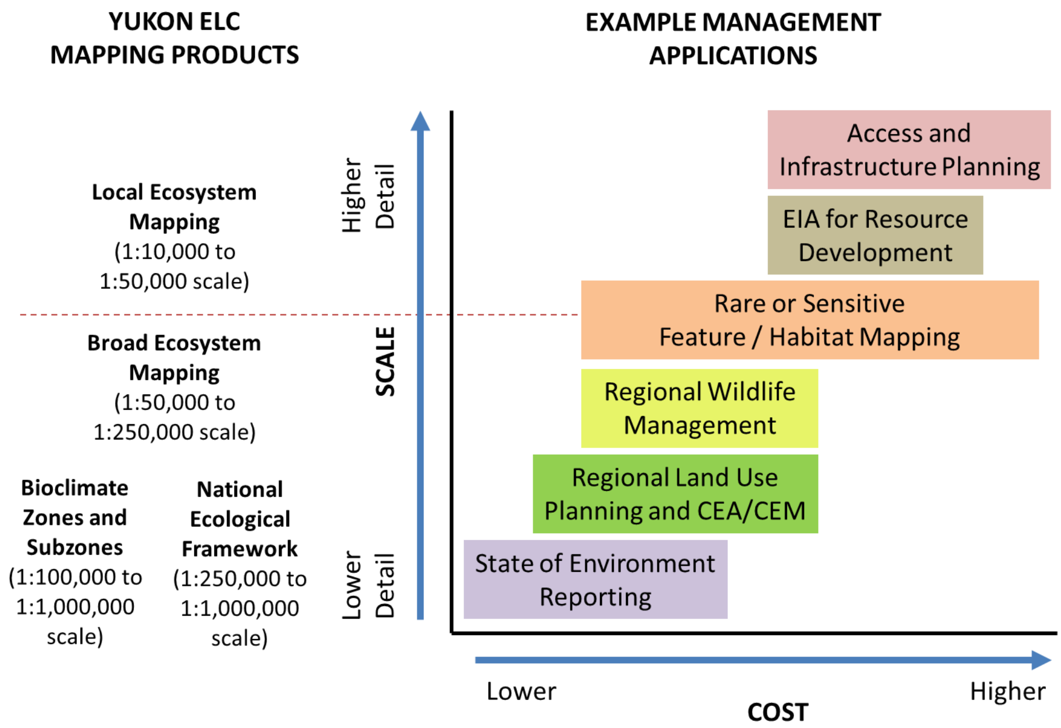

Figure 5. Generalized relationship between mapping scale and cost, showing example management applications and relevant Yukon ELC mapping products. Figure adapted from J. Meikle and Silvatech (2008).

4.1.3 Representing Map Features – Polygons versus Grids

The spatial representation of map units is an important consideration for mapping. The spatial properties (shape and area) of ecosystem map units can be represented through either raster (grids) or vector (polygons) geometry. Raster-based ecosystem mapping divides the mapping area into a grid of equally sized cells, and assigns an ecosystem class to each cell or group of cells. This approach is used in satellite image classification where each pixel receives a discrete value. In contrast, vector approaches represent ecosystem map units as polygons, and each polygon may represent a single ecosystem or multiple ecosystems based on proportions. Examples of raster and vector mapping are shown in Figure 6.

Both raster and vector mapping have benefits and drawbacks. Raster approaches are typically used for creating predictive maps, while vector approaches are commonly used in the creation of manual ecosystem maps. Vector mapping more accurately represents the true size and geometry of map features, including linear features such as rivers or roads. In comparison, due to its 'simple' geometry and layered approach to creating resultant products, raster mapping is both more computationally efficient when used in a GIS and allows for efficient data updates and map revisions when new information or improved data layers become available over time.

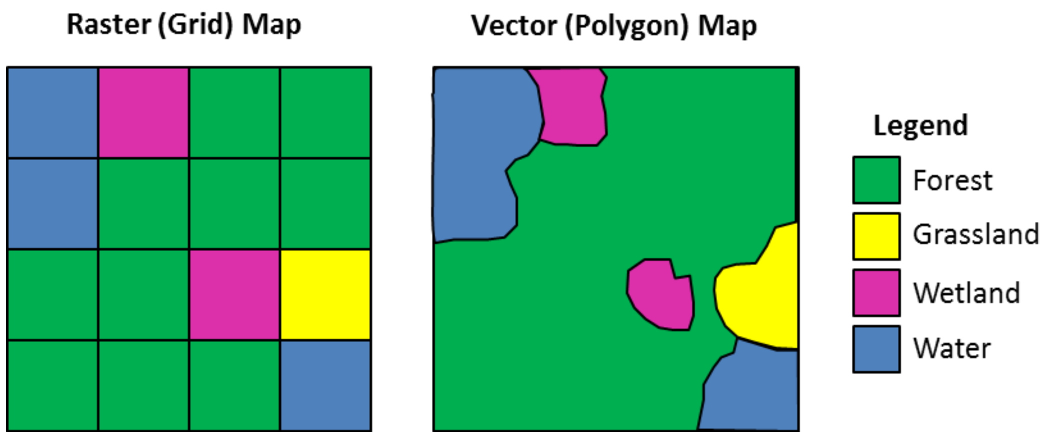

Figure 6. Examples of raster (grid) and vector (polygon) map feature geometry that can be used to represent ecosystem map units.

4.1.4 Map Unit Size

Very small real-world features cannot be represented as discrete polygons or pixels on ecosystem maps. Vector mapping requires a minimum polygon size to be determined, which is a function of the scale of available base feature mapping and desired ecosystem mapping scale. For most applications, a minimum map polygon size of 0.5 cm^2 (e.g., 0.7 cm × 0.7 cm) is recommended. At different map scales, this minimum map polygon size corresponds to land areas of:

- 0.5 ha at a scale of 1:10,000;
- 2.0 ha at 1:20,000;
- 12.5 ha at 1:50,000;
- 50.0 ha at 1:100,000; and
- 306 ha at 1:250,000

For raster mapping, the grid cell size determines the minimum size of an ecosystem map unit. Determination of a suitable grid cell size should be based upon the resolution of the most generalized input source data layer. For most broad ecosystem mapping projects completed in Yukon, a 25m or 30m cell size has been used. These cell sizes correspond to land area of 0.625 and 0.90 ha, respectively. A 30m cell size matches the resolution of the Yukon 30m digital elevation model, an important GIS data input for broad ecosystem mapping.

4.1.5 Field Sampling

Field sampling is required to confirm ecosystem unit classes and boundaries, to collect data for ecosystem descriptions in reports, and to develop or refine the classification of ecosystem units. Prior to beginning a mapping exercise, field surveys are also used to familiarize mappers with the project area and its ecosystem characteristics. Section 6.0 of this report describes where field sampling generally fits in an ecosystem mapping project.

Survey intensity refers to the relative level of field sampling effort completed during a mapping project. It is a measure of sampling density that can be characterized as the percentage of polygons receiving field inspection. Depending on the mapping scale and intended use, different levels of survey intensity are required to adequately sample a project area. Table 5 shows the recommended percentage of polygon inspections and methods based on study area size, mapping scale and desired interpretations. These recommended survey intensity levels have been adapted from RIC (1998) to better reflect Yukon mapping scales and requirements. In Table 5, a survey intensity level 2 is adequate for most 1:20,000 to

1:50,000 scale ecosystem mapping applications. This survey intensity provides a reasonable balance between cost and reliability.

Readers are directed to Section 6.0 of RIC (1998) for detailed information on field sampling methods and concepts. It is important to recognize that the field sampling methods described by RIC (1998) and introduced here are intended for polygon-based mapping. At this time, field sampling methods for conducting raster-based ecosystem mapping have not been formally developed but the concept of sampling density remains relevant.

Table 5. Recommended survey intensity levels for different scales of polygon-based ecosystem mapping. Adapted from: Table 6.3, RIC (1998).

YBF Mapping Levels	Survey Intensity Level *	Percentage of Polygon Inspections	Ratio of Full Plots : Ground Inspections : Visual Checks **	Area Covered by 0.5 cm^2 (minimum polygon size)	Study Area Size	Interpretation Examples
Local Ecosystems (detailed scales) <1:20,000	1	51-75%	10 : 40 : 50	0.25 – 2.0 ha	10 – 10,000 ha	Access and infrastructure planning; detailed environmental assessment; silviculture planning, etc.
Local Ecosystems (less detailed scales) 1:20,000 – 1:50,000	2	20-50%	5 : 30 : 65	2.0 – 12.5 ha	5,000 – 50,000 ha	Wildlife, land use planning, environmental assessment, forestry planning, etc.
Broad Ecosystems >1:50,000	3	5-10%	0 : 25 : 75	12.5 ha – 306 ha	10,000 – 1,000,000	All regional applications (wildlife, regional land use planning, cumulative effects, etc.)

Notes:
***Survey Intensity Level**: RIC (1998) survey intensity levels have been aggregated to better reflect Yukon mapping requirements as follows (RIC Levels 1 and 2 = YBF Level 1; RIC Levels 3 and 4 = YBF Level 2; RIC Levels 5, 6 and R = YBF Level 3).
****Ratio of Inspection Types**: *Full Plot* refers to complete vegetation, soil and site information collection; *Ground Inspection* refers to generalized vegetation, soil and site information collection; *Visual Check* refers to brief field notes and for large remote project areas, aerial reconnaissance (transects or similar).

4.1.6 Map Accuracy

Map **accuracy** describes how 'correct' the map is when compared to the real world. Map accuracy refers to two aspects of mapping:

- Thematic (classification) accuracy: are the map units correctly classified when compared to the real world? (e.g., is a dry-terrace coniferous forest in the real world classified as this unit on the map?); and

- Spatial (feature) accuracy: are the map units represented correctly? Do they have the correct area, are they in the correct location, and do they have the same shape (geometry) as real world features?

Ecosystem mapping often has standards for an acceptable level of classification accuracy. In most situations, achieving a polygon classification accuracy of 65% is considered adequate. The following example illustrates the concept of measuring classification accuracy. If 100 map polygons are randomly checked through field work and 50 polygons are found to be classified accurately, then the map could be assumed to have a classification accuracy of 50%.

Assessing the accuracy of raster maps developed through GIS modeling is more challenging as it requires consideration of both the input data sources and the resultant mapping, and whether the assessment should be directed towards individual cells or groups of cells. At this time, Environment Yukon has not developed rigorous methods for assessing raster GIS mapping or spatial accuracy.

Performing an accuracy assessment is different than using field survey information to calibrate or train mappers during the mapping process. A true accuracy assessment should be completed by a third-party assessor, but this may become prohibitively expensive. All mapping practitioners should strive to report their product accuracy using whatever best practices methods are available to them. Readers are directed to Meidinger (2003) for additional guidance and methods on how to conduct accuracy assessments on different ecosystem map products.

ECOSYSTEM UNITS

Guidelines for mapping broad and local ecosystem units are provided below. The bioterrain mapping concept is the initial step for delineating broad and local ecosystem units.

4.1.7 Bioterrain Mapping

Broad and local ecosystem mapping is based on the concept of **bioterrain mapping**. Bioterrain mapping identifies terrain, slope, landform, surficial material and soil conditions that affect the distribution of ecosystems through their influence on moisture, nutrients, temperature and insolation. Bioterrain units are the relatively stable, enduring features upon which vegetation, and ecosystems, develop. When identifying bioterrain units, mappers should not focus on identifying vegetation conditions – the goal is to identify relatively uniform site conditions that influence vegetation development. Vegetation conditions are then combined with the bioterrain unit to form the integrated ecosystem unit. Generally, within a bioclimate zone or subzone, the pattern of ecosystems that develop on bioterrain units is relatively predictable.

Table 6 provides examples of general bioterrain map units; Figure 7 illustrates general bioterrain landforms. While there is no formal bioterrain classification, mappers are encouraged to produce a working legend, similar to Table 6, to show how terrain, slope, landform and soil conditions relate to different ecosystem units. When delineating bioterrain units as part of local ecosystem mapping, practitioners are encouraged to refer to the definitions and descriptions of terrain features as described in *Terrain Classification System for British Columbia* (Howes and Kenk 1997) with consideration of Yukon-specific terrain processes (i.e., permafrost). Broad ecosystem units are based on generalized bioterrain units, with a focus on landforms similar to those shown in Figure 7 (broad ecosystem bioterrain units are termed broad ecosystem types; see Table 7).

Table 6. Example bioterrain conditions for local ecosystem mapping. Adapted from Table 6.1 of RIC (1998).

EXAMPLE BIOTERRAIN MAP UNITS		
Landscape Position	**Surficial Material**	**Soil Depth or Texture**
Level	Fluvial (Floodplain)	Fine-textured
		Coarse-textured (rapidly-drained)
	Glaciofluvial Terrace	Coarse-textured (rapidly-drained)
		Medium-textured
	Morainal Till	Coarse-textured
		Medium-textured
	Eolian	Coarse-textured (rapidly-drained)
	Lacustrine	Fine-textured (rapidly drained)
	Organic	Poorly drained
Moderate Slope	Morainal Till	Medium-textured
	Glaciofluvial	Coarse-textured (rapidly-drained)
		Medium-textured
	Colluvial	Deep
		Shallow
Steep South-facing Slope	Colluvial	Deep
		Shallow
	Morainal Till	Deep
		Shallow
Steep North-facing Slope	Colluvial	Deep
		Shallow
	Morainal Till	Deep
		Shallow

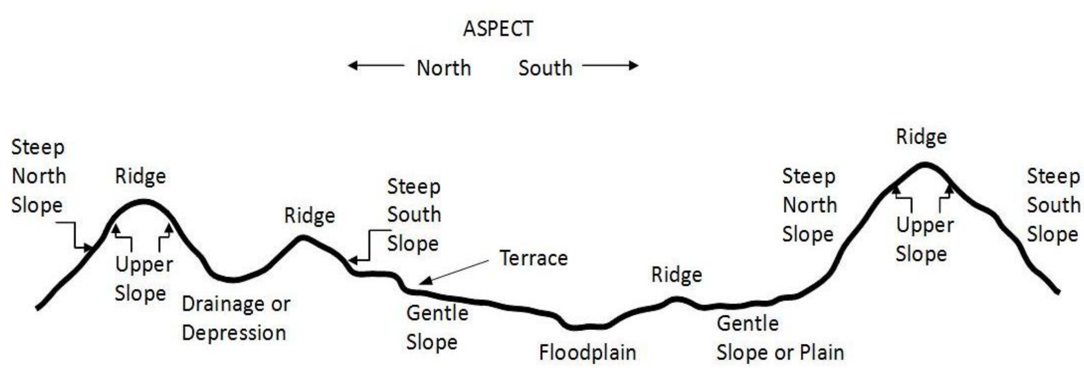

Figure 7. Example toposequence of generalized bioterrain (ecosystem types) used for broad ecosystem mapping.

Table 7. Recommended broad ecosystem type descriptions for non-permafrost landscapes. Broad ecosystem types are generalized bioterrain units.

Moisture Group	Broad Ecosystem Type		Description
DRY	UPLAND Ecosystems (100/200)	Ridge (110)	Slope crests with convex surface form (moisture shedding sites).
		Steep South Slope (120)	Slopes >25% with warm aspects (south and southwest facing-slopes with orientation between 136° and 284°, as measured in a clockwise direction).
		Upper Slope (130)	Slopes of varying steepness located below Ridges (110) but above Steep South (120), Steep North (150) or Gentle Slopes (140).
		Dry Terrace and Plain (230)	Generally level high river terraces and undulating outwash plains composed of coarse textured glaciofluvial or eolian materials. These landforms are a special case of Gentle Slope and Plain (140), and are defined by their surficial materials.
MOIST		Gentle Slope and Plain (140)	Level or gently sloping (<15%) areas composed of non-glaciofluvial or non-eolian surficial materials. These BEU types are typically well to moderately drained morainal till, and usually represent 'reference sites' for bioclimate zones or subzones. In valley bottoms and gently rolling terrain, this BEU type may comprise large areas of the landscape. In some situations, particularly in permafrost landscapes, it may be appropriate to create two slope classes from this BEU type: e.g., Level (<5% slope) and Gentle Slope (6-15%). In this case, Level sites should be identified as (140) and Gentle Slopes as (220). Mappers are encouraged to investigate slope and vegetation patterns within their project area and use appropriate slope values.
		Steep North Slope (150)	Slopes >25% with cool aspects (north and northeast facing-slopes with orientation between 310° and 85°, as measured in a clockwise direction).
WET		Drainage/Depression (160)	Catchments and drainages in uplands with concave slope form (moisture receiving sites). These catchment areas may occur below Ridges (110) or Upper Slopes (130), or may occur as depressions within more level areas.
	WETLAND Ecosystems (300)	Wetlands (310)	Bogs, fens, marshes and swamps with various vegetation development.
		Floodplains (370/380/390)	Flat (<5% slope) areas along rivers influenced by fluvial processes (flooding, erosion and deposition). These areas contain 'riparian ecosystems'. Floodplains may be subdivided into areas of Low, Moderate and High flood frequency.
	Water and Ice (400)		Open waterbodies and large rivers defined by base feature mapping. Ice may be glaciers or perennial snow patches.

4.1.8 Broad Ecosystem Units

Broad ecosystem units (BEUs) are derived from combinations of landform, special feature/surficial materials mapping, as well as vegetation and landcover. Landform and special features/surficial materials are generalized bioterrain conditions (ecosystem type) used to infer general site conditions that represent the relative moisture and nutrient regime of BEUs.

To date, at least four broad ecosystem mapping projects using similar methods have been completed in Yukon. Mapping areas include North Yukon (Francis et al. 2005), the Peel Watershed (Meikle and Waterreus 2009), the Dawson Planning Region (Makonis et al. 2012a) and the Ross River region of west-central Yukon (Makonis et al. 2012b). The Dawson and Ross River projects provide the most relevant examples of BEUs and methods listed here.

BEUs include a **type** and **phase**, and are organized by relative moisture groups.

1. BEU Type

BEU type is a generalized bioterrain unit that describes the landform or landscape position, representing the stable site upon which vegetation develops. BEU types are grouped into three relative soil moisture classes—dry, moist or wet. BEU types in different bioclimate zones or subzones have different vegetation potential. A standard suite of BEU types and codes has been developed and are recommended for use throughout Yukon (Table 8).

Permafrost has a strong influence on the relative moisture conditions, site productivity, and vegetation potential of BEU types. For example, in areas of extensive permafrost, such as northern Yukon, the BEU type 'gentle slope and plain' is wet and poorly drained. In southern Yukon, a region with only localized permafrost distribution, this BEU type is typically the mesic moisture condition.

2. BEU Phase

BEU phase describes the general vegetation or land cover condition occurring on a BEU type. Six potential phases can occur on most BEU types: herb-bryoid (1), shrub (2), deciduous (3), mixedwood (4), coniferous (5), and rock/exposed (6). The classification level used to map vegetation phases are based on formation level of the Canadian National Vegetation Classification. At the formation level physiognomy plays the predominant role.

When combined, BEU types and phases form broad ecosystem units (Table 8). While a standard suite of broad ecosystems conceptually exist for all of Yukon, the bioclimate context in which a BEU occurs is required for ecological interpretation. When broad ecosystems are located within a given bioclimate zone or subzone, they can be described with more certainty and within a narrower range of vegetation and ecological conditions. For example, low elevation steep south-facing slopes in northern Yukon may be forested, while in southern Yukon they are predominantly grasslands.

Table 8. Standardized BEU type and phase codes for Yukon.

Moisture Group	BEU Type		BEU Phase	Broad Ecosystem Unit (BEU)
DRY	UPLAND Ecosystems (100/200)	Ridge (110)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Ridge – Herb-Bryoid (111) Ridge – Shrub (112) Ridge – Deciduous (113) Ridge – Mixedwood (114) Ridge – Coniferous (115) Ridge – Rock/Exposed (116)
DRY		Steep South Slope (120)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Steep South-Facing Slope – Herb-Bryoid (121) Steep South-Facing Slope – Shrub (122) Steep South-Facing Slope – Deciduous (123) Steep South-Facing Slope – Mixedwood (124) Steep South-Facing Slope – Coniferous (125) Steep South-Facing Slope – Rock/Exposed (126)
DRY		Upper Slope (130)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Upper Slope – Herb-Bryoid (131) Upper Slope – Shrub (132) Upper Slope – Deciduous (133) Upper Slope – Mixed-wood (134) Upper Slope – Coniferous (135) Upper Slope – Rock/Exposed (136)
DRY		Dry Terrace and Plain (230)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Dry Terrace – Herb-Bryoid (231) Dry Terrace – Shrub (232) Dry Terrace – Deciduous (223) Dry Terrace – Mixedwood (234) Dry Terrace – Coniferous (235) Dry Terrace – Rock/Exposed (236)
MOIST		Gentle Slope and Plain (140)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Gentle Slope – Herb-Bryoid (141) Gentle Slope – Shrub (142) Gentle Slope – Deciduous (143) Gentle Slope – Mixedwood (144) Gentle Slope – Coniferous (145) Gentle Slope – Rock/Exposed (146)
MOIST		Steep North Slope (150)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Steep North-Facing Slope – Herb-Bryoid (151) Steep North-Facing Slope – Shrub (152) Steep North-Facing Slope – Deciduous (153) Steep North-Facing Slope – Mixedwood (154) Steep North-Facing Slope – Coniferous (155) Steep North-Facing Slope – Rock/Exposed (156)
WET		Drainage/Depression (160)	Herb-Bryoid (1) Shrub (2) Deciduous (3) Mixedwood (4) Coniferous (5) Rock/Exposed (6)	Drainage and Depression – Herb-Bryoid (161) Drainage and Depression – Shrub (162) Drainage and Depression – Deciduous (163) Drainage and Depression – Mixedwood (164) Drainage and Depression – Coniferous (165) Drainage and Depression – Rock/Exposed (166)
WET	WETLAND Ecosystems (300)	Wetlands (310)	Herb-Bryoid (1) Shrub (2) Treed (5)	Wetland – Herb-Bryoid (311) Wetland – Shrub (312) Wetland – Treed (315)
WET		Floodplains (370/380/390)	High Flood Frequency (370): • Gravel Bar-Herb (1) • Shrub (2) Moderate Flood Frequency (380): • Deciduous (3) • Mixedwood (4) Low Flood Frequency (390): • Coniferous (5)	High Flood Frequency (370): • Floodplain – Gravel Bar-Herb (371) • Floodplain – Shrub (372) Moderate Flood Frequency (380): • Floodplain – Deciduous (383) • Floodplain – Mixedwood (384) Low Flood Frequency (390): • Floodplain – Coniferous (395)
WET	Water and Ice (400)			Lake (401) River (402) Ice (Glacier) (403)

* Note: each BEU type and phase may occur in different bioclimate zones. At this time, unique codes for each BEU within different bioclimate zones have not been developed.

4.1.8.1 Mapping

Broad ecosystems are usually mapped using modeled GIS approaches (PEM) with raster map unit feature representation. The specific methods used to map broad ecosystems will depend on the availability, resolution and quality of data (vegetation and landcover, elevation model, surface material/special feature mapping, etc.), and the ecological characteristics of the project area. The goal of a mapping exercise is to identify the generalized bioterrain units (BEU types) listed in Table 7 and then to integrate landcover or vegetation mapping (BEU phase) to create BEUs (Table 8).

Landform, slope and aspect conditions are characterized through the topographic analysis of digital elevation models. Surficial material and base feature mapping are used to delineate special soil conditions (e.g,. glaciofluvial or eolian materials and floodplains), waterbodies and rivers. Landcover and vegetation data will change over time. Currently, landcover inputs may include classified satellite imagery (e.g., Earth Observation for Sustainable Development of Forests (EOSD)), Yukon Vegetation Inventory (forest inventory), Yukon Fire History mapping, and manually interpreted landcover information for portions of project areas. The derived BEUs are then interpreted within the context of bioclimate zones or subzones.

4.1.9 Local Ecosystem Units

Local ecosystem units are comprised of one or more groups of adjacent ecosites that can be mapped together. The ability to accurately delineate local ecosystems depends on map scale, available ground-truth data, skill of the interpreter and knowledge of relationships between bioterrain units and vegetation associations within a specific region.

Local ecosystem units include an **ecosite** and **ecosite phase**. Within a bioclimate subzone, ecosites are organized based on landscape position. Along the toposequence, characteristic ecosites occur in relatively predictable locations, based on slope, aspect, parent material, and soil moisture and nutrient conditions. The **reference ecosite** generally occurs in the relatively level, moderately drained position. Permafrost conditions may affect the location of reference ecosites. The identification of ecosites in the mapped unit depends on bioclimate zone and subzone as well as knowledge about ecosystem patterns within a specific region.

Table 9 provides an example of ecosites and ecosite phase developed for use along a portion of the Alaska Highway Pipeline corridor.

To date, several local ecosystem mapping projects using different classification and mapping methods have been completed. Examples include City of Whitehorse ecosystem mapping, Southern Lakes wetlands mapping, and the Selwyn project environmental baseline studies.

Table 9. Example ecosites and ecosite phase, and their corresponding moisture and nutrient conditions, developed for use along a portion of the Alaska Highway Pipeline corridor in southern Yukon. Source: T. Conville, Stantec.

Ecosite	Ecosite Name	Moisture Range	Nutrient Range	Phase	Phase Name
A	Dry Grassland	Xeric	Poor-Very Rich	A1	Dry Grassland
B	Bearberry-Lichen	Subxeric-Submesic	Very Poor-Poor	B1	Pl/Bearberry-Lichen
				B2	Pl-Sw-Sb/Bearberry Lichen
				B3	Sw-Sb/Bearberry-Lichen
				B4	Aw/Bearberry-Lichen
C	Dry Riparian	Subxeric-Mesic	Medium-Very Rich	C1	Sw-Pb(Aw)/Willow-Silverberry
				C2	Willow-Silverberry-Mountain Avens
				C3	Silverberry-Mountain Avens-Forb
D	Buffaloberry	Submesic-Mesic	Medium	D1	Pl/Buffaloberry
				D2	Pl-Aw/Buffaloberry
				D3	Aw/Buffaloberry
				D4	Sw-Aw/Buffaloberry
				D5	Sw-Pl(Fa)/Buffaloberry
E	Labrador Tea - Crowberry	Submesic-Mesic	Very Poor-Poor	E1	Pl(Aw)/Labrador Tea-Crowberry
				E2	Pl-Sb-Sw/Labrador Tea-Crowberry
				E3	Sb-Sw/Labrador Tea-Crowberry
F	Prickly Rose-Willow	Mesic-Subhygric	Medium	F1	Aw/Prickly Rose-Willow
				F2	Sw-Aw/Prickly Rose-Willow
				F3	Sw(Sb)/Prickly Rose-Willow
G	River Alder-Currant	Mesic-Subhygric	Rich	G1	Pb(Aw)/River Alder-Currant
				G2	Sw-Pb(Aw)/River Alder-Currant
H	Moist Riparian	Mesic-Hygric	Rich-Very Rich	H1	Willow-Alder-White Spruce-Grass
				H2	Forb-Grass Meadow
I	Labrador Tea-Bog Birch	Subhygric-Hygric	Very Poor-Medium	I1	Pl/Labrador Tea/Bog Birch
				I2	Pl-Sw-Sb/Labrador Tea-Bog Birch-Horsetail
				I3	Sw-Sb/Labrador Tea-Bog Birch-Horsetail
J	Horsetail	Subhygric-Hygric	Medium-Rich	J1	Pb-Sw(Aw)/Horsetail
				J2	Sw(Fa-Pl)/Horsetail
K	Bog	Subhygric-Hydric	Very Poor-Poor	K1	Sb/Labrador Tea-Cottongrass-Peatmoss
				K2	Leatherleaf-Cotton Grass-Peat Moss
L	Poor Fen	Subhygric-Hydric	Poor-Medium	L1	Sb(Lt)/Bog Birch-Peatmoss-Golden Moss
				L2	Bog Birch (Black Spruce)-Peat Moss-Golden Moss
M	Rich Fen	Subhygric-Hydric	Rich-Very Rich	M1	(Lt)/Dwarf Birch-Willow-Sedge-Golden Moss
				M2	Sedge-Golden Moss
N	Marsh	Hydric	Medium-Very Rich	N1	Mudflat Marsh
				N2	Pond Marsh

4.1.9.1 Mapping

Local ecosystems are mapped at scales of 1:10,000 to 1:50,000. In Yukon, local ecosystem maps are usually produced through the manual interpretation of imagery (aerial photographs or fine scale satellite imagery) and delineating polygons either on hardcopy mapping or in a digital mapping environment. Using polygon (vector) mapping methods, the delineation of map units at a finer (e.g., large scale such as 1:10,000) resolution generally results in polygons being of more uniform composition. When only one ecosite occurs in the map polygon, this is called a **simple polygon**. At smaller map scales (e.g., 1:50,000), site conditions become less uniform and map polygons may contain more than one ecosite or phase—these are referred to as **complex polygons** (e.g., a map polygon is composed of 60% ecosystem unit *x* and 40% ecosystem unit *y*).

While polygon-based mapping methods are most common, local ecosystems may also be represented by raster cells using GIS modeled approaches. If raster approaches are used, a single pixel may represent either a single ecosite, similar to a simple polygon, or a group of ecosites, similar to complex polygons.

Some Yukon projects have also developed hybrid map products (e.g., Alaska Highway Pipeline Corridor case study). If hybrid methods are to be used, the practitioner should assess accuracy of available input data for the study area. Most available land cover mapping such as EOSD or Yukon Vegetation Inventory (forest inventory) is not adequate when used alone to predict vegetation associations and should be combined with other soil, surficial material and topographic analysis. The largest scale of base feature mapping in Yukon outside of municipal areas and major corridors is 1:50,000, limiting the ability to create detailed local ecosystem maps across large areas.

When mapping local ecosystems, the Yukon ELC Program recommends following mapping guidelines as established for *Terrestrial Ecosystem Mapping in British Columbia* (RIC 1998) and the *Terrain Classification System for British Columbia* (Howes and Kenk 1997). Environment Yukon follows species name authority as maintained by the Yukon Conservation Data Centre (CDC) and surficial geology/terrain attributes established by the Yukon Geological Survey. Standardized ecosite and ecosite phase map codes for Yukon are currently being developed. Prior to starting a new mapping project, practitioners are encouraged to contact the ELC Coordinator regarding mapping units and naming conventions (see Section 6.0).

5.0 DATA COLLECTION AND MANAGEMENT

The Yukon ELC Program does not currently specify formal digital spatial data format requirements for input layers or final ecological map products. At this time there have been relatively few projects completed and several are legacy projects completed prior to these *Guidelines*. The Yukon ELC Program does receive guidance from other groups on standards for field data collection and the use of digital data. A small set of digital data guidelines has been established with respect to preferred input data for the production of ELC mapping.

FIELD DATA COLLECTION

Environment Yukon is developing a field manual to to assist field surveyors in the completion of Yukon ecosystem field forms. The Yukon manual generally follows the field data collection standards of British Columbia's *Describing Terrestrial Ecosystems in the Field*, 2nd Edition (BC Ministry of Forests and Range and Ministry of Environment 2010). The Yukon manual will include several modifications to describe ecosystems with specific consideration of Yukon ecological conditions.

At this time Environment Yukon only produces field forms for site, soil and vegetation, and a general form for project metadata. Some tree mensuration data is often collected and is recorded in the comments section of the field form. Following protocols established by the Yukon Geological Survey, the Yukon ELC Program has adopted the *Terrain Classification System for British Columbia* (Howes and Kenk 1997) as a legend standard and database structure for surficial geology mapping in Yukon. The Howes and Kenk (1997) standards have been modified to accommodate additional landforms, processes and permafrost features common in Yukon[1].

All data collected using Environment Yukon field forms can be entered into the department's **Yukon Biophysical Inventory System** (YBIS). All field data collected through the Yukon ELC Program is entered and stored in YBIS.

DATA STORAGE AND RETRIEVAL

YBIS is a web-based Oracle application for the storage and retrieval of vegetation plot data, soil classification and description, and terrain classification although other types of data, mainly relating to habitat assessment projects, have also been stored in the system. YBIS data entry tools match Yukon data forms.

In addition to manually entering non-digital legacy data and new data into YBIS, considerable effort has been undertaken to convert data collected over the past 30 years from other digital formats into YBIS. There are currently 68 projects in YBIS in various states of completion. Most of these projects were led by Environment Yukon.

The Yukon ELC Program invites holders of biophysical data in the private and public sectors and First Nation government agencies to contribute field ecological data to YBIS. The ELC Coordinator may contact private sector proponents for use of biophysical inventory data used in project assessments or baseline studies but it is the responsibility of the Yukon ELC Program to enter the data into YBIS. Over time, the goal is to have ELC practitioners use YBIS to enter their own field data. Similarly YBIS data may be requested by a practitioner for the purpose of verifying map products or developing ecological interpretations.

DIGITAL DATA

At this time, the Yukon ELC Program has not established formal standards around digital data capture (e.g., RIC 2000). There have been relatively few detailed mapping projects completed by Environment Yukon with multiple ecosystem attributes; most mapped applications have been broad ecosystem raster maps. For local ecosystem mapping, where a proponent captures digital data beyond ecosite and ecosite phase, the ELC program follows *Digital Data Capture in British Columbia* (RIC 2000).

The Yukon ELC Program recommends the data sources listed in Table 10 as standard digital data for producing broad and local ecosystem mapping.

[1] Yukon Geological Survey adopted standards for surficial geology mapping in Yukon following Howes and Kenk (1997) but have also incorporated some modifications to accommodate important Yukon terrain processes. http://www.geology.gov.yk.ca/pdf/Terrain_Classification_System_summary.pdf

Table 10. Recommended digital data for broad and local ecosystem mapping.

Name	Descriptions	Source	Local (< 1:30K)	Local (1:30k to 1:50k)	Broad (1:50k to 1:250k)
Yukon 16m Digital Elevation Model (DEM)[1]	Derived from planimetricly corrected 1:50k NTDB (contours, spot heights, and other features with known elevation).	Download 16m DEM from the Yukon government site. ftp://ftp.geomaticsyukon.ca/DEMs/CDED_50k/	3	2	1
Yukon 30m Digital Elevation Model (DEM)[1]	Derived from 1:50k NTDB (contours, spot heights, and other features with known elevation.	Download 30m DEM from the Yukon government site. ftp://ftp.geomaticsyukon.ca/DEMs/mosaics/yt_30m_dem.tif *for methods see http://www.env.gov.yk.ca/publications-maps/geomatics/data/30m_dem.php	3	2	1
EOSD land cover map 25m pixel	The Earth Observation for Sustainable Development of Forests (EOSD) land cover map is based on Landsat 7 Enhanced Thematic Mapper (ETM+) data and represent circa year 1999-2001 conditions.	SAFORAH http://www.saforah.org/ or contract the ELC Coordinator	2	3	3
Yukon Vegetation Inventory 1:50,000	Yukon forest inventory includes a number of ecological modifiers and non-forest vegetation attributes.	FTP site Geomatics Yukon (http://www.geomaticsyukon.ca/data/datasets)	3	1	1
Ecoregions of Yukon 1:1,000,000	Yukon Ecozones, Ecoregions and Ecodistricts (described in Smith et al. 2004)	FTP site Geomatics Yukon (http://www.geomaticsyukon.ca/data/datasets) This linework is in the process of being updated for the Yukon Region	3	3	1
CanVec 1:50,000	CanVec is a digital cartographic reference product generated by Natural Resources Canada. Orthocorrected (Landsat 7) offers a complete Canadian coverage by consolidating data from the best available sources. CanVec is quality vector data that complies with international Geomatics standards.	http://www.geomaticsyukon.ca/data/datasets (current to October 19, 2012) or http://files.environmentyukon.ca/yukon_canvec/ (current to May 9, 2012)	3	2	1

Mapping Scales: 1 = data source recommended for use; 2 = data source used with caution; 3 = data source should not be used.

[1]As a general guideline, the 30m DEM should be used with NTDB Edition 2 base data mapping and the 16 m DEM used with newer NTDB Edition 3, Canvec and/or instrument sensed data (satellite imagery, GPS). Most Yukon 50k vector data in current use is derived from/against NTDB Edition 2. The 30m DEM is considered a better product as compared to the 16m across valley bottoms and in hilly regions where the source contours are of higher intervals. The most efficient way to examine this difference is to generate shaded relief images and look for tell-tale artifacting particular to each scale: "benches" and "waves" in the 16m, and features which are just a little too smooth and soft looking in the 30m.

6.0 CONDUCTING AN ELC MAPPING PROJECT

Detailed methods for conducting an ELC mapping project in Yukon will vary depending on the geographic area, available information and intended applications. Section 6.0 of the *Standard for Terrestrial Ecosystem Mapping for British Columbia* (RIC 1998) should be referenced for detailed guidelines on conducting ELC mapping projects. Adequate pre-planning and developing clearly defined project objectives should be important parts of all projects.

An important use of ELC mapping in resource development activities is to provide a common base map from which different environmental interpretations and ratings required by assessment processes and regulators can be developed. Project proponents are encouraged to initiate correspondence with Environment Yukon biologists and habitat specialist early in the ELC project planning process to ensure that ELC mapping methods and products are designed to support required interpretations.

Recommended steps for conducting a broad or local ecosystem mapping project in Yukon are shown in Figure 8.

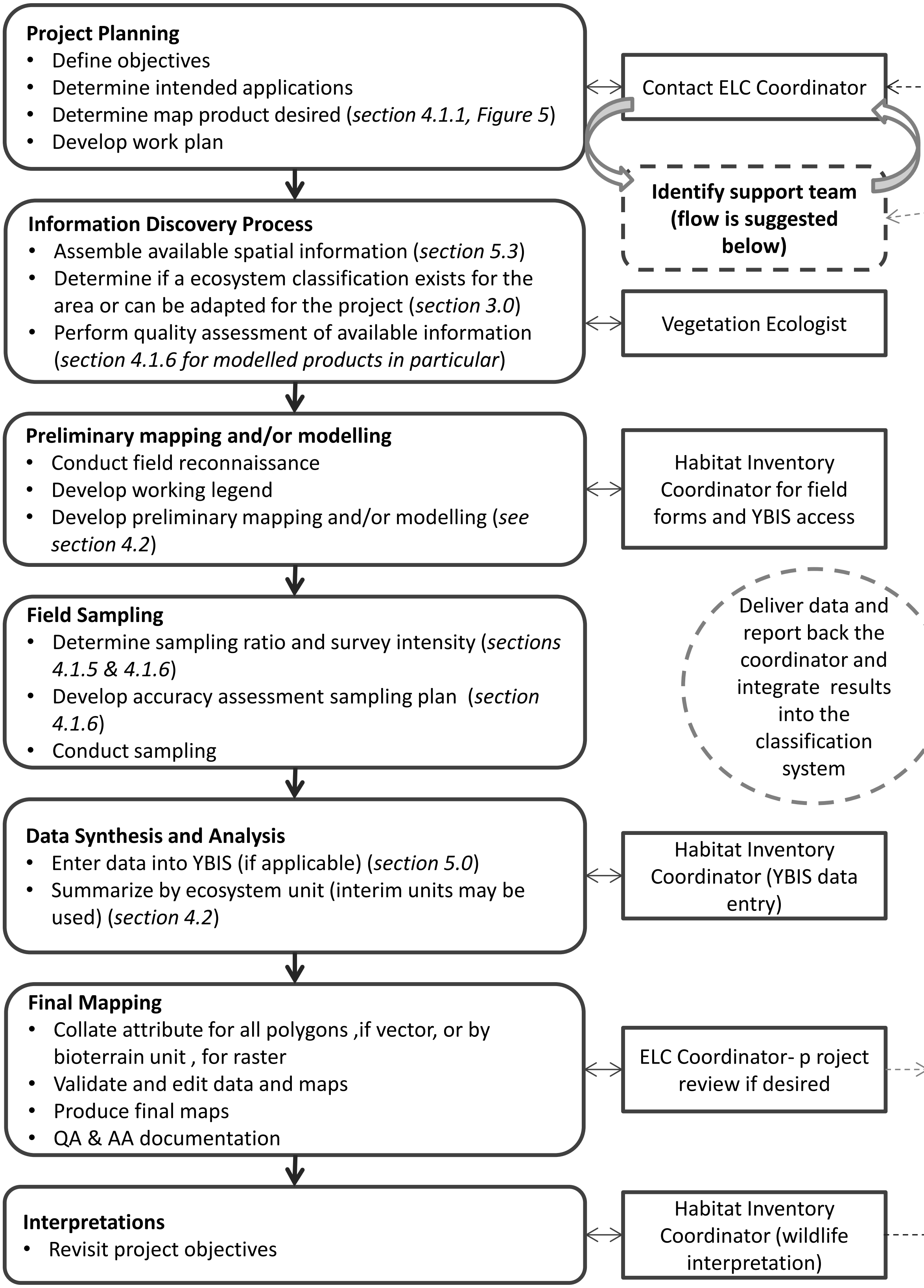

Figure 8. Recommended steps for conducting an ecosystem mapping project in Yukon. Adapted from Figure 2.1 in BC Ministry of Environment (2010) and Figure 6.1 in RIC (1998).

CONTACTS AND ADDITIONAL INFORMATION

Contacts	Activities
Nadele Flynn, **Ecological and Landscape Classification (ELC) Coordinator** Environmental Planning, Policy and Planning Branch, Environment Yukon email: elc@gov.yk.ca work: (867) 667-3081 fax: (867) 393-6213	• Ecological and Landscape Classification 5-Year Strategic Plan • Contributing to the Technical Working Group • Bioclimate ecosytem classification and ecoregion mapping • Ecosystem mapping (bioclimate/broad/local)
Val Loewen, **Habitat Inventory Coordinator** Habitat Programs, Fish & Wildlife Branch, Environment Yukon email: Val.Loewen@gov.yk.ca work: (867) 667-5281	• Yukon Biophysical Inventory System Access and Information • Yukon Handbook for Describing Ecosystems in the field and field forms • Wildlife Habitat Ratings/Interpretation

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	• Vegetation Classification:
	    ○ Yukon Vegetation Associations Arctic
	    ○ Yukon Vegetation Associations Subarctic

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APPENDIX I - GLOSSARY

References used in developing the glossary: Ecosystem Classification Group. 2010. Ecological Regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northweset Territories, Yellowknife, NT, Canada. X + 245pp. + inset map.

alpine – The ecological zone that occurs above an elevational tree line, characterized by a distinct climate and vegetation.

arctic – The ecological zone north of the latitudinal tree line, characterized by a distinct climate and vegetation.

association – a plant community type at the lowest level of the CNVC hierarchy, with consistency of species dominance and overall floristic composition, as well as having a clearly interpretable ecological context in terms of site-scale climate, soil and/or hydrology conditions, moisture/nutrient factors and disturbance regimes, as expressed by diagnostic indicator species. E.g., Picea glauca / Hylocomium splendens Association (White Spruce / Step Moss).

bioclimate – All the climatic conditions (climate factors) of a region that have a fundamental influence on the survival, growth, and reproduction of living organisms.

Biogeoclimatic Ecosystem Classification (BEC) – A hierarchical ecosystem classification system applied in British Columbia that describes the variation in climate, vegetation, and site conditions throughout the province.

biogeoclimatic zone – A level in the British Columbia Biogeoclimatic ecosystem classification system that represents areas with the same regional climate. See ecoclimatic region, ecoregion, and ecological region.

Biophysical Land Classification – An approach to land classification that combines the physical and biological components of the environment. This hierarchical classification system originally included four levels, within which the physical components of classification are sometimes more heavily weighted than the biological components. The term biophysical was subsequently replaced by "ecological".

boreal –

1. Pertaining to the north.
2. A climatic and ecological zone that occurs south of the subarctic, but north of the temperate hardwood forests of eastern North America, the parkland of the Great Plains region, and the montane forests of the Canadian cordillera.

classification – The systematic grouping and organization of objects, usually in a hierarchical manner.

climate – The accumulated long-term effects of weather that involve a variety of heat and moisture exchange processes between the earth and the atmosphere.

climatic climax – Stable, self-perpetuating vegetation developed through succession in response to long-term climatic conditions, as opposed to edaphic climax.

edaphic climax – Stable, self-perpetuating vegetation developed through succession on azonal sites. See also climax.

climatic index – Number indicating a combination of climatic factors, most often temperature and precipitation, in order to describe the vegetation distribution.

climax – Stable, self-perpetuating vegetation that represents the final stage of succession.

CNVC – Canadian National Vegetation Classification.

continuous permafrost – Permafrost occurring everywhere beneath the exposed land surface throughout a geographic region with the exception of widely scattered sites, such as newly deposited unconsolidated sediments, where the climate has just begun to impose its influence on the thermal regime of the ground, causing the development of continuous permafrost

continuous permafrost zone – The major subdivision of a permafrost region in which permafrost occurs everywhere beneath the exposed land surface with the exception of widely scattered sites.

deciduous forest – A plant community with a composition made up of 75% or more of deciduous trees. Syn. broadleaved forest.

ecodistrict – A subdivision of an ecoregion based on distinct assemblages of relief, geology, landform, soils, vegetation, water, and fauna. Canadian ecological land classification (ELC) system unit. Scale 1:500,000 to 1:125,000. The subdivision is based on distinct physiographic and/or geological patterns. Originally referred to as a land district. See ecological district.

ecological district – Portion of land characterized by a distinctive pattern of relief, geology, geomorphology, and regional vegetation. See ecodistrict.

ecological factor – Element of the site that can possibly influence living organisms (e.g., water available for plants). This term is also frequently used to refer to ecological descriptors.

ecological region – A region characterized by a distinctive regional climate as expressed by vegetation.

ecological unit – Very general term used to refer to a mapping or classification unit of any rank and based on ecological criteria.

ecology – Science that studies the living conditions of living beings and all types of interactions that take place between living beings on the one hand, and living beings and their environment on the other hand.

ecoprovince – A subdivision of an ecozone that is characterized by major assemblages of landforms, faunal realms, and vegetation, hydrological, soil and climatic zones. Canadian ecological land classification (ELC) system unit.

ecoregion – An area characterized by a distinctive regional climate as expressed by vegetation. Canadian ecological land classification (ELC) system unit. Scale 1:3,000,000 to 1:1,000,000. Originally referred to as a land region. See ecological region and biogeoclimatic zone.

ecosite – an area with a unique recurring combination of vegetation, soil, landform, and other environmental components.

ecosystem –

1. A complex interacting system that includes all plants, animals, and their environment within a particular area.
2. The sum total of vegetation, animals, and physical environment in whatever size segment of the world is chosen for study.
3. A volume of earth – space that is set apart from other volumes of earth – space in order to study the processes and products of production, particularly those transactions between a community of organisms and its nonliving environment.

ecozone – An area of the earth's surface representing large and very generalized ecological units characterized by interacting abiotic and biotic factors; the most general level of the Canadian ecological classification (EC) system.

edaphic – Related to the soil.

edaphic climax – See climax.

edaphic grid – A two-dimensional graphic illustrating the relationship between soil moisture and soil fertility.

edatopic grid – See edaphic grid.

elevational zone – Altitudinal zonation of vegetation.

environment – The summation of all living and nonliving factors that surround and potentially influence an organism.

forest – A relatively large assemblage of tree-dominated stands.

habitat – The place in which an animal or plant lives. The sum of environmental circumstances in the place inhabited by an organism, population or community.

inventory – The systematic survey, sampling, classification, and mapping of natural resources.

landform – The various shapes of the land surface resulting from a variety of actions such as deposition or sedimentation, erosion, and earth crust movements.

landscape – A heterogeneous land area composed of a cluster of interacting ecosystems that are repeated in similar form throughout. Landscapes can vary in size, down to a few kilometres in diameter.

medium texture – Intermediate between fine-textured and coarse-textured (soils). (It includes the following textural classes: very fine sandy loam, loam, silt loam, and silt).

mesic – Describing the sites that are neither humid (hydric) nor very dry (xeric). Average moisture conditions for a given climate.

mixed-wood – Forest stands composed of conifers and angiosperms each representing between 25 and 75% of the cover; for example, trembling aspen and white spruce mixed-wood forests.

moisture regime – Refers to the available moisture supply for plant growth estimated in relative or absolute terms.

mountain – Land with large differences in relief, usually refers to areas with more than 600 m of relief.

nutrient – Usually refers to one of a specific set of primary elements found in soil that are required by plants for healthy growth, such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur.

nutrient regime – The relative level of nutrient availability for plant growth.

parent material – The unconsolidated and more or less chemically unweathered material from which soil develops by pedogenic processes.

permafrost – Ground (soil or rock and included ice and organic materials) that remain at or below 0^{o} C for at least two consecutive years.

phase – (as in ecosite phase) A subdivision of the ecosite based on the dominant species in the canopy.

physiognomy – (from http://cnvc-cnvc.ca accessed July 23, 2013) The structure or outward appearance of vegetation or of a plant community as expressed by the dominant growth forms. The CNVC recognizes seven physiognomy types:

forest: a vegetation community characterized by tree species > 5 m tall (by CNVC convention), the crowns of which generally form a continuous canopy with typically > 30% cover (by CNVC convention); a large area of tree-dominated stands.

woodland: a vegetation community characterized by tree species > 5 m tall (by CNVC convention), the crowns of which form a sparse, discontinuous canopy as a result of ecological limitations such as climate, shallow soils, wetlands, etc; by CNVC convention, woodland canopies are typically between 10% and 30% cover.

Shrubland: a vegetation community characterized by shrub species, > 10 cm tall.

grassland: a vegetation community characterized primarily by grass species, typically occurring on arid sites.

forb meadow: a vegetation community characterized by forb species, often occurring on moist sites.

dwarf Shrubland: a vegetation community characterized by shrub species that have a prostrate growth form and are <10 cm tall.

cryptogamic vegetation: vegetation characterized by cryptogamic species, typically bryophytes and lichens.

plain – A relatively large, level, featureless topographic surface.

plateau – An elevated area with steep-sided slopes and a relatively level surface platy – Consisting of soil aggregates that are developed predominately along the horizontal axes, laminated; flaky.

plot – A vegetation sampling unit used to delineate a fixed amount of area for the purpose of estimating plant cover, biomass, or density. Plots can vary in their dimensions depending on the purpose of the study and the individual researcher.

potential – General evaluation of the possible biological productivity or carbon production potential of a site resource (or an area) usually expressed in terms of values to an appropriate management regime. It may be generally established or estimated from site components that represent a permanent character (e.g., soil quality).

productivity – A measure of the physical yield of a particular crop. It should be related to a specified management. Merchantable wood volume productivity is generally expressed in m^3/ha/yr. It may be further subdivided into types (gross, net, primary) or allocations (leaves, wood, above ground, below ground).

reconnaissance – A level of field analysis that involves relatively quick sampling for the purpose of obtaining general information about an area. In some cases, sampling quality may be high, but the intensity of sampling is very low relative to the size of the total area being studied.

reference site – sites that best reflect the regional climate and are least influenced by the local topography and/or soil properties. They tend to have intermediate soil moisture and nutrient regimes, mid slope positions on gentle to moderate slopes, with moderately deep to deep soils and free drainage (exception is in areas where permafrost is a characteristic of the regional climate). These sites assist in the identification and characterization of a regional ecological system.

relief – The difference between extreme elevations within a given area (local relief).

site – The place or the category of places, considered from an environmental perspective that determines the type and quality of plants that can grow there.

slope – The steepness of an inclined surface, measured in degrees or percentages from the horizontal.

subarctic – A zone immediately south of the Arctic characterized by stunted, open-growing spruce vegetation.

succession – The progression within a community whereby one plant species is replaced by another until a stable assemblage for a particular environment is attained. Primary succession occurs on newly created surfaces, while secondary succession involves the development or replacement of one stable successional species by another on a site having a developed soil. Secondary succession occurs on a site after a disturbance (fire, cutting, etc.) in existing communities.

successional stage – Stage in a vegetation chronosequence in a given site. Syn. seral stage.

taiga – Refers to a coniferous boreal forest. Often, this term is used to refer to the vegetation zone of transition between boreal forest and tundra. This vegetal formation corresponds to a forest – tundra.

toposequence – A sequence of related soils that differ one from the other primarily because of topography and its influence on soil-forming processes. The relationship between soil and vegetation types, primarily a response to different relief.

tree line – The uppermost elevation or northern limit of tree growth, usually on upland sites.

tundra – Treeless terrain, with a continuous cover of vegetation, found at both high latitudes and high altitudes. Tundra vegetation comprises lichens, mosses, sedges, grasses, forbs and low shrubs, including heaths, and dwarf willows and birches. This vegetation cover occurs most widely in the zone immediately north of the boreal forest including the treeless parts of the forest-tundra ecotone adjacent to the tree line. In high altitudes, tundra occurs immediately above the forest zone, and the upper altitudinal timberline. The term “tundra” is used to refer to both the region and the vegetation growing in the region. It should not be used as an adjective to describe lakes, polygons or other physiographic features. Areas of discontinuous vegetation in the polar semi-desert of the High Arctic are better termed barrens. Unvegetated areas of polar desert may be caused by climatic (too cold or too dry) or edaphic (low soil nutrients or toxic substrate) factors or a combination of both.

upland – A general term for an area that is elevationally higher than the surrounding area, but not a plateau.

vegetation – The general cover of plants growing on the landscape.

vegetation potential – (also vegetation climax) The species or plant community that will form the stable-mature vegetation on a site. The existing species or plant association may be different from the vegetation climax due to site disturbance and successional stage.

vegetation type – An abstract vegetation classification unit not associated with any formal system of classification.

APPENDIX II – CASE STUDIES

CASE STUDY I: ECOREGIONS OF YUKON

Nadele Flynn(material extracted from Ecoregions of Yukon update report by John Meikle and Karen McKenna – review by primary authors is required)

Background

In 1991 a group of Yukon specialists initiated a review of the 1979 Ecoregions of Yukon. Based on field experience gained since 1979 the group contributed a new version of Yukon Ecoregions to the National Ecological Framework (NEF) in1995. This 1995 version of Ecoregions of Yukon, reported on in 2004 (Smith et al. 2004) was correlated to the mapping by British Columbia (Demarchi 1996) and by Alaska (Gallant et al. 1995). Figure 1 shows the 1995The NEF map, showing Ecozones and Ecoregions. is illustrated in Figure 1.

Project overview

In 2011, the ecological and landscape classification program formed an ecoregion working group to revise the 1995 linework to better match adjacent ecological regions developed in NWT, BC and Alaska. The Yukon ecoregion revisions also incorporated new availability of key input layers such as surficial and land cover/vegetation mapping, DEMs and advances in GIS technology. Given the familiarity with the 1995 NEF, its application in management and planning, ecoregion revisions attempted to retain the 1995 stratification unless there were compelling reasons for change. The revised Ecoregions of Yukon are shown in Figure 2.

Methods

Ecoregions of Yukon is largely a top-down mapping process and the divisional hierarchy is nested. The lowest level of the hierarchy is the Soil Landscapes of Canada Unit (SLC). Ecozones, Ecoregions and Ecodistricts are subdivisions at the continental scale of climatic zones, with increasing attention to physiography as map scale increases. The SLCs are organized according to a uniform national set of soil and landscape criteria based on permanent natural attributes. There are many reasonable ways to distinguish Yukon ecoregions. Ecoregion divisions are delineated using features that are relatively stable or enduring - at least over several decades (e.g. changing climates affect criteria that influence tree line and these features can change locations in periods of of hundreds of years).

While considering changes to the NEF (1995) we continued to recognize major physiographic and climatic distinctions. At the ecozone level we did bring in a stronger regional climate element and related the ecozone level to the bioclimate framework.

To the extent possible, proposed changes accommodate improvements to linework in adjacent jurisdictions. While little has changed along the Yukon-British Columbia boundary, both Alaska and the Northwest Territories have produced important and well-reasoned revisions.

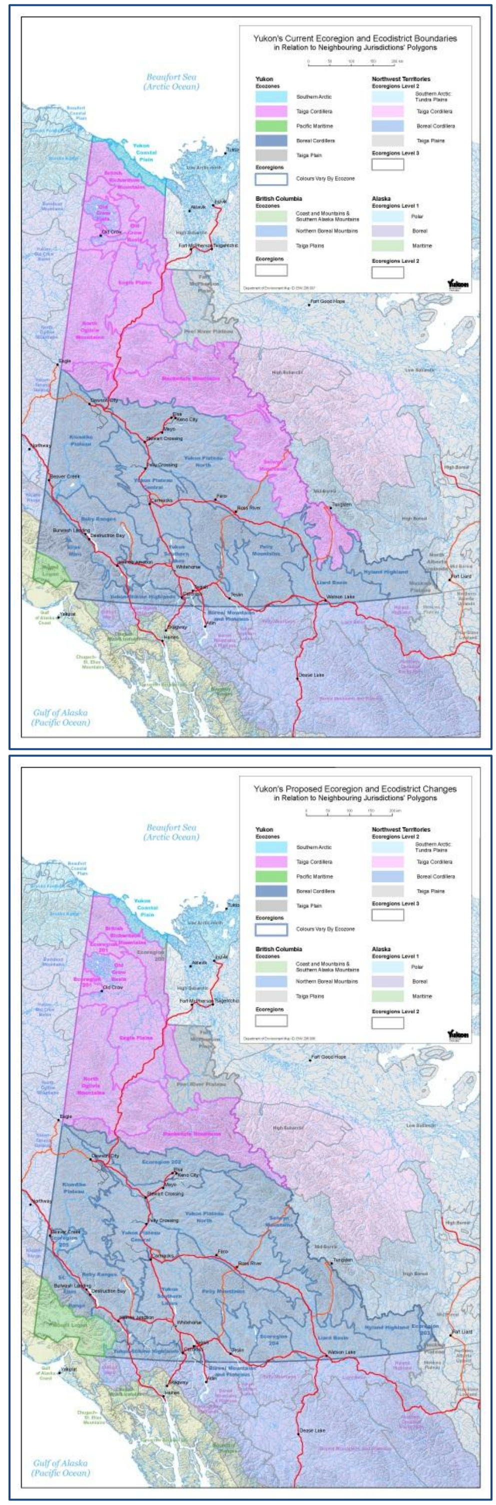


Figure 10 Revised Ecoregions of Yukon (2013)

How the product was used

Ecoregions of Yukon is used for broad scale management applications. Its nested-hierarchical nature can be used to define ecologically relevant management units at various scales. Ecoregions of Yukon (NEF 1995; Smith et al. 2004) is frequently referenced to place landscapes into their ecological context. Ecoregions of Yukon can also be used as a framework for conservation network planning, ecological reporting, wildlife management and ecological representation.

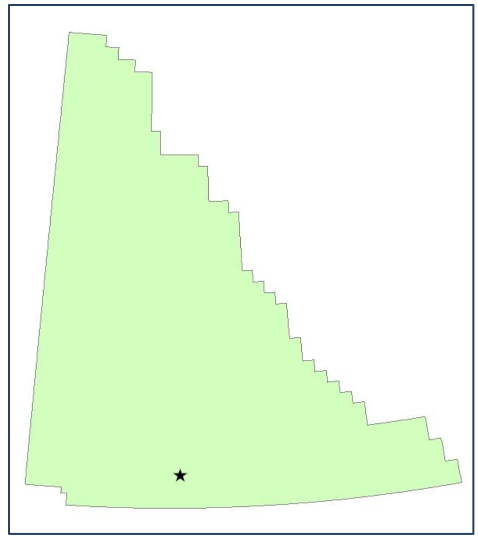
Important observations

- There are no proposed changes to concepts of Taiga and Boreal ecozones. The Working Group proposed an adjustment to the linework to use the height of land (watershed break) to differentiate between Taiga and Boreal. The watershed break matches well with climatic differences on the leeward and windward side of mountain chains, thus is also reflected in the demarcation of the boreal high and taiga wooded bioclimate zones;
- In order to accommodate revisions along the Alaska and Northwest Territories boundaries, new ecoregions are suggested that have the majority of their expression in the adjacent jurisdiction;
- Smaller revisions resulting in minor changes to boundaries based on the higher resolution Soil Landscapes of Canada mapping and regional ecosystem mapping completed for regional land use planning, which generally do not change ecoregion concepts;
- Ecodistricts were entirely redistributed to be more consistent with Soil Landscape Units and their attributes, and to reflect ecological processes operating (i.e. active fluvial systems, large extents of cold-air drainage, landforms and soil assemblages); and
- Soil Landscape Component (SLC) map and attribute revisions were completed using an 1:250,000 NTDB base. An earlier version of the SLC map (SLC version 2.2) was last updated in December 1996 and used a 1:1,000,000 NTDB base.

CASE STUDY II: SOUTHERN LAKES WETLAND MAPPING

By: Anne-Marie Roberts (A.Roberts Ecological Consulting)

Background



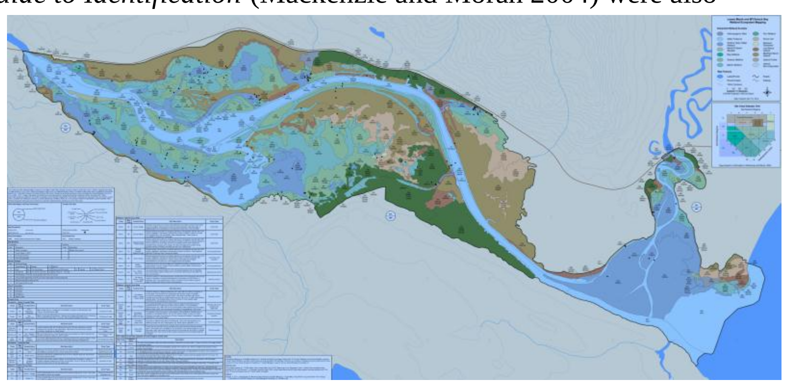
Yukon Energy Corporation proposed the Southern Lakes Enhanced Storage Project that would increase the winter full supply water level of Marsh Lake by 0.3m and potentially lower the low supply level by 0.1m. The concept would use the existing Lewes control structure to manage water storage, holding back water in the summer and fall and releasing water throughout the winter. Baseline studies within the Southern Lakes area were conducted to assess potential effects from a proposed change in the operation of Marsh Lake water storage. As part of the baseline studies, wetland ecosystem mapping of four representative and important wetland areas was completed. This mapping is being used together with bathymetric layers and hydrological models to evaluate impacts on wetlands.

Project overview

In 2010-11, 1:10,000 scale wetland ecosystem mapping was completed for four wetland complexes within the Southern Lakes area: Lewes Marsh, Nares Lake wetland, Tagish/6 Mile wetlands, and Monkey Beach wetlands, located mid-way along Marsh Lake. Mapping was conducted using principals of the Draft Yukon ELC system and the BC Terrestrial Ecosystem Mapping (TEM) process, with some additional information collected specifically for wetland sites. A. Roberts Ecological Consulting and Ardea Biological Consulting completed mapping for AECOM and Yukon Energy Corporation in Whitehorse.

Methods

The methodology used for the wetland mapping followed the *Standards for Terrestrial Ecosystem Mapping in British Columbia* (RIC 1998) and *Standard for Terrestrial Ecosystem Mapping (TEM) Digital Data Capture in British Columbia* (RIC 2000), using principles outlined in *The Yukon Ecosystem and Landscape (ELC) Framework: Overview and Concepts - Interim Draft* (Flynn and Francis 2011). Elements of wetland description and classification derived from the *Wetlands of British Columbia: A Guide to Identification* (Mackenzie and Moran 2004) were also used. The methodology had the following phases:



- Review of existing wetland and ecosystem mapping information
- Pre-typing and field planning
- Ecosystem field plots
- Detailed elevation and bathymetry data collection
- Post field data processing and final ecosite unit development
- Wetland and associated ecosite edatopic grid and generalized toposequences
- Final orthophoto interpretation and polygon delineation, labelling and mapping
- Quality Control and Assurance Process

Each ecosite map unit was summarized in a detailed expanded legend that includes a representative photo and list of characteristic vegetation by layer as well as site information.

How the product was used

The map provides a baseline record that can be used in monitoring and assessing effects of proposed water management changes over time. The wetland ecosystem maps, together with the bathymetric and DEM contours and hydrological models, are being used in the assessment of potential ecological impacts of modifying the water regime. Wetlands by their nature are dynamic ecosystems that fluctuate with annual and inter-annual variation. The transition zones between wetland types can be relatively sharp or gradual. The assessment phase of this project will use this static ecosystem map in the assessment of a dynamic system using various sources of information such as modeled water depth (based on continuous average of water level measured at Marsh Lake together with bathymetric and DEM contours) and modeled and estimated duration and timing at depth (based on water depth and hydrological models developed for the project). This information will inform the range of potential changes to wetland communities and vegetation, aiding in the assessment of potential impacts to fish and wildlife.

Important observations

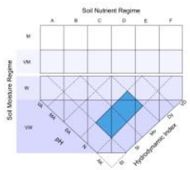
- This scale of wetland ecosystem mapping was only possible with use of recent 1m digital orthophotos and the 5m DEM.
- Bioclimate concepts were incorporated mainly using wetland units from biogeoclimatic concepts in BC. However, the most current Yukon ELC information was also incorporated and considered.
- Some of the vegetation units were analogous to those described in Wetlands of BC; whereas others were unique to this study or only partially described by other classifications.
- Challenges of describing and classifying encountered wetlands that are not described in the BC guidebook include:
    - Having sufficient data and plots to delineate, describe and classify previously not described types with confidence;
    - Fully understanding the expected conditions for previously not described types, especially given the spatially limited nature of this project; and
    - Developing a classification results in a more costly project than using an existing classification and modifying for project specific site types. The greater cost is mainly associated with the need for more plot data to describe new site types and more time to interpret data and describe new types.
- The influence of permafrost on vegetation units that are largely defined by water regime are not fully understood or defined in the Southern Lakes and are not captured in the BC guidebook. In the Southern Lakes wetland mapping, a few locations were encountered that based on the definition of marshes and fens, fell into the marsh type but due to permafrost at less than 1m depth appeared to be functioning more as fens.
- A 1:10,000 scale map is very useful for understanding and modeling potential impacts to habitats at a relatively fine scale. To create this type of map without a previous classification system in place (i.e. the BC Wetland guidebook or the BC Biogeoclimatic site series) required more time and money because of the need to develop a project specific classification and ecosite descriptions that would be useful in the interpretation of potential effects.

Bioclimatic Zone	Site Class	Class Code	Cover Types	Ecosite Code	Ecosite Unit Name
BOL	**Marsh**	**Wm**	**Graminoid**	**BW**	**Beaked sedge - Water sedge**

Mineral wetland dominated by emergent graminoid macrophytes and less than 25% aquatic vegetation. Saturated to permanently flooded hydrolic conditions. The most common and widespread Marsh ecosite unit. This site is commonly found on gleyed mineral soils.

Species diversity is low and plant cover is strongly dominated by beaked sedge (*Carex utriculata*) and/or water sedge (*C. aquatilis*) with scattered forbs, aquatics, and mosses. On sites that experience surface drying, species diversity increases and sites become more meadow like.

Floristically, this site can be very similar to the Sedge Fen (SF) and the two sites are primarily differentiated by the BW growing on mineral soils and the SF growing on organic soils.



The BW site is similar to the site description of the Beaked sedge - Water sedge (Wm01) site described in Mackenzie and Moran (2004).

SITE INFORMATION	
Elevation (masl):	660-663
Slope (%):	0-2
Aspect (º):	140, no aspect
Slope Position:	DP, LV, TO, LW
Structural Stage:	**2b**
Surficial Material:	L, F
Hydrodynamic Index:	Si-Mo
pH:	N
ASMR:	VW **6-8**
SNR:	**C, (D-E)**

Assumed Modifiers:	j
Mapped Modifiers:	y
Number of Plots:	42
Plot Numbers:	006, 044, 060, 074, 076, 079, 082, 086, 227, 229, 230, 231,407, 800, 804A, 804B, 807, 809, 810, 812, 818, 814, 1000, 1005, 1007,1006, 1017, 1019, 1029, 1046, 1051, 1056, 1058, 1059, 1078, 1083, 1084, 1091, 1098, 1110, 1111, 1115
List of Mapped Units:	BW2b, BWy2b

Occurrence:

The most common ecosystem.
Mapped in 202 out of 652 polygons.
407 ha out of 3533 ha

Tree Layer (0)	**Shrub Layer** (0)	**Herb Layer** (55-**79**-90)	**Moss Layer** (0-**46**-90)
		Carex utriculata, C. aquatilis, Hippurus vulgaris, Comarum palustre, Cerastium arvense	*Drepanocladus, Calliegeron, Amblystegium riparium*

CASE STUDY III: PEEL WATERSHED HABITAT SUITABILITY MAPPING

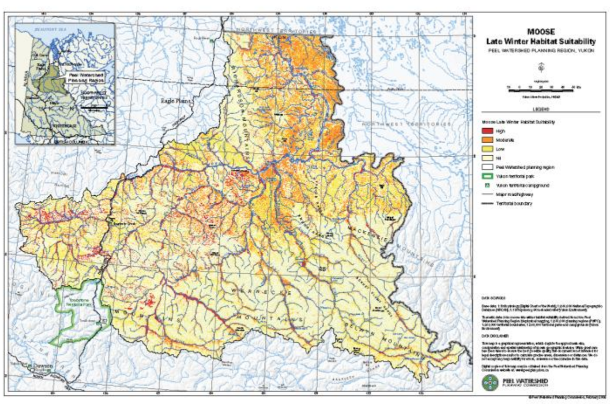
By: Sam Skinner (former Land Use Planner for the Peel Watershed Planning Commission)
& Dr. Donald Reid (Wildlife Conservation Society Canada)

Background

In 2004, the Peel Watershed Planning Commission was established to develop a regional land use plan for most of the Peel Watershed within the Yukon. One of the Commission's mandates was to use and consider traditional and local knowledge. The Commission's initial consultations resulted in their 2005 *Issues and Interests* Report. This report, and the Commission's *Concluding Remarks* on it, gave planning staff and local conservation experts at Yukon Government and Wildlife Conservation Society Canada adequate guidance to develop the *Conservation Priorities Assessment: Criteria and Indicators Report*. This report recommended that habitats of a number of species be mapped across the region in order to inform conservation priorities. Habitat maps for most of these species were either absent or incomplete, and therefore many habitat maps needed to be modelled, ideally using local and expert knowledge.

Project overview

Over two years, planning staff and local conservation experts at Yukon Government and Wildlife Conservation Society Canada collaboratively developed habitat suitability and species diversity maps based on the 25m *Ecological Land Classification* (ELC) product for the Peel Watershed (Meikle and Waterreus 2008). The goal of this exercise was to provide comprehensive mapping, across the planning region, of the distribution of species-specific habitats of varying quality so that subregional concentrations of high value habitats across many species could be identified to assist in establishing land use zoning.



Methods

At community workshops in Mayo, Dawson City and Fort McPherson, and in interviews in Whitehorse, hosting people familiar with the Peel watershed and its wildlife, a PowerPoint presentation showed on-the-ground images typical of each of the 31 ELC classes. Each ELC class was considered to be a discrete habitat. Attendees were asked to collectively rank the habitat suitability of each class for different species or herds (Porcupine Caribou Herd, Boreal Caribou Herd, Bonnet Plume Caribou Herd, moose, Dall's Sheep, Grizzly Bear, marten, waterbirds, breeding birds – species richness, birds of conservation concern, and plant endemism and rarity) for critical seasons. Commission members and biologists chose the suite of species as Indicators of the interests and values brought forward in the Criteria and Indicators process (e.g., subsistence resources; rare species; scale-dependent species). Biologists who were confident in their understanding of a certain species in the region were also asked to rank the ELC classes. At the workshops, each ELC class was ranked on a four point scale (Nil – High value), based on local knowledge and scientific expertise.

Expert biologists were then consulted to interpret the resultant rankings, to suggest ways to reconcile disagreeing ranks, and to quality check the resultant map(s). Bird biologists were also asked to estimate the number of bird species and the number of bird species of conservation concern that may breed in each of the classes.

How the product was used

The resultant maps and methods were published alongside maps of other conservation values and discussions in the Commission's 2008 *Conservation Priorities Assessment Report.* This report, together with the Commission's 2008 *Resource Assessment Report*, became the primary reference for the Commission and their staff while developing the draft and recommended land use plan.

The Commission and staff used a number of tools (e.g., a GIS overlap analysis, Marxan and Zonation) to merge or "roll-up" the large number of maps in these reports in order to locate areas of especially high conservation priority or areas of especially high land use conflicts. Despite not being published, these analyses informed some of the Commission's decisions. In the end, the broad understanding that developed while writing the two 2008 reports appeared to be more useful than the roll-up analyses.

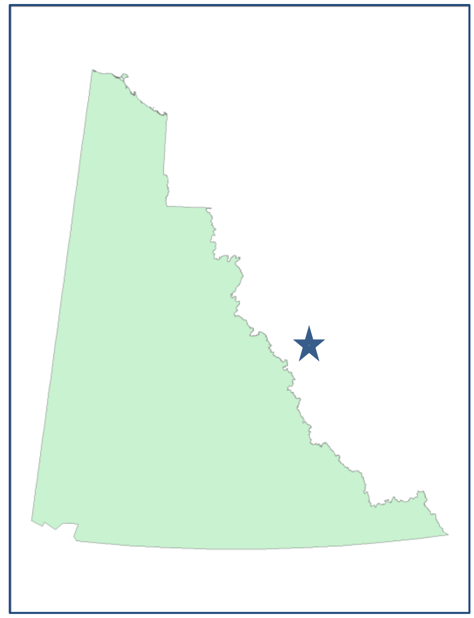
Important observations

- The need to inform land use planning (e.g., zoning, management guidelines) with wildlife data depends on an ability to comprehensively map the distributions of diverse wildlife species or the distribution of habitats that are likely currently occupied by a species or may be so in the future.
    - The YG Wildlife Key Area (WKA) database provides polygonal mapped data showing areas of particularly high occurrence (actual distribution) for a specific species. This mapping is rarely complete for a species over an entire planning region, so its utility is lessened. However, the WKA can have high value in sub-regional planning, and in checking the quality of habitat mapping.
    - The habitat suitability approach depends on a region-wide map of habitats (some form of ELC mapping) and a process of applying rankings of quality to those habitats, species by species. It is a more abstract process, dependent heavily on the scale and particular parameters used to model the habitat classes. These constraints can result in a mismatch between the mapped model and the actual distribution of a species.
- The habitat suitability mapping would not have been possible without the ELC mapping or a similar land-classification system that provides a region-wide mapping of habitats (a habitat map is a pre-requisite for an interpretive map of habitat quality).
    - Habitat suitability mapping can use EOSD (Earth Observation for Sustainable Development – land cover map) together with other data as was done with the Peel ELC. However:
        - In mountainous areas, the EOSD shows a significant amount of the "Shadow" class. This, together with some "Cloud" pixels leaves more work for the habitat modeler (or results in poorer models).
        - In mountainous regions, EOSD classes can differ considerably in habitat attributes depending on their elevation, so a bioclimate or elevation zonation mask is required.
        - The ELC has 50% more ecologically relevant classes than the EOSD. More fine-grained suitability determinations are therefore possible.
        - It is not immediately clear if the EOSD's approach to "splitting" broad vegetation classes (e.g., dense, open or sparse) is more informative than the Peel ELC's approach (e.g., high, low-mid, riparian, or wetland *and* wet, moist, or dry). A comparison of the habitat suitability between the "High Elevation Coniferous Forest" class and the "Low-Mid Elevation Dry Coniferous Forest" class showed few major differences (except for Dall's Sheep).
            - Potentially splitting the classes every way would be more informative (e.g., Low-Mid elevation wet open coniferous forest), though this would result in a very large number of habitat types. The EOSD dense/open/sparse split may have been dropped because of accuracy, usefulness or other problems.

        - Alternatively, a cleaned EOSD + topographic position data + DEM + moisture model may allow a modeler/facilitator more flexibility in choosing what information is most relevant when running a local/expert knowledge workshop. In this case preliminary EOSD ranks could be adjusted by "modifier" rankings for other factors. This may or may not be compatible with the new Environment Yukon habitat suitability mapping guidelines.
    - Habitat suitability mapping may be possible using forest cover mapping together with other data, such as fire history mapping and DEMs. However:
        - Forest cover mapping does not cover the whole territory, focuses on harvestable forest stands, and is often dated. However, this approach may be useful for regions with complete and recent coverage.
        - Forest cover attributes may be more informative than EOSD-derived habitat classes for some species (e.g., those limited by forest tree species, age class or canopy conditions), and less informative for other species (e.g., alpine species; early seral specialists).
- Land classifications were similar to those in the North Yukon Planning Region's ELC, which facilitated comparisons.
- An important assumption when "rolling up" maps (e.g., overlap analysis, Marxan and Zonation) is that all contributing spatial data are comprehensive, or "wall-to-wall" – there are no gaps in knowledge throughout the region. This requirement must be weighed against data quality. In some cases, somewhat speculative but comprehensive data may be more informative than detailed but very localized data.
- The ELC (and derivatives) extended beyond the Peel Region's boundary by a set distance (i.e., a buffer). This was very useful in allowing some subsequent analyses to go right to the boundary, or even a bit beyond.
- The 25m pixel size in general was adequate for the required interpretations.
    - 25m data yielded attractive maps that were not obviously pixelated.
    - Using 25m data in the software "Zonation" was too time-consuming. Input data for that analysis was therefore generalized. This software will not likely be used in upcoming planning processes.
- There were some concerns over seemingly spurious pixels or "dirty" transitions between classifications, so Commission staff attempted to reconcile these boundaries using a filtering approach. These cleaned versions were never used because the resultant regional patterns were no different.
- There were seemingly spurious pixels representing lentic environments next to lotic ones. This problem was significant for only one habitat suitability map (waterbirds). For this product, the ELC was first cleaned to remove the spurious pixels. YLUPC still has the model/script for this cleaning process and is available upon request.
- The ELC alone was adequate for expert-driven habitat suitability modeling for some species. Though not perfect, the models were more easily explained and yielded results that roughly matched the experts' understanding of regional patterns. However, habitat suitability for other species, like Dall's Sheep, was more context dependent. Habitat suitability models for these species had to incorporate several other data layers (e.g., projected snow depths) in addition to the ELC classes.

CASE STUDY IV: LITTLE RANCHERIA HERD WINTER RANGE, SOUTHEAST YUKON

By: Shawn Francis (S. Francis Consulting Inc.)



Background

In the mid-1990s, the level of forest harvesting activity in southeast Yukon increased dramatically. Within a few years, over 700,000 m3 of timber was harvested around the community of Watson Lake, in an area that had experienced limited previous harvesting activity. A forest products mill was constructed and plans were being developed for additional volumes. Much of the harvesting activity and planning was within the winter range of the Little Rancheria woodland caribou herd. Concerns over existing and potential future habitat impacts within the herd's range prompted an evaluation of caribou winter habitat quality and use, resulting in habitat management recommendations.

Project overview

Four different landcover and ecological map products were examined for their potential to adequately represent winter range caribou habitat values. Environment Yukon was the lead agency. Habitat mapping and caribou use is described by Florkiewicz et al. (2003). Resulting habitat management recommendations are described by Adamczewski et al. (2003).

Methods

Four different habitat and ecosystem mapping approaches were compared: 1) 1:50,000 scale forest inventory mapping (DIAND 1995); 2) 1:250,000 scale Broad Ecosystem Inventory mapping (AEM 1998), 3) 1:100,000 scale surficial geology mapping (Reid 1975; Rostad et al. 1977); and 4) 1:50,000 scale derived ecosystem map. The derived ecosystem map was created specifically for the winter range assessment by grouping forest ecosystems of the Southeast Yukon forest ecosystem classification (Zoladeski et al. 1996) according to similar landforms and surficial materials (McKenna 1996). Spatial map units were then developed by intersecting the 1:50,000 scale forest inventory polygons with surficial geology mapping using GIS methods. Ecosystems were classified based on ecological rule sets using a predictive mapping approach.

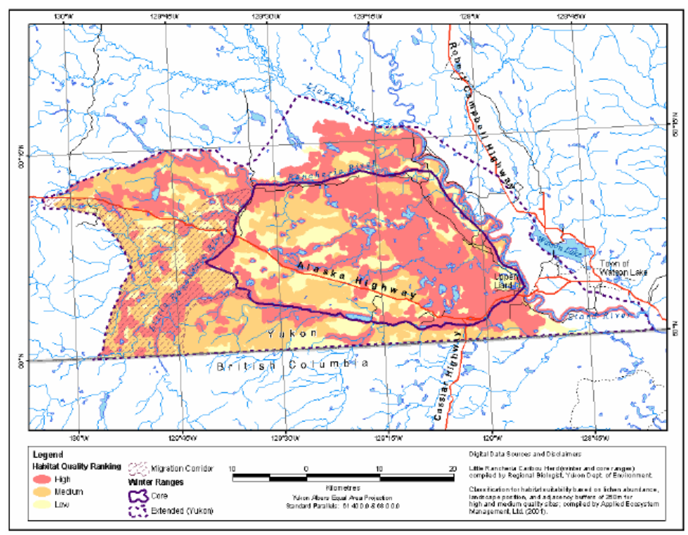


Figure 1. LRH winter range habitat suitability map, based on derived ecosystem units (red = high).

How the product was used

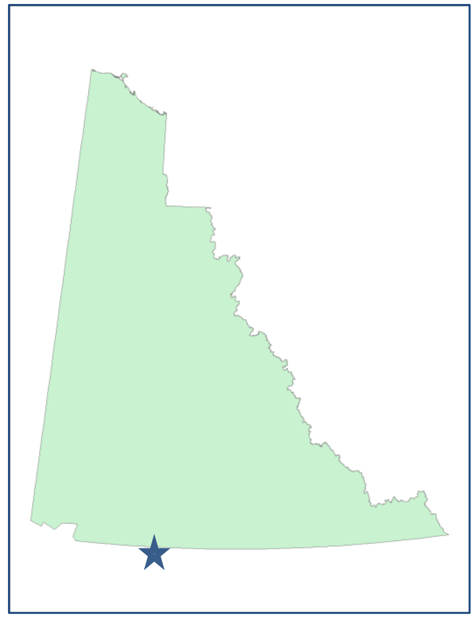
Based on a spatial analysis of caribou GPS and radio telemetry locations in relation to ecosystem units, winter habitat suitability ranks were developed for each ecosystem, and a habitat suitability map was produced (Figure 1). Caribou preferred habitats with the highest cover of lichens. The habitat suitability mapping, and an associated risk assessment, was then used to develop caribou habitat management recommendations to guide future forest management strategies (Adamczewski et al. 2003).

Important observations

- The 1:50,000 scale forest inventory was not able to capture important ecological differences between forest communities. Pine forests growing on glaciofluvial versus morainal materials were very different ecological communities, resulting in important differences in caribou habitat values.
- The 1:250,000 scale broad ecosystem inventory mapping represented the landscape well, but the spatial scale was too generalized for the scale of planning required by this project.
- The derived ecosystem mapping based on surficial geology/terrain features, forest cover polygons, and interpreted forest communities was able to differentiate important ecological communities and their corresponding caribou winter habitat values. The map product was also found to be an appropriate scale for forest management planning. Incorporating terrain and surficial geology conditions into the ecosystem classification was felt to be the key improvement over forest inventory mapping.
- The process used to develop the derived ecosystem mapping highlighted the importance of having an ecosystem classification that could be represented spatially (i.e., is mappable), a challenge also recognized by other users of the first approximation Southeast Yukon field guide (Zoladeski et al. 1996).

CASE STUDY V: CITY OF WHITEHORSE LOCAL ECOSYSTEM MAPPING

By: Shawn Francis (S. Francis Consulting Inc.)



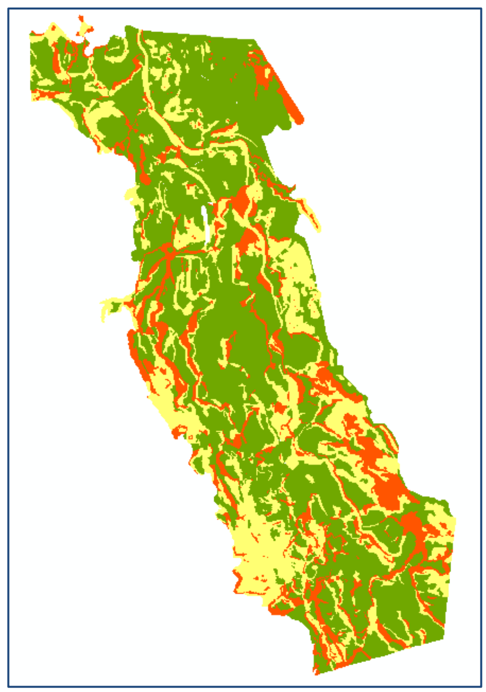
Background

In 1998, the City of Whitehorse was updating its Official Community Plan and developing new subdivisions. The City had commissioned studies to identify important fish and wildlife habitats through focal groups and knowledgeable citizens (AEM 1998) but the mapping that resulted from this work was general in nature, and challenging to apply to subdivision planning. In response to this concern, ecosystem mapping with associated ranking of wildlife values and environmental sensitivity was suggested as a useful alternative to the mapping of generalized wildlife areas.

Project overview

Over a period of three years, 1:20,000 scale ecosystem mapping was completed for most of the City of Whitehorse (Figure 1). Each ecosystem unit was ranked for different fish and wildlife values and environmental sensitivity using expert-based habitat suitability methods. Mapping and environmental interpretations were completed by Applied Ecosystem Management Ltd. (AEM).

Methods



Detailed methods are described in AEM (2000a). Mapping concepts generally followed those of RIC (1998). Bio-terrain units, based on the map units of Mougeot et al. (1998), were used as the primary ecological map unit. Vegetated ecosystems were developed based on a review of previous vegetation and ecological mapping in the Whitehorse area, including Oswald and Brown (1986), Boyd et al. (1982), Davies et al. (1983) and AEM 1999. Vegetation structural stages were modified from RIC (1998).

Detailed 1m resolution digital orthophotos were available for entire project area, as well as base feature and digital terrain models, providing a high degree of mapping resolution. Terrain and ecosystem units were manually interpreted and digitized on-screen in MapInfo GIS. Field sampling was used to guide both the mapping concepts and also to perform quality assurance checks. A wildlife habitat and environmental sensitivity ranking was applied to each ecosystem unit based on establish criteria (AEM 2000b).

How the product was used

The City of Whitehorse Planning Department used the ecosystem mapping to determine new zoning designations for Official Community Plan updates. New subdivisions directly incorporated the ecologically sensitive areas and important wildlife habitats into their design.

Important observations

- The ecosystem mapping would not have been possible without the detailed City of Whitehorse digital orthophoto and associated base feature mapping.
- The vegetation units were not standardized, and therefore difficult to correlate with other vegetation and ecosystem classifications. However, a retrospective review suggests many units could be correlated with CNVC associations.
- Bioclimate concepts were not incorporated in the project, as all mapping was completed in the Yukon River valley and surrounding lower forested slopes.

Figure 1. City of Whitehorse ecosystem map themed for environmental sensitivity (green = low; red = high).

CASE STUDY VI: ALASKA PIPELINE PROJECT PREDICTIVE ECOSYSTEM MAPPING

By: Terry Conville (Stantec Consulting)

Background

To meet the regulatory requirements of a proposed pipeline from Alaska to Alberta, the Alaska Pipeline Project completed ecosystem mapping (between 2010 and 2012) to provide up to date baseline information that would support an Environmental Impact Assessment of the proposed project footprint.

Project overview

ELC mapping for portions of the Alaska Pipeline Project (APP) within Yukon and BC was created using a modified Predictive Ecosystem Mapping (PEM) approach. This approach included the mapping of ecological site units within the existing ecorgion framework of Yukon (Smith et al. 2004). The mapping team completed 1:20,000 scale PEM using the most recent data and information available that was suitable for the project objectives and required interpretations. In Yukon the mapping was completed within a 1500m wide corridor along the proposed 750 km route.

Methods

The mapping approach adhered to fundamental ecological principles. The difference in the modified-PEM approach, as compared to traditional mapping methods based on air photograph interpretation alone, is the digital organization and manipulation of the ecological building blocks in a knowledge-based modeling environment. Available data sets from the Yukon Government were reviewed and used, including: planimetric, hydrological, and a DEM created from the Yukon NTDB, EOSD land classification mapping, existing Yukon Forest Inventory, as well as ecoregion linework and available terrain mapping from other sources and projects. Additional focused air-photo interpretation was carried out for specific (difficult to model) ecological features of the Yukon landscape. The data was organized by ecoregion and combined in a raster GIS environment. Selected attributes were chosen and developed from the base data according to their spatial and thematic quality, and then combined together using fuzzy logic algorithms.

Field data collection was carried out in 2010 and 2011 by a TEM team which consisted of a soils/terrain, vegetation, and wildlife specialist. This work was used to classify the ecosystems and characterize the environmental relationships across the landscape. Further the field work was used to inform the development of the ecosystem knowledge base within the study area. Standardized data collection protocols were developed and followed for all field work activities. Over 300 field sample sites were established (more than ½ of these were detailed ground plots).

How the product was used

The ELC mapping product was used as an ecological base map for determining the representation and distribution of ecosystems across the project area, as well as for:

- identification of rare and endangered communities and species
- identification and location of old forest
- identification of wetland types
- soil and terrain assessments
- wildlife habitat capability and suitability

Secondary applications also include biodiversity assessment, determination of cumulative environmental effects, climate change strategies and analysis, reclamation planning and mitigation and monitoring.

Important observations

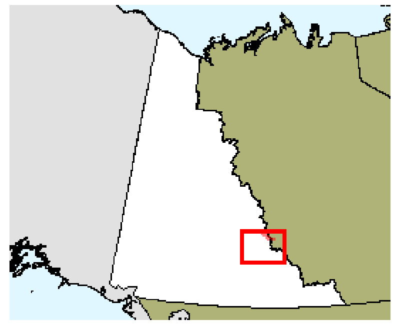
- This project required development of a project specific (site level) ecosystem classification across various ecoregions within the southern Yukon
- Consistent coverage of moderate resolution vegetation cover was not available at the time of this project
- Development of a moderate resolution DEM would prove very beneficial for local scale mapping
- Focused materials and exceptions mapping was a key input source layer
- Updated disturbance (fire and human) mapping is required

CASE STUDY VII: SELWYN PROJECT ENVIRONMENTAL BASELINE STUDIES

Terrestrial Ecosystem Mapping (TEM) and Wildlife Habitat Suitability Mapping

By: Tania Tripp and Jackie Churchill (Madrone Environmental Services Ltd.)

Background

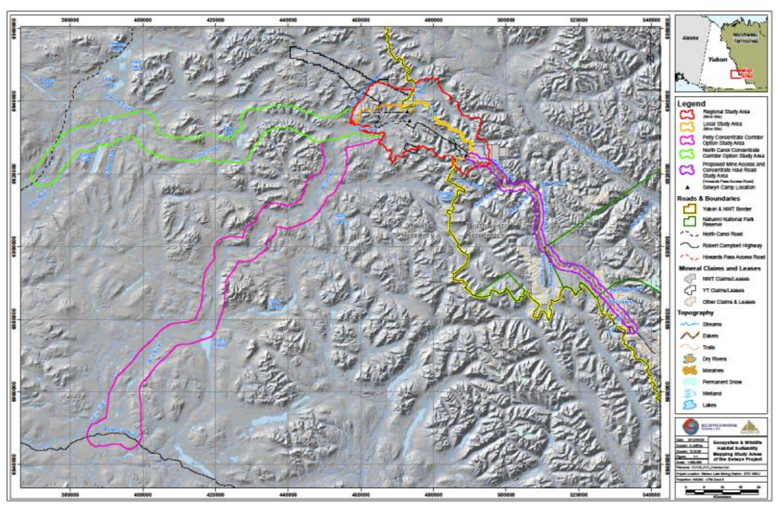


Madrone Environmental Services Ltd. (Madrone) was retained by Selwyn Chihong Mining Ltd. (SCML) to complete environmental baseline studies, including terrestrial ecosystem mapping (TEM) and wildlife habitat suitability interpretations, for a proposed zinc-lead Mine Site (The Selwyn Project) and associated infrastructure. These studies were prepared to support the Project Proposal submissions to the Yukon Environmental and Socioeconomic Assessment Board (YESAB), and the Mackenzie Valley Environmental Impact Review Board (MVEIRB), and any associated permitting requirements for the advancement of the Project.

The Project is located in the Howard's Pass area of the Selwyn Mountains, located in the western portion of the Nahanni Map area (NTS 105I), straddling the Yukon Territory/Northwest Territories border (Figure 1).

Project Overview

From 2007 until 2012 baseline environmental assessments for vegetation and wildlife habitat suitability were completed for approximately 226,000 ha within the Yukon, as well as an additional 15,000 ha in the Northwest Territories. The study area delineated around the proposed mine site for ecosystem (vegetation community) mapping covered an area of 56,839 ha (the Don Creek Watershed). Reports were produced for each of the areas mapped that include a description of the physical environment of the areas, the field data collection and mapping methodologies, and the distribution and composition of vegetation communities. The report and associated maps were used to identify and quantify ecosystems and vegetation that may be impacted by future development activities.



The ecosystem mapping was also used for modelling wildlife habitat suitability throughout the Project area for multiple wildlife species including, but not limited to, Woodland Caribou, Grizzly Bear, Moose, Wolverine, American Beaver, and Trumpeter Swan.

Methods

<u>Ecosystem Classification System</u>

During initiation and through completion of the vegetation baseline studies for the Selwyn Project, no standard for ecosystem mapping was available in the Yukon. Therefore, one was developed for the mine site study area in 2007 that worked within the standardized Terrestrial Ecosystem Mapping (TEM) framework developed and established for British Columbia (Pojar et al. 1987, BC Resource Inventory Standard [RIC] 1996, and BC Resources Information Standards Committee [RISC] 1998). TEM uses a hierarchical ecosystem classification system where lines are delineated around differences in bioterrain and ecological features creating a series of polygons. Bioterrain mapping identifies terrain features and landforms (e.g., aspect, slope), while ecological mapping identifies plant communities, site modifiers, structural stage and disturbances (BC RISC 1998). The rationale for this classification system approach was to produce a hierarchical, objective, intuitive classification that reflected the bioterrain features of the landscape, with sufficient detail to categorize specific vegetation associations that could be used for wildlife habitat modelling.

As part of the ecosystem mapping process, a systematic, hierarchical approach to classify the landscape into broad ecological zones was applied to the study areas based on background research, air photos, and field observation. The broad ecological zones reflect an integrated expression of regional climate, soils, vegetation, topography, and time (Pojar et al 1986), and are analogous to the biogeoclimatic (BGC) zones that are the standard used throughout BC. The pattern of undisturbed climax vegetation communities reflect the abiotic features and climatic influences in a consistent and repeatable pattern within a zone and are not solely driven by elevational limits (Meidinger and Pojar, 1991).

Vegetation classification and associated coding for map labels were adapted from relevant Yukon studies (including Zoladeski et al. 1996, Lipovsky and McKenna 2005, and Silvatech 2007) to suit the environment of the study area and provide data in a format that would fulfill project objectives. These classification studies were compared to adjacent (forested) BGC units for adjacent regions in British Columbia (DeLong 2004). Additional guides describing plant indicator values and local reports were also reviewed including the ecosystem network report prepared for the La Biche river watershed (Loewen et al., 1999), and the Wolverine Project Environmental Assessment Report prepared for Yukon Zinc Corporation (AXYS, 2005). Wetland units were classified according to the Wetland and Riparian Ecosystem Classification (WREC) system which is based on the BEC system (Mackenzie and Moran, 2004). Background materials on the geological history, biophysical mapping and ecological classification, land management, rare species, protected areas, soils, and other relevant topics were also researched.

Based on the information available at the time, vegetation community labels were created that described the dominant vegetation type based on drainage and nutrient regimes (see attached table with examples). Polygons were then assigned labels (for vegetated and non-vegetated units), generally following the biophysical approach by assigning plant communities to discrete, homogeneous ecosystems within broad ecological zones. Ecosystem profiles integrating bioterrain and ecosystem data were adapted from the draft legend prior to final polygon labelling to provide a working tool.

<u>Preliminary Mapping</u>
For the Mine Site portion of the Selwyn Project area hardcopy black and white aerial photographs taken in 2004 were used for ecosystem mapping using stereoscopes for viewing and mapping directly on the photos. The remaining project area was mapped using orthophotos ranging from 1992 to 2004 and ArcGIS9.3, 3D PurVIEW software, which allowed for mapping directly on-screen at a scale of 1:15,000.

The photos were pre-typed for bioterrain (surficial geology material, thickness, expression, processes, modifiers, and drainage) following BC RIC (1996) standards and Howes and Kenk (1997). Photos were then pre-typed for terrestrial ecosystem mapping, which consisted of stratifying the area into clearly visible ecological zones (analogous to delineating biogeoclimatic zones), then subdividing bioterrain polygons where multiple discrete ecosystem polygons were visible, and adjusting the existing bioterrain polygons to align with the ecosystem polygons where applicable (BC RISC 1998).

<u>Field Verification</u>
Customized data collection forms were developed for soils and bioterrain and vegetation, with interpretive keys for field crews. For consistency, a blank edatopic grid, a standard site characterization tool, was included in the field cards for the vegetation mapper to rapidly assess the relative soil moisture and nutrient status of the site.

At each field site, a representative location (plot) within the polygon was chosen for assessment. Plots with comprehensive data collection are termed “ground inspections” with less detailed field verification referred to as “visual inspections”. The same field form was used for both levels of field inspection. As per BC RISC (1998) guidance, the assessments generally characterized a 20 m x 20 m plot, but dimensions were modified for linear or irregular ecosystems. At the more detailed "ground inspection" plots, full soil pits were dug and evaluated, species presence and cover were recorded for all vegetation present within each layer on site, and bioterrain features and processes were noted.

Other parameters collected at all plots included UTM co-ordinates, elevation, aspect, slope, drainage, soil moisture and nutrient regimes, canopy closure, stand structural stage, photos and – where applicable – other ecosystems comprising the polygon, if the polygon was a mosaic of more than one type. Features relevant for wildlife habitat suitability for a pre-determined list of species and life history stages were also recorded. The field crew discussed their data to ensure that relative assessments of drainage and other parameters were consistent.

Final Mapping

All polygons were assigned a final ecosystem label and polygon boundaries (linework) were modified based on the field assessment. Where applicable, ecosystem site modifiers were mapped following BC RISC (1998) to depict aspect, slope, material thickness, and other features. Ecosystem structure was also classified according to BC RISC (1998) structural stages to reflect stand development and provide important wildlife habitat information. Structural stages, however, were developed to reflect the range of ecosystems throughout BC, and only a subset of these occurs in the Project area.

A total of 2,970 verification plots were completed during TEM field sessions in 2007, 2010, and 2011 for the Selwyn Project Area (including the proposed mine site and additional infrastructure study areas) (see attached table). The plot data provided valuable insight into the ecosystem classification system used as well as increased the accuracy of the ecosystem and wildlife map products. The high sampling intensity and detailed mapping resulted in a polygon size and accuracy level that can support interpretations corresponding to BC RISC standards for survey intensity Level 4 (15-25% polygon verification). Data was collected to a standard modified to suit this particular project with more intense sampling around proposed development footprints.

Important Observations

- Ecosystem mapping is useful to obtain baseline conditions for large landscape areas.
- The vegetation/ecosystem mapping has numerous future applications including wildlife habitat mapping, identifying/quantifying areas impacted during development activities, planning restoration/compensation activities and protecting rare/special features within the landscape.
- The scale of ecosystem mapping over large landscape areas can lead to limitations in delineating and identifying small-scale features.
- Environmental studies can be conducted at varying intensity levels to meet a range of project objectives and scopes. Broad, overview scale inventory projects that typically include a large area and show regional trends with less detail are termed regional study area (RSA). Site-specific projects require more detail and focus on a smaller area are termed local study area (LSA). There is a distinct lack of standard to what scale (size of area) is appropriate for the RSA for projects of this nature. Using watershed boundaries is logical, however, distinct, natural landform boundaries are not always present or obvious for all ecosystem mapping projects within the Yukon (i.e., vast expanses of flat topography throughout a significant portion of the Yukon).
- The vegetation RSA for the Selwyn Project included the SCML mining claim blocks within Don Creek watershed and surrounding watershed sub-basins within Yukon Territory and Northwest Territories; this area is 56,839 hectares. The RSA was then subdivided into local study areas, zones of influence and development footprint areas for subsequent wildlife and vegetation potential impact assessments.
- Field verification is critical to ensure a reasonable level of mapping accuracy.
- Ecosystem mapping requires air photo/orthophoto coverage and associated base feature mapping. Mapping limitations can occur based on the quality (resolution), year, season, and time of day when the image was taken.

- Mapping of non-forested units from air photo interpretation is subject to a higher degree of uncertainty than more clearly visible units. Experience in the project area and the draft legend and profiles were used to support these interpretations, which integrated the bioterrain information to extrapolate the ecosystem type most likely to occur on the site.
- Shaded areas on air photos were also based on bioterrain labels and their aspect, slope, and adjacent polygon cover.
- Digital mapping (ArcGIS/PurVIEW) is a more efficient and cost effective mapping method compared to traditional hardcopy mapping. The other key advantage to on-screen mapping with high resolution photos is the ability to zoom in to areas that are less obvious in order to assign a more accurate label to a given polygon feature.
- The vegetation classification system was standardized across all areas mapped for all portions of the Selwyn Project. Due to the lack of a standardized ecosystem classification system for the Yukon, however, these results would be difficult to compare to other ecosystem mapping conducted throughout the Yukon.

Conclusion

The TEM product for this project was designed to provide a tool that can be used to monitor changes in abundance and distribution of plant species and vegetation within and around the future project footprint. This data can further be used to support project design and management decisions, and for focal species wildlife habitat modelling. The final products provide baseline information that can be used in support of future recommendations and mitigation associated with the Selwyn Project.

During project initiation, ecosystem classification in the Yukon was in the early developmental stages due to the limited distribution of ecosystem projects, and there had been very little data collected in the Selwyn Mountains. To develop an appropriate ecosystem classification for the Project, Madrone adapted and modified existing classifications to suit the local conditions. For future environmental baseline studies, a standardized ecosystem classification system for the Yukon will enable ease of comparing results between projects, improved data collection and coverage for the region, and increased efficiencies and cost savings.

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