STRATEGIC PLAN FOR KOOTENAY BOUNDARY REGION: ECOSYSTEM MAPPING TO SUPPORT WILDLIFE AND HABITAT STEWARDSHIP

Prepared by

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In addition, several subject matter experts from various consulting companies, were consulted to provide feedback related to the mapping requirements, challenges and recommendations for identifying these priority ecosystems on the landscape. This information was compiled by Madrone Environmental Services Ltd. through feedback provided at series of three workshops (January/ February 2022). Madrone Environmental Services Ltd., along with also led development and documentation of the ease of mapping priority ranking system for the Kootenay Boundary Region. Ministry review and final compilation of all materials was completed as part of finalization of this document.

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Acronym	Description
BCGW	British Columbia Geographic Warehouse. A central government repository of spatial and non-spatial data. The data includes Base Mapping information, such as heights of land, rivers, lakes, roads, place name and administrative boundaries, as well as government program information, like forest cover, ecosystems, economic and health indicators.
BCSIS	BC Soil Information System.
BEC	Biogeoclimatic Ecosystem Classification.
BEI	Broad Ecosystem Inventory.
BEM	Broad Ecosystem Mapping.
BEMVRI	Broad Ecosystem Mapping and Vegetation Resource Inventory.
BEU	Broad Ecosystem Unit.
BGC	Biogeoclimatic.
CDC	Conservation Data Centre.
CEF	Cumulative Effects Framework.
EA	Environmental Assessment.
EO	Element Occurrence.
EXC	Exceptions Mapping.
DEM	Digital Elevation Model. A three-dimensional representation of the Earth's bare surface.
DTEIF	Describing Terrestrial Ecosystems in the Field.
EBM	Ecosystem-Based Management.
ENV	Ministry of Environment & Climate Change Strategy.
FGDB	File Geodatabase.
FLNR	Ministry of Forests, Lands, Natural Resource Operations and Rural Development.
FREP	Forest and Range Evaluation Program.
FWA	Fresh Water Atlas. The Freshwater Atlas is a standardized dataset for mapping British Columbia's hydrological features. The atlas defines watershed boundaries and provides a connected network of streams, lakes, and wetlands. This network serves as the foundation for sophisticated analysis and modelling.
LiDAR	Light Detection and Ranging.
LMH	Land Management Handbook.
LUT	Look-up Table.
nBEC	Biogeoclimatic Ecosystem Classification based non-forested Ecosystems.
NEM	Terrestrial Ecosystem Mapping without Bioterrain.
PEM	Predictive Ecosystem Mapping.
RISC	Resource Information Standards Committee.
RSF	Resource Selection Functions.
SAR	Species at Risk.
SDM	Species Distribution Modelling.
SEI	Sensitive Ecosystem Inventory.
SIFT	Soils Information Finder Tool.
SIL	Survey Intensity Level.
SOIL	Soil Inventory Mapping.

Acronym	Description
TBT	Bioterrain Mapping.
TEM	Terrestrial Ecosystem Mapping.
TEMNSS	Terrestrial Ecosystem Mapping with no Structural Stage.
TEI	Terrestrial Ecosystem Information.
TEIS	Terrestrial Ecosystem Information System.
TIM	Terrain Inventory Mapping.
TRIM	Terrain Resource Information Management. A series of 1:20,000 scale topographic base maps that provides the base data for the Province of British Columbia. TRIM is a set of three-dimensional digital files that support development and management of land-related information.
TSM	Terrain Stability Mapping.
TSR	Timber Supply Review.
LiDAR	Light Detection and Ranging. LiDAR is an active remote sensing technology used to map the earth's surface. Point clouds may be utilized to generate Digital Elevation Models (DEM).
VRI	Vegetation Resources Inventory. Vegetation Resources Inventories (VRI) is a photo-based, two-phased vegetation inventory design consisting of photo interpretation and ground sampling.
WET	Wetland Mapping.
WHR	Wildlife Habitat Ratings.

1 Introduction

The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) and Ministry of Environment & Climate Change Strategy (ENV) have produced this Strategic Plan for Kootenay Boundary Region ecosystem mapping to support wildlife and habitat stewardship with funding from the provincial Together for Wildlife Strategy (Together for Wildlife – T4W).

Together for Wildlife is the provincial strategy to improve wildlife and habitat stewardship across British Columbia. The strategy commits to 5 goals and 24 actions to achieve the vision: *Wildlife and their habitats thrive, are resilient, and support and enrich the lives of all British Columbians (FLNR 2020).*

Goal 2 of the strategy states: Data, information, and knowledge drive better decisions. This strategic plan contributes to this goal and the specific Action 4, to fill critical gaps in mapping wildlife habitat, including developing wildlife population and habitat supply models, and better understand the effects of climate change on wildlife. Improved ecosystem mapping for the region will contribute to addressing these gaps and improving the quality of wildlife and habitat models. Ecosystem mapping also contributes to managing for habitat resilience by identifying priority areas for restoration and enhancements such as wetlands and grasslands. Priority areas based on multi-disciplinary Terrestrial Ecosystem Information (TEI) ensures that habitat decisions are informed by current vegetation, site potential, climate and soil/landform relationships.

In addition, ecosystem mapping supports Goal 3, specifically under Action 8 by providing spatial data to help establish clear and measurable objectives linking wildlife populations to habitat. Under Action 8, the province has committed to developing provincial stewardship frameworks and regional stewardship plans for priority species and populations. Not only does this stewardship planning apply to terrestrial wildlife species and their habitats, but also includes ecosystem objective-setting if and where appropriate. The quantity, quality, spatial distribution, and trends in forested, grassland, alpine and wetland ecosystems is critical to understanding and setting habitat objectives.

Terrestrial Ecosystem Information (TEI) in BC is defined as the inventory, mapping, and modeling of terrestrial ecosystems, soils, terrain, habitat, and species and are collected and captured in accordance with established provincial Resource Information Standards Committee (RISC) standards[1].

TEI mapping and modeling stratifies the landscape, according to a combination of features such as: climate, physiography, surficial material, bedrock geology, soil, and vegetation. This mapping can be used to help support multiple natural resource initiatives such as Cumulative Effects Framework

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[1] https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/inventory-standards

(CEF), Timber Supply Review (TSR), Ecosystem-Based Management (EBM), conservation of species at risk (SAR) and protected areas, First Nations consultation and engagement, Environmental Assessments (EA), land use planning, oil and gas development, forest and range planning including Forest and Range Evaluation Program (FREP) monitoring, climate change adaptation and mitigation, major project reviews, BC wildfire safety assessments, wetland modeling, water demand modeling, and conservation of hunted and trapped wildlife, among others.

In the Kootenay-Boundary region, the initiatives that have relied on TEI include:

Initiative	**Regional Focus**	**Relevant Terrestrial Ecosystem Information**
✓ Collaborative Stewardship Framework	• Projects under the CSF Forum include, but are not limited to, collaborative wildlife stewardship, huckleberry stewardship, and the development of a Ktunaxa Guardian program.	• The Ktunaxa-BC huckleberry stewardship planning has used huckleberry associated ecosystem mapping and modelling to delineate areas for specific stewardship actions.
✓ Cumulative Effects Framework	• Completed assessments in the Elk Valley for Aquatic Ecosystems (Riparian Habitat & Westslope Cutthroat Trout), Old and Mature Forest, Grizzly Bear, and Bighorn Sheep. • Completed a streamflow, sedimentation, and riparian ecosystem hazard analysis for the Kettle River watershed.	• Ecosystem mapping and modelling was required for the each of the completed assessments, especially for riparian habitat, old and mature forest and grizzly bear habitat. • Limitations because of poor quality wetland and riparian ecosystem mapping were noted in the Kettle River watershed hazard analysis.
✓ Forest Landscape Planning	• There is no pilot currently in the region. In the future, the FLP will incorporate wildlife stewardship planning and objectives.	• The mapping of non-forested ecosystems would be a valuable input for future FLP. • Existing PEM mapping would likely be used by default but there are limitations as noted in this document.
✓ Modernized Land Use Planning	• Ktunaxa-BC land stewardship planning is ongoing with throughout the SE Wildlife Corridor (Elk/Flathead Valleys).	• This initiative would benefit from seamless TEM mapping for the region. • Existing PEM mapping would likely be used by default but there are limitations as noted in this document.
✓ Old Growth Strategic Review	• The review sets initial old growth management priorities for new policy development intended to meet objectives for economic, conservation, and cultural values.	• Mapping completed for old and ancient forests contribute to identifying wildlife and biodiversity priorities in the region.
✓ Species and Ecosystems at Risk	• Recovery actions and implementation including specific	• Recovery actions often include improved inventory and habitat modelling and especially for non-

Initiative	Regional Focus	Relevant Terrestrial Ecosystem Information
Recovery Planning and Action	actions for caribou and Northern leopard frog recovery.	forested ecosystems that rare and endangered species rely on.
✓ FRPA[2] Government Action Regulation (GAR)	• GAR Designation are an ongoing priority in the region, including Wildlife Habitat Areas, Ungulate Winter Range, & Wildlife Habitat Features.	• Finer scale ecosystem mapping, such as TEM, provides the detail needed to support any non-expert based modelling of winter range and wildlife habitat attributes.

In addition, there are several other BC government led initiatives linked to TEI information and data including:

- Site Productivity Dataset provides site index estimates province-wide for commercial tree species using available ecosystem data (spatial delineations and descriptions) from existing PEM and TEM datasets, coupled with SIBEC data
- PEM Research Project
- Multi-year large scale seamless TEM mapping initiatives within the Coast Region based on land management objectives (Great Bear Rainforest and Haida Gwaii)
- Avalanche path derived ecosystem mapping for Kootenay Lake TSA
- High Elevation grassland ecosystem mapping for Cranbrook TSA

The TEI available in the Kootenay Boundary Region has spatial and attribute gaps. These inventories were collected over the past four decades under a variety of standards and for a variety of purposes. A review and gap analysis of the available data and mapping products is required to evaluate their utility to the Together for Wildlife goals. Filling information gaps will help to complete an ecosystem knowledge base and inform decisions. Inventory actions include mapping and modelling, field data collection, research and development, education and outreach, forming partnerships and building continuous improvement processes.

The focus of this project is to guide development of a regional strategic plan for ecosystem mapping to provincial RISC standards to support wildlife and habitat stewardship. This includes a gap analysis of existing information and guidance on priorities and strategies for next steps, such as developing new methods and standards in support of wildlife goals. Results of this project are provided both within the body of this document and associated appendices and Excel spreadsheets, providing more detailed results of the available TEI data, a gap analysis, expert input on mapping or modelling of priority ecosystems, and the results of the prioritization (ease of mapping). This plan identifies the regional need for region-wide mapping and data at a refined scale that is scientifically defensible, consistent, well documented and can be used to meet a variety of regional land management needs.

[2] *Forest and Range Practices Act*

However, the completion of a Provincial standard seamless ecosystem mapping for the entire region would require significant government funding and support. This plan provides a foundation for this initiative and a starting place for working towards this ultimate goal. It also provides information for communicating Together for Wildlife ecosystem mapping priorities in the Kootenay Boundary Region to existing and potential partners and stakeholders.

This Strategic Plan has the following objectives:

- Provide background information on the Kootenay Boundary Region with respect to Together for Wildlife strategies and the potential benefit of using ecosystem mapping for wildlife management in the Region (Section 2);
- Provide background information on Terrestrial Ecosystem Information (TEI) including a high-level summary of the types of ecosystem classification, mapping and inventory options available (Section 3);
- Discuss ecosystem mapping and modelling methods including project type selection considerations including benefits and limitations (Section 4);
- Develop decision tools, such as flowcharts, for use in evaluating existing mapping and for choosing mapping methods for priority ecosystems or species (Section 4)
- Complete a gap analysis and review of existing TEI products within the Kootenay Boundary Region with a focus on regional priority ecosystems and wildlife species habitats (Section 5, Appendix C);
- Develop an 'ease of mapping' prioritization approach for Regional ecosystem mapping actions using the results of the gap analysis (Section 6);
- Provide expert input on mapping or modelling of priority ecosystems and wildlife species habitats within the Kootenay Boundary Region (Section 7, Appendices D and E); and
- Provide recommendations and next steps for ecosystem mapping prioritization and mapping of priority ecosystems and wildlife species habitats within the Kootenay Boundary Region (Section 8).

2 Background

2.1 Region at a Glance

The Kootenay Boundary Region of southeast BC has varied terrain characterized by a series of north-south trending mountain ranges (Rockies, Purcells, Selkirks and Monashees) and is diverse for wildlife and their habitats as it contains forests, grasslands, alpine meadows, glaciers, wetlands and inland temperate rainforests (FLRNO 2016a). In the drier rain shadows, grasslands with open ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) forests are found in the valley bottoms of the southeast. Along the Columbia River, vast wetlands are found in low lying areas and provide important habitat for waterfowl and numerous other wetland and water dependent birds. These lower open areas transition to mixed coniferous-dominated forests in mid-elevations and to rugged subalpine and alpine habitats of the Rocky and Purcell Mountain Ranges. Populations of elk, deer, and bighorn sheep are important managed wildlife species in this area and provide diverse benefits to ecosystems, Indigenous communities, hunters, and recreationalists.

To the west, the generally wetter Selkirk Mountain Range is characterized by more densely forested areas dominated by western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) stands in lower areas. Greater precipitation levels result in more habitat types associated with vigorous vegetation growth, and open areas on the valley bottoms are more limited than further to the east. Several river systems have been dammed, creating large hydro-electric reservoirs, and provide important fisheries for recreational anglers. Mid-elevation areas are characterized by dense conifer forests that transition into open parkland forests followed by the non-forested areas of subalpine and alpine at higher elevations. Large ungulates are typically less abundant in these wetter, mid-elevation forested areas, however, black bear and furbearers are generally more plentiful in these wetter forests than drier forests to the east. Sources of natural disturbance in the Region include wild fires, forest insects and diseases and flooding (FLRNO 2016a)

In the Kootenay-Boundary region, there is a general lack of quality non-forested ecosystem (nBEC) mapping, which have been identified as key ecosystem types and priority habitats for numerous wildlife species. The majority of ecosystem mapping in BC is focused on lower elevation, agriculture and forest lands. Only 13% of the Kootenay-Boundary region has TEM coverage, and much of the PEM mapping does not adequately capture these non-forested ecosystem types. Therefore, in the Kootenay-Boundary, to date and due partly to the lack of ecosystem mapping information, core ecological values and primary habitat management objectives have focused on population management of elk, deer, bighorn sheep, mountain goat, moose, and cougar. In addition, priority habitat activities have included access management due to high road density, cumulative effects assessments in the Elk Valley, and habitat enhancement and restoration of fire-maintained ecosystems and wetlands.

2.2 Together for Wildlife Strategy

Within the mandate of Together for Wildlife, wildlife is defined as terrestrial vertebrates and invertebrates that are provincially yellow or blue listed, in addition to plant communities, habitats or habitat features that support life requisites of these species. Although this strategy focuses on terrestrial, and not "at risk" wildlife, the actions identified will, in many situations, also benefit aquatic species and species at risk. Strong linkages with the programs responsible for these species will help to ensure coordinated delivery.

At the onset of the project, BC government regional staff identified priority terrestrial ecosystems to consider for ecosystem mapping in the Kootenay Boundary Region (Table 1). These ecosystems were identified as a priority because of their ecological vulnerability and importance to the life requisites of regionally important species and those listed in the Identified Wildlife Management Strategy under the *Forest and Range Practices Act* (FRPA).

Goal 5 of Together for Wildlife focuses on collaborative wildlife stewardship that advances reconciliation with Indigenous governments. This strategic plan is a technical document that will contribute towards information sharing and be a starting place for engagement with Indigenous governments on their priorities for ecosystem mapping. The list of ecosystems in Table 1 has not yet been engaged on with Indigenous Nations or stakeholders. It is a ‘living’ list and provides a starting point for future collaboration and technical work related to the stewardship of these ecosystems.

Table 1: Identified Priority Terrestrial Ecosystems for Regional Ecosystem Mapping

Identified Priority Ecosystems	Brief Description
Whitebark and Limber Pine	High elevation, upper subalpine ecosystems ranging from timberline, where these five-needle pine may occur as stunted krummholtz, down to closed subalpine forest.
Avalanche Path Derived	A shrubland dominated by alders or other shrubs, where periodic snow and rock slides prevent coniferous forest establishment and where moisture is plentiful for much of the growing season. Lower areas may support rich herbaceous growth.
High Elevation	A high-elevation herbaceous community, dominated by moisture-loving herbs and sedges, on wetter sites in the alpine and subalpine forest areas. Parkland ecosystems include a high-elevation mosaic of stunted tree clumps referred to as krummholtz, and herb or dwarf shrub-dominated openings.
Wetlands	Ecosystems developed under high water tables or other increased moisture conditions; includes fens, bogs, swamps, marshes, shallow open water, meadows, and shrub-carrs; is usually composed of shrub or graminoid vegetation, but sometimes may have open tree cover.
Riparian Areas	Areas that border streams, lakes and wetlands and can be a blend of streambed, water, trees, shrubs and grasses.
Cottonwood Floodplain Forests	Broadleaf tree-dominated ecosystems occur as middle bench ecosystems, where the frequency of flooding has reduced, allowing for the establishment of cottonwood.
Aspen Dominated	Stands of prevailingly even-aged, pure stands, and, in later successional stages. May contain shade-tolerant conifers. May be a pioneer or occur as self-perpetuating stands without major disturbance.
Grassland & Brushland	Grassland ecosystems are graminoid-dominated associations that occur on deep soils, but sites are dry because of very rapid soil drainage, insolation and/or lack of precipitation. Brushland ecosystems are dryland shrub-dominated ecosystems that occur at low elevations outside of semi-arid climates but where conditions are too dry or warm for tree establishment.
Open Forests	Upland forests that are drier than average because of upper-slope position, warm aspect, steep sites, or dry, shallow, or coarse-textured soils.
Old and Ancient Forests	Natural stands of forest dominated by large or old trees and their associated ecological communities.

Identified Priority Ecosystems	Brief Description
Huckleberry-associated Ecosystems	Landscapes of important black huckleberry (*Vaccinium membranaceum*) patches for bear forage and cultural values.
Cliff, Rock outcrops & Talus	A mixture of steep bedrock cliffs, escarpments, sparsely vegetated rock and outcroppings with little soil development and relatively low vegetative cover. Talus of rubbly or blocky colluvial areas, at the base of rock outcroppings or escarpments.
Caves	Caves are underground chambers that vary in size and length but have continuous air flow. That means that true caves have both entry and exit ports, though they may be inaccessible to people.

2.2.1 Climate Change and Wildlife

The Ministry of Forests, Lands and Natural Operations completed reports in 2016, titled*:*

- *Adapting natural resource management to climate change in the Kootenay Boundary Region: Considerations for practitioners and Government staff (*FLNR 2016a).
- *Climate Change Vulnerability of B.C.'s Fish & Wildlife Species – First Approximation* (FLNR 2016b).

As there is strong scientific evidence that climate change will significantly affect British Columbia's ecosystems adapting natural resource management to climate change is necessary to foster resilient ecosystems (FLRNO 2016a). Climate shapes disturbance regimes, species distributions and ecological communities. Climate envelopes (the climate associated with an ecosystem today) represent one way of integrating climate pressures to demonstrate potential ecosystem change. Models project that BC's biogeoclimatic ecosystem climate envelopes will move up to 300m higher in elevation and 170km farther north by the year 2050 (Wang et al. 2012), however, projections for the Kootenay Boundary Region show complex patterns, with bioclimate envelopes that fit most closely to this region in the 2080s being found today as far south and east as Colorado and Kansas, and as far north as coastal Alaska (FLNR 2016a). In the KBR, on average, over 1°C of warming has occurred during the 20th century, with warming occurring in all seasons; by the 2050s, temperature is expected to warm an additional 1.1 to 3.2° (FLNR 2016a). In addition, precipitation in the Region is projected to increase by 10 to 25% in winter, spring and fall, and decrease by up to 30% in summer. These trends will also impact snowpack levels, disturbance types, frequency and intensity as well as hyrdology regimes throughout the KBR (FLNR 2016a).

Climate is just one factor of formation that dictates ecosystem distribution and potential. BC's diverse geology, topography, biota and disturbance history will all impact how ecosystems respond to climate change at any given location. In addition, these factors will dictate potential and opportunity for ecosystems and species to relocate, expand their ranges, migrate to new areas, shift seasonal and temporal migration patterns, or alter movement patterns. Ecosystem mapping is required to produce robust climate scenarios to identify regional wildlife and ecosystems vulnerability to climate change, as well as opportunities to foster landscape resilience. For example, wetland restoration in areas where soils, aquifers and ground water buffer wetlands from drought, may have greater restoration success over longer time frames thus optimizing restoration investment.

2.3 Benefits of Ecosystem Mapping for Wildlife and Habitat Stewardship

Ecosystem inventory and mapping provides a baseline of existing conditions and site potential, depending on the chosen methods and project goals. These inventories provide the basis for habitat supply models and a spatial framework for predicting ecosystem change in response to climate change, land use, and other threats to wildlife. Terrestrial Ecosystem Information (TEI) mapping and modeling can be used for various analyses that inform ecosystem management, including abundance and patterns of wildlife habitat, the amount and location of ecosystem connectivity and migration corridors, the amount and type of disturbance and patch sizes and distribution. Ecosystem mapping can also be used to identify ecological values such as high-priority or rare ecosystems, including provincially red- or blue-listed ecological communities. These inventories can all be used to help quantify and track ecosystems over time to help preserve and enhance biodiversity. Ecosystem classification maps ecosystem potential and can often include disturbance codes that can thus inform restoration actions. The terrain and soils attributes that are part of the ecosystem mapping field data collection and polygon attribute table, identify enduring landform features and geomorphic processes that influence the mosaic and variety of ecosystems.

Seamless TEI ecosystem mapping products, such as Terrestrial Ecosystem Mapping (TEM) can provide accurate and reliable measures of ecosystem conditions, capture enduring features in the landscape and support wildlife habitat interpretations. This information in combination with other data can help regional biologists track and quantify ecosystem changes over time and be a useful tool to assist in the development of biologically meaningful management strategies.

TEM is used by the BC Conservation Data Centre (CDC) to assign provincial Conservation Status Ranks to ecological communities[3]. TEM is also used to identify potential occurrences of rare ecological communities and similarly, suitable habitat for plant and animal species. Plant species depend on ecological conditions to provide suitable habitat for growth. For example, many rare species are found in areas with atypical ecological conditions, including unique rock types, and extremes of wet, dry, rich or poor sites. TEM can thus be used in combination with knowledge of a species' habitat requirements to identify areas of higher probability of its occurrence. TEM also often forms a base for mapping or modeling of suitable habitat for wildlife species through the identification of ecological conditions that are suitable for their growth or reproduction.

Ecosystem mapping can further help regional biologists complete analyses for various parameters such as habitat patterns, habitat abundance, the amount of ecosystem connectivity and wildlife movement corridors available, wildlife habitat assessments and edge calculations between habitat types (CIT 2004, Hunter 1990, Bowman et al 1996, Gates and Giffen 1991, Bowman et al 1996, Squires et al 2013). For example, the edge or ecotone - where two ecosystems come together - often supports a high diversity of wildlife species. Examples include the ecotones of forests and wetland, or shrublands adjacent to grasslands. Some animals and plants require the special environment of an edge while other species are primarily associated with one of the two ecosystems that make up the edge (Dijak and Thompson 2000, Gates and Giffen 1991, Darveau et al 1995, Machtans et al 1996). By determining the size, shape and arrangement of ecological communities, managers can assess the amount of edge habitat located within a specific area. The creation of a TEI ecosystem mapping project can help determine the amount of edge for various ecosystems.

Managing communities to capture ecological diversity should provide suitable habitat for both species that require large areas of unbroken habitat and species that need edge habitat (Hunter

[3] https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre

1990). As some vulnerable species – notably certain large mammals and birds – require extensive tracts of habitat, a conservative approach to maintaining biological diversity should emphasize avoiding fragmentation of habitats (McIntyre 1995, Weir and Harestad 2003, Hargis et al 1999, Kie et al 2002). TEI mapping database can be used in a patch size and distribution analysis.

Soil biota, which form the largest portion of terrestrial ecosystem biodiversity, provide critical ecological services to wildlife. These less studied and understood systems benefit from the management of ecosystem health, including ecosystem diversity, distribution and condition. Ecosystem mapping also contributes to the understanding of the diversity of environmental conditions that contribute to soil biodiversity in B.C. and will contribute to global information gaps (Guerra 2020).

Viewed from a time scale of ecosystem succession and the spatial scale of landscapes, ecosystem management can readily enhance biological diversity. It is important to maintain and protect a reasonable area and distribution of each ecosystem to maintain populations of the species that are associated with the various habitats and ecological communities as a whole (CIT 2004, Chapin et al 1998, Kie et al 2002, Weir and Harestad 2003). TEI mapping projects with up-to-date structural stage information can help to spatially define areas of old growth forest, which can then be used to assess and monitor whether-or-not biodiversity targets are being achieved. In addition, Sensitive Ecosystem Inventory (SEI) projects, are often used by local governments as a tool for fostering ecosystem management and reporting on the condition and viability of specific ecosystem categories such as wetlands, riparian areas, grasslands and old forests, through Official Community Plans (OCP) and development permit applications.

Ecosystem mapping should also be considered an appropriate tool for calculating rates of disturbance and setting appropriate targets for acceptable risk. Ecosystem mapping can be used as the foundation for interpreting the amount and potential impacts of changes across an area from natural disturbances such as fire or insect and from anthropogenic disturbances (Pelletier 2006, Mowat 2006, Chapin et al 1998, Darveau et al 1995, St. Clair et al 1998). Some of the attributes such as structural stage or site disturbance modifiers (fire, insect) within a TEI mapping database can be updated to represent these changes in an area. This foundation could also be used in managing an area so that it is following natural successional pathways such as having a landscape composed of a mix of structural stages that emulates natural disturbance regimes for the area. Knowing the current amount, structural stage range and distribution of the ecological communities within an area can help with long-term planning, setting of long-term goals and manage risks to the ecological integrity of an area or region.

In addition, the bioterrain attributes in a standard TEM can support numerous land management objectives including many for wildlife. Bioterrain mapping captures enduring features on the landscape that form the basis for ecosystem development and succession and ultimately create the conditions for plant and wildlife habitat. For example, the use of substrate information, such as low coarse fragments and friable textures, can indicate ecosystem potential and habitat for burrowing species. Similar information can be used to identify areas of higher berry productivity which could be an important factor when identifying bear habitat. Bioterrain attributes can also assist in the identification of potential escape terrain for sheep and goat or areas that may be prone to soil borne diseases that could impact ungulates. Geomorphic processes and features can help identify high value habitat mosaics and associated specific features, such as caves, avalanche paths, floodplains/terraces/fans, cliffs, scarps, landslides, cliff top dunes, volcanoes, waterfalls, karst and kame/esker complexes. As many of these features are small and typically outside the range of what is "mappable" at the ecosystem level, these features can be captured as separate point, line, or polygon layers using provincial standards and templates. These features can then be linked to the ecosystem-based polygons and/or retained as distinct layers, dependent on the project requirements. Bioterrain attributes will likely also become increasing important due to changing climatic conditions and could be used to help predict ecosystem and habitat changes. For example, areas of thin soils may be more prone to drought and areas underlain by thick sequences of materials may contribute deep and longer cycling groundwater inputs.

As such, the completion of a seamless TEI ecosystem mapping product with regional coverage and up-to-date structural stage would be a valuable tool for resource management and aid in maintaining and protecting biodiversity as this mapping can be used to identify, locate and measure the abundance of various wildlife habitat characteristics such as ecosystem representation, patch size, fragmentation and connectivity and amount of edge habitat among others.

3 Ecosystem Classification and Mapping

3.1 Terrestrial Ecosystem Information

The ENV, Knowledge Management Branch, is the custodian of TEI in BC, responsible for loading and storing TEI inventory and mapping data. TEI is defined as the inventory, mapping, and modeling of terrestrial ecosystems, soils, terrain, habitat, and species and is managed through the Terrestrial Ecosystem Information System (TEIS) and accessible through DataBC. The TEIS includes the development, management, and provision of TEI standards, information access tools, data storage systems, end-user support and related training materials, data access, and data submission websites.

Collectively, TEI includes Terrestrial Ecosystem Mapping (TEM), Predictive Ecosystem Mapping (PEM), Sensitive Ecosystem Inventory (SEI), terrain mapping, soils survey, Wildlife Habitat Ratings (WHR) mapping, Species Distribution Modelling (SDM), Broad Ecosystem Inventory (BEI), Ecoregion Classification, wetland mapping (WET) and other related inventory and mapping. TEI inventory and mapping data are collected and captured in accordance with established provincial RISC standards. TEI mapping and modelling results in the stratification of a landscape into map units (polygons), according to a combination of features, primarily climate, physiography, surficial material, bedrock geology, soil, and vegetation. These associated polygons are assigned attributes based on site characteristics that can be used to help identify biological values and inform management strategies.

TEI projects are assigned to a specific project type (Appendix A) and all mapping projects that have been submitted to the ENV have been allocated a Business Area Project ID (BAPID); this identification number is used to identify and track digital project information.

The current extent of publicly available Provincial coverage of Terrestrial Ecosystem Mapping and Bioterrain type projects by Natural Resource Region are depicted on Figures 1 and 2, respectively.

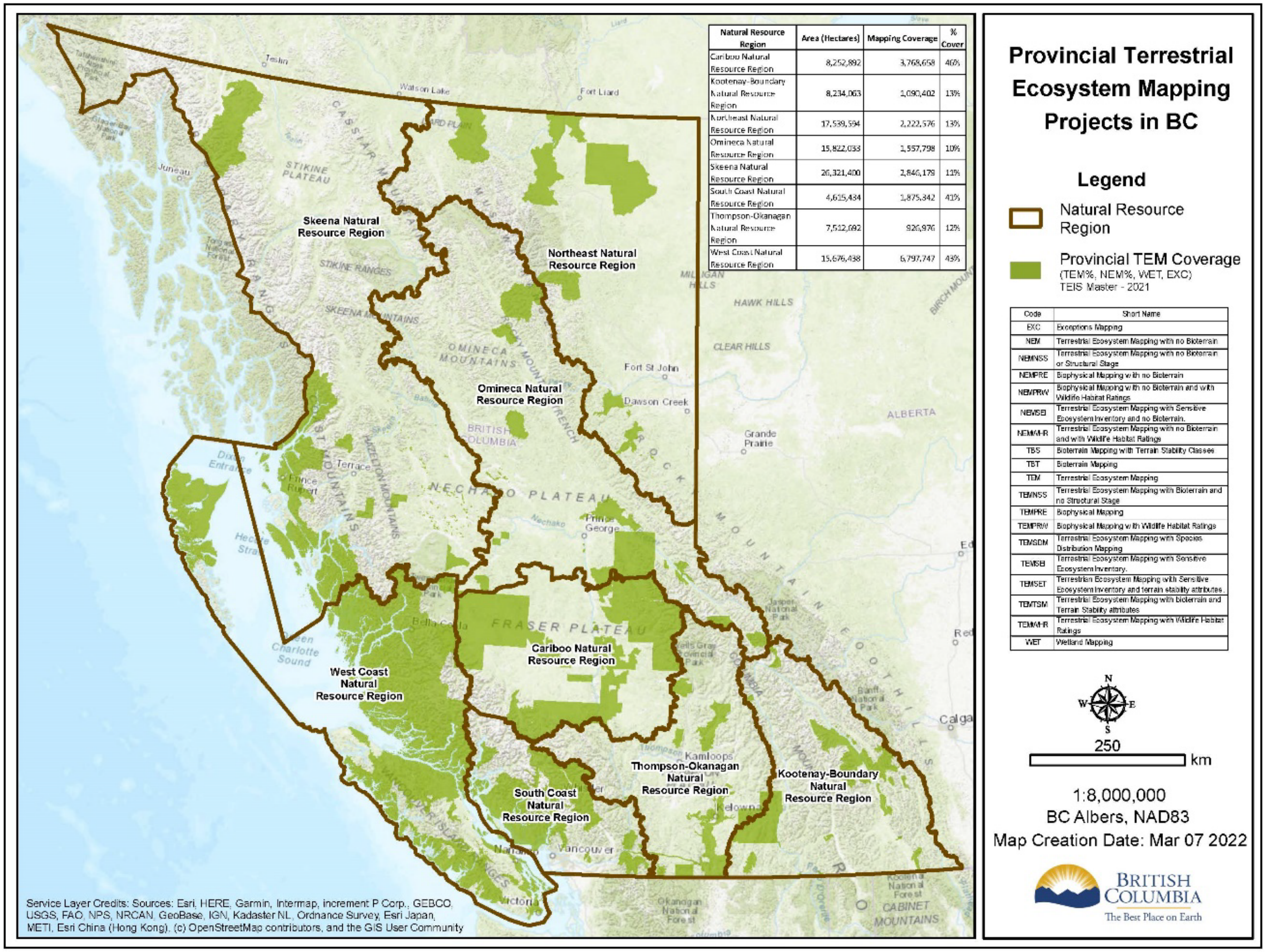
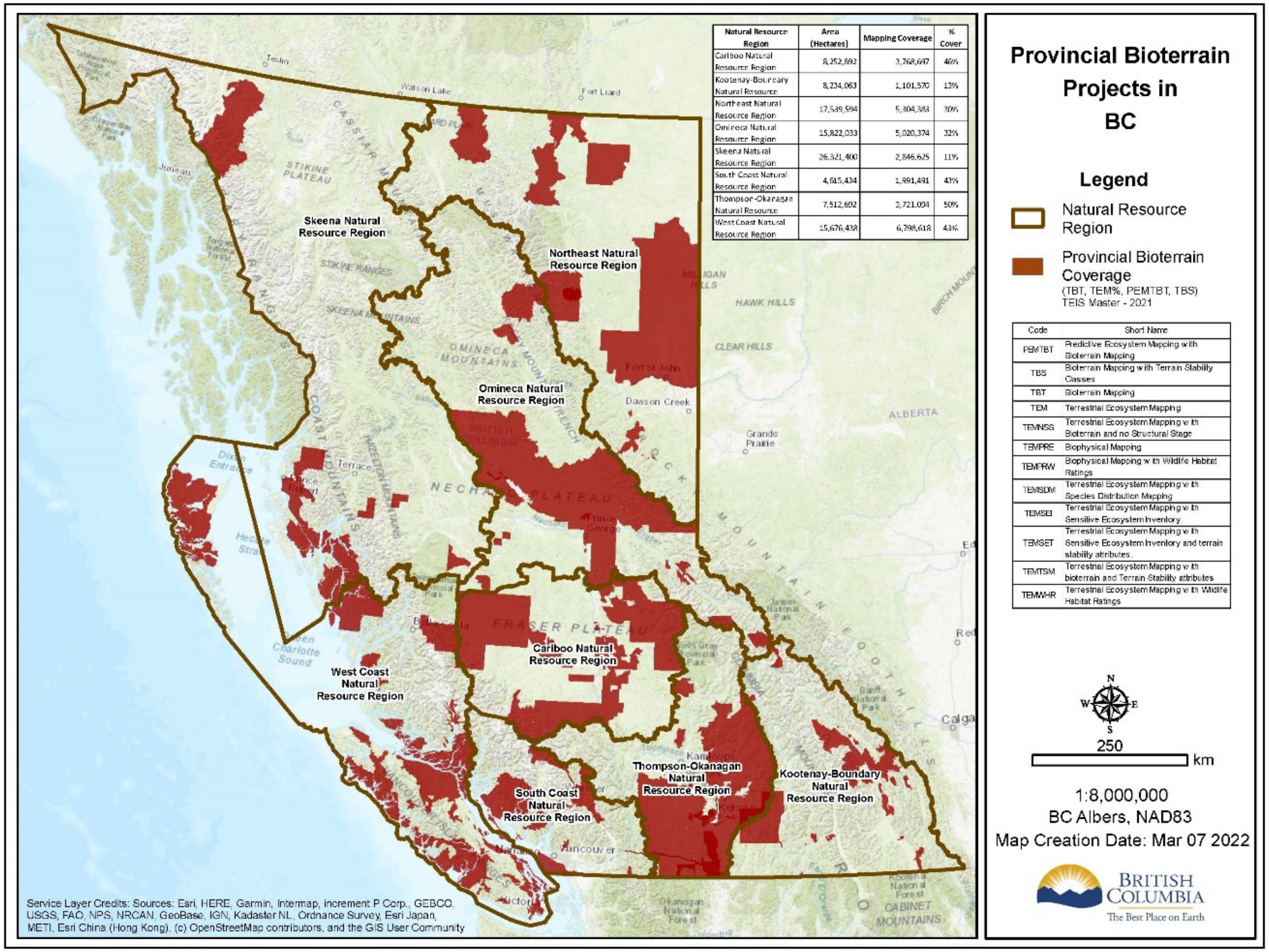


Figure 1: Overview of Publicly Available Provincial Terrestrial Ecosystem Mapping Coverage



Natural Resource Region	Area (Hectares)	Mapping Coverage	% Cover
Cariboo Natural Resource Region	8,252,892	3,768,697	46%
Kootenay-Boundary Natural Resource	8,234,063	1,101,570	13%
Northeast Natural Resource Region	17,539,594	5,304,383	30%
Omineca Natural Resource Region	15,822,033	5,020,374	32%
Skeena Natural Resource Region	26,321,400	2,846,625	11%
South Coast Natural Resource Region	4,615,434	1,991,491	43%
Thompson-Okanagan Natural Resource	7,512,692	3,721,094	50%
West Coast Natural Resource Region	15,676,438	6,798,618	43%

Code	Short Name
PEMTBT	Predictive Ecosystem Mapping with Bioterrain Mapping
TBS	Bioterrain Mapping with Terrain Stability Classes
TBT	Bioterrain Mapping
TEM	Terrestrial Ecosystem Mapping
TEMNSS	Terrestrial Ecosystem Mapping with Bioterrain and no Structural Stage
TEMPRE	Biophysical Mapping
TEMPRW	Biophysical Mapping with Wildlife Habitat Ratings
TEMSDM	Terrestrial Ecosystem Mapping with Species Distribution Mapping
TEMSEI	Terrestrial Ecosystem Mapping with Sensitive Ecosystem Inventory.
TEMSET	Terrestrial Ecosystem Mapping with Sensitive Ecosystem Inventory and terrain stability attributes.
TEMTSM	Terrestrial Ecosystem Mapping with bioterrain and Terrain Stability attributes
TEMWHR	Terrestrial Ecosystem Mapping with Wildlife Habitat Ratings

Figure 2: Overview of Publicly Available Provincial Bioterrain Mapping Coverage

3.2 Broad Ecosystem Classification and Mapping

3.2.1 Ecoregional Classification

The Ecoregion Classification system is used to stratify British Columbia's terrestrial and marine ecosystem complexity into discrete geographical units at five different levels. The two highest levels, Ecodomains and Ecodivisions, are very broad and place British Columbia in a global-scale of geographic context. The three levels of finer classification, Ecoprovinces, Ecoregions, and Ecosections, are progressively more detailed and narrow in scope and relate segments of the Province to one another. They describe areas of similar climate, physiography, oceanography, hydrology, vegetation, and wildlife potential and were originally mapped at 1:500,000 for regional strategic planning.

The most detailed level of the classification system, the Ecosection, is used at the regional level, with the Biogeoclimatic Ecosystem Classification (BEC) system and associated Biogeoclimatic (BGC) mapping, to delineate broad ecological units throughout B.C. Since the last published Ecosection update (2006) there have been many changes to the BGC mapping data. Ecosection updates have been made to the mapping and the report but are interim products that have yet to be published to provincial repositories or incorporated into Federal, North American and Global Ecoregion maps. The Ecoregion Classification is used for ecosystem and species reporting and for prioritizing conservation actions.

The Kootenay Boundary Region consists of the Southern Interior Mountains Ecoprovince and portions of the Southern Interior Ecoprovince. These two Ecoprovinces are divided up into 7 Ecoregions and their associated Ecosections.

3.2.2 Biogeoclimatic Ecosystem Classification

Biogeoclimatic Ecosystem Classification (BEC) is an ecosystem classification system used within the Province of British Columbia that provides a practical way of distinguishing many terrestrial ecosystems (Pojar et al. 1987). BEC is currently managed at provincial and regional levels by the BC FLNR BEC Program. The BEC system defines an ecosystem as a landscape area uniform in five basic components: climate, soil, vegetation, animals and microorganisms with an emphasis on the interrelationship between these components (Klinka et al 2018).

This system is used to recognize and identify different ecosystems and to plan sound ecological management decisions. The BEC system divides the Province into different biogeoclimatic zones, each with different climate, topography and vegetation. These zones are usually divided into smaller units called subzones and variants based on further differences in climate, vegetation and soils. Within each smaller subzone or variant unit, the landscape contains a mosaic of ecosystems created by varying site conditions. At the site level, ecosystems are described based on vegetation, soil, and site characteristics. These smaller units are known as site series and are defined as all sites capable of producing the same mature or climax plant communities within a biogeoclimatic subzone or variant. Changes in in soil factors, plant species composition and structure occur over time associated with (large-scale) disturbance (i.e. succession) can result in a number of seral communities occurring at different stages of ecological development. However, these sites would all still be classified as same climax community using the BEC system according to their potential to produce similar plant communities at late successional stages. Site series classification also assumes that sites with similar vegetation potential have similar environmental properties, particularly soil nutrient and moisture regimes.

The BEC system and its associated units are described in a series of regional field guides/ land management handbooks (LMHs) developed by the Provincial Government. Typically, field guides describe site series classification units using environmental properties characteristics and characteristics of late successional plant communities. They are also an excellent source for regional information on climate, geology and soils.

The following regional LMHs and associated supplements are the most current classification systems for the Kootenay Boundary Region, as of 2022:

- LMH 20. A field guide for Site Identification and Interpretation for the Nelson forest region (Braumandl and Curran 1992)
    - Supplement 1: IDFxh4, ICHdw2, ICHdm, ESSFdm (Braumandl and Dysktra 2005).
- LMH 70. A field guide to site classification and identification for southwest British Columbia: The South-Central Columbia Mountains (MacKillop and Ehman 2016)
- LMH71. A Field Guide to Ecosystem Classification and Identification for Southeast British Columbia: the East Kootenay (MacKillop, Ehman, Iverson, and McKenzie 2018)
    - A temporary supplement to land management handbook 71: Two biogeoclimatic subzones/variants in the Golden-Invermere TSAs (MacKillop 2018)
- LMH75: A Field Guide to Ecosystem Classification and Identification: Boundary—Eastern Okanagan—Shuswap--Southern Arrow (MacKillop 2021)

In addition, to the regional LMHs and associated with BEC, provincial classification systems for wetlands and non-forested ecosystems have been published. In 2004, a guide to wetland identification (Mackenzie and Moran 2004) was published to describe common wetland ecosystems to the plant association level. This field guide presents a site classification and interpretative information for wetlands and related ecosystems across British Columbia using realm, group, class and site association. In 2012, a technical report was released that describes BEC classification for non-forested ecosystems in British Columbia (Mackenzie 2012). This provides guidance for classification to realm, group and class. In some regions select site associations have been defined in the field guides and draft classifications, for example, alpine and grasslands.

All current BEC units and codes can be found within the current BEC database BECdb (v12, published in 2021) and existing inventory data contained within the BEC Master VPro[4] database, with additional information available from the BC FLNR BEC Program website[5].

There are currently 15 BEC zones defined in the Province. The most up to date BEC linework for the Kootenay Boundary Region defines 5 BEC zones (Table 2.) The associated Appendix B provides the current BEC units in the Kootenay Boundary Region as per BECv12 (published in 2021). It should be noted that changes to the BEC database have been ongoing since 2004. In some cases, BEC units have been renamed or BEC zone and subzone elevation lines have been refined; these changes vary over different parts of the Province.

Table 2: List of the current BEC zones found in the Kootenay Boundary Region

BEC Zone Code	BEC Zone Name	# Associated subzones and variants
ESSF	Engelmann Spruce – Subalpine Fir	30
ICH	Interior Cedar – Hemlock	14
IDF	Interior Douglas-fir	7
IMA	Interior Mountain-heather Alpine	1
MS	Montane Spruce	3

3.2.3 Broad Ecosystem Inventory and Mapping

Broad Ecosystem Inventory (BEI) is a method of classifying and mapping broad ecosystem habitat units, as well as the suitability (existing productivity with present vegetation) and capability (potential productivity with optimal vegetation for a species) of the landscape, to support various wildlife species (RIC 1998a). Broad ecosystem units have been mapped at a scale of 1:250,000 for the entire province, but this classification has been mapped at a finer scale for some smaller project areas. The current BEI classification spatial layer available in the BC Data Catalogue is loosely tied to the BEC system but has not been updated since 1998. As there have been many changes to BEC and its associated BGC mapping since this time, updates to both the BEI classification and data are required.

Broad Ecosystem Mapping (BEM) is a desktop-based method that takes existing BEI mapping and updates its database structure to follow a structure similar to the TEI standard file geodatabase (FGDB) format (RISC 2015). Structural stage information is updated using Vegetation Resource

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[4] VPro is an ACCESS© database developed by the Ministry of Forests, Research Branch for data entry, management, and analysis of the provincial ecological (BEC) data. It allows users to manipulate, summarize, and analyze data in hierarchical classifications.

[5] https://www.for.gov.bc.ca/hre/becweb/program/index.html

Inventory (VRI) projected age information based on the dominant age class for each BEM polygon. Ecosection and BEC information are assigned to existing BEM polygons based on majority area of overlap with each polygon using current published information at the time of the project. No new linework is created during the update process. Slope and aspect information is also assigned to each BEM polygon using Terrain Resource Information Mapping (TRIM) and/or Digital Elevation Model (DEM). Freshwater Atlas (FWA) large lakes, small lakes, and wetlands are added as new polygons or new components to existing polygons based on existing BEI standards.

Broad Ecosystem Mapping and Vegetation Resource Inventory (BEMVRI) is a desktop method that takes an existing BEM or creates a new BEM and subsequently assigns the Broad Ecosystem Unit (BEU) label to existing VRI polygons based on majority area of overlap with each VRI polygon. Updates are made to improve consistency between the BEU labels and the VRI polygons. Although reasonable effort is applied to updating ecosystem labels, many of the polygons likely reflect a false level of detail, and as such, the ecosystem labels should be used acknowledging this limitation. After BEU labels are updated, structural stage and stand composition information are assigned to each of the BEMVRI polygons. The TRIM DEM is used to assign site modifiers, such as slope and aspect, to the BEMVRI polygon.

BEM and BEMVRI products can be used to produce wildlife capability and suitability products using similar methods to other TEI ecosystem mapping and modelling based approaches. These methods have been used for three different projects in Northern BC, but future work is required to correlate and finalize documentation of the overall process for producing BEM and/or BEMVRI products.

3.3 Ecosystem Mapping and Inventory

Ecosystem mapping is the stratification of a landscape into map units, according to a combination of ecological features, primarily climate, physiography, surficial material, bedrock geology, soil, and vegetation. Ecosystem mapping data is collected and captured in accordance with established RISC standards. Most ecosystem mapping data has been recently converted to the TEI standard file geodatabase format. Amendments to the inventory and digital ecosystem mapping standards are ongoing. Most datasets include polygon and point coverages, reports, and field data.

Ecosystem unit is the term used in the RIC standards (RIC 1998b) to define local and vegetation developmental level units within the biogeoclimatic zones, subzones or variants. These smaller units are typically derived from the BEC site series classification (refer to Section 3.2.2) and further differentiated with site structural stage and site condition attributes. Classifying and defining the ecosystem units would be the primary focus of any ecosystem mapping project completed.

Ecosystem mapping codes for use during TEI mapping projects are contained within a list of Provincially standard approved codes (TEI Unit 2022). These codes have been compiled from the BEC units and Site Series information for forested, non-forested and sparsely-vegetated ecosystems from the BEC Site Series – Attribute table (BEC Database v12 - 2021), various Regional Land Management Handbooks, the BEC non-forested Ecosystems (nBEC) in BC (2012), as well as the TEI natural non-vegetated and anthropogenic codes (as per the Coding Updates for Non-Vegetated, Sparsely Vegetated, and Anthropogenic Units (TEI Unit 2020a).

Ecosystem mapping should include an inventory or ground sampling component as it is important to verify the accuracy of the pre-typed mapping that was done using GIS. As such, varying Survey Intensity Levels (SIL) can be applied depending on project objectives and end-uses. A SIL is calculated based on the proportion of polygons that are sampled in the field and is intended to provide a measure of the accuracy of the mapping.

Field data to support ecosystem mapping are collected in accordance with Describing Terrestrial Ecosystems in the Field (DTEIF) manual. The 2nd edition of this manual was published in 2010 and updated in 2015 (BC Ministry of Forests and Range and Ministry of Environment 2015). The DTEIF manual supports the use of standard Ecosystem Field Forms, including site, soil, vegetation, mensuration, wildlife habitat assessment, tree attributes for wildlife, and coarse woody debris data forms.

Within the Kootenay Boundary Region, a number of ecosystem mapping projects have been completed, typically at scales of 1:20,000 (ranging from 1:10,000 to 1:50,000). Figures 1 and 2 in Section 3.1 show the current extent of publicly available Provincial coverage of Terrestrial Ecosystem Mapping and Bioterrain type projects for the Kootenay Boundary Region. Additional details are provided as part of the Gap Analysis in Section 5 and Appendix C.

3.3.1 Terrestrial Ecosystem Mapping

Terrestrial Ecosystem Mapping (TEM) is a multi-disciplinary mapping methodology generally informed by BEC, geology, terrain, soils, vegetation, hydrology, slope and aspect, among other attributes (RISC 1998b). TEM requires direct air photo or satellite imagery interpretation of ecosystem attributes and landscape distribution by a mapper(s). Polygons are delineated by interpreting imagery of vegetation and landforms, and assigning ecosystem, soil and terrain classification codes prior to conducting field work. Typically, digital 3D imagery is used in conjunction with other sources of spatial data to facilitate desk top identification of ecosystems. TEM approaches follow established RISC standards and incorporates the BEC system attributes (e.g., site series). TEM is recommended for ecosystem mapping at scales of 1:5,000 to 1:20,000 and is often the basis for producing other thematic derivatives such as sensitive ecosystems or wildlife habitat.

Other commonly used TEM based project types include:

- Terrestrial Ecosystem Mapping without Bioterrain (NEM) which include projects where mapped ecosystem polygons are not derived from bioterrain polygons.
- Terrestrial Ecosystem Mapping with no Structural Stage (TEMNSS) that consist of ecosystem mapping projects completed to RISC standards with mapped ecosystem and bioterrain attributes but no structural stage attributes.

3.3.2 Predictive Ecosystem Mapping

Predictive Ecosystem Mapping (PEM) is a modelled approach to ecosystem site series mapping. PEM follow a results-based approach with established RISC data standards that govern data submission and accuracy assessment but allows for flexibility in the methods for generating the model/map results (RIC 1999a). PEM was developed to support forest management, and the standards and accuracy thresholds are aimed at the management of the forested land base. Some PEMs use existing knowledge of ecosystem attributes and relationships to predict BEC site series for each spatial unit, which may be a raster pixel or a polygon. These PEMs (1999 – 2020) are based on the 25m DEM and are recommended for ecosystem mapping at scales of 1:20,000 to 1:50,000. More recently, data driven and machine learning approaches using LiDAR are being explored by the PEM methods project, which is a partnership between the ENV, FLNR, academic partners, and contractors. The project aims to create a predicted site series map for the province through standards, scripts and protocols for field data collection, model generation by BEC subzone variant, and model validation. The 2022/23 work plan includes a pilot in the Kootenay Boundary.

3.3.3 Sensitive Ecosystem Inventory

The purpose of a Sensitive Ecosystems Inventory (SEI) projects is to identify remnants of rare and fragile terrestrial ecosystems and to encourage land-use decisions that will ensure the continued integrity of these ecosystems (RISC 2006). The information is derived from aerial photography, supported by selective field checking of the mapping in a given area. The SEI methodology may be based on original air photo interpretation for SEI polygons or may be an SEI theme based on TEM polygons. The SEI ecosystem types identified vary from region to region, according to the natural ecosystems found there, but usually include forested ecosystems, woodlands, wetlands, riparian areas and natural meadows and grasslands. Few and easily understood classes make SEI appealing to NGOs for conservation planning, and local governments for community plans and zoning. Most of the SEI data has been converted to the TEI file geodatabase format.

3.3.4 Wetland Mapping

Wetland Mapping (WET) projects identify wetland ecosystems as there is an increased need for wetland identification and inventory in support of ecosystem, habitat, and water management. Of particular importance is identifying the distribution, abundance, and connectivity of wetland and riparian ecosystems. Wetlands and riparian ecosystems are included in other TEI inventory and mapping types, however, there is a need for consistent regional and province-wide mapping. Consistent data on wetland extent and type will facilitate analysis on ecosystem function, condition, and trends. The TEI unit is working towards creating cost-effective, consistent, defensible, and repeatable wetland maps with supporting documentation that improves current inventories. An example of some current products related to wetland inventory is the Williston Wetland Explorer Tool

(WWET)[6] which is available in the BC Data Catalogue and provides online access to recent wetland mapping products completed for the area.

3.3.5 Ecological Communities Element Occurrence Mapping

The BC Conservation Data Centre (CDC) maps known element occurrences (an area of land and/or water where a species or ecosystem is known to have been) of red- and blue-listed species and ecosystems. The CDC database includes the best available information and is updated on a regular basis (BC CDC 2021).

- An element occurrence record (EO) can consist of one or more source features (i.e. observations). For species, an EO is generally equivalent to a population. For ecological communities, the EO may represent a stand or patch of an ecological community, or a cluster of stands or patches of an ecological community (BC CDC 2021). Many ecological community EOs are mapped produced from TEM polygons which can represent up to three different ecosystems, therefore EOs can contain more than one ecosystem component.
- An EO has conservation significance and is relevant in land management decisions (BC CDC 2021).
- An EO is not an observation. It is a value-added product that includes assessment of observations for conservation significance and includes verification of the information source (BC CDC 2021).
- All EOs are polygons with the size of the polygon usually reflects the locational uncertainty associated with the source data, represented with varying sized circles. Some polygons may be larger to reflect the actual area covered by the element occurrence (BC CDC 2021).

In addition, an EO Rank is used to describe the probability of persistence of the element at a particular location. The rank is based on the probability of persistence or estimated viability or ecological integrity of an EO with respect to other occurrences of the same element. The rank provides an assessment of the likelihood that, if current conditions prevail, the element occurrence will persist for a defined period of time, typically 20-100 years (NatureServe 2002, BC CDC 2021).

EO Ranks may be used in conjunction with Conservation Status Ranks to:

- Prioritize which element occurrences should be recorded and mapped
- Help prioritize EOs for conservation planning or action, both locally and range-wide

Ranks are assigned by considering the following information about each element occurrence:

- Condition
- Size

[6] https://catalogue.data.gov.bc.ca/dataset/williston-wetland-explorer-tool-wwet-application

- Landscape context

Additional information on EO mapping and ranking is available from the BC CDC Program website[7].

Within the Kootenay Boundary CDC EO mapping exists delineating areas of ecosystems at risk as well as species and ecosystems at risk range data. It should, however, not be considered a complete source of all species and ecosystems at risk as EO mapping is continually being updated to assess and incorporate data from various sources, including TEM and other submissions. It also should be noted, based on the sensitivity of this data, some access is currently restricted. Additional details are provided as part of the Gap Analysis in Section 5 and Appendix C.

3.3.6 Vegetation Resource Inventory

The Vegetation Resources Inventory (VRI) is a two-phased process including a photo interpretation phase which involves estimating vegetation polygon characteristics from aerial imagery, and a ground sampling phase that provides the information necessary to determine how much of a given attribute is within the inventory area and to verify the accuracy of the photo estimates (BC Forest Inventory 2021).

VRI is intended to cover the entire land base of BC, irrespective of ownership or vegetation values and will result in the vegetated land base being delineated into polygons based on similar vegetation characteristics visible on aerial imagery. Polygon delineation is based on the BC Land Cover Classification Scheme. This land classification scheme includes both vegetated and non-vegetated cover classes over the entire provincial landscape. Polygons identified by the land classification scheme are further divided into similar vegetated or non-vegetated polygons. Delineated polygons are assigned descriptions that are either estimates of polygon characteristics or contain other information relating to the polygon such as site position, ecological information (primarily soil moisture regime - SMR and soil nutrient regime - SNR), species composition, age of the leading species, height of the leading species, tree basal area and tree density (BC Forest Inventory 2021).

VRI mapping and data is often used and incorporated into ecosystem mapping and modelling projects for purposes such as informing site series or structural stage and stand composition assignment.

Additional information on VRI mapping and inventory is available from the BC Forest Inventory Program website[8].

Within the Kootenay Boundary VRI mapping exists delineating similar vegetated or non-vegetated polygons. Additional details are provided as part of the Gap Analysis in Section 5 and Appendix C.

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[7] https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre

[8] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory

3.4 Soils Information and Mapping

Soils and landform mapping describe and classify soils in a particular area (polygons). Mapping is supported by field data describing site, soil, and horizon characteristics from soil pits. Soil samples may be collected and analyzed at the lab to measure specific soil properties such as texture or % organic carbon. Underlying landform characteristics (e.g., parent material and slope steepness) are also described in soils maps and field data. Soils maps show the distribution and extent of soil types and characteristics, with detailed descriptions presented in reports accompanying the mapping project. The Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests and Range and British Columbia Ministry of Environment, 2015), Canadian System of Soil Classification (Soil Classification Working Group 1998) and Soil Inventory Methods for B.C. (RIC 1995) are typical resources for completing soil inventory and mapping in BC.

The BC Soils Information Finder Tool (SIFT) provides online access to soils mapping and soils capability maps. Soils data in the BC data catalogue includes soil survey project boundaries and soil survey polygons (also viewable in SIFT). GIS data packages are also available through the catalogue. The data packages include data from the BC Soil Information System (BCSIS) which is a database containing site descriptions, soil horizon data, and laboratory analysis results.

Additional information and access to SIFT is available on the Soil program website[9].

Within the Kootenay Boundary Region, a number of soils mapping projects have been completed including Soil Survey Mapping typically at a 1:50,000 scale and Agriculture Soil Capability Mapping at 1:50,000 and 1:250,000 scales. Additional details are provided as part of the Gap Analysis in Section 5 and Appendix C.

3.4.1 Soil Inventory Mapping

Soil Inventory Mapping (SOIL) for BC has been completed at a variety of scales, including:

- 1:1,000,000 scale soil landscapes of BC mapping covering the entire province,
- 1:50,000-1:250,000 scale soil and landform mapping (covering approximately two-thirds of the province, and
- 1:20,000 scale soil mapping of the Okanagan, Lower Mainland and southeastern Vancouver Island.

Recent work on digital soils mapping has employed machine learning and other modelling methods to predict soils attributes such as parent material, carbon content, and available water holding capacity.

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[9] https://www2.gov.bc.ca/gov/content/environment/air-land-water/land/soil/soil-information-finder

3.4.2 Soil Capability Mapping

Soil capability (for agriculture, forestry, etc.) and other derivative soil mapping (e.g., soil drainage, potential for erosion, flooding, suitability for septic tank effluent absorption, etc.) are based on soil survey data.

3.5 Terrain Inventory and Related Mapping

Terrain inventory and mapping describes the characteristics and spatial distribution of surficial materials, landforms, and geomorphological processes. The bulk of the digital terrain inventory, terrain stability, and bioterrain mapping data has been converted to the TEI standard file geodatabase format. Most datasets include polygon and point coverages, reports, and field data. Typical resources for terrain inventory and mapping in BC include:

- Terrain Classification System for British Columbia (Howes and Kenk 1997)
- Guidelines and Standards to Terrain Mapping in British Columbia (RIC 1996a)
- The Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests and Range and Ministry of Environment 2015)
- Guidelines for Professional Services in the Forest Sector – Terrain Stability Assessments (ABCFP and APEGBC 2010)
- Landslide Classification and Inventory System for British Columbia with Digital Standards-Draft 1 (Ministry of Environment 2007)
- Mapping and Assessing Terrain Stability Guidebook (BC Ministry of Forests and Ministry of Environment 1999)
- Terrain Stability Mapping in BC: A Review and Suggested Methods for Landslide Hazard and Risk Mapping (RIC 1996b)

Within the Kootenay Boundary Region, a number of terrain mapping projects have been completed, typically at scales of 1:20,000 (ranging from 1:10,000 to 1:50,000). Additional details are provided as part of the Gap Analysis in Section 5 and Appendix C.

3.5.1 Terrain Inventory Mapping

Terrain Inventory Mapping (TIM) is a multi-purpose inventory that follows the Terrain Classification System for British Columbia (Howes and Kenk 1997) and is intentionally generic in nature to serve a variety of land use planning and management needs. Specialized terrain related mapping methodologies used in BC include: bioterrain mapping, terrain stability mapping, and landslide inventory.

3.5.2 Bioterrain Mapping

Bioterrain Mapping (TBT) is a modified approach to terrain mapping which combines the recognizable permanent terrain and landscape features defined in the Terrain Classification System for British Columbia (Howes and Kenk, 1997), with recognizable biological features defined in the

TEM methodology and inferred soil drainage characteristics as defined by the Canada Soil Survey Committee (1978).

3.5.3 Terrain Stability Mapping

Terrain Stability Mapping (TSM) is an enhanced method of terrain mapping that identifies areas prone to landslides and slope failures. Terrain stability maps usually contain information about terrain, soil drainage, slope steepness, and terrain stability classes. Terrain stability or slope stability is the susceptibility of a terrain polygon to slope failure. There are two types of terrain stability maps: reconnaissance and detailed terrain stability mapping. Terrain stability mapping is used to identify geohazards for risk management by wildfire emergency response. Occasionally the Ministry receives landslide inventory project data but does not anticipate receiving a large number of these projects in the future. Draft landslide inventory standards have been developed (Ministry of Environment 2007).

3.5.4 Exceptions Mapping and Enduring Features Mapping

Exceptions Mapping (EXC) and Enduring Features Mapping are simplified version of bioterrain that map features influencing ecology. These include landforms subject to repeated disturbance such as avalanche zones, fans, floodplains, and landslides, as well as areas that influence soil moisture and nutrient extremes such as wetlands, seepage zones, thin materials, bedrock outcrops and areas of extreme textures (very fine or vary coarse).

3.5.5 Surficial Materials and Landform Mapping

A simplified approach for mid to small scale classification of surficial materials and landforms is being developed jointly by the Knowledge Management Branch and Water Sustainability and Protection Branch to better support decision making. This project is testing a machine learning approach to improve on the provincial Quaternary Geology spatial layer.

3.6 Wildlife Species and Habitat Mapping/Modelling

3.6.1 Species Distribution Modelling and Wildlife Habitat Ratings

Species Distribution Modelling (SDM) and Wildlife Habitat Ratings (WHR) Mapping are both common methods used to predict the overall distribution or range of a particular species across geographic space and time using environmental data (RIC 1999b, RISC 2004, RISC 2008). Species distribution modelling in BC is usually more generalized than WHR mapping and predicts the suitability of different environments within a study area for occupation by a particular species. SDM typically includes environmental data such as temperature, precipitation, and elevation as model inputs. Most SDM techniques are based on deductive modelling, which is based largely on expert knowledge, or on inductive modelling, which uses the relationship between observations of species, habitat features or sign and spatial predictors, or on a combination of deductive and inductive approaches.

SDM is often done at the landscape level or regional scale to support a specific land use decision process and typically uses ecosystem mapping as model inputs.

Wildlife Habitat Ratings (WHR) Mapping identifies areas in a landscape that provide life requisites for a particular wildlife species. WHR mapping uses known or assumed wildlife-habitat relationships to predict habitats that a species would likely use in different seasons to provide different life requisites, such as what habitats moose may use in the winter for thermal cover and snow interception. The scale of wildlife habitat mapping varies based on available input data, knowledge of wildlife-habitat relationships, and project objectives. Ecosystem mapping is the framework for applying habitat ratings and commonly uses TEI data such as TEM, PEM or BEM. However, vegetation resource inventory (VRI), digital elevation models (DEM), and other environmental data/models can also be used as inputs for wildlife habitat models. In addition, there are other modelling methods such as Resource Selection Functions (RSF) that assesses which habitat characteristics are important to a specific population or species of animal, by assessing a probability of that animal using a certain resource proportional to the availability of that resource in the environment. Wildlife habitat mapping and other modelling methods may use other data such as LiDAR, SPOT, or Landsat imagery and classification to create raster data sets that may be used instead of, or in addition to, point or polygon-based data.

Wildlife habitat ratings define the relative importance of various ecological units to wildlife and reflect a habitat's potential to support a particular species by comparing it to the best available habitat for that particular species in the Province. WHR are a standard-based approach to habitat modeling that uses plot data and/or expert knowledge to interpret habitat values from ecosystem inventories (RIC 1999b, RISC 2004). A habitat capability rating is defined as the ability of the habitat, under the optimal natural conditions for a species to provide its life requisites, irrespective of the current condition of the habitat. A habitat suitability rating is defined as the ability of the habitat in its current condition to provide the life requisites of a species.

Standardized ecosystem classification and inventory methods are employed to prepare map information from which wildlife interpretations can be derived. The Ecosystem-based Resource Mapping (ERM) toolkit was used in the past to facilitate the process of generating interpreted themes from TEM and PEM products. Although the original tools are no longer compatible with current technology, the Province is working on improved tools to support the WHR standards such as Python and R scripts.

Within the Kootenay Boundary Region, publicly available wildlife mapping and modelling projects that have been completed. Additional details are provided as part of the Gap Analysis in Section 5 and Appendix C.

3.6.2 Wildlife and Habitat-Based Model Types

Wildlife species and habitat modelling can take various forms and it important to recognize that models are a simplification of reality that are used to meet specific objectives. When using existing data sources, it is imperative that data planned for use in modelling be assessed and verified to be appropriate for the intended use of the model.

Common wildlife and habitat-based model types include the following:

- **Written Species Account (Descriptive)** - Describing the 'habitat' by a written description is an example of a wildlife and habitat model. Within the description of habitat, the assumption is made that what is not described is not habitat (i.e., a yes or no rating). However, often species account will provide some indication of the condition (e.g., sufficient, good) of the habitat. A written species account is often the first step in determining a model that is more tractable for calculation. Examples of species accounts are provided for Identified Wildlife under the *Forest and Range Practices Act* in the document: Accounts and Measures for Managing Identified Wildlife (WLAP, 2004).
- **Index Based** - These models assign an arbitrary habitat supply value (e.g., 0 to 1) to the amount of a given habitat attribute. These are most often expert opinion driven models to derive the relationship. The relationships are often based on a single dependent variable, though in some cases a composite of several relationships may be created. Examples are habitat suitability index, habitat capability index, or simple habitat ratings (e.g., high, medium, low).
- **Regression Based** - These empirical models statistically determine a relationship between a dependent indicator associated with a value for an organism (e.g., nest site presence/absence) with independent habitat variables (e.g., stand age, number of standing dead trees). Examples are linear and logistic regression models.
- **Classification Based** - These empirical models use algorithms to distinguish between habitats with different assigned habitat supply values (e.g., species presence/absence). Classification may be either for similarity or difference. Examples are discriminant analysis and tree-based models.
- **Probability Relationships** - These models determine a rating (or a probability) of habitat supply based on conditional relationships with habitat. These models may be derived by expert opinion, empirical, or a combination. Examples of such model types are Belief Based (e.g., Bayesian Belief Networks) or Fuzzy Logic. The fuzzy logic model is a logical mathematical procedure based on the 'IF-THEN' rule system, which allows the human thought process to be reproduced in a mathematical form..

4 Ecosystem Mapping and Modelling Methods

4.1.1 Project Type Selection Considerations

There are numerous ecosystem mapping/modelling approaches project types (i.e. TEM vs SEI vs PEM) that can be used to stratify and classify the landscape into map units. To select an appropriate approach, project objectives, end goals, and utility for use and potential future uses should be considered. In addition, factors such as areas of interest as well as data availability, coverage, quality/reliability and quantity are important to assess. Policy, management and partnership/funding opportunities, including associated timeframes and cost considerations, may also influence the final methods selected. For example, BEI is an ecosystem mapping approach appropriate for broad level strategic planning of large geographic areas while TEM and PEM are examples of approaches typically completed at landscape level scales for operational planning and management. Specifically, TEM is often the best approach when planning for the whole landscape or where other considerations such as wildlife habitat mapping are of interest in the study area, while projects with only a Sensitive Ecosystem focus may be best suited to an SEI approach (RISC 2006).

In addition, not only can mapping/modelling approaches vary by the general project type, but methods can often be varied within each type (i.e. mapping scale, level of field sampling, attribute selection etc.) in order to customize the end products to best suit project objectives and meet future end uses.

As such, some of the key methods and factors for consideration when selecting an approach are detailed in the Sections below and include:

- Imagery based direct mapping versus modelling including machine learning and/or expert knowledge models
  - Vector versus raster based spatial products
- Use of existing data vs new mapping including considerations for outdated mapping which may require data cleanup and/or conversion due to the age of mapping and potential for imagery, disturbance and classification updates
- Landscape level (seamless) coverage versus delineation of specific features
- Delineation of static/enduring features such as terrain versus dynamic features such as structural stage and disturbance
  - Image interpretation versus modelling using other spatial data for dynamic features
  - Single versus multiple layers to distinguish static from dynamic features
  - Ability to update over time
- Mapping scale and polygon size
  - Resolution/accuracy considerations
- Attribute selection such as the inclusion of bioterrain, realm/group/class and structural stage attributes, and ability to crosswalk or correlate to other classification systems or future uses
- Level of field verification (Survey Intensity Level - SIL)

Figures 3 and 4 provides a decision tree for determining the project type based on the key methods and factors for consideration as outlined above.

Uses:	Project Type Examples
• Management of ecosystem and wildlife habitat features, small-ranging species, uncommon and small-patch habitat (e.g., provincially and federally listed species and ecosystems). • Identify and display small and uncommon ecological features such as caves, mineral licks, perennial pools, etc. that are difficult to map across the entire region • Wildlife Habitat Area and Wildlife Habitat Feature designations • Critical Habitat designations • Small study areas (e.g., conservation lands mapping and official community plans, local study area for environmental assessment)	• Sensitive Ecosystem Inventory (SEI), Exceptions Mapping (EXC), Terrestrial Ecosystem Mapping (TEM), Wetland Mapping (WET)
• Map and model the distribution of regional priority ecosystems • Informs specific valued components for cumulative effects • Establish zoning and development permit areas for local government • Medium size study area (e.g., Tree Farm License (TFL) area, landscape unit, community watershed, provincial parks and large conservation lands)	• Predictive Ecosystem Mapping (PEM), Terrestrial Ecosystem Mapping (TEM), Terrain Mapping (TER), Soil Mapping (SOIL), Wildlife Habitat Ratings (WHR)
• Management of wide-ranging species and matrix ecosystems • Complete seamless TEI mapping database with up-to-date structural stage covering the entire region • Map and model habitat characteristics such as ecosystem representation, patch size, edge habitat, fragmentation, connectivity, etc. • Provide a spatial framework for predicting ecosystem change in response to climate change, land use, and other threats to wildlife • Large study areas (e.g., Timber Supply Area (TSA), province-wide, Natural Resource Sector (NRS) regions)	• Broad Ecosystem Mapping (BEM), Broad Ecosystem Inventory (BEI), Broad Ecosystem Mapping Vegetation Resource Inventory (BEMVRI)

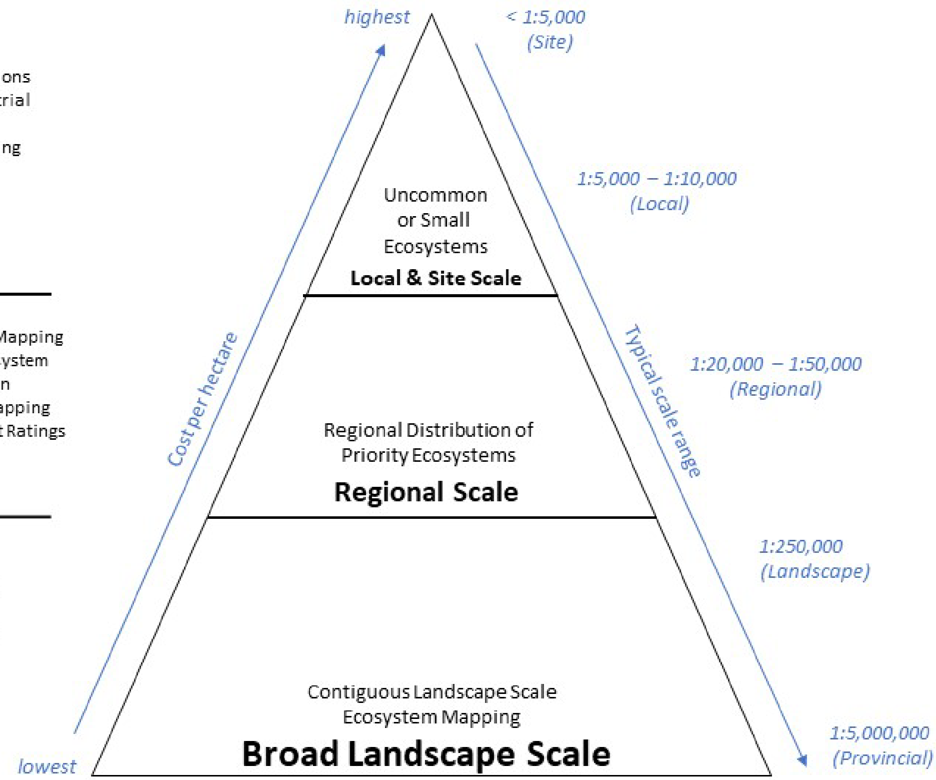
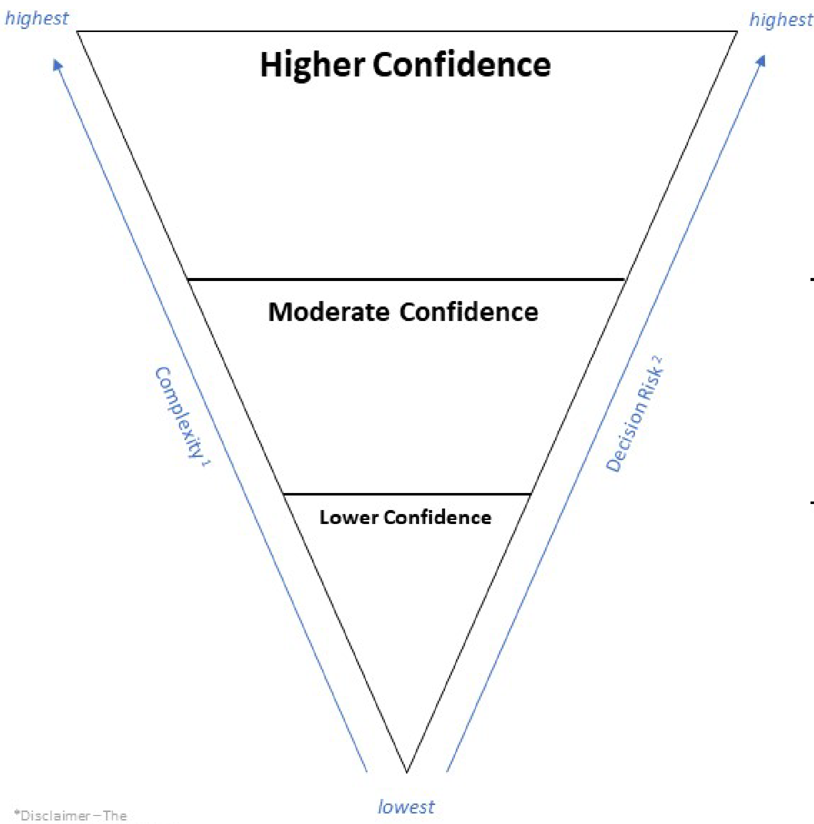


Figure 3: Cost and Scale Considerations for Ecosystem Mapping



Decision Characteristics:	Ecosystem Characteristics:	Mapping Characteristics:
• High consequences/risk • High economic impacts • competing land use needs/development pressures • High number of stakeholders • Uncertainty is high (e.g., lack or limited knowledge/data) • Well defined values • Politically sensitive • Outcome of decision is highly sensitive to ecosystem information (i.e., critical influencing factor)	• Provides critical ecosystem services (e.g., biodiversity, water quality, climate resilience) • Complex landscapes (e.g., number of ecosystem types and spatial patterns) • Site level variability and complexity is high (e.g., transitional ecosystems, temporal variations, seasonal patterns) • Uncommon, small or difficult to detect • Vulnerable	• Use-specific (i.e., targeted) mapping • Spatially explicit • High accuracy/reliability • Fine resolution/scale • Higher survey intensity level (observation densities) • Detailed classification (e.g., Site-level)
• Allocate limited resources (e.g., restoration) • Regional and operational strategic and planning level decisions and needs • Legislated requirements (e.g., land use orders) • Unknown, vague or poorly defined need • Multiple uses or needs	• All ecosystem types, sizes, patterns, variability and complexity	• General purpose mapping • Multidisciplinary products (e.g., ecosystem, terrain, wildlife) • Seamless coverage • Serving several unknown needs
• Low consequences/risk • Low economic impacts • Provincial strategic and planning level decisions • Simple, well-defined question or values • Broad-based decision making • Outcome of decision is less sensitive to ecosystem information	• Matrix, common, zonal and/or wide-ranging ecosystems • Resilient ecosystems and landscapes • Simple and predictable landscapes	• Large study area, low risk • Landscape level proportions (e.g., percentage of watershed or Timber Supply Area) • Coarse resolution/scale • Broad-level classification

*Disclaimer – The mapping, ecosystem, and decision characteristics are examples and may not be an exhaustive list

[1] Complexity describes the variability of mapped characteristics and spatial patterns (e.g., attributes, spatial distribution, number of mapping categories or ecosystem codes). For example, number of BEC zones or geology types.

[2] Assess relative risk to evaluate available options in the context of multiple contributing factors (e.g., ecological value/rarity, legislation, and/or economic value) and the probability of the decision impacting those factors/values identified.

Figure 4: Ecosystem Mapping Considerations of Complexity and Decision Risk

4.1.1.1 Mapping and Modelling

Ecosystem maps in BC are typically produced and verified either by imagery based direct mapping, using digital based mapping using orthophotos or satellite imagery, or by applying modelling algorithms using spatial data layers, to predict the extent and location of ecosystems across the landscape. Machine learning and/or expert knowledge models, including cross-walking or the use of look-up tables (LUTs), are examples of modelling methods. Traditional methods of classifying and mapping ecological units, such as TEM, can be labour intensive, costly, subjective, static and inconsistent, but are often considered more accurate and reliable measures of ecosystem conditions, that better capture enduring features in the landscape and support future interpretations such as wildlife habitat mapping, compared to modelled approaches. In contrast modelled approaches are typically more cost-effective, consistent and allow for repeatable as well as re-running of models using different or updated parameters or data sources to adapt to changing conditions. Within TEI, examples of imagery based direct mapping include BEI, TEM, SEI, TIM, TBT, TSM and SOIL, while PEM, WET, SDM and WHR are examples of modelling-based products. Figure 5 provides a decision tree for determining the project type based on taking either a mapping or modelling-based approach

Determining the foundational method, mapping or modelling, for stratifying and classify the landscape into map units is an important initial consideration. In many cases, project objectives will define the best method however, tradeoffs between cost, resolution, and accuracy must also be measured against the intended use of the information. It is important to identify the key attributes required for the final product, such as a habitat model, to select the method that will best provide this information. Other factors such as data availability, coverage, quality and accuracy may influence the approach selected especially if input data for modelling are not equivalent throughout the area of interest. For example, modelling using machine learning without relevant spatial data coverage or expert-knowledge based models where required knowledge is not available for the area of interest, would exclude these as appropriate options. Alternatively, if an area had no imagery available, mapping such TEM would not be possible. These factors indicate the importance of completing an assessment of the existing ecosystem and other available spatial data during the project scoping phase.

Another consideration for selecting a mapping or modelling approach is that often models are more generalized and trained to be accurate for a particular purpose. This can result in models predicting certain features better than others and using the modelled map for applications that differ from the original goal of the model can be inappropriate. For example, to date, PEM products are generally more accurate for forested ecosystems compared to non-forested ecosystems such as alpine, grassland, or wetland ecosystems due to the generalizations made by the models when classifying non-forested polygons. In contrast, for ecosystem classification using mapping approaches such as TEM, all features should be captured to the same level, however this can be influenced by imagery (age, quality etc.), mapping scale and mapper experience and knowledge of the landscape, ecosystems and features present within the area of interest.

Vector versus raster-based spatial data and end products should also be considered when selecting mapping or modelling approaches. Vector data is often associated with direct mapping methods as it uses spatial coordinates to define the locations of points, lines, and areas (polygons) to identify locations on the landscape. Raster data is often associated with modelling approaches and uses a series of cells to represent locations. Vector data stores and represents data that has discrete boundaries and can be assigned multiple attributes and data fields. As vector data has discrete spatial boundaries and is generally easy to interpret and view, it is often preferred by end-users for operational planning and management. However, vector-based data can be complex, time consuming and expensive which may limit it utility for certain projects, especially projects covering large areas. Raster data is formed by each cell receiving the value of the feature that dominates the cell. It has a simple data structure that well represents continuous features. Raster data is generally easy to use and inexpensive, however it lacks discrete boundaries and due to the cell-based grid matrix, it can be difficult to display and interpret. Modelling using raster data is often preferred in situations requiring large areas of the land base to be assessed and are often converted to vector spatial polygons during project finalization to increase the utility for end-users.

Both mapping and modelling approaches should also involve field verification to inform the final ecosystem classifications and support more accurate end products. However, modelling approaches often also require an independent/external accuracy assessment, to obtain unbiases assessment of the models thematic and spatial accuracy. The requirement for accuracy assessments for modelled approaches is related to constantly evolving and diverse methods and procedures used, due to changing technologies and data sources, as well as the lack of consistent input data across the Province. An ecosystem mapping accuracy assessment protocol for assessing the thematic accuracy of large-scale ecosystem mapping (i.e., Predictive and Terrestrial Ecosystem Mapping) was developed by the Province (Meidinger 2003). The protocol presents a statistically unbiased approach to evaluate and score the acceptability or accuracy of the mapping by assessing randomly selected map units (i.e. polygons). The protocol requires the development of a sampling plan outlining methods used for the assessment including factors such as protocol level, sample size, assessment method and target error. Assessing the accuracy of complex thematic maps is critically important to determining appropriate uses for ecosystem mapping, however these assessments are often costly to complete (Meidinger 2003). Modelled maps that do not have an accuracy assessment require expert interpretation to determine the accuracy and utility of the mapping when applying the mapping to purposes that differ from the original project objectives.

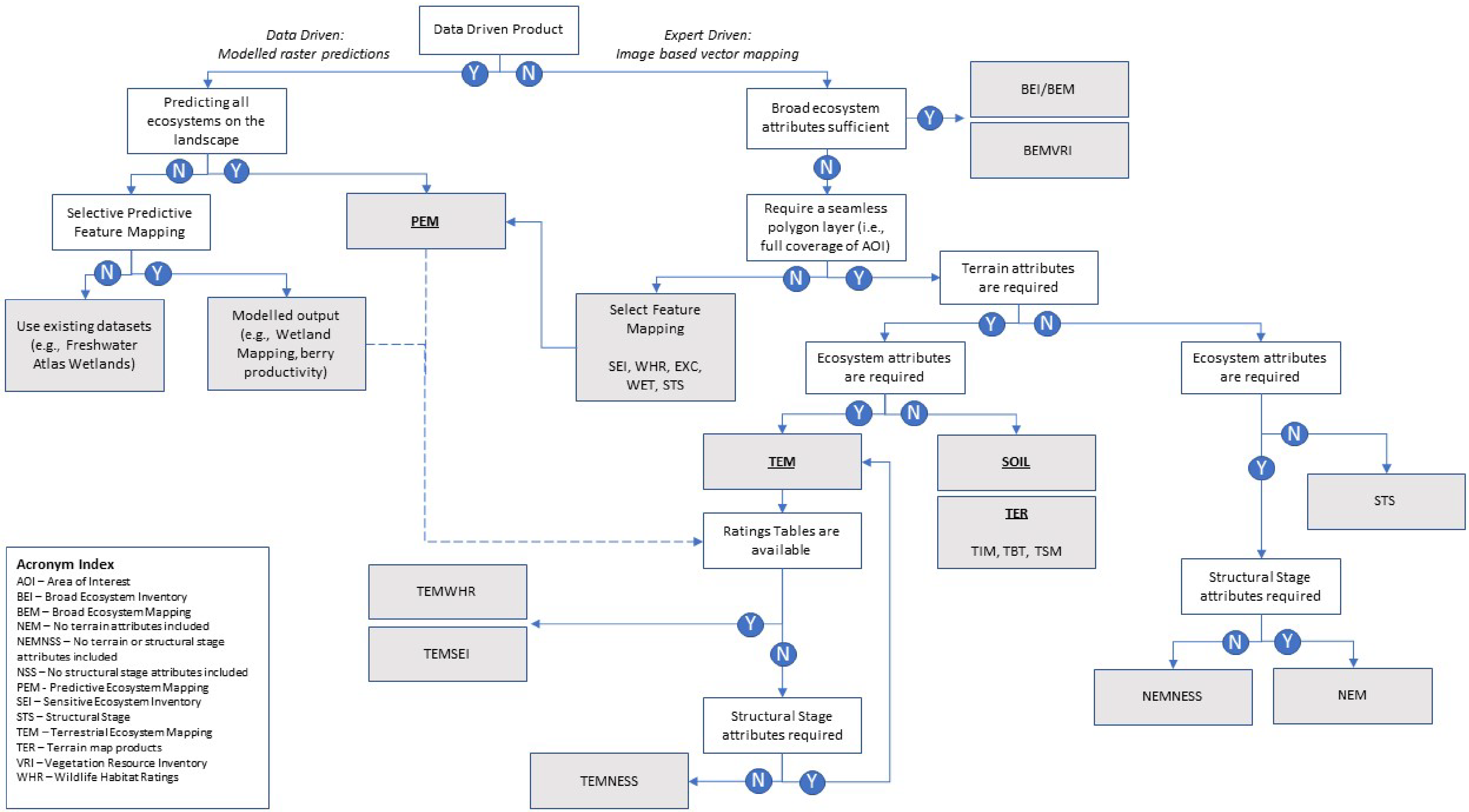


Figure 5: Ecosystem Mapping and Inventory Project Type Decision Tree

4.1.1.2 Use of Existing Data and New Mapping

The use of existing data compared to completing new mapping is another factor that should be considered when initiating an ecosystem mapping or modelling project. An assessment of the existing ecosystem and other available spatial data during the project scoping phase should be completed. Metadata and associated documentation including project reports associated with existing data should also be reviewed. These sources may contain key information about the data's content, purpose, intended use and any issues or known limitations that may exist within the data. Figure 6 provides a decision tree for the evaluation of existing mapping and inventory data.

The review of existing data should not only include a verification of the data coverage or extent by type but also evaluate the data content (i.e. information or attributes contained within the data) and quality of the data (i.e. resolution, accuracy, completeness, age, scale, polygon size – minimum/ maximum/average, level of verification – field/QA/AA, mapper experience etc.). For ecosystem modelling, as existing data forms the base of these products, it is imperative that data planned for use in modelling be assessed and verified to be appropriate for the intended use of the model.

As such, the results of data assessments can directly influence the type of project selected as well as the required approach (i.e. data clean-up/conversion, edge-matching of multiple projects to each other or new mapping etc.) and associated costs for project completion. For example, considerations for incorporating outdated mapping into a project, which may require data cleanup and/or conversion due to the age of mapping and potential for imagery, disturbance and classification updates is an important step.

Consideration of how data coverage, content and quality may link to project objectives or future uses is also necessary. For example, if VRI data coverage is not available for an entire area of interest, using the age data, solely from this source may not be a good option for producing a model output. In addition, if existing mapping data was completed 20 years ago at 1:50,000 scale, the mapping may not be detailed enough or reflective of current conditions, especially in areas where disturbance due to development or industry has or is occurring, and therefore may have limited utility for land management planning. This may be an example where updates to the existing could be completed or where new mapping is justified. Lastly, mapping that does not contain structural stage values may not be useful for wildlife habitat mapping and population of these values may be required to meet the project goals. However, using structural stage information within an existing mapping project should be assessed prior to use to determine how it was assigned, as it may have been modeled using age information or assigned by a mapper based on imagery of a certain age.

Completing new mapping and modelling is an option to fill in gaps between existing products, replace existing mapping or map new areas entirely. New mapping can be more costly than using existing data, as is or with updates to meet current standards and/or be reflective of current conditions, using new data sources and technology. However, new mapping can be customized specifically to current project objectives. It may also be more efficient, consistent, reliable and accurate and create a better seamless end product than attempting to clean up, convert or update existing products.

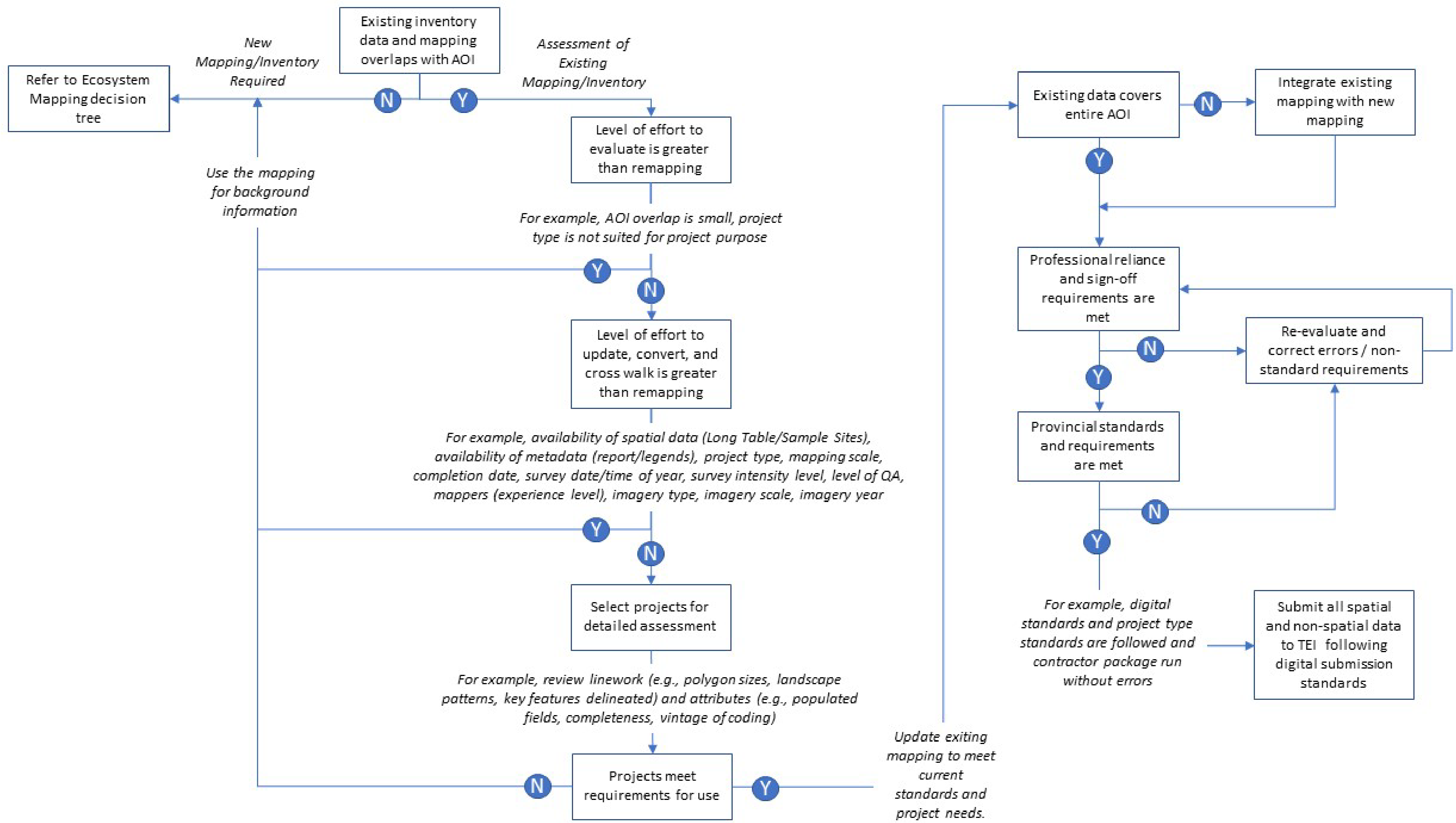


Figure 6: Evaluation of Existing Mapping and Inventory Data Decision Tree

4.1.1.3 Seamless Coverage and Delineation of Specific Features

Landscape level (seamless) coverage or delineation of specific features is another consideration when selecting an ecosystem mapping or modelling approach. Seamless coverage refers to mapping or modelling with polygons covering the entire area of interest, regardless of the types of features present within the area. The delineation of specific features focuses on identifying the location and extent of a subset of pre-determined map units on the landscape and consists of multiple disjointed polygons.

TEM and PEM are examples of approaches resulting in seamless coverage of an area of interest, whereas SEI Mapping, Reconnaissance Terrain Stability Mapping or Ecological Communities Element Occurrence Mapping are examples of mapping capturing specific features. In general, mapping of specific features can be used to flag areas for more detailed inventory prior to making land use decisions and to facilitate landscape level planning. Also depending on project objectives, it is often a less intensive and more cost-effective approach to identify key features of interest, including rare or sensitive elements such as wetlands or grasslands. For example, if the end goal of a project is solely to identify all the wetlands in an area for conservation and management, mapping only these features would be appropriate. However, this approach does limit potential future uses such as habitat modelling, as the matrix of surrounding ecosystems remains unknown.

Despite the cost and additional effort required to complete seamless mapping or modelling, it is generally the preferred approach due to its full coverage, adaptability and utility for multiple purposes. As all features on the landscape are identified, full ecosystem representation within an area of interest can be determined based on any or all features occurring. This is a valuable tool in helping with maintaining and protecting biodiversity on the landscape and associated land management planning. There is also value in knowing the context of adjacent map units across the area of interest. For example, for land management planning it may be important to identify wetlands or riparian areas surrounded by natural forested habitat as opposed to within an area of development. Seamless mapping can also use themes, using the associated attribute data, to model for specific ecosystem types, such as grasslands or rock outcrops or important wildlife habitat features such as avalanche tracks or wetlands. The ability to use seamless products as a method of both identifying and measuring the abundance of various wildlife habitat characteristics such as ecosystem representation, patch size, fragmentation and connectivity and amount of edge habitat among others is also valuable.

4.1.1.4 Static and Dynamic Features

Delineation and attribution of static/enduring features such as terrain and dynamic features such as structural stage and disturbance is another consideration when selecting ecosystem mapping or modelling approaches. As conditions on the landscape change over time, due to numerous factors such as natural succession and disturbance or development-based alterations, mapping products will become outdated. However, based on the type of change, mapping may become outdated relatively quickly and not be accurate enough for specific end-uses such land management planning.

In addition, data availability and quality can also vary over time. For example, new or expanded coverage of high-resolution imagery or LiDAR may result in data becoming available for an area previous captured with older sources. New technologies can also result in new information over time.

Traditional, image-based interpretation projects typically map the landscape by delineating and attributing both static and dynamic features based on the best imagery source available for the area of interest, considering the imagery vintage, quality, and coverage. These projects capture the spatial extent and attributes of all features of interest within one layer and generally result in a mapping product that is easy to understand, use and interpret.

However, across a landscape many natural and anthropogenic factors influence potential changes in dynamic features such as structural stages. Typically, a mapping product is not continually updated to reflect changes in structural stage from events that can potentially change an area's structural stage such as fire or insect damage or harvesting. Unless updated with available VRI, stand age data or disturbance layers, a TEI mapping product will reflect the structural stage of an area based on the year of the imagery that was used, which should be as close as possible to the year the product was completed.

As an alternative approach, some more recent mapping projects have not included dynamic-based attributes within the mapping and/or produced multiple mapping layers to distinguish static from dynamic features. This allows for the dynamic features not directly linked to the static features which can be updated over time without influencing the static features within a mapping layer. This can be advantageous but also requires additional understanding by end-users to either populate additional attributes from base data or work with multiple sources of ecosystem mapping data instead of just one layer.

Other methods such as cross-walking or the use of look-up tables (LUTs) using mapped attributes from within an existing ecosystem mapping/modelling project or from other base data layers (i.e. VRI age data as an indicator for structural stage) can also be used to update or populate dynamic attribute features as well as additional ecosystem, soils, terrain, wildlife or vegetation-based information such as rare ecosystems, and theme mapping products accordingly. For example, if an ecosystem previously mapped within an area of interest is now considered rare, the mapping can be updated accordingly to account for this change in status. Currently, a provincial initiative is underway to develop standardized methods for modelling and linking structural stage to Terrestrial Ecosystem Mapping (TEM) with initial pilot studies being conducted in coastal landscape units and priority Biogeoclimatic Units within the Great Bear Rainforest (Madrone 2022).

Alternatively, modelling approaches, that are not primarily based on a static imagery source, can be a good option when considering the need to incorporate both static and dynamic features into a single ecosystem product. Modelling allows for changing conditions to be captured as models can be re-run, as new, updated or different data becomes available to produce ecosystem products based on current data.

4.1.1.5 Scale and Polygon Size

Map scale is the relative size of an area on the ground compared to that area represented on a map. The amount and types of information which can be captured and displayed from ecosystem mapping is dependent on the map scale. Map scale is primarily limited by the scale of the source imagery used in mapping and varies based on project type and objectives (RISC 2006).

Historically, traditional manual mapping methods of delineating ecosystem polygons on hardcopy aerial photographs in stereo (3D), resulted in the scale of mapping projects being determined by the scale of the air photos used. With current technologies, including digital on-screen mapping in ArcGIS using 3D mapping software, such as PurVIEW or Summit Evolution, mapping scale can be selected based on imagery quality and resolution, as well as by mapping type and project objectives. The use of on-screen imagery interpretation also allows for the option of “zooming” to view the imagery at larger scales than the overall project map scale, and to more accurate identify and capture a features extent or boundary, such as wetlands or grasslands. Using these new mapping methods, scales from 1:5,000 to 1:10,000 are commonly utilized.

For broad level strategic planning of large geographic areas, scales of 1:100,000 to 1:250,000 are appropriate. Interpretations are generalized and limited to identifying broad areas with a general level of conservation value required to manage ecosystems at risk. This scale of mapping may be used to identify priority areas for larger scale mapping. BEI is an example ecosystem mapping approach appropriate for 1:100,000 to 1:250,000 scale projects (RISC 2006).

Scales of 1:10,000 to 1:50,000 are often used for landscape level planning and management including ecosystem representation, conservation and land acquisition priorities, zoning, Official Community Plans, Development Permit Areas, general forest productivity, wildlife habitat mapping and protection, element occurrence mapping and the identification of ecosystems at risk. TEM and PEM are examples of approaches typically completed at landscape level scale (RISC 2006).

Site level planning and management such as park use planning, environmental impact assessments, development planning, and restoration efforts require large scale mapping (<1:5,000 to 1:10,000) to provide the appropriate level of detail required to adequately identify and manage key features such as ecosystems at risk. For example, planning for restoration of damaged ecosystems at risk requires detailed mapping and intensive surveying to determine management, mitigation, development design, and restoration techniques (RISC 2006).

Polygon size is associated with the scale of mapping selected but also the mapping type and landscape characteristics of the mapping area. Table 3 includes the recommended minimum polygon sizes based on scale from the TEI Digital Data Submission Standards (RISC 2015). However, in order to capture small key or sensitive features a minimum polygon size of 0.5 ha is often recommended for most ecosystem projects, regardless of scale.

Table 3: Minimum feature size recommendations

Mapping Scale	Recommended Minimum Feature Area (on ground)	Recommended Minimum Feature Widths (on ground)
1:5,000	0.5 hectare	5 metres
1:10,000	1.0 hectare	10 metres
1:20,000	2.0 hectare	20 metres
1:50,000	5.0 hectare	50 metres

Average polygon size should also be considered during an ecosystem mapping/modelling project. For most areas of the Province, an average polygon size of 10 to 20 ha would be reasonable for mapping at 1:20,000 scales, with an average polygon size of 10 to 15 ha generally recommended for most ecosystem projects regardless of scale. Along with minimum polygon size, average polygon size can also give an indication of the overall map projects accuracy. Average polygon size is also an important consideration when determining the level of field verification as the Survey Intensity Level (SIL) as sampling density is characterized either as the percentage of polygons that have been field inspected, or as the actual density of field inspections on an area basis (hectares per field inspection) (RIC 1998).

On-screen imagery interpretation with the ability to "zoom" has allowed for increased ability to view, identify, and capture important or sensitive features on the landscape. Not only can small features be located but also the boundaries of key features are able to be captured more accurately at a refined scale. Table 4 includes the recommended guidelines for maximum zoom for digitizing polygons from the TEI Digital Data Submission Standards (RISC 2015).

Table 4: Recommended maximum digitizing zoom

Project Scale	Recommended Zoom Scale	Detailed Polygon Zoom Scale (i.e. Riparian/Wetland)
1:5,000	1:2,500	1:2,000
1:10,000	1:5,000	1:4,000
1:20,000	1:10,000	1:8,000
1:50,000	1:25,000	1:20,000

4.1.1.6 Attribute Selection

As ecosystem mapping and modelling projects often have specific project objectives, end goals, and requirements for potential future uses, the attributes selected for inclusion need to be considered during the initial project approach selection phase. In some cases, projects may require information from attributes that are not always included in mapping projects. For example, information about tree crown closure, stand composition modifiers, and site disturbance may be required to rate habitat capability and suitability for certain wildlife species. These attributes would therefore have to be included for the ecosystem map to be interpreted for these purposes. Alternatively, a data set including soil and humus form attributes would be required to determine forest site sensitivity (RIC 1998b). To ensure the required or desired information is captured, to meet project objectives or potential future uses, determining the information and attributes to be mapped or modelled is an important initial step. Attribute selection should also consider the future ability to crosswalk or correlate to other classification systems. For example, look-up tables (LUTs) developed from mapped attributes from within an existing ecosystem mapping/modelling project or from other base data layers (i.e. VRI age data as an indicator for structural stage) can be used to populate additional ecosystem, soils, terrain, wildlife or vegetation-based information such as rare ecosystems, and theme mapping products accordingly. However, there are other considerations such as project costs, timeframes, and policy/management-based requirements, which also must be considered. For example, terrain attributes are often excluded to reduce project costs and timeframes.

However, to have a versatile final ecosystem product that can meet numerous land management-based goals including determining ecosystem representation, developing wildlife population and habitat supply models, and identifying rare or sensitive ecosystems or habitats, the following attributes are generally recommended for inclusion:

- Ecosection unit
- Biogeoclimatic unit
- Ecosystem attributes including site series, realm, group, class, site modifier(s), structural stage, stand composition and disturbance
- Bioterrain attributes including terrain texture, qualifying descriptor, surficial/subsurficial material and surface/subsurface expressions
- Geomorphological processes
- Soil drainage

For example, the realm, group and class fields allow for higher level BEC site classification within the ecosystem mapping database.

- Realm of the ecosystem (‘Site Realm’) delineates major biotic types that reflect gross differences in water abundance, quality, and source including Estuarine (E), Marine (M), Freshwater (O), Terrestrial (T) and Wetland (W) realms (MacKenzie 2012).
- Group of the ecosystem (‘Site Group’) designates a broad association of functionally similar ecosystems based on a dominant cluster of ecologically relevant environmental features such as Alpine (A), Avalanche (V), Flood (F), Grassland (G), Subalpine (shrub) (S) and Rock (R) (MacKenzie 2012).
- Class of the ecosystem (‘Site Class’) describes ecosystems with similar underlying environmental attributes that support similar characteristic vegetation physiognomy and

species adaptation guilds at climax such as fellfield, grassland, heath, meadow, shrub thicket, low bench flood, mid bench flood, high bench flood, active flood, shrubland, krummholtz, outcrop, cliff, talus, swamp, shallow water, bog and fen (MacKenzie 2012).

The realm, group and class fields allow ecosystem mapping data to be “rolled-up” into categories that are more interpretable, user-friendly and themeable. For example, all different types of bog wetlands identified within a project can be included and displayed on map products in a single category.

Lastly, despite the initial time and cost investment, including bioterrain attribution within an ecosystem mapping product, generally results in a better TEM product than ecosystem mapping based solely on ecological features such vegetation, slope, and aspect. Ideally, all ecosystem mapping, not just products with terrain attribution, should be based on enduring bioterrain features. For example, landform, also known as surface expression, usually describes material thickness and slope morphology. These descriptors typical provide information on rooting depth, the storage capacity for moisture and nutrients in ecosystems and the movement of nutrients and moisture through the landscape (EDI 2018, Tripp and Temmel 2017). Also, identifying the geological processes that are active within a mapping area provides additional information on influences on ecosystem development over time (EDI 2018).

4.1.1.7 Level of Field Verification

Both mapping and modelling approaches should involve field verification to inform the final ecosystem classifications and support more accurate end products. For mapping project types, field data is used to confirm ecosystem and terrain map unit designations and boundaries, to collect data for ecosystem descriptions in reports, and to develop or refine the classification of ecosystem units. For modelling approaches, field data provides both the information necessary to modify the knowledge base and to test the accuracy, consistency and sensitivity of predictions.

The sampling intensity selected is typically dependent on the project objectives as well as mapping scale, study area size, project timeframes, available funds and access considerations. Survey intensity is a measure of sampling density, characterized either as the percentage of polygons that have been field inspected, or as the actual density of field inspections on an area basis (hectares per field inspection) (RIC 1998).

The Provincial RIC standards outline six survey intensity levels (SIL) for ecosystem mapping and some of the associated factors to consider when planning a mapping project (Table 5). SIL 1 is the highest survey level and recommended for site specific projects requiring highly accurate mapping such as restoration planning, establishing conservation covenants, element occurrence mapping and site environmental impact assessments for developments. SIL 2 is generally recommended for local government land use planning (zoning, OCP, and DPs), greenways and park planning, element occurrence mapping and medium scale pre-planning developments. SIL 3 and 4 are typically used for landscape level land use planning, land acquisition priorities, habitat mapping and habitat protection, element occurrence mapping and conservation priorities. A SIL 4 is recommended for most TEM projects since it provides a reasonable balance between cost and reliability leading to map products that could be used for ecosystem representation, wildlife suitability or capability mapping, and source of information for resource management and planning. SIL 5 and R (reconnaissance) can be used in cases where SIL 4 is too costly and lower reliability is acceptable. SIL 5 can also be used for ecosystem representation, general forest productivity, local resource planning, landscape management planning. SIL R is typically recommended for regional planning and broad landscape management planning and should only be conducted by ecologists who have considerable field experience in the ecosystems of the study area (RIC 1998).

Along with total plots, the ratio of plot types is also an important consideration. Field inspections are of three types: full plot, ground inspection, and visual check. Together they are usually carried out in a 5:20:75 proportion, respectively (Table 5). However, as stated in the Provincial standards, inspection ratios are guidelines and actual project ratios should be set by project ecologists responsible for administering project (RIC 1998). Therefore, based on project objectives and requirements, plot ratios may be modified, however it should involve communication with Ministry ecologists and subsequent documentation of the rationale. To facilitate this, it is recommended a variance request be submitted for review by the TEI Unit. Data collection procedures for all plots should follow the Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests and Range and BC Ministry of Environment 2015) which sets coding and methodology standards for data collection of ecosystem plots in BC. Full plots, recorded on the Ecosystem Field Form (FS882), provide the most detailed ecological data for a point sample and are intended for classification of site series, confirmation or classification of biogeoclimatic units, and development of ecosystem unit descriptions and summary statistics. Ground inspections are abbreviated ground-based plots from which data are recorded to confirm the identification of the ecosystem unit or polygon designation or determine polygon boundaries using Site Visit Forms (FS1333). Visual checks are the least detailed and are intended to be quick inspections for mapping purposes and typically include confirming site series, site modifiers, structural stage and terrain attributes, briefly describing vegetation, assessing biogeoclimatic mapping, recording ecosystem or terrain component percentages, evaluating polygon boundaries, or noting special features. Visual checks can be conducted on the ground, from the air (helicopter), or from viewscapes. However, emphasis should be on the ground-based plots as air calls and viewscapes are limited in the types of information which can be confirmed. Map reliability is most likely to be improved if more ground is covered during field work (RIC 1998).

In addition, as well-planned field sampling is more cost-effective, productive and results in more reliable map products, developing a sampling plan is important. The sampling plan should identify the SIL and associated plot ratios selected, as well as target ecosystems, landscape features or priority areas for field verification within the area of interest.

Table 5: Survey Intensity Levels for Ecosystem Mapping (adapted from RIC 1998)

Survey Intensity Level	% of Polygon Inspections	Ratio of Full Plots: Ground Insp.: Visual Checks[10]	Suggested Scales	Range of Study Area (ha)	Hectares per inspection[11]			
					1:5,000	1:10,000	1:20,000	1:50,000
1	76-100	2:15:83	1:5,000-1:10,000	20-500	0.9-1.2	3.8-5	15-19	91-120
2	51-75	3:17:80	1:10,000-1:20,000	100-10,000	1.3-1.8	5.1-9	20-29	121-178
3	26-50	5:20:75	1:10,000-1:50,000	5,000-50, 000	1.9-3.7	8-14	30-59	182-350
4[12]	15-25	5:20:75	1:20,000-1:50,000	10,000-500,000	3.8-6.3	15-25	60-100	364-607
5[13]	5-14	5:20:75	1:20,000-1:50,000	10,000-1,000,000	6.4-17	26-76	101-302	650-1820
R[14,15]	0-4	0:25:75	1:20,000-1:50,000	50,000-1,000,000+	18-94+	77-370+	303-1500+	2275-9100+

[10] Inspection ratios are guidelines; actual project ratio should be set by project ecologists responsible for administering project.
[11] Values are guidelines only and are based on an average polygon size of 9-16 ha.
[12] Survey intensity level recommended for most mapping. This provides a reasonable balance of cost and reliability.
[13] Survey intensity level recommended when Level 4 is too costly and lower reliability is acceptable.
[14] Survey intensity level recommended when Level 4 is too costly and lower reliability is acceptable.
[15] Level R (reconnaissance) ecosystem mapping should only be conducted by ecologists who have considerable field experience in the ecosystems of the study area.

4.1.2 Limitations

The approaches selected for ecosystem mapping and modelling projects may have associated limitations, especially if the data is being used for purposes other than originally intended. Users should be aware that mapping done for one purpose may not be appropriate for other uses. For example, the mapping may not document the attributes important for other mapping applications or may not meet the standards used for other mapping types (such as SIL, minimum attribute criteria, and completeness of data). Care should be taken to ensure that the pertinent data is contained in each project when assessing its utility for a purpose that differs from the original project objectives. Also, the diverse methodologies used to create mapping or modelled products can make it difficult to make comparisons between projects, especially when comparing the attributes and ecosystem coding applied to polygons, as different projects may have different criteria for determining how codes were applied. Therefore, metadata and associated documentation should always be included with all new projects and reviewed prior to using existing data to identify key information about the data's content, purpose, intended use and any issues or known limitations that may exist within the data.

4.1.3 Recommendations

The most comprehensive approach to ecosystem mapping in BC is TEM completed at a minimum to a SIL 4 with bioterrain and vegetation structural stage attributed. A seamless TEM SIL 4 product can provide accurate and reliable measures of ecosystem conditions, capture enduring features in the landscape and support wildlife habitat interpretations (EDI 2018). However, due to the extent of the Kootenay Boundary region completing a full seamless SIL 4 TEM product may not be a realistic or viable option due to the associated costs and timeframe for completion. As such the use and incorporation of existing data, where possible, into a seamless ecosystem layer is recommended. To ensure existing data is appropriate for use it must also be assessed. This review should include a verification of the data coverage or extent by type and evaluate the data content (i.e. information or attributes contained within the data) and quality of the data (i.e. resolution, accuracy, completeness, age, scale, polygon size – minimum/ maximum/average, level of verification – field/QA/AA, mapper experience etc.). Identifying and assessing existing information can be completed through a gap analysis.

Therefore, a gap analysis of all available TEI data as well as other relevant information and data sources was completed as part of developing this strategic plan and is documented in Section 5 and Appendix C. In addition, a priority ranking system was developed based on the ease of mapping that can contribute to determining what areas should be prioritized during the production of TEI products for the Kootenay Boundary Region (Section 6).

5 Gap Analysis

A gap analysis of spatial data and information available for the Kootenay Boundary Region was undertaken to support the Kootenay Boundary Strategic Plan and included five broad tasks:

- Review TEI data available in the TEIS operational environment.
- Review imagery availability and determine access and distribution.
- Track and store spatial data forwarded or recommended by regional ecologists and project team members.
- Create a map exchange document (mxd) of all spatial data available.
- Summarize findings by Landscape Unit for priority ranking.

Data reviewed during the gap analysis included:

- Ecosystems projects and data managed by the TEI unit within the TEIS operational environments[16]
- BEC mapping and the associated site specific plot data
- Regional, provincial, and non-government products
- Data managed by the BC Geographic Warehouse (BCGW)
- Imagery (LiDAR, Orthophotos, Stereo Models, Satellite Imagery, DEMs)

The methods, including a list of data uncovered and links to the data, as well as the results and limitations of the gap analysis have been provided in Appendix C. The results of the gap analysis have been summarized by landscape unit so that they can be ranked to determining what areas could be prioritized during the production of TEI products for the Kootenay Boundary Region (Section 7). An Excel spreadsheet associated with this Strategic Plan contains detailed results of the gap analysis. (KB_Region_Data_Availability_and_Priority_Ranking.xlsx).

6 Prioritization of Regional Ecosystem Mapping Actions

Upon the completion of the gap analysis and assessment of available mapping data, a priority ranking system was created. The priority ranking system was developed based on the ease of mapping that can contribute to determining what areas could be prioritized during the production of TEI products for the Kootenay Boundary Region. It is recognized that there are additional considerations for regional prioritization such as policy and land use planning, as well as incorporating the priorities of Indigenous governments.

[16] Projects that overlap the KBR but have not yet been loaded to the TEIS operational environments need to be identified. A review of TEI project folders have not been investigated for projects and data that may overlap with the KBR.

Initial prioritization is based on technical categories derived from the data gathered during the gap analysis. Each area will be prioritized based on the defined technical categories followed by an overall prioritization rank.

This section will describe how rankings were calculated based on data gathered by the gap analysis and provide a summary of the results for each described category. The list of data used in the gap analysis including links to the data, have been provided in Appendix C. The detailed results are provided in the Excel spreadsheet associated with this Strategic Plan (KB_Region_Data_Availability_and_Priority_Ranking.xlsx).

6.1 'Ease of Mapping' Prioritization

The prioritization to indicate ease of ecosystem mapping efforts assumes that the more data available within the landscape unit, results in a higher level of mapping efficiency. Prioritization is based on seven data categories, in order of importance: Stereo Model Photocenters, LiDAR Coverage, Available Plot Data, Available TEM Coverage, VRI Coverage, Road Density, and Number of Ecological Zones (BEC complexity). The order of importance was developed in concert with several subject matter experts, including ecosystem/terrain mappers and wildlife biologists, at series of three workshops (Section 7).

The rankings or bins applied in the associated Excel spreadsheet are described in the tables below and later added together to produce a final prioritization rank. Binning is based on different factors depending on the layer in questions. Some rely on data naturally clustering within the region (Natural Breaks), where others use mapping standards as a guild (RISC SIL level), or are expert driven by experienced ecosystem mappers to determine the ranks for LiDAR coverage for example.

6.1.1 Data Coverage Assumptions

There are several data sources that cover the entire province of BC. Instead of listing these as 100% coverage for each landscape unit it can be assumed that this data is available to aid in mapping efforts.

DEM rasters are available at a 25m cell size across the province. These rasters can be used to process slope, aspect, and elevation values, and create hillshades. TRIM data is available through the DataBC Catalogue and contains contours, roads, streams, and water features. Freshwater Atlas is another source containing water features; lakes, rivers, stream networks, watersheds, and wetland layers. Orthophoto availability has improved significantly in the last 10 years. It is assumed that satellite and aerial imagery will be available for mapping purposes. ESRI's World Imagery Map is updated regularly as new images are captured from a multitude of contributors[17]. This user friendly basemap provides a resolution of one meter or better. KBR is covered by a mosaic of orthoimagery ranging in years

[17] http://downloads.esri.com/esri_content_doc/da/WorldImageryMap_ContributorsDA70.pdf

from 2015-2020, with the majority of the imagery from 2016 and 2018 though patches of 2020 imagery can be found in the north and eastern areas of the region.

6.1.2 Stereo Model Photocenters

Stereo models allow the mapper to visualize the landscape in 3D and observe patterns that may not be as obvious from the imagery or contours, which is extremely important for accurately delineate bioterrain features. Stereo imagery can also provide the mapper with information about forest structure, which is particularly valuable for identifying old forest and other ecosystems that have a specific structure (e.g., grassland vs. brushland).

Stereo models are available in for much of the KBR. Images are available for 2004, 2005, 2006, 2007, and 2011 for the Kootenay Boundary Region with varying coverage by year. Stereo model coverage has been inferred by buffering the total coverage of photocenter points available for both .sjs or ZI format to represent on the ground footprint of coverage. Using existing data as a guide, a digital footprint of a 1:20,000 scale airphoto is 21,160,002 m^2 (21.1 km^2). This was the buffer distance applied to the photocenters and dissolved into a coverage of data availability. This estimated polygon coverage was then summarized by landscape unit.

It is important to note that while points indicate existing data the reality of what is truly available through the Digital Imagery Service (DIS) may differ. For example, ZI setups are more labor intensive for the DIS to provide and the level of effort and turnaround time may exceed project timelines. It should be noted that the inferred coverage is likely an over estimation of what data is readily available. The variation between estimated coverage and actual data available can range from 10-75% difference from final indicators. Table 6 describes how ranks were determined for this category with the results presented on Figure 7.

Table 6: Ranking for stereo model coverage

Coverage of Landscape Unit (%)	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
>90	1	High	168	84
51-90	2	Moderate	26	13
10-50	3	Low	5	3
< 10	4	Very Low	1	< 1

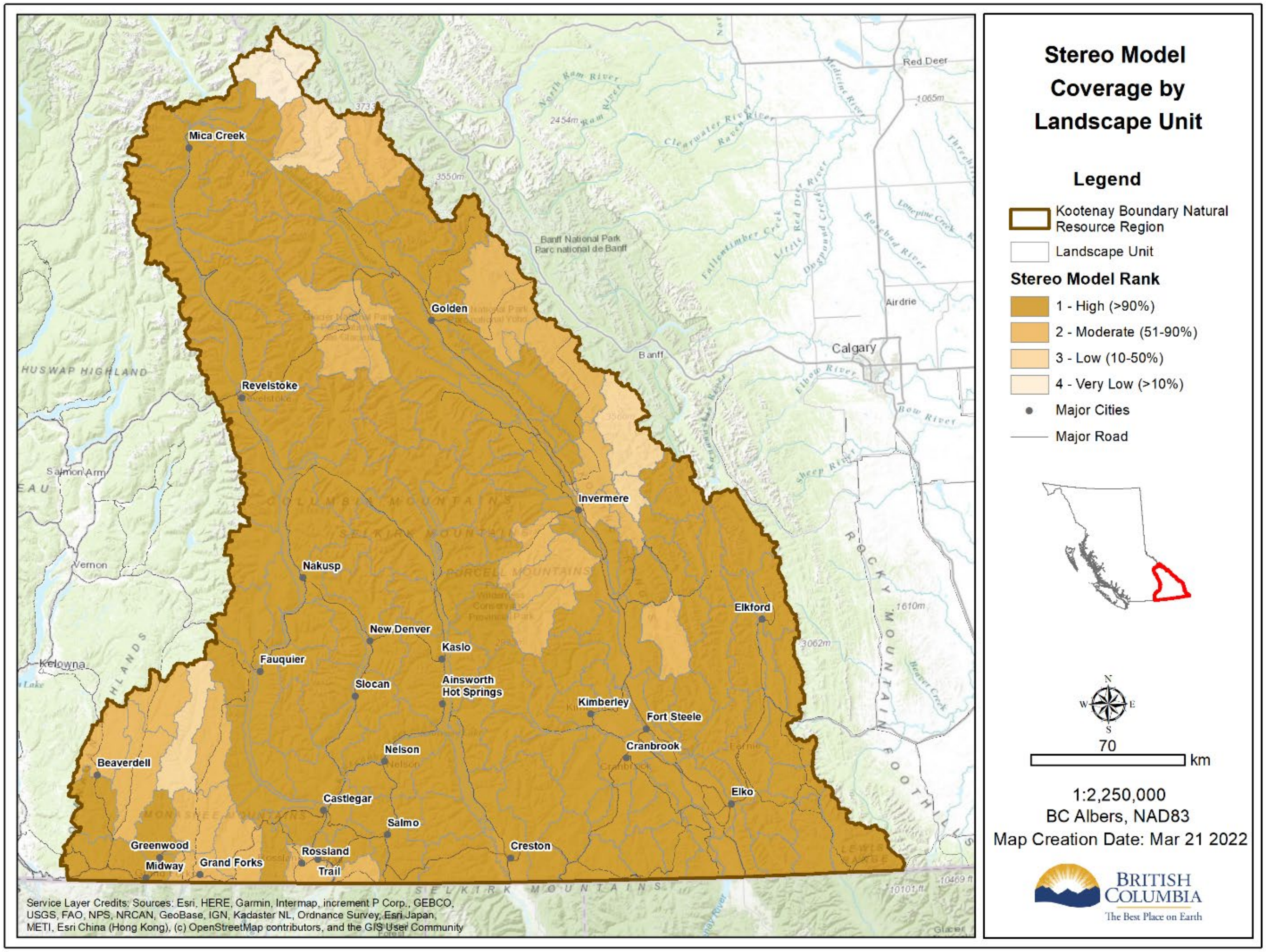


Figure 7: Overview of Stereo Model Coverage

6.1.3 LiDAR Coverage

LiDAR provides a map of the earth's surface. This is an extremely valuable tool when ecosystem mapping as it can provide the mappers with information that may not otherwise be obvious from contours and imagery alone. For example, it can allow the mapper to pick out small features such as forested depressions, caves, cliffs that may be hidden by the vegetation. It is also helpful for mapping enduring features on the landscape, refining riparian areas and identifying initiation zones for avalanche tracks. Section 7 further describes examples where LiDAR is beneficial, or critical, for mapping some priority ecosystems.

LiDAR extents for each of the source layers (Open LiDAR Portal, LiDAR BC, Internal FLNR LiDAR Coverage) were merged into a single extent and intersected with the Landscape Units to determine a single coverage to exclude areas where source extents may overlap in area. The ranks below are based on the total coverage of an individual landscape unit. Table 7 describes how ranks were determined for this category with the results presented on Figure 8.

Table 7: Ranking for LiDAR coverage

Coverage of Landscape Unit (%)	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
>90	1	High	27	14
51-90	2	Moderate	56	27
10-50	3	Low	51	26
< 10	4	Very Low	66	33

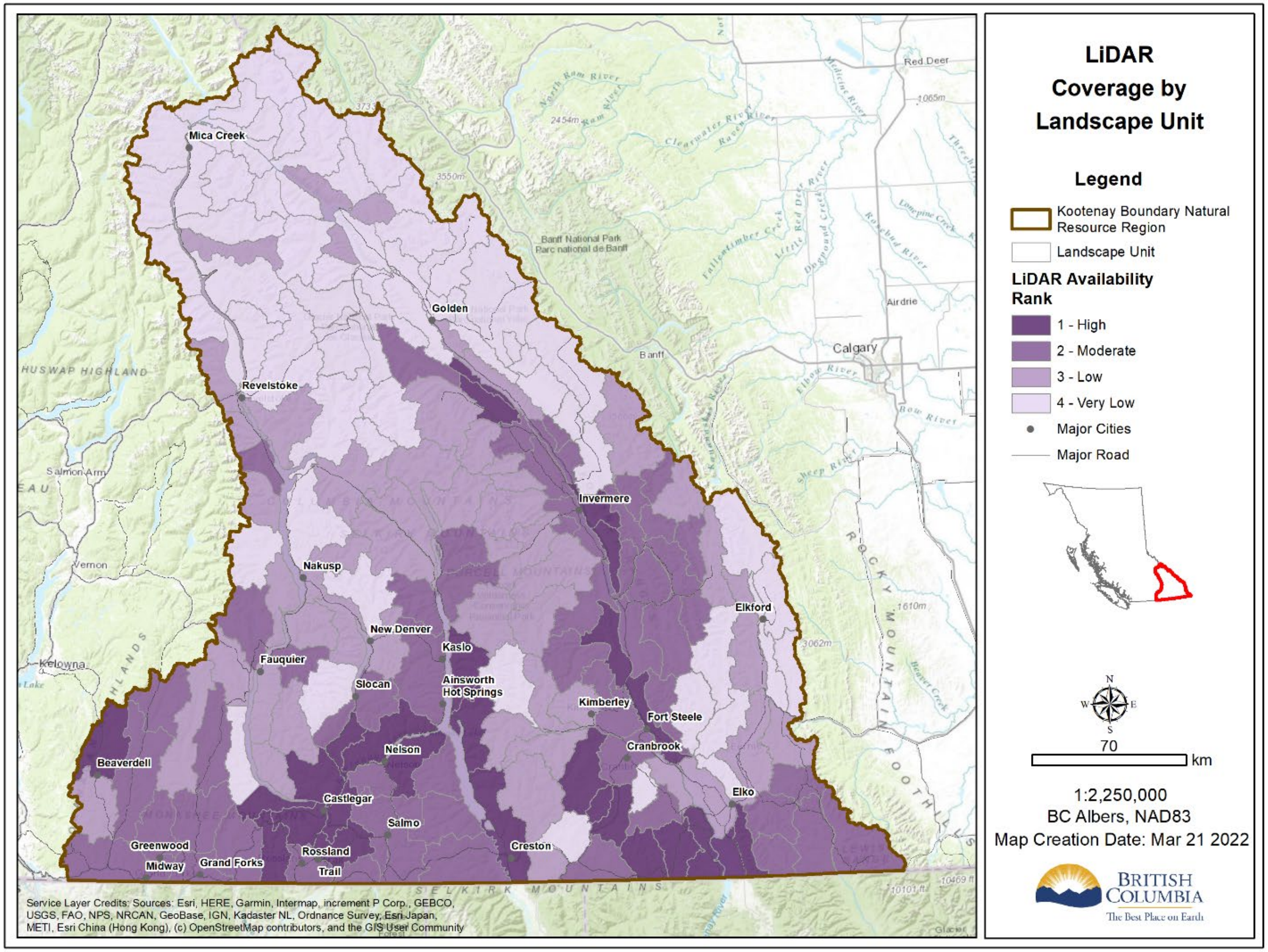


Figure 8: Overview of LiDAR Coverage

6.1.4 Available Plot Data

Existing plot data can be a valuable addition to an ecosystem mapping project as it provides site level information. The data will generally provide information about the site including soil nutrient and soil moisture, leading species, terrain characteristics and drainage. This can be used by the mapper to confirm or adjust their ecosystem mapping call for that area. For example, the plot information may suggest an area is drier, or richer than what the ecologist mapped, and this can be used to update the mapping accordingly. Existing plots can also be added to plots collected for the project, thereby potentially increasing the number of polygons that were field verified, resulting in a lower SIL.

Plot data was compiled for both the TEIS Master Sample Site Points layer and the BEC Master plot locations. As there may be duplication in plots between TEIS and BEC, where TEIS points were spatially similar to the BEC plot locations, they were removed. A search radius of 50m (determined by visually assessing the plots on screen) was applied and 182 duplicate plots were removed. Most of these plots were found in BAPID 219. The plot counts were quantified for each landscape unit and ranked based on the breaks in the table below. Further detailed assessment of the plot data available and their suitability to be incorporated into mapping projects would be required. The age of the data collected (<20 years ago) and the accuracy of the GPS units used are important considerations prior to using the data. Table 8 describes how ranks were determined for this category with the results presented on Figure 9.

Table 8: Rank by TEM/BEC plot availability

Plots Per 100 ha*	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
>1.00 (SIL 4 or lower)	1	High	6	3
0.33-0.99 (SIL 5)	2	Moderate	31	16
<0.33 (SILR)	3	Low	161	80
0	4	Nil	2	1

* Based on 1:20,000 scale mapping (Table 6.4; RIC 1998)

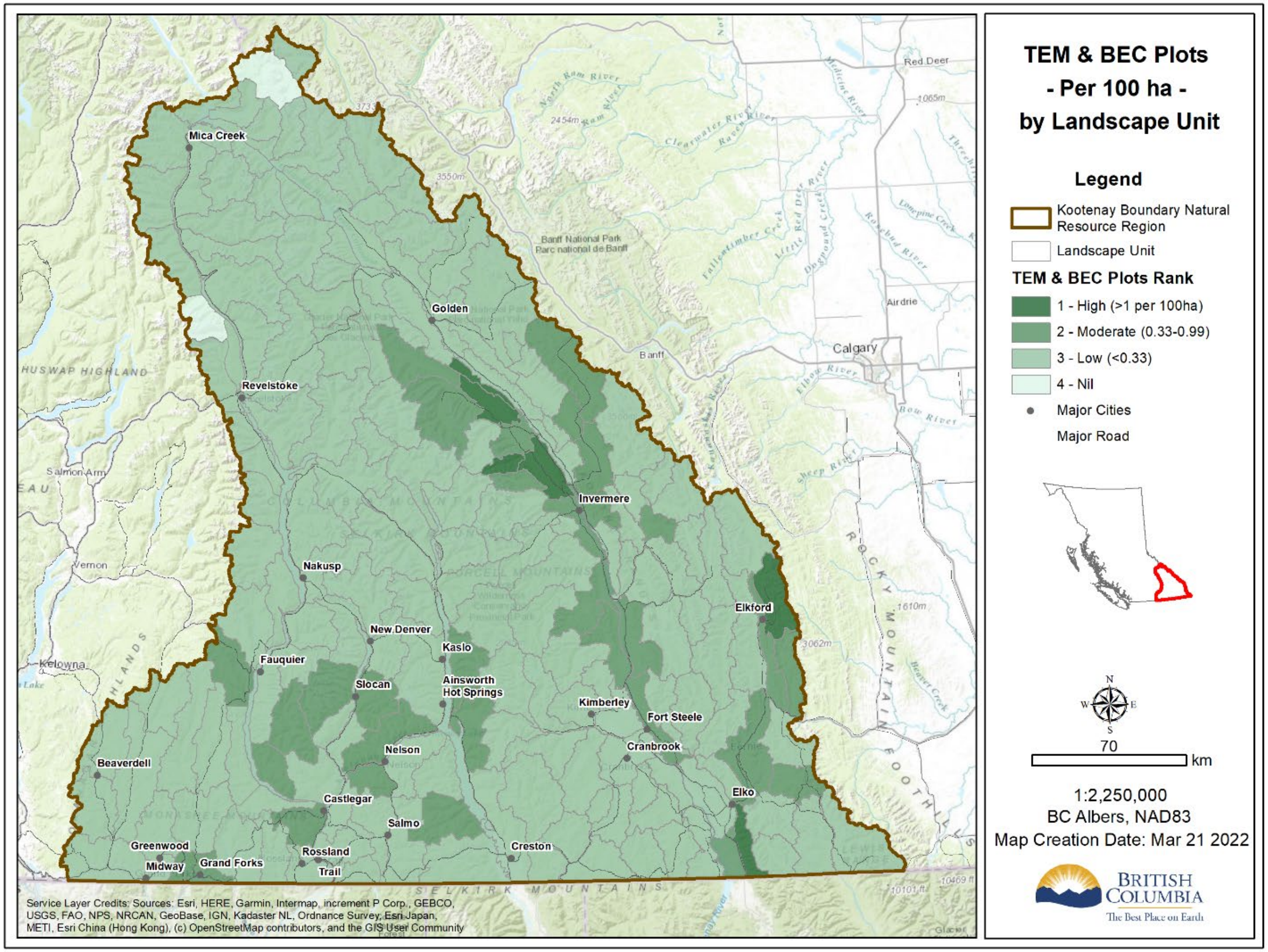


Figure 9: Overview of Plot Data Coverage

6.1.5 Available TEM Coverage

Like existing plot data, availability of TEM is valuable as it can provide a starting point for mapping going forward. For example, new mapping could be prioritized to edge match with existing products to fill in an area of interest for wildlife, with habitat ratings then assigned to the mapped ecosystems. Even outdated mapping can, in some cases, be updated or cross walked to reflect the current standards with little effort. The age of the existing mapping does play a role in its usefulness, however, particularly for dynamic ecosystems (e.g., rivers and floodplains). Refer to Section 4.1.1.2 for more details on the use of existing data as well as the assessment decision tree for ecosystem mapping (Figure 6).

The available ecosystem data category was created to rank existing ecological projects. Within this category, landscape units that are ranked the highest will have the best available existing TEM products. Landscape units that have a low or nil score will require the most effort to produce a high-quality TEM product, such as TEM SIL4 with structural stage. Table 9 describes how ranks were determined for this category with the results presented on Figure 10.

Table 9: Coverage rank by TEM project coverage

Coverage of Landscape Unit (%)	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
≥ 75	1	High	5	3
≥ 50 and < 75	2	Moderate	8	4
< 50	3	Low	7	3
0	4	Nil	180	90

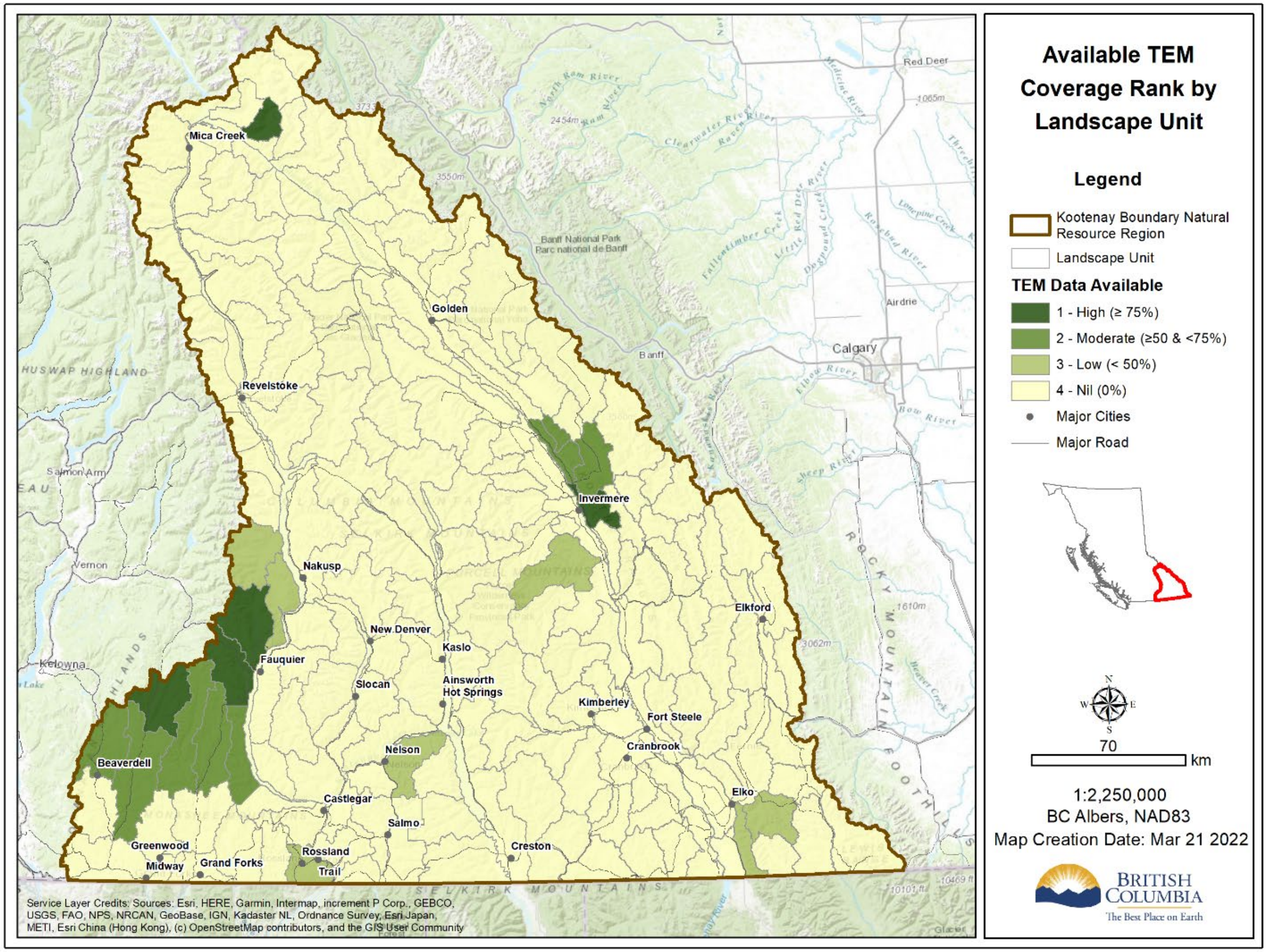


Figure 10: Overview of Existing TEM Coverage

6.1.6 VRI Attribution

VRI is meant to inform on vegetation coverage across the entire BC land base. Unfortunately, not 100% of all VRI polygons contain full attribution to inform on age of forested units, height, and canopy closure – all attributes that aid in TEM mapping. Projected forest age plays a particularly important role as it can assist in determining structural stage and stand information for TEM polygons. The ranking below is based on the coverage of VRI polygons that have full attribution (i.e., where PROJ_AGE_1 IS NOT NULL). Table 10 describes how ranks were determined for this category with the results presented on Figure 11.

Table 10: Coverage rank by VRI data coverage

Coverage of Landscape Unit (%)	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
>90	1	High	50	25
51-90	2	Moderate	122	61
10-50	3	Low	26	13
< 10	4	Very Low	2	1

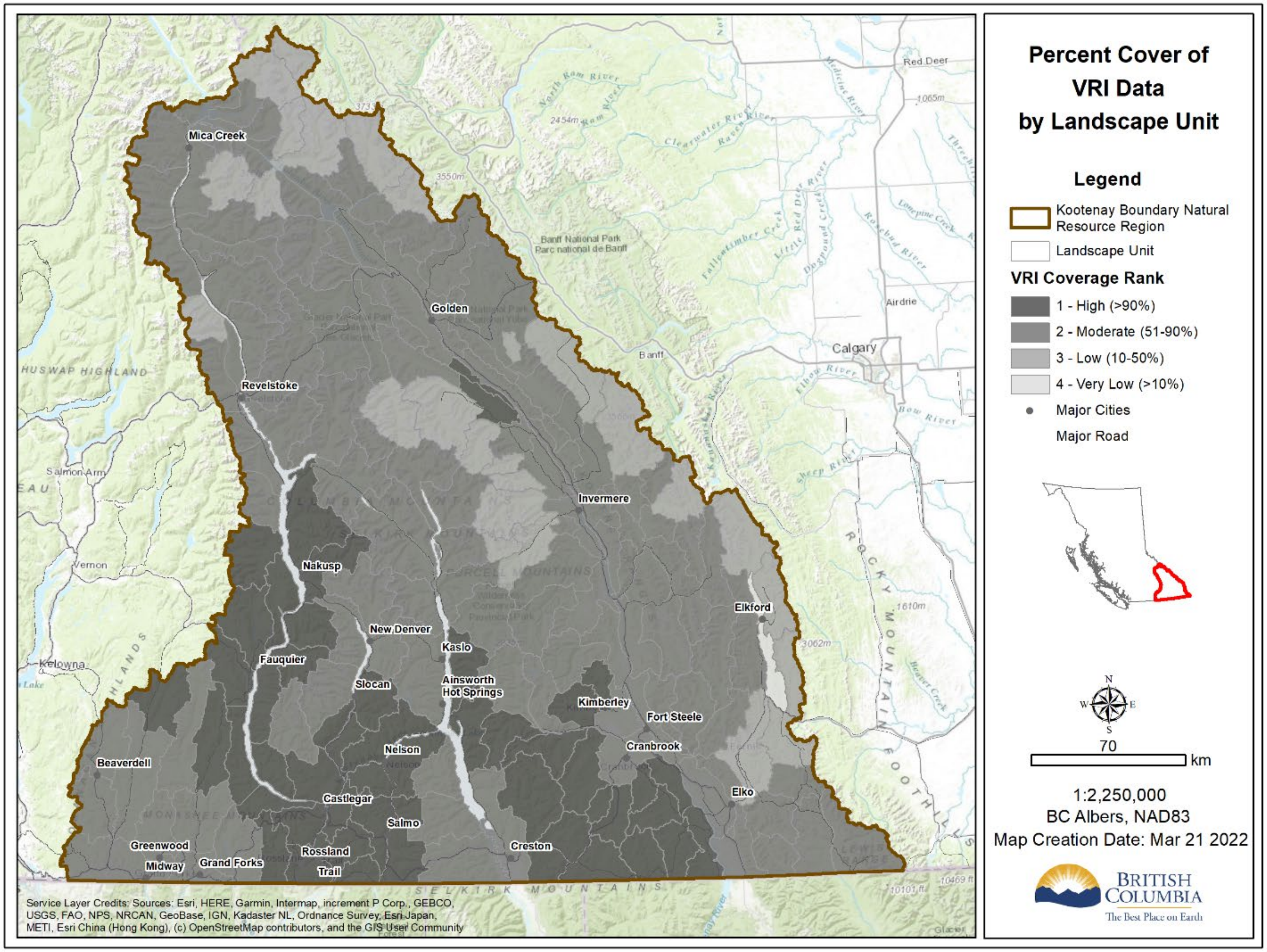


Figure 11: Overview of VRI Data Coverage

6.1.7 Road Density

Road density is a factor in determining mapping efficiencies regarding physical access during field verification efforts. Remote landscape units with little road access are difficult to conduct field efforts without relying on other methods of access such as helicopters. The ranks in the table below correlate with those created by the Cumulative Effects Framework which was the source data used to intersect with the landscape units. Table 11 describes how ranks were determined for this category with the results presented on Figure 12.

Table 11: Rank by Road Density

Road Density Class	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
Class 7: > 2.50	1	High	58	29
Class 6: 1.76 - 2.50	2	Moderate	74	37
Class 5: 1.26 - 1.75	3	Low	47	24
Class 4: 0.76 - 1.25	4	Very Low	21	10

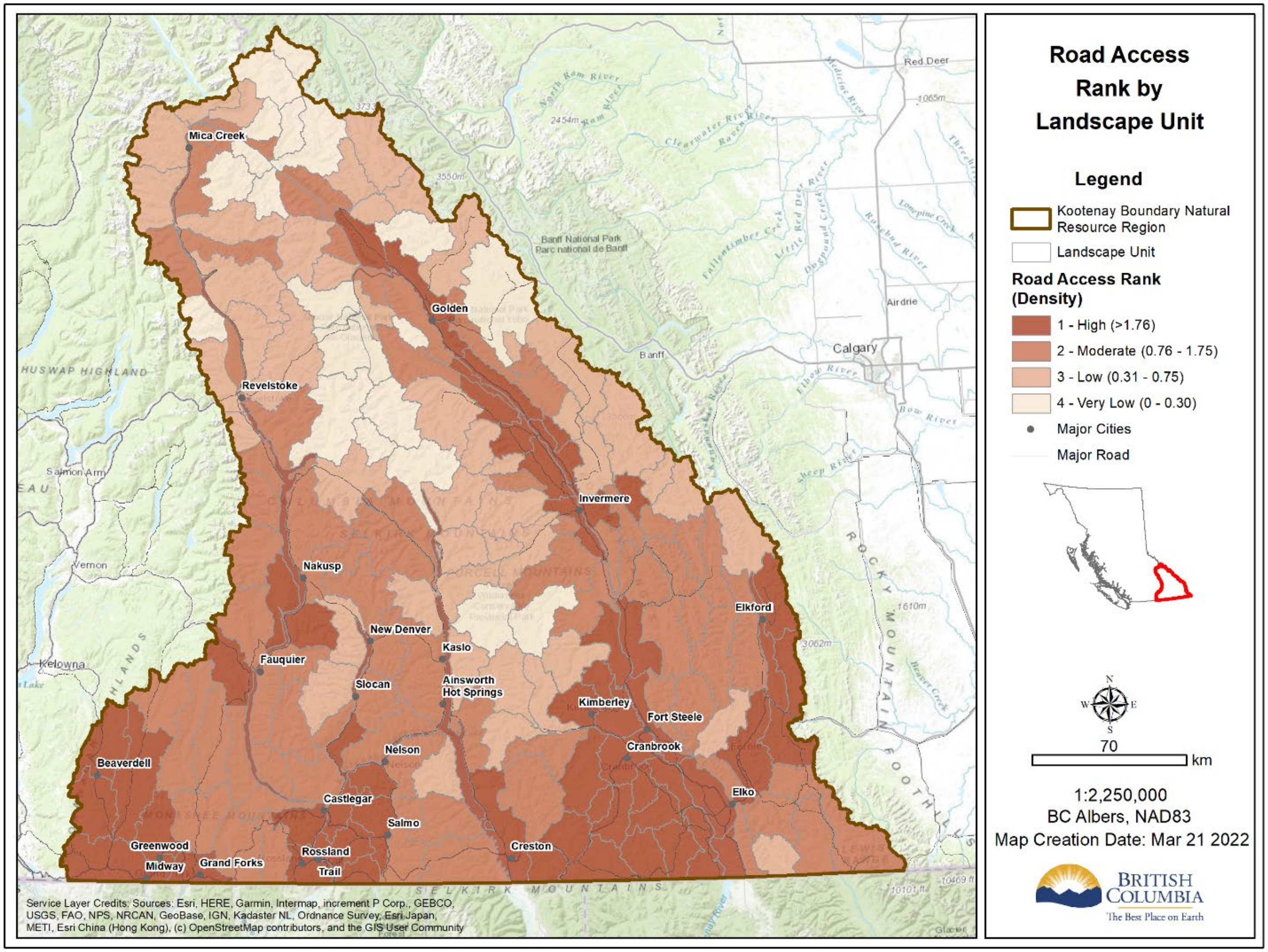


Figure 12: Overview of Road Access Ranking

6.1.8 Number of Biogeoclimatic Ecosystem Classification (BEC) Units

The number of Biogeoclimatic Ecosystem Classification (BEC) within a landscape unit can influence the amount of time required to complete any ecosystem mapping project. The mapper must be familiar with all the ecosystems that could occur within each of the BEC units being mapped. Ecosystem types that occur as a particular site series in one subzone may not be the same site series in another. Therefore, it can be assumed that the level of effort increases with the number of biogeoclimatic subzone/variants found within a landscape unit. Polygon delineation, attribution and field verification efforts also increase with the number of biogeoclimatic subzone/variants found within a project area.

The number of BEC units is used as a proxy in determining the potential number of biogeoclimatic subzone/variants that can be found within a landscape unit. Table 12 describes how ranks were determined for this category with the results presented on Figure 13.

Table 12: Ranks that define the number of BEC units category

Number of BEC Units	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
1 – 5	1	High	26	13
5 – 8	2	Moderate	105	53
8 – 10	3	Low	40	20
> 10	4	Very Low	29	14

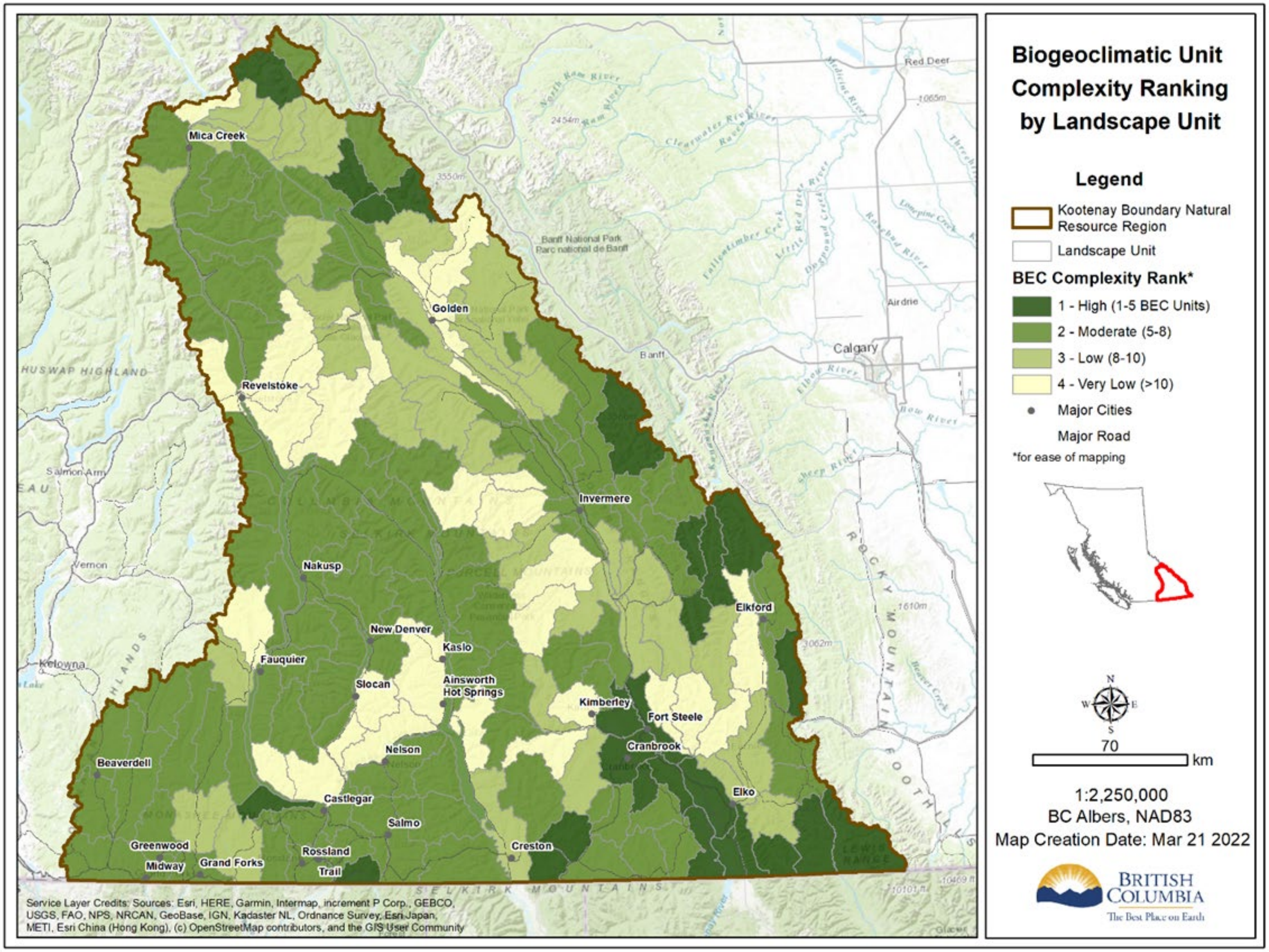


Figure 13: Overview of BEC Complexity

6.1.9 Overall Technical Priority Rank for 'Ease of Mapping'

The overall technical priority rank is calculated based on the summation of the seven technical categories that have been described in the previous sections (Section 6.1.2 to Section 6.1.8). An overall technical priority rank was calculated for each landscape unit with detailed results provided in the Excel spreadsheet associated with this Strategic Plan (KB_Region_Data_Availability_and_Priority_Ranking.xlsx).

It is assumed that the landscape units that are ranked with a high rank (1) will be products that can be updated at a lower cost than other projects. It has been assumed that these highly ranked projects have the potential of being completed to a TEM SIL 4 with structural stage attribution standard. Table 13 and Figure 14 depict how the overall technical priority rank was assigned to each unit.

Table 13: Description of the overall technical priority rank for ease of mapping

Technical Category Summation	Rank	Priority	Number of Landscape Units	Percent of Total Landscape Units (%)
Summation ≤ 16	1	High	69	35
Summation 17 to 19	2	Moderate	71	36
Summation ≥ 20	3	Low	58	29

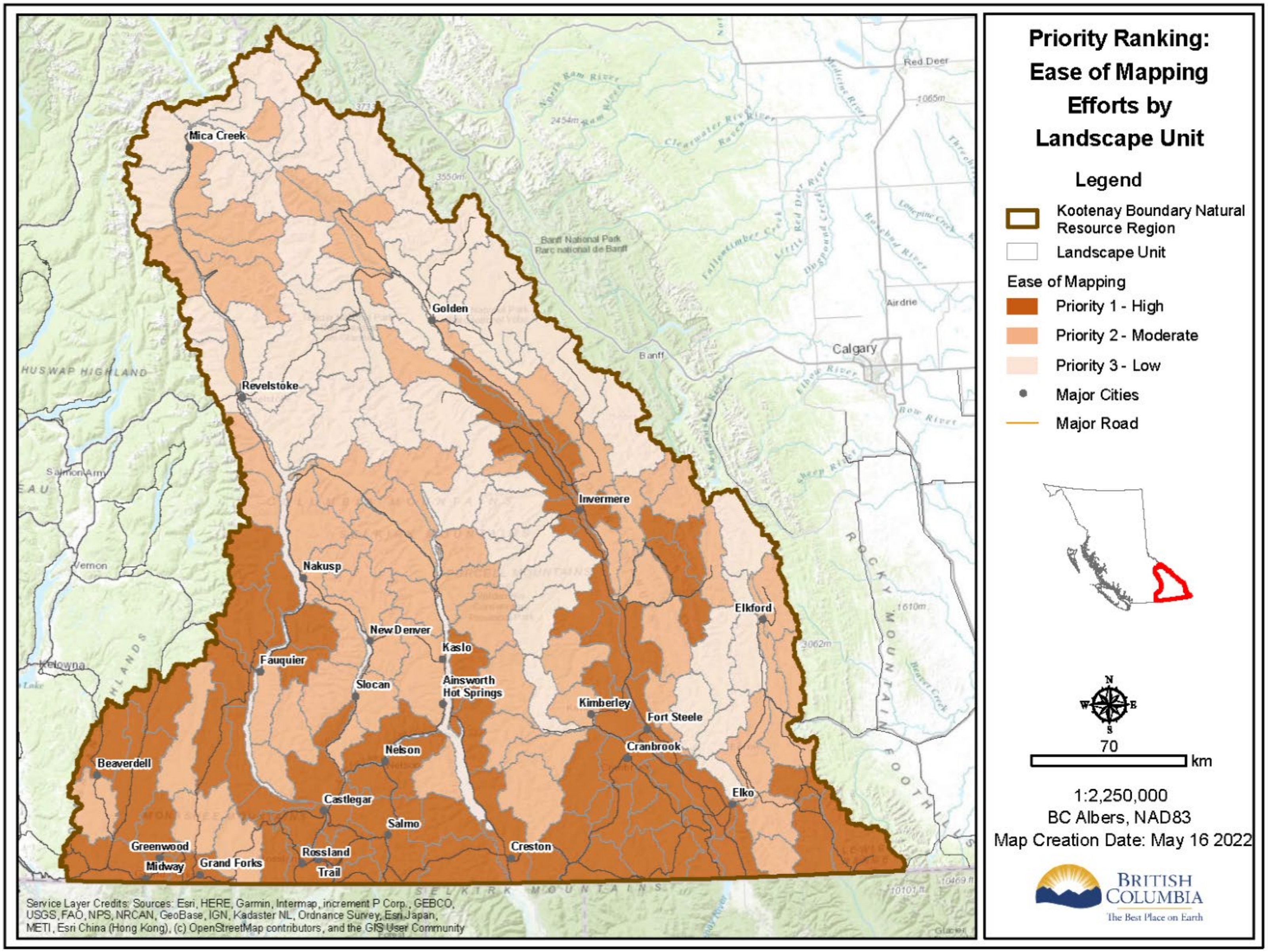


Figure 14: Overview of overall technical priority rank for ease of mapping

7 Expert Input on Ecosystem Mapping and Modelling of Priority Ecosystems for Wildlife Habitat Stewardship

As referred to in Section 2.2, at the onset of the project, regional resource management staff defined priority terrestrial ecosystems for ecosystem mapping in the Kootenay Boundary Region including whitebark and limber pine, avalanche tracks, high elevation, wetlands, riparian areas, cottonwood floodplain forests, aspen dominated forests, grasslands and brushlands, open forests, old and ancient forests, huckleberry patches, and cliff, rock outcrops, caves and talus (Table 1).

Two major components were completed with respect to aiding future ecosystem mapping and modelling efforts of these priority ecosystems. First, a Kootenay Boundary Region focused Priority Terrestrial Ecosystems and Wildlife Crosswalk was completed and reviewed by Provincial and Regional ecologists based on the TEI Ecosystem Codes List/BECv12 ecosystem units (Appendix D). This process involved a review and assignment of all current ecosystem mapping codes by BEC unit (TEI Unit 2022) to assigned priority ecosystem groups including: Aspen, Avalanche, Cottonwood Floodplain, Grassland/Brushland, High Elevation Meadow/Parkland, Huckleberry, Open Forest, Riparian, Rock, Wetland and Whitebark/Limber Pine. Regional review was provided, documented and incorporated at multiple steps through the crosswalk process. This crosswalk represents an initial categorization of current TEI standard ecosystem mapping units to the priority ecosystems identified in the Kootenay Boundary Region. It depicts how ecosystem mapping can be used to identify priority ecosystems on the landscape and ultimately used for Wildlife Habitat Stewardship. Results of the crosswalking for each priority ecosystem type as well as key considerations are included in Appendix D, as well as within an Excel spreadsheet associated with this Strategic Plan (KBR_BEC_PriorityHabType_Eco.xlsx).

In addition, several subject matter experts, including ecosystem/terrain mappers and wildlife biologists, were consulted to provide feedback related to the mapping requirements, challenges and recommendations for identifying these priority ecosystems on the landscape, summarized in Appendix E. This information was compiled through feedback provided at series of three workshops (January/ February 2022) and based on review of project related reports and supporting information. Workshop attendees and contributors included several Ministry staff as well as subject matter experts from various consulting companies.

A high-level summary of the results of this consultation including considerations for mapping and modelling priority ecosystems is provided in Table 14. A detailed review of the benefits of each priority ecosystem for wildlife, as well as a description of mapping challenges, requirements and recommendations is provided in Appendix E.

Table 14: Considerations for mapping Priority Ecosystems to Support Wildlife and Habitat Stewardship

Priority Ecosystem Type	Example Focal Wildlife Species[18]	Ideal Input Sources	Recommended Minimum Scale	Capacity within TEIS	Comments/Challenges
High Elevation	Wolverine, Grizzly Bear, Bighorn Sheep, Mule Deer, Elk, and Mountain Goat	- 3D colour imagery preferred but can be mapped using 2D colour imagery with DEM	1:10,000	- Can be queried by BEC - Can be captured in the ecosystem attributes in the TEI Long Table	- Limited coding for alpine units - Subclasses must be captured within user-defined fields (need subclass added to the TEI Long Table) - Access to these ecosystems is often challenging for verification
Avalanche Tracks	Grizzly Bear, Wolverine, Moose, Bighorn Sheep, Mule Deer, Elk, Mountain Goat, Northern Goshawk,	- LiDAR - 3D colour imagery - Terrain	1:10,000 but 1:5,000 or less is ideal, especially to differentiate herbs	- Can be captured in the ecosystem and terrain attributes in the TEI Long Table	- Can be done without field work but typing can be extensive as interpretation is challenging - Distinguishing between initiation zones (not avalanche) and chute and run-out zones can be difficult (this can be more easily determined when LiDAR is available) - Infrequently impacted treed zones can be hard to identify - Limited reliability with existing mapping as many smaller features likely to be missed when mapped at smaller scale (e.g., 1:20,000)
Riparian	Grizzly Bear, Moose, Flammulated Owl, Western Screech-Owl, Great Blue Heron, Rocky Mountain Tailed Frog, Coeur d'Alene Salamander, Fringed Myotis	- LiDAR preferred - 3D colour imagery but can be mapped using 2D - Recent imagery (<5 years)	1:5,000	- Can be captured in the ecosystem and bioterrain attributes in the TEI Long Table	- Can be poorly captured and inconsistently mapped with disconnected polygons - Dynamic ecosystems – linework has limited shelf life and will require updates - Large scale required to refine linework

[18] Examples of regional species identified in Table E-1 of Appendix E (*KBR Wildlife Focal Species, FRPA Applicability, Conservation Framework Priority, and Association With Priority Ecosystems*).

Priority Ecosystem Type	Example Focal Wildlife Species[18]	Ideal Input Sources	Recommended Minimum Scale	Capacity within TEIS	Comments/Challenges
Wetlands	Grizzly Bear, Moose, Mule Deer, Elk, Great Blue Heron, Rocky Mountain Tailed Frog, Great Basin Spadefoot, Painted Turtle, Silver-haired Bat, Townsend's Big-eared Bat	- 3D colour imagery, but can be mapped using 2D - LiDAR for forested wetlands - Freshwater Atlas (FWA) - Field plots	1:10,000 but better at 1:5,000 for small features	- Can be captured in the ecosystem and bioterrain attributes in the TEI Long Table - Hydrogeomorphic system and subsystem captured in field forms but not in the TEI Long Table	- Field work necessary to classify individual wetlands to site association level (SIL 3 recommended) - Consider requirement to prioritize field sampling in wetlands rather than a balanced distribution of field plots across ecosystems - High elevation wetlands not well classified - Large scale mapping allows for smaller wetlands to be captured - LiDAR can show the land surface that may be hidden by vegetation
Old and Ancient Forests	Grizzly Bear, Wolverine, Mule Deer, Elk, Flammulated Owl, Williamson's Sapsucker, Northern Goshawk, Coeur d'Alene Salamander, Northern Myotis	- LiDAR - 3D imagery - VRI - Plot data with structural stage information and/or mensuration	1:10,000	- Can be captured in the structural stage field in the TEI Long Table	- Difficult to see characteristics, attributes and structure without 3D - Often require field work to definitively identify - Hard for less experienced mappers to identify (potential for under or over-representation) - Provincial layers may be available as reference (e.g. VRI)
Open Forest	Bighorn Sheep, Moose, other ungulate species, Lewis' Woodpecker, Western Rattlesnake	- LiDAR - Crown closure - 3D imagery - VRI - Soils data	1:10,000	- Units known to be Open Forest can be captured by the BEC, site series and structural stage	- Need agreed-upon definition across disciplines and may require consultation with Regional Ecologists on which units are Open Forest - Some open forests have encroachment – potential for restoration - Dependent upon BEC

Priority Ecosystem Type	Example Focal Wildlife Species[18]	Ideal Input Sources	Recommended Minimum Scale	Capacity within TEIS	Comments/Challenges
Whitebark Pine (Pa) and Limber Pine (Pf)	Grizzly Bear, Marten, Flammulated Owl	- Existing field plots - Plot data and reporting from the US - Colour and high-resolution recent imagery (<5 years) - VRI to identify Whitebark Pine (Pa) and Limber Pine (Pf) sites	1:5,000	- Units identified as supporting Pa or Pf could be pulled from existing mapping - Map as point features (TEI Symbols Points) when <10% polygon	- Difficult to capture these features when mapping - Limitations within current classification - Need more field data (full plots) - Recent imagery required to capture current condition (susceptible to disease) - Large-scale mapping to pull out small patches from the landscape - Add to field crew checklist and capture as point features
Aspen-dominated (drier sites)	Moose, Mule Deer, White-tailed Deer, Williamson's Sapsucker, Northern Goshawk	- Colour imagery - VRI to identify Aspen (At) leading sites	1:20,000	- Units identified as At-leading could be pulled from existing mapping	- Important wildlife habitat values for migratory birds, ungulates and other species - High soil biodiversity sites - Not easily modelled as they can be found throughout the landscape
Cottonwood (Act) Floodplain Forests	Elk, deer, moose, Grizzly Bear, Lewis' Woodpecker, Great Blue Heron, Silver-haired Bat	- LiDAR preferred - 3D colour imagery, though 2D with 25 m DEM minimum, may suffice - VRI to identify Act leading sites	1:5,000	- Floodplains can be captured in the ecosystem and bioterrain attributes in the TEI Long Table - Units identified as Act-leading could be pulled from existing mapping	- Need agreed-upon definition across disciplines - Further refinements required to pull out Act-dominated floodplains from riparian areas (often lumped with riparian mapping) - Colour imagery to determine Act from other species - LiDAR to refine polygon linework

Priority Ecosystem Type	Example Focal Wildlife Species[18]	Ideal Input Sources	Recommended Minimum Scale	Capacity within TEIS	Comments/Challenges
Grasslands	Bighorn Sheep, Long-billed Curlew, Common Nighthawk, Great Basin Spadefoot	- 3D or LiDAR preferred but DEM with 2D may suffice - Plot data - Soils data - Recent data including level of disturbance, invasive species	1:5,000	- Can be captured in the ecosystem attributes in the TEI Long Table - Existing mapping likely requires cross-walking to new codes	- Higher reliability at lower elevations - Clear direction required to differentiate between grassland and brushland – some seral grasslands can have significant shrub cover - SIL3 provides best reliability as field data is key to accurately mapping these ecosystems
Brushlands	Moose, Elk, other ungulates as important winter forage	- Soils data - 3D preferred but 2D may suffice - LiDAR to capture height of shrubs	1:20,000	- Several brushland units identified in the classification	- Description of these ecosystems is inconsistent around the Province - Includes disclimax brush and low elevation brush - Often associated with shallow soils – having soils data can help determine natural brushlands - Fairly distinctive to identify using aerial imagery
Mid to High Elevation Brush	Summer forage for Moose, Elk, and Bighorn Sheep	- Colour imagery	1:20,000	- Can be captured using BEI for some BEC units but not consistent - Coding to query these is complicated and inconsistently mapped	- Challenge to distinguish from brushy avalanche tracks - Challenging to map – no clear guidance on how to map these (modifiers, stand composition, etc.). - Colour imagery to capture deciduous vs. coniferous

Priority Ecosystem Type	Example Focal Wildlife Species[18]	Ideal Input Sources	Recommended Minimum Scale	Capacity within TEIS	Comments/Challenges
Huckleberry -associated	Grizzly Bear forage	- Soil attributes - VRI (crown closure) - LiDAR (crown closure) - Canopy closure (field data) - Canopy height - Remote sensing imagery from different seasons - Drainage - Aspect - Infrared imagery	1:10,000	- Units with huckleberry as a leading species can be pulled from existing mapping	- Although site name may include huckleberry, there are other factors affecting whether huckleberry occurs - Presence of the plant does not equal berry presence - Very complicated to pull these features out – many input sources required to find where they occur - May be more appropriate to support ongoing research efforts
Cliff, Rock outcrops & Talus	Cougar, Mountain Goat, Western Rattlesnake, Rubber Boa, multiple species of bat	- 2D/3D colour imagery - LiDAR preferred to determine size of talus	1:10,000 but can be seen at 1:20,000	- Can be captured in the classification by site series and/or Realm/Group/Class in the TEI Long Table - Vegetation growing on these units captured using structural stage	- Vulnerable to climate change - No classification for herb/shrub/treed talus – needs to be captured in the structural stage - Consider using point and line features for these fine filter habitats - Large scale and LiDAR preferred to determine talus versus rock in some cases
Caves	Cougar, most species of bats such as Townsend's Big-eared Bat and Long-eared Myotis	LiDAR necessary to identify caves	1:5,000 or less	- Not currently classified - Capture as point features (TEI Symbols Points)	- Difficult to see without LiDAR – cannot be detected from imagery - Smaller caves will be captured at a finer scale - Not being reported when observed on the ground - Add to field crew checklist and capture as point features

8 Recommendations

Together for Wildlife's vision is that wildlife and their habitat thrive, are resilient, and support and enrich the lives of all British Columbians. To work towards this vision, the Province is committed to new investments and developing new partnerships to collaboratively deliver wildlife stewardship. Stewardship activities need to be strategic to respond to the multiple pressures facing wildlife and habitat in the region.

As such, this strategic plan has documented how Terrestrial Ecosystem Information can support wildlife and habitat stewardship by identifying biological values and inform management strategies that align with the broader Together for Wildlife goals applicable for the KBR. The plan provides recommendations as a guide for establishing priorities for future work, and as guidance for the appropriate use of products and potential methods for future projects. It will assist in making decisions based on key considerations to determine the best product fit for a given project and provide guidance to increase the quality of ecosystem mapping and modelling.

Recommended high-level actions that can assist with next steps and future opportunities for ecosystem mapping to support wildlife and habitat stewardship are provided below. This information is specific to the Kootenay Boundary Region but the actions can be applied in other regions throughout the Province.

8.1 Use the Strategic Plan

This section includes recommended actions on using the information provided within the Strategic plan. The information and decision tools are intended as options for consideration, to help guide the steps of project development.

- Acquire background knowledge
    - Use the background information on the Kootenay Boundary Region and Together for Wildlife strategies to understand the potential benefit of using ecosystem mapping for to wildlife management (Section 2)
    - Use the background information on TEI to gain insight into the ecosystem mapping and inventory options available (Section 3)
    - Identify linkages to corporate mandates and existing strategies
    - Identify potential expertise and resources needed to complete the project (Section 7, Appendices D and E)
    - Identify potential collaborators and partners (Sections 8.3 and 8.4)
- Establish priorities for future work including project objectives and priority ecosystems or species
    - Define a problem statement or question to determine project objectives
    - Prioritize and refine areas of interest within the KBR for ecosystem mapping projects with regards to Together for Wildlife Goals (Sections 6 and 8.2)

- Determine the appropriate project type and methodology to meet project goals
    - Use ecosystem mapping and modelling methods and project type selection considerations to understand the benefits and limitations of different project types (Section 4)
    - Use decision tools to select mapping methods (Section 4)
        - Determine scale needed and estimate cost using Figure 3
        - Determine the confidence needed (i.e. risk, complexity) using Figure 4
        - Determine the appropriate TEI product using Figure 5
    - Use expert input to refine methods as needed based on considerations for specific priority ecosystems and wildlife species habitats (Section 7, Appendices D and E)
- Compile and assess existing information
    - Complete a gap analysis and review of existing TEI products for the area of interest following the guidance provided in Section 5 and Appendix C
    - Use the decision tool provided in Figure 6, if mapping does exist for an area of interest, to efficiently assess if the product should be used, improved, or if new mapping is recommended

8.2 Prioritize and Select Study Areas

Based on the results of the priority rankings for ease of mapping (Section 6) and the framework provided within the plan, it is recommended that land managers within the Kootenay Boundary Region take additional steps to prioritize and refine targeted areas of interest, with the landscape units ranked as high (1) overall for ease of mapping being a logical starting point. Other considerations likely will include policy implementation, management objectives, land tenure, partnerships/collaboration (i.e. First Nations, local governments, stakeholders etc.), funding as well as biodiversity considerations. This discussion is centered on the need for the Kootenay Boundary Region to respond to development pressures and conservation issues, developing and maintaining relationships with First Nations and other interest holders, and the ability to leverage funds and expertise to support ecosystem mapping projects.

The following questions can guide decision makers in prioritizing ecosystem mapping projects with regards to Together for Wildlife Goals:

- Is there an urgent regional wildlife or habitat pressure that relies on ecosystem mapping to inform decisions?
- Does the project advance on the ground implementation of a provincial or regional wildlife strategic or tactical planning objective?
- Is there a supporting partnership with local First Nations or other interest holders with shared interests or compatible goals in the area?
- Is there ability to leverage funds, support or expertise to map the area of interest from these partnerships?

8.3 Engage and Collaborate

Goal 5 of Together for Wildlife focuses on collaborative wildlife stewardship that advances reconciliation with Indigenous governments. To determine and refine priorities and project objectives engagement and collaboration is required. As indicated in Section 2.2, the list of ecosystems in Table 1 has not yet been engaged on with Indigenous Nations or stakeholders. It is considered a 'living' list and a starting point for future collaboration and technical work related to the stewardship of these ecosystems. This strategic plan is intended to be used for information sharing and to be a starting place for engagement with Indigenous governments on their priority wildlife species, habitats and ecosystems as well as priorities for ecosystem mapping and wildlife stewardship within the KBR.

8.4 Build Partnerships

Under Action 8 of Together for Wildlife, the Province has committed to developing provincial stewardship frameworks and regional stewardship plans for priority species and populations. As part of this building partnerships is a key component. Partnerships with Indigenous Nations, federal/regional/local governments, conservation groups, stakeholders and other groups can lead to identifying and promoting shared stewardship opportunities through shared interests or compatible goals. As ecosystem mapping can be costly, it also allows for potential option to leverage funds to meet common goals and initiatives. It also can allow for a consideration of policy requirements such as private land stewardship through bylaws to establish develop permit areas in regional districts, when initiating projects.

8.5 Support Education and Outreach

Goal 2 of the Together for Wildlife strategy states that data, information, and knowledge drive better decisions. As such, it is important to provide education and outreach opportunities for Ministry staff and partners on TEI products and their utility for ecosystem and wildlife stewardship. Education and outreach should include the following actions:

- Identify, determine needs, and support opportunities for outreach to a variety of partners and stakeholders
- Deliver workshops and presentations
- Contribute to resource materials such as developing condensed supplemental documentation, extension notes and decision tools to support information sharing and knowledge transfer
- Make data and information available and accessible (i.e., open data sources, open access licensing, Data and Information Sharing Agreements)

8.6 Continuous Improvement Cycle

Supporting a continuous improvement and update cycle allows for incorporation of new technologies and data which can help address Action 4 of the Together for Wildlife strategy, to fill critical gaps in mapping wildlife habitat, including developing wildlife population and habitat supply models, and better understand the effects of climate change on wildlife. The continuous improvement cycle should include the following actions:

- Consider new data sources, technologies, and methods
    - Drone and camera surveys or time series imagery analysis to measure and quantify ecosystem seasonal variations and change through time
- Update TEI data, information and standards based on user feedback and updated mapping and data modelling methods including spatial frameworks, scripting and automation of processes and disseminating this information to the public
- Support research and analysis including pilot studies
    - Compare methods based on priority ecosystem types and habitats for focal species in targeted areas (i.e., TEM versus PEM)
    - Conduct ecosystem monitoring using benchmark ecosystems in disturbed and undisturbed areas to establish baseline conditions and monitor change over time to better understand seasonal trends and long-term trends and the potential impacts of climate change
- Build ecosystem mapping capacity and expertise
    - Assessing and developing lists of qualified professionals
    - Training courses and/or certifications
    - Mentoring of developing ecosystem mappers and practitioners

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Appendix A: List of TEI Project Types

Project Type Code	Name	Description
AGCAP	Agricultural Capability	Projects that map agricultural capability from soils information and data.
ESA	Environmentally Sensitive Areas	Environmentally Sensitive Areas polygons mapped ES1 and ES2. Areas with actual or potentially fragile or unstable soils that may deteriorate after harvest. Older mapping type. No longer RISC standard. Superseded by TSM.
NEM	Terrestrial Ecosystem without Bioterrain	Projects where mapped ecosystem polygons are not derived from bioterrain polygons.
NEMNSS	Terrestrial Ecosystem with no Bioterrain or Structural Stage	Projects where mapped ecosystem polygons are not derived from bioterrain polygons and there is no structural stage attribution
NEMPRE	Pre-TEM with no Bioterrain	This project was completed before TEM was established (biophysical mapping) and mapped polygons are not derived from bioterrain polygons.
NEMWHR	Terrestrial Ecosystem without Bioterrain with Wildlife Habitat Ratings	Wildlife habitat ratings mapping was themed from mapped ecosystem polygons that were not derived from bioterrain polygons.
PEM	Predictive Ecosystem	Project where mapped ecosystems are derived from a model.
PEMTBT	Predictive Ecosystem with Bioterrain	Project where mapped ecosystems are derived from a model and with bioterrain mapping attributes included.
PEMWHR	Predictive Ecosystem with Wildlife Habitat Ratings	Wildlife habitat ratings mapping was themed from mapped ecosystems derived from a model.
PREM	Predictive Rare Ecosystem	Project where ecosystems considered rare have been mapped from ecosystems derived from a model.
SEI	Sensitive Ecosystem	Project where ecosystems considered sensitive have been mapped. Usually derived from another ecosystem mapping project.
SOIL	Soil Inventory Mapping	Soil mapping typically includes information about the soil association (Pedon), landform/parent materials and topographic/slope class.

Project Type Code	Name	Description
SOILSW	Soils Inventory with Wildlife Habitat Ratings	Soils inventory mapping project with interpreted wildlife habitat ratings.
TBT	Bioterrain	Project where bioterrain mapping is available as a stand-alone product.
TEM	Terrestrial Ecosystem	Project where mapped ecosystems are completed to RISC standards and mapped attributes include ecosystem units, structural stages and bioterrain.
TEMNSS	Terrestrial Ecosystem with no Structural Stage	Project where mapped ecosystem is completed to RISC standards and mapped attributes include ecosystem units and bioterrain but does not include structural stage attributes.
TEMPRE	preTEM (e.g., biophysical mapping)	Project completed before the establishment of RISC standards (1998).
TEMWHR	Terrestrial Ecosystem with Wildlife Habitat Ratings	Project where wildlife habitat ratings mapping was themed from terrestrial ecosystem mapping.
TIM	Terrain Inventory	Project where terrain mapping has been completed and available as stand-alone product.
TSM	Terrain Stability	Project where terrain stability mapping has been completed.
TSMDET	Detailed Terrain Stability	Project where detailed terrain stability mapping has been completed.
TSMREC	Reconnaissance Terrain Stability	Project where reconnaissance level terrain stability mapping was completed.
WET	Wetland Mapping	Project where wetland mapping has been completed.
WHR	Wildlife Habitat Rating	Projects where wildlife habitat ratings were determined following RISC standards. Projects may have been themed from a TEM, PEM, BEI, SEI or other project, but were conducted independently of the original project.

Appendix B: BEC Units of the Kootenay Boundary Region (BECv12)

BEC Unit Code	BEC Zone Name	Subzone Variant Name
ESSFdc1	Engelmann Spruce -- Subalpine Fir	Dry Cold Monashee
ESSFdc2	Engelmann Spruce -- Subalpine Fir	Dry Cold Cascade
ESSFdcp	Engelmann Spruce -- Subalpine Fir	Dry Cold Parkland
ESSFdcw	Engelmann Spruce -- Subalpine Fir	Dry Cold Woodland
ESSFdk1	Engelmann Spruce -- Subalpine Fir	Dry Cool Elk
ESSFdk2	Engelmann Spruce -- Subalpine Fir	Dry Cool Columbia
ESSFdkp	Engelmann Spruce -- Subalpine Fir	Dry Cool Parkland
ESSFdkw	Engelmann Spruce -- Subalpine Fir	Dry Cool Woodland
ESSFmh	Engelmann Spruce -- Subalpine Fir	Moist Hot
ESSFmm1	Engelmann Spruce -- Subalpine Fir	Moist Mild Raush
ESSFmm2	Engelmann Spruce -- Subalpine Fir	Moist Mild Robson
ESSFmm3	Engelmann Spruce -- Subalpine Fir	Moist Mild Spillimacheen
ESSFmmp	Engelmann Spruce -- Subalpine Fir	Moist Mild Parkland
ESSFmmw	Engelmann Spruce -- Subalpine Fir	Moist Mild Woodland
ESSFvc	Engelmann Spruce -- Subalpine Fir	Very Wet Cold
ESSFvcp	Engelmann Spruce -- Subalpine Fir	Very Wet Cold Parkland
ESSFvcw	Engelmann Spruce -- Subalpine Fir	Very Wet Cold Woodland
ESSFwc2	Engelmann Spruce -- Subalpine Fir	Wet Cold Monashee
ESSFwc4	Engelmann Spruce -- Subalpine Fir	Wet Cold Selkirk
ESSFwcp	Engelmann Spruce -- Subalpine Fir	Wet Cold Parkland
ESSFwcw	Engelmann Spruce -- Subalpine Fir	Wet Cold Woodland
ESSFwh1	Engelmann Spruce -- Subalpine Fir	Wet Hot Columbia
ESSFwh2	Engelmann Spruce -- Subalpine Fir	Wet Hot St Mary
ESSFwh3	Engelmann Spruce -- Subalpine Fir	Wet Hot Salmo
ESSFwm1	Engelmann Spruce -- Subalpine Fir	Wet Mild Fernie
ESSFwm2	Engelmann Spruce -- Subalpine Fir	Wet Mild Purcell
ESSFwm3	Engelmann Spruce -- Subalpine Fir	Wet Mild Ymir
ESSFwm4	Engelmann Spruce -- Subalpine Fir	Wet Mild Moyie
ESSFwmp	Engelmann Spruce -- Subalpine Fir	Wet Mild Parkland
ESSFwmw	Engelmann Spruce -- Subalpine Fir	Wet Mild Woodland
ICHdm	Interior Cedar -- Hemlock	Dry Mild
ICHdw1	Interior Cedar -- Hemlock	Dry Warm West Kootenay
ICHmk1	Interior Cedar -- Hemlock	Moist Cool Okanagan
ICHmk4	Interior Cedar -- Hemlock	Moist Cool Elk
ICHmk5	Interior Cedar -- Hemlock	Moist Cool Kootenay
ICHmw1	Interior Cedar -- Hemlock	Moist Warm Kinbasket
ICHmw2	Interior Cedar -- Hemlock	Moist Warm Slocan
ICHmw3	Interior Cedar -- Hemlock	Moist Warm Thompson
ICHmw4	Interior Cedar -- Hemlock	Moist Warm Ymir
ICHmw5	Interior Cedar -- Hemlock	Moist Warm Granby
ICHvk1	Interior Cedar -- Hemlock	Very Wet Cool Columbia

BEC Unit Code	BEC Zone Name	Subzone Variant Name
ICHwk1	Interior Cedar -- Hemlock	Wet Cool Shuswap
ICHxw	Interior Cedar -- Hemlock	Very Dry Warm
ICHxwa	Interior Cedar -- Hemlock	Very Dry Warm
IDFdh	Interior Douglas-fir	Dry Hot
IDFdk5	Interior Douglas-fir	Dry Cool Columbia
IDFdm1	Interior Douglas-fir	Dry Mild Kettle
IDFdm2	Interior Douglas-fir	Dry Mild Kootenay
IDFxk	Interior Douglas-fir	Very Dry Cool
IDFxx1	Interior Douglas-fir	Very Hot Very Dry Kettle
IDFxx2	Interior Douglas-fir	Very Dry Very Hot Kootenay
IMAun	Interior Mountain-heather Alpine	Undifferentiated
MSdk	Montane Spruce	Dry Cool
MSdm1	Montane Spruce	Dry Mild Okanagan
MSdw	Montane Spruce	Dry Warm

Appendix C: Gap Analysis

A gap analysis of spatial data and information available for the Kootenay Boundary Region was undertaken to support the Kootenay Boundary Strategic Plan. The methods, including a list of data uncovered and links to the data, as well as the results and limitations of the gap analysis have been provided below. All the data reviewed and used for the gap analysis are provided in Appendix C-1 and an Excel spreadsheet associated with this Strategic Plan contains detailed results of the gap analysis (KB_Region_Data_Availability_and_Priority_Ranking.xlsx).

The licencing and security of spatial data should be reviewed before products are distributed to contractors for updates and mapping. Data Loan Agreements (DLA) are used to outline the data to be distributed, who it is to be distributed to, and the conditions under which it is shared. LiDAR data is particularly valuable and expensive to collect. Access to LiDAR licensed as a provincial or 3rd party restricted product generally requires a Data Information Sharing Agreement (DISA) or DLA. Sharing imagery such as orthophotos, satellite imagery, stereo models, or airphotos from the provincial Imagery Drive requires that the Ministry and contractor enter into a DLA with the Digital Imagery Service. Data managed by GeoBC such as TRIM products or “Access Only” datasets in the Data Catalogue require a separate DLA be arranged with GeoBC.

TEI Coverage Overview and Limitations

Terrestrial Ecosystems Inventory (TEI) data is an amalgamation of projects that have been submitted to the Terrestrial Ecosystems Information group for archiving and management. The last data load publication occurred in 2016. A selection of more recent projects have been loaded to the TEI internal master geodatabases and tracked, therefore current project information will need to be requested from the TEI Unit during project initiation. Projects submitted to the operational database do not form a seamless layer and there isn't always a single authoritative project for an area. There may be many projects associated with the same area of interest and project boundaries often overlap. As well, attributes are not always consistently populated between projects so even though a project may be more recent, it may be missing attribute information that has been provided in an older project. In order to establish which projects are authoritative over others it is important to review the metadata available for each project in the TEIS Project Boundaries layer and any associated reports that may have been uploaded to the Ecological Reports Catalogue[19] (EcoCat). It is also recommended that project attributes are reviewed in order to evaluate the suitability of the data from each project to assess utility with the current project objectives and requirements.

Business Area Project ID (BAPID) is the overarching piece of information that links TEI projects to associated data and information. The BAPID for a project may be incorporated into a definition query to refine TEI spatial layers and is also searchable in the EcoCat to obtain reports and other non-spatial

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[19] https://a100.gov.bc.ca/pub/acat/public/welcome.do

data related to a project. It is recommended that the BAPID of each of the projects identified is used to query the TEIS Project Boundaries layer in order to investigate TEIS projects, or if certain projects should take precedence in areas of overlap.

A project boundary is generated for each project that is submitted to the TEI group and added to a master TEI project boundaries layer. The layer includes attributes for important project metadata such as project scale, survey intensity level, project type, and BAPID. It also includes links to reports and associated data for a project in EcoCat. Project reports are the authoritative source for related project information.

The TEIS Master Operational Environment has detailed attribute information loaded to the TEIS Master long tables in a standardized format. Along with the TEIS Master Long Table there are also separate long tables for other project types and information the project contains including PEM, Soil, non-PEM projects, and projects deemed to contain "sensitive" information. Projects that have been deemed "sensitive" are flagged by the *Sensitive Data* field of the TEIS Master Project Boundary layer. Regardless of project type, projects that have been deemed as "sensitive" are loaded to a long table specific to projects that contain sensitive information. The majority of TEI projects submitted to the TEI group have a project boundary in the project boundary layer, however, not all projects have detailed attribute information loaded to the long table. Furthermore, projects that have not been loaded to the long table may or may not have detailed attribute project data stored in a project folder. Detailed attribute information that has not been loaded to the long table has not been standardized and may exist in archaic spatial formats.

Data and information related to Wildlife Habitat Ratings (WHR) is not loaded to the TEIS master long table. WHR data and information resides in the project folder associated with a particular BAPID. The only way to discern whether a project includes WHR information in the project folder is if a project has been assigned the WHR project type. For projects loaded to the TEIS operational environment, disagreements between the project type field of the project boundary layer and the long table are known to exist. It has also been found that projects not assigned the WHR project type may include WHR information in the project folder. Furthermore, projects that contain WHR information and data that have not been loaded to the TEIS operational spatial layers cannot be discovered through spatial analysis.

Methods

The gap analysis included five broad tasks:

- Review TEI data available in the TEIS operational environment.
- Review imagery availability and determine access and distribution.
- Track and store spatial data forwarded or recommended by regional ecologists and project team members.
- Create a map exchange document (mxd) of all spatial data available.
- Summarize findings by Landscape Unit for priority ranking.

The tasks resulted in the generation of a number of files that were used to find, organize, and communicate the results of the gap analysis. A map exchange document (mxd), KBR_Overview.mxd was created as part of the analysis so that data recommended and reviewed could be examined spatially. An excel workbook, KBR_LayerList.xlsx, was created that lists all the data and the associated file paths of datasets included in the mxd to ensure that the data could easily be located. Table C-1 provides a summary of the files developed for the gap analysis. All the data reviewed and used for the gap analysis are provided in Appendix C-1.

Table C-1: Gap Analysis Products

Document	Description
TEI_DATA.xlsx	An in-depth review of ecosystems projects managed by the Terrestrial Ecosystem Information Unit that are available for the KBR.
KBR_LayerList_ALL.xlsx	Lists of all data and information that has been recommended to aid in ecosystem mapping and updates.
KBR_Overview.mxd	An mxd that pulls together all data targeted to aid in ecosystem mapping and updates. The filepaths of all datasets are included in KBR_LayerList_ALL.xls.
Python Scripts	Various python snippets for reviewing TEI project attributes, generating unique lists of ecosystems components, and formatting data for KB_Region_Data_Availability_and_Priority_Ranking.xlsx.
KB_Region_Data_Availability_and_Priority_Ranking.xlsx	Summarizes the results of the gap analysis against landscape units.
GapAnalysis_LU_Summary_Methodology.docx	An in-depth review of the gap analysis methodology.

Terrestrial Ecosystem Information (TEI) Project Overview

Ecosystems projects managed by the TEI unit that occurred within the Kootenay Boundary Region (KBR) were reviewed for the gap analysis. Projects that have been loaded to the TEIS master operational environment have been run data validation and loading using the Contractor Package and have been standardized according to TEI protocol. Only projects that had detailed attribute information loaded to the TEIS Master long tables have been analyzed as part of the gap analysis, as it was out of the project scope to review each project folder, convert spatial formatting to a data type compatible with ArcMap, and assess whether the appropriate spatial data exists.

The KBR boundary was overlayed with TEIS_Master_Project_Boundaries from the TEIS Master Operational Environment to identify TEI project boundaries that overlap the KBR. Edge projects, defined as areas where the project boundary intersected with the KBR but where a significant number of project polygons did not fall within the region were not included in the analysis.

The TEI Project Boundary only layer was found to be unreliable for determining whether detailed project data had been loaded to the TEIS long tables or not. In light of discrepancies between the TEIS long tables and project boundary layer a set of scripts, Step1_Attribute_Overview.py and Step2_Attribute_Overview.py, were developed to programmatically generate summary statistics of the long table project attributes.

To get a broad idea of coverage for each of the different project types included in the TEIS environment for the entire KBR, definition queries which grouped BAPIDs by project type were applied to the TEIS Master Project Boundaries layer. The definition queries used to select for BAPIDs of a particular project type can be found within the TEI_DATA.xlsx. BAPIDs of the same project type were then clipped to the KBR boundary and dissolved to aggregate the project areas so that overlapping projects would not skew the total area of project coverage by each project type.

A unique list of ecosystem units for TEI projects was generated so that all ecosystem codes could be assessed to determine potential conversion requirements to update to current ecosystem codes . A definition query was applied to select for all TEI projects from the long table that overlayed the KBR. The subset of the long table was applied to the Get_Unique_Ecosystems_List.py script to generate a unique list of ecosystem units. In order to differentiate ecosystem units from specific projects for use in project level data assessments, the script was modified to obtain a unique list of ecosystem units by BAPID (i.e. Get_Unique_Ecosystems_List_w_BAPID.py).

Wildlife Habitat Rating (WHR) Information

Due to issues associated with identifying projects that contain WHR information, TEI project folders were programmatically searched for filenames particular to WHR data and information (i.e. included 'whr' characters using the Filename_search.py script). The script compiles a list of filepaths that point to files that include those characters in the filename. The results are contained within TEI_WHR_Projects.xls The script can be modified to search for different file names or types, such as non-publicly available TEM project types have not been loaded to the TEIS master operational environment. The majority of projects identified had not been loaded to the spatial TEIS Master Environment. The TEI project tracker database, BAPID Tracker, was used to identify the location of these projects (i.e. area or mapsheets) to determine if they occurred within the KBR and subsequently add these projects to the analysis.

Summarize by Landscape Unit for Priority Ranking

A subset of landscape units (LUs) that overlayed the Kootenay Boundary Region was used to refine the gap analysis. A summary of LUs for the Kootenay Boundary Region is included as Appendix C-1. A series of python snippets were used to format the output of spatial overlays for input to the final priority ranking excel. Summaries against LUs were generated for TEI projects, imagery, the cumulative effects 2021 human disturbance layer, Regional products, and various layers from the BCGW recommended by project team members. The results can be found in the KB_Region_Data_Availability_and_Priority_Ranking.xlsx workbook.

It appears that Fresh Water Atlas (FWA) data was used to determined "Lake" polygons in the *Landscape Units of British Columbia - Current* layer for the KBR. However, lakes do not appear to have been consistently cut into the landscape unit layer. There are instances where only half of a lake has been digitized as "Lake". Metadata for the layer does not include information on minimum lake size used to cut lakes into the layer. Instead of relying on the LU layer to define bodies of water a field was added to KB_Region_Data_Availability_and_Priority_Ranking.xlsx that summarizes bodies of water according to FWA data by LU.

Imagery

Indexing was used to find the coverage for each type of imagery for the KBR. The Indexing was overlayed with the LU layer and python snippets were used to format the output of the overlay for the KB_Region_Data_Availability_and_Priority_Ranking.xlsx workbook.

Other Spatial

Spatial data forwarded by the regional ecologists, non-government organizations, and project team members was tracked in the KBR_LayerList.xlsx workbook and may be visualized and reviewed in the KBR_Overview.mxd. Layers from the BCGW thought to forward ecosystem mapping and updates were added to KBR_LayerList.xlsx. Spatial considered “other” that was summarized by landscape unit in the KB_Region_Data_Availability_and_Priority_Ranking.xlsx workbook includes Fresh Water Atlas Lakes, and Rivers, the Human Disturbance layer produced for Cumulative Effects (2021), Road Density for the KBR (2021), BEC Version 12 (BCGW), and the master BEC plot locations for the KBR (Kootenay Boundary regional drive).

Results

The review of data and information necessary for ecosystem mapping and updates to the KBR included but was not limited to:

- TEI projects and their associated plot data
- Spatial and non-spatial products produced by the Kootenay Boundary Region that have not been submitted to the TEI group for management,
- Products completed by regional non-governmental organizations,
- BEC mapping and the associated plot data,
- Imagery and TRIM products,
- BC Geographic Warehouse products, and
- Other provincial layers deemed valuable.

Refer to Appendix C-2 for a detailed list of all products that were reviewed and utilized in the gap analysis.

TEI Project Coverage

A total of 200 TEI project boundaries were found within the KBR (Table C-2). 102 projects did not have detailed attribute information loaded to the long table while 98 projects had standardized attributes loaded to the long table. 11 TEM projects have been submitted to the TEI group for the region and only cover about 5.71% of the land base. The majority of projects completed for the region are TSM projects (Table C-3). There are 30 soils projects identified by the TEIS project boundary layer that are applicable to the KBR. Of those projects, 11 are loaded to TEIS_Soils_of_BC, and 3 of them are only found in Soils_Best_Available. The 11 projects loaded to TEIS_Soils_of_BC cover 6,717,310 ha (81.58%) of the KBR (Table C-3).

Table C-2: Summary of TEI Boundary Only Projects

Project Type Code*	Number of Projects	Total Area (Ha)	Percent of Total KBR
AGCAP	2	5343348.29	64.89
PEM	4	1508823.95	18.32
SOIL	19	8209979.59	99.71
SOILSW	1	138250.83	1.68
TSM	44	1584177.75	19.24
TSMDET	1	6137.26	0.07
TSMREC	17	870833.38	10.58
Null**	14	534610.89	6.49

* See Appendix A for a full description of TEI Project Type Codes
** Projects without a value assigned in the “PROJ_TYPE” field

Table C-3: Summary of TEI Projects Loaded to TEI Long Tables

Project Type Code*	Number of Projects	Total Area (Ha)	Percent of Total KBR
ESA	2	2143790.08	26.04
NEM	1	77745.85	0.94
NEMWHR	1	2631.45	0.03
PEM	13	7816293.49	94.93
SOIL**	11	6717310.37	81.58
TBT	2	10634.62	0.13
TEM	11	469860.34	5.71
TEMPRE	1	5266.07	0.06
TEMWHR	8	557466.89	6.77
TIM	12	4900590.45	59.52
TSM	31	3372507.15	40.96
TSMDET	1	106772.53	1.30
TSMREC	4	2815937.92	34.2

* See Appendix A for a full description of TEI Project Type Codes
** Projects loaded to TEIS_Soils_of_BC

16 projects loaded to the long table had an Ecosystem Survey Intensity Level (ESIL) less than or equal to 4 while 7 projects have a ESIL greater than 4 (refer to Table 5 in Section 4.1.1.7 for a full description of ESIL levels). Out of the 98 projects loaded to the long table 75 projects did not have an ESIL assigned (Table C-4).

Table C-4: Summary of Long Table Project ESIL Values

Ecosystem Survey Intensity Level*	Number of Projects
1	1
3	4
4	11
5	1
P	4
R	2
(blank)	75

* See Table 5 in Section 4.1.1.7 for a full description of ESIL levels

Wildlife Habitat Rating (WHR) Data and Information

A total of 23 projects were found to include files with 'whr' characters within their project folders (Table C-5).

Table C-5: Summary of Projects which contain WHR data for the KBR

BAPID	Project Name
9	Kirbyville TEM
183	East Columbia Lake TEM
196	Premier Diorite TEM
198	Fort Sheppard TEM
202	Slocan Radium Fla18979 TEM
218	Galton Range TEM
219	Steamboat Mountain TEM
222	Cummins River TEM
226	Wood River TEM
238	TFL14 Spillimacheen TEM
4032	TFL3 Radium PEM
4033	TFL23 PEM REVISIT
4186	TFL 23 Caribou (WHR)
4200	TFL 15 (Weyerhaeuser - OK Falls) (SEI)
6435	Cranbrook Invermere Wildlife Assessment for TSF for 2015
6458	Invermere TSA Wildlife Habatat Assessment for TSR
6460	Wildlife Habitat Assessment – Flammulated Owl – Cranbrook-Invermere-Kootenay Lake-Arrow
6461	Kootenay Lake TSA Wildlife Habitat Supply Assessment for TSR
6462	Wildlife Habitat Assessment – Northern Goshawk – Cranbrook-Invermere-Kootenay Lake-Arrow
6463	PEM for the Tech Coal area using the 2013 Cranbrook PEM logic and updated exceptions mapping
6464	Wildlife Habitat Assessment – Flammulated Owl – Cranbrook-Invermere-Kootenay Lake-Arrow
6529	West Kootenay Badger Project
6605	Columbia National Wildlife Area NEMWHR

Existing Field Data (Plots)

Field plots for TEI projects and BEC were sourced for the gap analysis. 2,289 plots have been loaded to the TEIS Master environment and are associated with 17 different projects. The majority of projects with plot data are Terrain Stability Mapping projects (TSM), while only 2 TEM projects have plot data loaded to the TEIS Master environment (Table C-6). A master compilation of BEC plots was reviewed and summarized by landscape unit in KB_Region_Data_Availability_and_Priority_Ranking.xlsx. Table C-7 depicts the BEC plots per Biogeoclimatic Unit for the KBR. See Appendix C-2 for a review of data sources related to plot data.

Table C-6: TEIS Master Sample Site Points

BAPID	Project Type*	Count of Associated Plots
218	TEMWHR	440
219	TEMWHR	1003
4509	TSM	332
4512	TSM	25
4655	TSM	31
4657	TSM	88
4658	TSM	67
4659	TSM	23
4660	TSM	22
4661	TSM	17
4662	TSM	103
4664	TSM	7
4665	TSM	11
4666	TSM	52
4667	TSM	31
4668	TSM	15
5128	TSM	22

* See Appendix A for a full description of TEI Project Type Codes

Table C-7: BEC plots by Biogeoclimatic Unit (all)

Biogeoclimatic Unit*	# of associated plots
ESSFdc1	132
ESSFdc2	14
ESSFdcp	2
ESSFdcw	21
ESSFdk1	644
ESSFdk2	712
ESSFdkp	416
ESSFdkw	589
ESSFmh	351
ESSFmm1	1

Biogeoclimatic Unit*	# of associated plots
ESSFmm3	436
ESSFmmp	83
ESSFmmw	150
ESSFvc	251
ESSFvcp	69
ESSFvcw	109
ESSFwc2	123
ESSFwc4	297
ESSFwcp	83
ESSFwcw	137
ESSFwh1	299
ESSFwh2	136
ESSFwh3	269
ESSFwm1	199
ESSFwm2	158
ESSFwm3	216
ESSFwm4	214
ESSFwmp	29
ESSFwmw	152
ICHdm	194
ICHdw1	751
ICHmk1	92
ICHmk4	254
ICHmk5	220
ICHmw1	132
ICHmw2	948
ICHmw3	247
ICHmw4	253
ICHmw5	304
ICHvk1	134
ICHwk1	444
ICHxw	168
ICHxwa	100
IDFdh	92
IDFdk5	460
IDFdm1	112
IDFdm2	578
IDFxk	211
IDFxx1	104
IDFxx2	337
IMAun	127
MSdk	1223
MSdm1	82

Biogeoclimatic Unit*	# of associated plots
MSdw	550

* See Appendix B for descriptions of Biogeoclimatic Units

Ortho Imagery

Ortho imagery available for the KBR is available through the Imagery Drive. Coverage differs by year but the most recent ortho imagery available is from 2017, has a resolution of 0.5m, and covers about 11.28% of the KBR land base (Table C-8). Prior to 2017 historic ortho imagery available for the region includes imagery from 2016, 2011- 2000, 1997 and 1995. The resolution of imagery captured prior to 2011 varies between 0.5 – 1m. Access to ortho may be granted by requesting permissions from the Digital Imagery Service to the appropriate folders on the Imagery Drive and downloading the imagery for use. If ortho is to be shared with and used by contractors, the Ministry and the contractor must enter into a Data Loan Agreement (DLA) with the Digital Imagery Service Department before any data is distributed. The main contact for ortho imagery is the Image Warehouse Specialist.

Table C-8: Summary of ortho imagery available for the KBR

Year	Resolution (m)	Coverage of KBR (ha)	Percent of Total KBR
2017	0.50	929172.37	11.28
2016	0.50	1650271.27	20.04
2011	0.50	1314823.13	15.97
All years	0.50, 0.75, 1.00	8091764.18	98.27

Light Detection and Ranging (LiDAR)

BC Timber Sales (BCTS) and GeoBC own the majority of the LiDAR data that has been discovered for the Kootenay Boundary Region. LiDAR is also owned by the Forest Analysis and Inventory Branch (FAIB) and companies such as Interfor, Teck, and Vaagen. Currently there are two inhouse web applications managed by GeoBC that offer an overview of LiDAR coverage for the province; BC's Open Data Lidar Portal[20] and the Lidar BC Inventory Information Portal[21]. A summary of the LiDAR sources for the KBR is provided in Table C-9. The main contact for information on LiDAR indexing and acquisition was the Chief Foresters Office Team Lead of Remote Sensing and Geospatial Applications.

20 https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=d06b37979b0c4709b7fcf2a1ed458e03

21 https://bcgov03.maps.arcgis.com/apps/MapSeries/index.html?appid=6a9bc439ba024d81b55980127e72de82#

While indices for LiDAR coverage have been provided, it is not guaranteed that LiDAR will be able to be obtained for all areas where known LiDAR exists. In some instances, it is likely that only the derivative products of LiDAR will be available for use (DEM, DSM etc). Partnerships with external companies are required to gain access to LiDAR licensed as restricted 3rd party access.

Table C-9: Summary of LiDAR Sources for the KBR

Source	Coverage of KBR (Ha)	Percent of Total KBR
BC's Open Data LiDAR Portal	1050985.65	12.76
LidarBC Inventory Information Portal	4135051.279	50.21884256
Regional LiDAR Datasets	895712.43	10.88

BC's Open Data LiDAR Data Portal is currently being updated regularly with new imagery. It offers the most easily accessible LiDAR available as all LiDAR data uploaded to the portal is open access. A public index is available on the web application and may be accessed through ArcGIS Online from which the index can be opened for viewing or analysis in ArcMap or ArcPro. A summary of the Open Access LiDAR Data from BC's Open Data LiDAR Data Portal is provided in Table C-10. Derivative products, which have the same coverage as the open portal point cloud index, include Digital Elevation Models (DEM) and Digital Surface Models (DSM). LiDAR data for 2017, 2018, and 2019 are available through the portal for the KBR, however bulk downloading of the raw point clouds and derivative products specified by the LiDAR Portal index is not currently supported. Hillshade, DEM, DSM and other products can be derived from raw point cloud LiDAR data.

Table C-10: Summary of Open Access LiDAR Data from BC's Open Data LiDAR Data Portal

Year	Coverage of KBR (Ha)	Percent of Total KBR
2017	496718.84	6.03
2018	503702.16	6.12
2019	50445.57	0.61

The LidarBC Inventory Information Portal is only available to internal government employees and requires a password to access the web application. The LiDAR coverage for the KBR indicated by the LidarBC Inventory Information Portal is indexed under 3 types of licensing: open, provincial, and restricted 3rd party and is summarized in Table C-11. GeoBC does not manage all the LiDAR data displayed by the LidarBC Inventory Information Portal. Licenses are held by various entities some of which are external to the provincial government.

Table C-11: Summary of LiDAR Indexing from the LiDAR BC Inventory Information Portal

Licencing	Area (Ha)	Percent of Total KBR
Open	2357599.16	28.63
Provincial	4837593.34	58.75
Restricted 3rd Party	4510571.93	54.78

LiDAR indexing for the region was also provided by the Chief Foresters Office Team Lead of Remote Sensing and Geospatial Applications (FLNR). Indexing was provided that was previously compiled for the region for a request made to GeoBC and BCTS. The index includes LiDAR data from 2017, 2018, and 2019 and includes a mix of open, provincial, and restricted 3rd party licensed LiDAR products controlled by both internal and external to government organizations (Table C-12).

Table C-12: Summary of LiDAR Indexing from the Chief Foresters Office (FLNR)

Licencing	Area (Ha)	Percent of Total KBR
Open	144911.5687	1.76
Provincial	3906394.233	47.44
Restricted	83745.47655	1.02

Other LiDAR discovered for the region includes LiDAR for the Elk Valley from 2014, owned by Teck, and LiDAR derivative products for the Boundary TSA (Table C-14). The Elk Valley data is currently managed under a data sharing agreement with Teck and is not open access. However, permission has been granted to Madrone Environmental Services Ltd. to use Teck's LiDAR for specific targeted ecosystem mapping or modelling for the KBR. The derivative LiDAR products for the Boundary TSA are associated with an ongoing inventory project in the timber supply area. While the raw point cloud data for the TSA is not accessible without a data sharing agreement, the derivative products of the raw data such as DEM's, canopy height models, and modelled streams may be distributed. Regional LiDAR datasets are available via the Kootenay Boundary Regional drive but permission must be granted for access to the folder. Access can be requested for through the NRS Service Desk[22].

Table C-13: Summary of Regional LiDAR Datasets

Dataset	Area (Ha)	Percent of Total KBR	Access
Elk Valley 2014	140532.99	1.71	Restricted, requires permission from Teck
Boundary TSA	755397.45	9.17	Restricted, only derivative products are readily available

Terrain Resource Information Management (TRIM)

TRIM data is managed by GeoBC. A 25m TRIM DEM as well as its associated point cloud and breaklines are available for the entire province. The DEM may be accessed and shared with contractors through the Imagery Drive. Permissions to access the DEM on the Imagery Drive must be granted by the Digital Imagery Service. In order to share TRIM data with contractors the Ministry must enter into a Data Loan Agreement (DLA) with GeoBC that outlines the responsibilities of the Ministry when sharing such data with contractors. If contractors are to set up access to the imagery drive, permission is granted on a folder-by-folder basis and requires the contractor to be issued an IDIR. The point cloud and breakline data associated with the TRIM DEM may be accessed by internal employees through the object store drive and downloaded by mapsheet or accessed by mapsheet through the basemap online store. Permissions to access the object store drive must be granted by GeoBC. Internal employees are not charged when "purchasing" data through the online store. Contractors that have an ongoing contract with the province should not have to pay for TRIM data, rather data should be downloaded by the ministry via the drive or online store and shared with contractors. Derivative products of the TRIM DEM include aspect, hillshade, and slope rasters which are all available through the Imagery Drive. TRIM products other than the DEM, it's derivative products, and its associated point cloud and breaklines may be accessed by internal employees through the BC Data Catalogue, or the object store drive.

Stereo Models

Stereo models are available in .sjs or ZI format for the majority of the KBR. The Digital Imagery Service does not have the capability to convert between .sjs and ZI formats. While a stereo model index of photo center points is readily available on the imagery drive, access to stereo model data must be approved and arranged by the Digital Imagery Service. .sjs models are available for 2004, 2005, 2006, 2007, and 2011 for the Kootenay Boundary Region with varying coverage by year. Upon request

[22] https://nrsservicedesk.gov.bc.ca/IM/scripts/LoginPage.asp?ErrorState=1&LoginAttempts=

stereo models in .sjs format can be posted to the Imagery Drive by the Digital Imagery Service for downloading. ZI setups can be made available as well but are more labor intensive for the Digital Imagery Service to provide. If stereo models of either format are to be shared with contractors, the contractor must enter into a Data Loan Agreement (DLA) with the province and Digital Imagery Service which outlines the terms of use. Once agreements are in place stereo model data is posted to the Imagery Drive where it can be retrieved by the Ministry and shared with contractors or accessed directly by contractors given they have been assigned an IDIR and have been given permission by the Imagery Service to access the appropriate folders on the Imagery Drive.

Vegetation Resource Inventory (VRI)

Vegetative Resource Inventory (VRI) polygons projected to the year 2020 (released January 2021) were used to overlay against the landscape units. VRI data is managed by the BC Forest Inventory Program and released yearly. The data was assessed where polygons contain projected forest age, projected height, and crown closure attributes. Where these attributes were null, VRI coverage was also considered null despite polygon delineation. Where attributes exist, coverage was summarized by landscape unit in KB_Region_Data_Availability_and_Priority_Ranking.xlsx.

Other Mapping Products

Provincial, Regional, and non-government products were sought after as part of the gap analysis. As well, a list of layers that may function as beneficial resources for ecosystem mapping updates have been targeted in the BCGW. All spatial data that was sourced is listed in the KBR_LayerList_ALL.xlsx workbook. All the layers referenced in KBR_LayerList_ALL.xlsx workbook were pulled into the KBR_Overview.mxd for review. Refer to Appendix C-2 for a detailed list of all products that were reviewed and utilized in the gap analysis.

The provincial cumulative effects (CEF) *Human Disturbance* layer for 2021 reports 1,630,996.87 ha (19.81%) of the KBR land base as being subject to some level of human disturbance within the last 20 years. The disturbance layer was accessed through the srm shared data library and offers a layer which ranks human disturbance on a 1-10 scale using groups such as agriculture and clearing, cut blocks, mining and extraction, rail and infrastructure, oil and gas geophysical, oil and gas infrastructure, power, recreation and urban. This layer will likely prove useful if pressure from development is incorporated as a parameter for determining priority areas for ecosystem mapping and updates.

A regional 2021 road density layer created by regional geospatial staff was also included in the assessment. This layer includes the most up to date road work for the Flathead area and is considered by regional staff to be the authoritative source for road density. Several other regional products that model T4W priority ecosystems were targeted as products that will likely be beneficial for ecosystem mapping and updates.

Other regional data provided included the NCC shared Sensitive Ecosystem Inventory (SEI) polygon data for the East Kootenays and Mount Broadwood. In addition, two iterations of avalanche chute data, one which included Grizzly habitat ratings and the other which included information on the vegetative layers was provided. A report prepared for the Columbia Basin Fish & Wildlife Compensation Program in 2001, *Conservation of Hardwoods and Associated Wildlife in the CBFWCP Area in Southeastern British Columbia*, which is posted to the Ecological Reports Catalogue (EcoCat) was also recommended.

Recommendations/Next Steps

Projects that overlap the KBR but have not yet been loaded to the TEIS operational environments need to be identified. A review of TEI project folders that have not had their project details standardized and loaded to the TEIS master operational environment were not investigated for missing project data. This process should involve a review of BAPID Tracker for projects submitted but not loaded and the use scripts to review project folders to identify relevant TEI project types such as TEM. As this process would take a significant amount of time to review project folders to locate spatial data and potentially convert, update and standardize spatial formats and data, this task was deemed out of scope for the gap analysis.

As ecosystem mapping has been completed at various times and for various purposes, a review of existing information is required. Many of these mapping products are currently out-of-date with current BEC (v12) classification including much of the existing ecosystem mapping in BC Parks and Protected Areas. Depending on the location of the TEI project and the year completed, the project may require classification updates since field guides and classification information has changed over time. For example, most of the early field guides and classification information were focused on forested ecosystems. Non-forested ecosystems were not mapped using consistent methods, and the descriptions and codes for non-forested ecosystems were derived by individual mappers and were not consistent between mapping projects.

Confirmation on LiDAR coverage and availability should also occur. While indices for LiDAR coverage have been provided, it is not guaranteed that LiDAR can be obtained for all areas where known LiDAR exists. In some instances, it is likely that only the derivative products of LiDAR will be available for use (DEM, DSM etc.). Partnerships with external companies are required to gain access to LiDAR licensed as restricted 3rd party.

Furthermore, imagery indexing that is available through the imagery drive and managed by the Digital Imagery Service requires updating and confirmation of stereo model coverage should occur. It has already been found that the photo centers indexed for stereo models do not accurately reflect what has been most recently archived. The images that are missing must be recovered from the original archive drives and requires additional effort by the Digital Imagery Service. Stereo models that must be recovered are organized by roll rather than letter block and year.

Appendix C-1: Summary of Landscape Units for the Kootenay Boundary Region

Provincial Identifier	Landscape Unit Name	Landscape Unit Area (ha)	% Coverage of KBR
-9999	Lake	121800.60	1.48
11	Akolkolex	60924.48	0.74
92	Big Eddy	31424.44	0.38
100	Bigmouth	44653.27	0.54
273	Cranberry	24348.50	0.30
327	Downie	80997.88	0.98
434	Frisby Ridge	16851.65	0.20
477	Goldstream	40275.33	0.49
568	Horne	55619.22	0.68
593	Illecillewaet	99800.70	1.21
624	Jordan	40900.22	0.50
730	LaForme	46447.92	0.56
746	Liberty	44462.79	0.54
855	Mica	39201.41	0.48
897	Mulvehill	19387.05	0.24
1028	Pingston	34736.25	0.42
1181	Soards	57374.50	0.70
1827	French	60803.65	0.74
1829	Redrock	16804.48	0.20
1831	Hamber Park	25337.45	0.31
1832	Upper Wood	49308.92	0.60
1833	Lower Wood	24923.48	0.30
1834	Encampment - Molson	21794.31	0.26
1835	Sullivan	64017.53	0.78
1836	Bush	59949.79	0.73
1837	Kinbasket	26313.32	0.32
1838	Cummings River Park	21826.58	0.27
1839	Tsar	17172.36	0.21
1840	Chatter - Prattle	34193.02	0.42
1841	Goosegrass	15618.81	0.19
1842	Valenciennes	31428.43	0.38
1843	Foster - Garrett	31245.66	0.38
1844	Windy - Sir Sandford	26179.98	0.32
1845	Swan	23806.57	0.29
1846	Blaeberry	69273.35	0.84
1847	Hope - Goodfellow	20172.08	0.24
1848	Bluewater	51389.61	0.62
1849	Blackwater	34292.98	0.42

Provincial Identifier	Landscape Unit Name	Landscape Unit Area (ha)	% Coverage of KBR
1850	Yoho National Park	121019.56	1.47
1851	Bachelor	56029.14	0.68
1852	Esplanade	15911.40	0.19
1853	Moberly	37446.28	0.45
1854	Ventigo	23815.29	0.29
1855	West Bench	44108.67	0.54
1856	Quartz	18632.58	0.23
1857	Kicking Horse - Beaverfoot	34861.35	0.42
1858	Mount Revelstoke National Park	18609.70	0.23
1859	Mount Revelstoke National Park	43661.49	0.53
1860	Kootenay National Park	78197.52	0.95
1861	Mount Revelstoke National Park	25425.57	0.31
1862	Mount 7	13207.01	0.16
1863	Canyon	12931.40	0.16
1864	Yoho National Park	8060.27	0.10
1865	Mount Revelstoke National Park	47857.85	0.58
1866	Upper Spillimacheen	47612.73	0.58
1867	Moose	12074.68	0.15
1868	McMurdo/Fraling	32228.42	0.39
1869	Cross	84886.39	1.03
1870	Kootenay	32174.75	0.39
1871	Twelve Mile	10703.33	0.13
1872	Lower Spillimacheen	26671.02	0.32
1873	Kootenay National Park	18915.70	0.23
1874	Fish	89758.21	1.09
1875	Bobbie Burns	76814.42	0.93
1876	Duncan River	55166.71	0.67
1877	Dunbar/Templeton	25211.77	0.31
1878	Luxor	9290.98	0.11
1879	Kootenay National Park	41457.78	0.50
1880	Kindersley/Macauley	23488.81	0.29
1881	Bugaboo	29681.63	0.36
1882	Albert	20792.47	0.25
1883	Steamboat	33277.79	0.40

Provincial Identifier	Landscape Unit Name	Landscape Unit Area (ha)	% Coverage of KBR
1884	Palliser	42528.54	0.52
1885	Westfall River	23037.70	0.28
1886	East Creek	62687.16	0.76
1887	Frances	12266.44	0.15
1888	Cochran	19933.79	0.24
1889	Trout	73353.57	0.89
1890	Upper Elk	66325.69	0.81
1891	Forster	16614.99	0.20
1892	Howser Creek	51509.07	0.63
1893	Pedley	21785.39	0.26
1894	Shuswap/Windermere	23249.28	0.28
1895	Halfway	76321.15	0.93
1896	East-Middle White	42730.95	0.52
1897	Horsethief	56018.94	0.68
1898	Fenwick	18540.73	0.23
1899	Invermere	26047.57	0.32
1900	North White	26792.02	0.33
1901	Lardeau Riever	47139.90	0.57
1902	Toby	45288.19	0.55
1903	East Columbia	20422.59	0.25
1904	Goldie	7651.12	0.09
1905	Grave	32308.48	0.39
1906	Goat River	69125.38	0.84
1907	Fording River	44206.24	0.54
1908	Kootenay	16759.71	0.20
1909	Brewer/Dutch	67422.74	0.82
1910	Nine Mile/Moscow	34977.91	0.42
1911	Glacier Creek	38689.17	0.47
1912	Jumbo	14549.51	0.18
1913	West Elk	64450.31	0.78
1914	East Elk	31226.26	0.38
1915	Doctor/Fir	45921.39	0.56
1916	Kuskanax	45801.37	0.56
1917	Fosthall	55951.70	0.68
1918	Hamill Creek	39846.99	0.48
1919	Blackfoot/Thunder	24427.65	0.30
1920	Wilson	58858.04	0.71
1921	Lussier/Coyote	55488.02	0.67
1922	Upper Bull	61952.77	0.75
1923	Findlay	53821.76	0.65
1924	Vipond	38794.47	0.47

Provincial Identifier	Landscape Unit Name	Landscape Unit Area (ha)	% Coverage of KBR
1925	Premier/Diorite	43267.74	0.53
1926	Fry Creek	61754.44	0.75
1927	McKian - Schroeder	41005.64	0.50
1928	Skookumchuck/Torrent	35516.47	0.43
1929	Alexander - Line	33032.40	0.40
1930	Barnes - Whatshan	61102.85	0.74
1931	Hills	41659.28	0.51
1932	Idaho	38266.67	0.46
1933	Buhl/Bradford	49158.87	0.60
1934	Caribou	40154.95	0.49
1935	Kaslo River	81996.17	1.00
1936	Riondel	42305.62	0.51
1937	Upper St. Marys	56288.59	0.68
1938	Galbraith - Dibble	49131.52	0.60
1939	Lost Dog - Mather	20303.53	0.25
1940	Wildhorse - Steeples	32867.26	0.40
1941	White Creek	38144.53	0.46
1942	Wasa - Picture Valley	31801.25	0.39
1943	Lower Elk	70631.06	0.86
1944	Eagle	48382.75	0.59
1945	Iron - Sulphur	38736.23	0.47
1946	St. Marys Prairie	31780.36	0.39
1947	Corbin Creek	41131.92	0.50
1948	Woden	31880.02	0.39
1949	Kimberley Watershed	34227.90	0.42
1950	Hoder	55034.21	0.67
1951	Gladstone	37150.86	0.45
1952	Lemon	40946.56	0.50
1953	Gray Creek	43238.78	0.53
1954	Gable	72533.16	0.88
1955	Rendell	53664.59	0.65
1956	Koch	50064.01	0.61
1957	Cranbrook	46657.32	0.57
1958	Redding Creek	38576.19	0.47
1959	West Arm	52936.00	0.64
1960	Perry	18014.43	0.22
1961	Perry - Moyie	53165.68	0.65
1962	Burrell	60358.55	0.73
1963	Hellroaring - Meachen	40901.29	0.50
1964	Upper Flathead	32220.19	0.39
1965	Sand Creek	18806.31	0.23

Provincial Identifier	Landscape Unit Name	Landscape Unit Area (ha)	% Coverage of KBR
1966	Pedro	19490.76	0.24
1967	Jaffray - Baynes Lake	46828.75	0.57
1968	Mayook - Wardner	23942.29	0.29
1969	Johnston	39329.87	0.48
1970	Lasca Creek	43252.32	0.53
1971	Midge Creek	38805.55	0.47
1972	Cranbrook Watershed	19250.85	0.23
1973	Trapping	55764.58	0.68
1974	Kettle	87702.79	1.07
1975	East Flathead	71538.49	0.87
1976	Goat River	77757.70	0.94
1977	West Flathead	53755.95	0.65
1978	Lodgepole - Bighorn	41495.21	0.50
1979	Teepee Creek	29349.68	0.36
1980	Duck Lake	70022.37	0.85
1981	Moyie Lake	30576.63	0.37
1982	Ladybird	46835.37	0.57
1983	Cayuse	29784.23	0.36
1984	Lamb Creek	12988.89	0.16
1985	Galton Range	20869.42	0.25
1986	Fortynine Creek	23187.06	0.28
1987	Linklater - Englishman	34387.63	0.42
1988	Bloom - Caven	35744.99	0.43
1989	Glade	21635.84	0.26
1990	Tobacco Plains	20621.41	0.25
1991	Darkwoods	49981.45	0.61
1992	Wigwam River	30948.38	0.38
1993	Kid Creek	34472.88	0.42
1994	Erie	40699.29	0.49
1995	Stagleap	57283.52	0.70
1996	Yahk River	36078.35	0.44
1997	Lynch	61505.21	0.75
1998	Dog	24402.44	0.30
1999	Kelly	50913.72	0.62
2000	Hawkins Creek	42758.19	0.52
2001	Blueberry	32824.92	0.40
2002	Boundary	46071.77	0.56
2003	Summit Creek	72033.36	0.87
2004	Christina	58669.22	0.71
2005	Bear	39215.73	0.48
2006	Sheep	36055.09	0.44

Provincial Identifier	Landscape Unit Name	Landscape Unit Area (ha)	% Coverage of KBR
2007	Moyie River	25992.50	0.32
2008	Rossland	28646.11	0.35
2009	Pend Oreille	19825.75	0.24
2010	Rock	81325.84	0.99
2011	Gilpin	30490.64	0.37

Appendix C-2: Data Reviewed in the Gap Analysis[23]

TEI Data

Data	Contact	Notes	Access
TEIS Master Long Table	TEI Unit TEI_Mail@gov.bc.ca	TEIS_Master_Long_Tbl contains the provincial compilation of Terrestrial Ecosystem Information (TEI) polygons with full RISC (Resource Inventory Standards Committee) standard attributes. These describe the physical and biological characteristics of ecosystems at a landscape level. TEIS_Master_Short_Tbl and TEIS_Master_Project_Boundaries are derived from the TEIS_Master_Long_Tbl. The TEIS_Master_Long_Tbl does not include detailed attribute information for PEM projects, Soil projects, or any project type that has been flagged as a Sensitive Ecosystem Inventory (SEI) project. PEM, Soil, and SEI projects are loaded to separate long tables.	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data.gdb\TEIS_Master_Long_Tbl
TEIS Master Sample Site Points	TEI Unit TEI_Mail@gov.bc.ca	TEI_Sample_Site_Points contains the point locations of field sites where inventory data was collected, and the TES_TAG that links to the original field data (such as ECI_TAG linking to Venus data).	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data.gdb\TEIS_Master_Sample_Site_Points
TEIS PEM Project Boundaries	TEI Unit TEI_Mail@gov.bc.ca	Predictive Ecosystem Mapping (PEM) project boundaries (study areas) and attributes describing each project (project level metadata), plus links to the locations of other data associated with the project (e.g., reports, polygon datasets, plotfiles, legends). PEM uses modeling to divide the landscape into units according to a variety of ecological features including climate, physiography, surficial material, bedrock geology, soils and vegetation. This layer is derived from the TEIS_Master_Project_Boundaries layer by filtering on the PROJECT_TYPE attribute.	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data_PEM.gdb\PEM_Master_Project_Boundaries
TEIS PEM Long Table	TEI Unit TEI_Mail@gov.bc.ca	Predictive Ecosystem Mapping (PEM) projects use a modeling approach to ecosystem mapping, whereby existing knowledge of ecosystem attributes and relationships are used to predict ecosystem representation in the landscape. Typical polygon attributes include Ecosection, BGC unit, Ecosystem unit and structural stage. PEM relies heavily on existing data and mapping information which may include the Bioterrain Mapping methodology, the Terrain Classification, Biogeoclimatic (BGC) Ecosystem Classification and Ecoregion Classification systems for BC. PEM is also used in conjunction with Vegetation Resource Inventory Mapping (VRI) and forms a common data input for Sensitive Ecosystems Inventory (SEI),	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data_PEM.gdb\PEM_Master_Long_Tbl

[23] Data utilized in gap analysis (KB_Region_Data_Availability_and_Priority_Ranking.xlsx) are denoted by a (*).

Data	Contact	Notes	Access
		and Wildlife Habitat Ratings (WHR) projects. As such some PEM data shown in this layer share common line work and attributes with SEI, TEM, WHR and VRI mapping products. This dataset should be used and interpreted in consultation with a qualified ecosystem and/or terrain mapper.	
TEIS Project Boundary for Projects that include information deemed “sensitive”.	TEI Unit TEI_Mail@gov.bc.ca	Terrestrial Ecosystem Information (TEI) project boundaries (study areas) for SENSITIVE projects, and attributes describing each project (project level metadata), plus links to the locations of other data associated with the project (e.g., reports, polygon datasets, plot files, legends). This feature class is derived from the TEI_Long_Tbl and TEIS_Project_Details. TEI inventories describe the physical and biological attributes of ecosystems.	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data_PEM.gdb\TEI_PROJ_BOUNDARIES_SENSITIVE
TEIS Long Table for Projects that include information deemed “sensitive”.	TEI Unit TEI_Mail@gov.bc.ca	Terrestrial Ecosystem Information (TEI) polygons for SENSITIVE projects, with key and amalgamated (concatenated) attributes derived from the RISC (Resource Inventory Standards Committee) standard attributes. These describe the physical and biological characteristics of ecosystems at a landscape level. TEI currently includes Terrestrial Ecosystem Mapping (TEM), Predictive Ecosystem Mapping (PEM), Sensitive Ecosystems Inventory (SEI), Terrain Mapping (TER) and Soil Mapping (SOIL). Mapping methods include manual air photo interpretation and modeling supported by limited field checking.	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data_PEM.gdb\TEI_ATTRIBUTE_POLYS_SENSITIVE
TEI Soils Long Table	TEI Unit TEI_Mail@gov.bc.ca	TEIS_Soils_of_BC - Soils long table located in the soils master environment (Soil_Env_Master)	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\Soil_Env_Master\Soils_ENV\Operational_Data.gdb\TEIS_Soils_of_BC
Soil Site plot dataset	TEI Unit TEI_Mail@gov.bc.ca	Soil Site dataset which includes soil pit site information and detailed soil pit descriptions and any associated lab analyses	https://catalogue.data.gov.bc.ca/dataset/soil-mapping-data-packages
Project Data for BAPID 6515	TEI Unit TEI_Mail@gov.bc.ca	Grasslands project data not loaded to master environment. Only exists in the BAPID project folder.	\\spatialfiles.bcgov\ARCHIVE\env\esd\eis\tei\TEI_project_data\TEI_Data\6515_Grassland_Mapping\6515_Grassland_Mapping

Imagery and TRIM products

Data	Contact	Notes	Access
Internally available LiDAR indexing*	Christopher Butson Christopher.Butson@gov.bc.ca (FLNR)	LidarBC Inventory Information Portal. 3 types of licensing are associated with the internal index: open, provincial, and restricted 3rd party. Licenses are held by various groups. GeoBC does not manage all the data indexed by the app and cannot guarantee access to all LiDAR products indicated by the index.	https://bcgov03.maps.arcgis.com/apps/MapSeries/index.html?appid=6a9bc439ba024d81b55980127e72de82#
BC's Open Data LiDAR Portal*	GeoBC Lidar@gov.bc.ca	LiDAR data portal. Point cloud, DEM, and DSM indexing and data are available through the portal and may be downloaded from the AGOL map application.	https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=d06b37979b0c4709b7fcf2a1ed458e03.
Lidar BC Inventory Information Portal*	GeoBC GeoBCInfo@gov.bc.ca Christopher Butson Christopher.Butson@gov.bc.ca (FLNR)	An inventory of LiDAR projects in the province meant to help coordinate data dissemination and reduce the potential of inefficient acquisition overlap. Includes municipal, provincial, non-profit, and federal sources. Classified into three licences: Open, Provincial, and Restricted 3rd Party.	https://bcgov03.maps.arcgis.com/apps/MapSeries/index.html?appid=6a9bc439ba024d81b55980127e72de82#
LiDAR Stored on KBR Regional Drive*	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLRORD)	A collection of LiDAR the region has compiled for use. LiDAR may require a DLA or DISA for use. Requires permissions to the folder.	\\Sfp.idir.bcgov\s164\S63098\Share\Geomatics\Data\LiDAR
25m TRIM DEM*	Tristan Joslin Tristan.Joslin@gov.bc.ca (GeoBC)	TRIM data is managed by GeoBC and offers provincial coverage of BC. The DEM is accessible through the Imagery drive.	\\Imagefiles.bcgov\imagery\dem\elevation\trim_25m\bcalbers\tif
Hillshade, TRIM product*	Tristan Joslin Tristan.Joslin@gov.bc.ca (GeoBC)	TRIM data is managed by GeoBC and offers provincial coverage of BC. The hillshade associated with the 25m TRIM DEM is accessible through the Imagery drive.	\\Imagefiles.bcgov\imagery\dem\hillshade\trim_25m
Point Cloud and breaklines associated with TRIM*	Tristan Joslin Tristan.Joslin@gov.bc.ca (GeoBC)	TRIM data is managed by GeoBC and offers provincial coverage of BC. The point cloud and breaklines associated with the 25m TRIM DEM may be downloaded by mapsheet from the Objectstore drive or the Base Map Online Store.	Objectstore Drive: \\objectstore.nrs.bcgov\TRIM_Data\DATAROOT\SHAPE Base Map Online Store: https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/base-map-online-store
Digital ortho-images (1937-2011)*	Angus Christian Angus.Christian@gov.bc.ca (Digital Imagery Service)	The most recent imagery available is from 2011, increasing coverage of the Kootenay Boundary Region is available if older imagery is utilized.	\\Imagefiles.bcgov\imagery\airborne\ortho_tiles

Data	Contact	Notes	Access
Stereo Models*	Angus Christian Angus.Christian@gov.bc.ca (Digital Imagery Service)	Readily available in .sjs format, ZI setups can be made available but are more labor intensive for the digital Imagery Service to provide. While a stereo model index is accessible on the imagery drive, access to stereo model data must be approved and arranged by the Digital Imagery Service.	\\Imagefiles.bcgov\imagery\stereo_model
Satellite Imagery, Sentinel (2017, 2018)*	Angus Christian Angus.Christian@gov.bc.ca (Digital Imagery Service)	Sentinel (2017, 2018)	\\Imagefiles.bcgov\imagery\satellite\sentinel
Satellite Imagery, Landsat (2018)*	Angus Christian Angus.Christian@gov.bc.ca (Digital Imagery Service)	Landsat (2018)	\\Imagefiles.bcgov\imagery\satellite\landsat\mosaic\shp\bcalb

Plot Data

Data	Contact	Notes	Access
BEC plot data*	Deb Mackillop (FLNR) Deb.MacKillop@gov.bc.ca	Master of all BEC Plot locations for the KBR. The most up to date plot data was shared by Deb Mackillop. BEC plot data is not available through the BCGW.	\\spatialfiles2.bcgov\WORK\FOR\RSI\RSI\Projects\debmackillop\T4W
TEI plot data*	TEI Unit TEI_Mail@gov.bc.ca	TEI_Sample_Site_Points contains the point locations of field sites where inventory data was collected, and the TES_TAG that links to the original field data (such as ECI_TAG linking to Venus data).	\\spatialfiles.bcgov\WORK\env\esd\eis\tei\TEI_GIS\TEI_master\TEIS_Env_Master\Operational_Data.gdb\TEIS_Master_Sample_Site_Points
Soil Site plot dataset	TEI Unit TEI_Mail@gov.bc.ca	Soil Site dataset which includes soil pit site information and detailed soil pit descriptions and any associated lab analyses	https://catalogue.data.gov.bc.ca/dataset/soil-mapping-data-packages

Other Provincial Products

Data	Contact	Notes	Access
Human Disturbance,	Tony Button (MOE)	Cumulative effects are defined in the BC cumulative effects framework as "changes to environmental, social and economic	\\spatialfiles.bcgov\WORK\srm\bcce\shared\data_library\disturbance\human_disturbance\2021\data\BC_C

Cumulative Effects Framework (2021)*		values caused by the combined effect of past, present and potential future human activities and natural processes".	EF_Human_Disturbance_2021.gdb\BC_CEF_Human_Disturb_BTM_2021_merge

Kootenay Boundary Region Products

Data	Contact	Notes	Access
Cottonwood Floodplain Forest	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Shapefile. Very little area covered (651.73 ha).	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Cottonwood Floodplain\Boundary cottonwood\Boundary_Riparian_Cottonwood 2013.shp
Grasslands & associated ecosystems	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Grasslands\Draft_EO_2021\KEI_FestcamEriombEremcap_EOs_2021\EO_SHAPE_2021_01_26_125508.gdb
High Elevation Ecosystems	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Shapefile	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\High Elevation Ecosystems\Alpine_Parkland_KBclip.shp
Huckleberry-associated Ecosystems, Provincial (Clayton Lamb)	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Raster (.tif). Clayton Lamb's thesis and food mapping for the entire province for many species. Other rasters located in the root folder *GB berry production kcal_ha*	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Grizzly Bear berry and plant food rasters\BC_2020\GB berry production kcal_ha\VACCMEM_kcal.tif
Huckleberry-associated Ecosystems, Southern KBR (Michael Proctor)	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data. Michael Proctor's huckleberry patch model for the southern portion of the KBR.	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\Grizzly Bear\Grizzly_Michael_Proctor\R4South_Huck_patches.gdb\R4_South_Huck_Patches
Limber Pine - High Habitat Suitability (Mid KBR)	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Whitebark and Limber Pine\LPMT6_Over80_Mid.gdb\Placemarks\Polygons
Limber Pine - High Habitat	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem

Data	Contact	Notes	Access
Suitability (North KBR)			Types\Whitebark and Limber Pine\LPMT6_Over80_North.gdb\Placemarks\Polygons
Limber Pine - High Habitat Suitability (South KBR)	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Whitebark and Limber Pine\LPMT6_Over80_South.gdb\Placemarks\Polygons
Old and Ancient Forests	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data. Query for SERAL_STAGE IN ('Mature', 'Old'). Numeric ages associated with codes are unknown.	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Old Growth Forests\Old_growth_2020analysis.gdb\KOOTENAY_Seral_Stage
Open Forest	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Open Forest\fmer04
Riparian Ecosystems	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Feature class polygon data. Riparian dataset that ALCES created for the Elk Valley CEMF Aquatic Assessment. This dataset has only one record and is missing any valuable attribute information.	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Riparian Ecosystems\RWCT.gdb\riparian_area_lidar
Road Density (2021)*	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	A layer produced by Geospatial Analyst, Vicky Young considered to be the most accurate road density layer by KBR regional staff. The layer describes road density by landscape unit. Edits to the Digital Road Atlas (DRA) for the Flathead area have not been submitted to DRA for updates. Therefore there may be slight discrepancies between the road dataset used in this analysis and the "official" DRA for the Flathead area.	\\spatialfiles\srm\nel\Local\Geomatics\Workarea\vyoung\2021\RegionalRoadDensity
Whitebark Pine Potential Range	Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Raster (.tif)	\\spatialfiles.bcgov\WORK\srm\nel\Local\Data\Terrestrial\Wildlife and Habitat\T4W Priority Ecosystem Types\Whitebark and Limber Pine\Hi5 WBP Potential Range\final_potential_range_products.gdb\CCE_WBP_Potential_Range_filt
Wildlife Tree point data	Amy Waterhouse Amy.Waterhouse@gov.bc.ca (FLNR) Audrey Ehman Audrey.Ehman@gov.bc.ca (FLNR)	Wildlife tree data model is still under development as an operational dataset. Looking to improve the attributes to track decay progress on the inoculated trees. There are also about 30 wildlife trees missing from the east side of Columbia lake that need to be tracked down. The dataset includes a few trees located outside KBR.	\\spatialfiles2.bcgov\WORK\FOR\RSI\RSI\Projects\debmackillop\T4W\inoculatedTrees2020_WorkingJuly20_21.gdb.zip

BC Geographic Warehouse Products

Data	Contact	Notes	Access
Natural Resource (NR) Regions*	Susan Westmacott Susan.Westmacott@gov.bc.ca FLNR	The spatial representation for a Natural Resource (NR) Region, that is an administrative area established by the Ministry, within NR Areas. Used to define the Kootenay Boundary Region for means of analysis.	https://catalogue.data.gov.bc.ca/dataset/natural-resource-nr-regions
Landscape Units of British Columbia – Current*	Rob Oostlander Rob.Oostlander@gov.bc.ca FLNR	Landscape Units are spatially identified areas of land and/or water used for long-term planning of resource management activities. Used for the KBR gap analysis to group summaries into smaller units.	https://catalogue.data.gov.bc.ca/dataset/landscape-units-of-british-columbia-current
Biogeoclimatic Ecosystem Classification (BEC) provincial linework (BECv12)*	Deb Mackillop Deb.MacKillop@gov.bc.ca (FLNR)	The current and most detailed version of the approved corporate provincial digital Biogeoclimatic Ecosystem Classification (BEC) map (version 12, September 2, 2021).	\\spatialfiles2.bcgov\work\FOR\VIC\HRE\Projects\Landscape\ProvBGC\CurrentWork\BGCv12\BGC_BC_v12.gdb
Broad Ecosystems Inventory Mapping (BEI)	TEI Unit TEI_Mail@gov.bc.ca	Polygon dataset that offers habitat ratings for various wildlife species. Updates to current BEI dataset stored in the BCGW are underway.	[WHSE_TERRESTRIAL_ECOLOGY.BEI_WILDLIFE_HABITAT_BIRDS_MV, WHSE_TERRESTRIAL_ECOLOGY.BEI_WILDLIFE_HABITAT_MAMLS_MV]
Conservation Data Center (CDC) Element Occurrence Data (EO)	Katrina Stipec cdcdata@gov.bc.ca (CDC)	A publicly available EO layer and a masked publicly available layer are available that approximate secured locations of species and ecosystems at risk. A mix of publicly available and government access only data depending on the type of data security applied to the occurrence data (open, susceptible to persecution or harm, or for proprietary reasons).	https://catalogue.data.gov.bc.ca/dataset/species-and-ecosystems-at-risk-publicly-available-occurrences-cdc https://catalogue.data.gov.bc.ca/dataset/species-and-ecosystems-at-risk-masked-secured-publicly-available-occurrences-cdc
Deciduous Forests in the Columbia Basin, BC	Amy Waterhouse Amy.Waterhouse@gov.bc.ca (FLNR)	The deciduous forest dataset is the result of queries to forest cover data conducted on a forest district by forest district basis. The EKCP study area spans 3 forest districts: All of Cranbrook and Invermere FDs, and part of Golden FD. In Cranbrook and Golden data for all canopy layers in the forest cover data bases (layers 1-3, and silviculture and veteran layers) was available. In the case of Cranbrook only the rank1 layer was available. Items _rnk1pct and _rnk1cls are	https://catalogue.data.gov.bc.ca/dataset/de74766b-7e34-4cd9-94e2-976438ab3a94/resource/a010cbea-65a8-47a3-840e-d8620f7541f1

Data	Contact	Notes	Access
		derived from the rank 1 layer in all FDs; items _other_total are the total area in other layers, available for Cranbrook and Golden.	
Freshwater Atlas (FWA) Lakes, Rivers, Streams, and Wetlands*	GeoBC GeoBCInfo@gov.bc.ca	FWA datasets are the authoritative source for delineating bodies of water. This data is typically used in allocation decisions, boundary definitions, planning processes and environmental monitoring, by internal and external stakeholders. In order to generate these datasets automated, mathematical and statistical algorithms were applied against the TRIM I stream network and the TRIM I elevation surface model.	https://catalogue.data.gov.bc.ca/dataset/93b413d8-1840-4770-9629-641d74bd1cc6
Habitat Enhancement - Burning and Slashing Activity - FWCP - Columbia Basin	Amy Waterhouse Amy.Waterhouse@gov.bc.ca (FLNR)	Habitat enhancement burn areas for the East Kootenay from 1997 to date.	https://catalogue.data.gov.bc.ca/dataset/87f3ff9f-490b-4099-a4bc-0f29fe272977/resource/818bbdfd-82ec-4211-ba60-982e0307d3f6
Digital Road Atlas (DRA)	GeoBC GeoBCInfo@gov.bc.ca	Authoritative dataset for defining roadways in the province. This layer can be used to derive road density. This data represents what is publicly available for the DRA.	https://catalogue.data.gov.bc.ca/dataset/bb060417-b6e6-4548-b837-f9060d94743e
Vegetative Resource Inventory (VRI) 2020*	Edward Fong Edward.Fong@gov.bc.ca (Forest Analysis and Inventory)	VRI data projected to current year and is updated annually. Attribution table for the Vegetation Composite Polygons Linked by Feature _id. Download from the Data Catalogue as a zipped gdb.	https://catalogue.data.gov.bc.ca/dataset/b2b6920f-2532-473a-8e7f-6bdc75f5b987
Parks, Ecological Reserves and Protected Areas*	Glenna Erlandson Glenna.Erlandson@gov.bc.ca (BC Parks - Provincial Services)	This dataset contains parks and protected areas managed for important conservation values and are dedicated for the preservation of their natural environments for the inspiration, use and enjoyment of the public.	https://catalogue.data.gov.bc.ca/dataset/bc-parks-ecological-reserves-and-protected-areas
Conservation Lands*	Natalie Work Natalie.j.Work@gov.bc.ca (GeoBC)	Conservation Lands spatial and attribute data. This includes related information on various types/classes of land secured for fish, wildlife and habitat conservation purposes. It includes Wildlife Management	https://catalogue.data.gov.bc.ca/dataset/conservation-lands

Data	Contact	Notes	Access
		Areas (WMA) designated by Order in Council (OIC). Source data are from Tantalis as well as the derived product from GeoBC.	
Wildlife Management Areas*	Crown Lands Registry Help clrhelp@gov.bc.ca (Lands)	Spatial representation (polygon) of the areas under the administration and control of the Conservation Lands Program of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development and designated as Wildlife Management Areas under the Wildlife Act due to the significance of their wildlife/fish values.	https://catalogue.data.gov.bc.ca/dataset/tantalis-wildlife-management-areas
Wildlife Habitat Areas*	Wildlife Species Inventory Team SPI_Mail@gov.bc.ca (Knowledge Management)	The dataset contains approved legal boundaries for wildlife habitat areas and specified areas for species at risk and regionally important wildlife.	https://catalogue.data.gov.bc.ca/dataset/wildlife-habitat-areas-approved
Ungulate Winter Range*	Naomi Nichol Naomi.Nichol@gov.bc.ca (Wildlife and Habitat)	The dataset contains approved legal boundaries for ungulate winter range and specified areas for ungulate species.	https://catalogue.data.gov.bc.ca/dataset/ungulate-winter-range-approved

Non-Government Products

Data	Owner	Contact	Notes	Access
LiDAR products for the Boundary TSA	-	Christopher Butson Christopher.Butson@gov.bc.ca (FLNR)	Only the derivative products of the Boundary TSA LiDAR are currently available for use. Access to the LiDAR dataset will require negotiation.	\\Sfp.idir.bcgov\s164\S63098\Share\Geomatics\Data\LiDAR
Avalanche chute polygon data with Grizzly habitat ratings	-	Audrey Ehman Audrey.Ehman@gov.bc.ca (FLNR)	Shapefile representing the outer boundary of Avalanche chutes within the Wetland and Upland Zones. Avalanche chutes have been rated for Grizzly bears. Txt files included as metadata.	\\spatialfiles2.bcgov\WORK\FOR\RSI\RSI\Projects\debmackillop\T4W\Avalanche_Mapping_RS\Colum_west_all_chutes
Avalanche chute vegetation layers polygon data	-	Audrey Ehman Audrey.Ehman@gov.bc.ca	Polygon shapefile representing avalanche chute vegetation layers within the Wetland and Upland Zones. Txt files included as metadata.	\\spatialfiles2.bcgov\WORK\FOR\RSI\RSI\Projects\debmackillop\T4W\Avalanche_Mapping_RS\Colum_west_all_chutes

Data	Owner	Contact	Notes	Access
		(FLNR)		
Sensitive Ecosystem Inventory (SEI) polygon data for the East Kootenays and Mount Broadwood	Nature Conservancy of Canada (NCC)	Trevor Reid Trevor.Reid@natureconservancy.ca (NCC) Anna McIndoe Anna.McIndoe@gov.bc.ca (FLNR)	Polygon data for the East Kootenays and Mount Broadwood SEI project	\\spatialfiles.bcgov\ARCHIVE\env\esd\eis\tei\TEI_project_data\TEI_Data\6597_KB_Region_Strategic_Ecosystem_Mapping\Original\Gap_Analysis\Data_Recieved\Trevor_Reid\MountBroadwood_SEI
Report: The Conservation of Hardwoods and Associated Wildlife in the CBFWCP Area in Southeastern British Columbia	Columbia Basin Fish & Wildlife Compensation Program	Bob Jamieson (BioQuest International Consulting Ltd.) Everett & Merle Peterson (Western Ecological Services Ltd.) Ian Parfitt (Columbia Basin Fish and Wildlife Compensation Program)	Report uploaded to EcoCat, publicly available	https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=41202

Appendix D: Priority Terrestrial Ecosystems and Wildlife Crosswalk

The Kootenay Boundary Region focused Priority Terrestrial Ecosystems and Wildlife Crosswalk was based on the TEI Ecosystem Codes List/BECv12 ecosystem units (TEI Unit 2022). This process involved a review and assignment of all current ecosystem mapping codes by BEC unit to assigned priority ecosystem groups including: Aspen, Avalanche, Cottonwood Floodplain, Grassland/Brushland, High Elevation Meadow/Parkland, Huckleberry, Open Forest, Riparian, Rock, Wetland and Whitebark/Limber Pine. As part of this compilation process updated information within the current LMHs (70/71/75 and supplements) were reviewed and updates were made as deemed appropriate. Results of the crosswalking for each priority ecosystem type as well as key considerations are included below (Tables D1 to D11), as well as within an Excel spreadsheet associated with this Strategic Plan (KBR_BEC_PriorityHabType_Eco.xlsx).

Contributors included the following Ministry staff:

- Jackie Churchill - ENV - Ecosystem Mapping Ecologist
- Deb MacKillop - FLNR - Research Ecologist, Kootenay Boundary Region
- Audrey Ehman - FLNR - Resource Technician, Kootenay Boundary Region
- Anna McIndoe - FLNR - Wildlife Habitat Specialist, Kootenay Boundary Region

Considerations made during the crosswalk process included:

- Excluded ESSFmm2 - occurs in spatial intersect between BECv12 and KBR but not within BECv12 DB or LMHs but retained ESSFmmw, ESSFmmp and ESSFvcp as assumed only excluded from BECv12db/LMHs as awaiting classification of woodland/parkland units
- Alpine grasslands (Ag) included for lower elevation BEC Units in Grassland priority habitat type (as per LMHs)
- Alpine grasslands (Ag) included in both High Elevation Meadow/Parkland and Grassland priority habitat type
- Shrub-carrs (Sc) included with the High Elevation Meadow/Parkland priority habitat type (not as Wetlands as per LMHs)
- Alpine wetlands (Wa) included with Wetlands priority habitat type in Alpine, Parkland, Woodland BEC units and higher elevation ESSF units (not included with High Elevation Meadow/Parkland priority habitat type as per LMHs)
- Mid-bench floodplain (Fm) included in Cottonwood Floodplain and Riparian priority habitat types
- Non-forested riparian units (Fa, Ff, Fl) and Hs/Hw units identified in BECv12 included in Riparian priority habitat type
- Huckleberry priority habitat type included ecosystems with "Huckleberry" in Site Series name in BECv12. A detailed review of vegetation lists in LMHs/BEC Master was not completed. Excluded from Alpine/Parkland/IDF and PP BEC units.

- Whitebark and Limber Pine priority habitat type included ecosystems with "Whitebark and Pa" in Site Series name in BECv12. A detailed review of vegetation lists in LMHs/BEC Master was not completed. Excluded from IMAun, MS, ICH, IDF and PP BEC units
- Aspen priority habitat type included ecosystems with "Aspen and At" in Site Series name in BECv12. A detailed review of vegetation lists in LMHs/BEC Master was not completed. Excluded from Alpine and Parkland BEC units
- For the Cottonwood Floodplain priority habitat type included ecosystems with "Cottonwood and Act" in Site Series name in BECv12. A detailed review of vegetation lists in LMHs/BEC Master was not completed. Excluded from Alpine, Parkland and ESSF BEC units

Table D-1: Aspen Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Aspen Priority Ecosystem Crosswalk					
ESSFdc1/Rt07	ESSFwm2/Rt07	ICHmk1/Rt07.1	ICHmw5/Rt07	IDFdm1/103$B	MSdk/Rt08
ESSFdk1/Rt07	ESSFwm3/Rt07	ICHmk1/Rt08	ICHmw5/Rt07.2	IDFdm1/Rt07	MSdm1/103$B
ESSFdk2/Rt07	ESSFwm4/Rt07	ICHmk4/103$B	ICHmw5/Rt08	IDFdm1/Rt07.1	MSdm1/Rt07
ESSFmh/Rt07	ICHdm/Rt07	ICHmk4/Rt07	ICHxw/103$B	IDFdm2/103$B	MSdm1/Rt07.1
ESSFmh/Rt07.1	ICHdm/Rt07.1	ICHmk4/Rt08	ICHxw/Rt08	IDFdm2/Rt07	MSdm1/Rt08
ESSFwc4/Rt07	ICHdm/Rt08	ICHmk5/103$B	ICHxwa/103$B	IDFdm2/Rt07.1	MSdw/103$B
ESSFwh1/Rt07	ICHdw1/103$B	ICHmw1/103$B	ICHxwa/Rt08	IDFdm2/Rt08	MSdw/Rt07
ESSFwh2/Rt07	ICHdw1/Rt08	ICHmw2/103$B	IDFdk5/103$B	IDFxk/111	MSdw/Rt08
ESSFwh3/Rt07	ICHmk1/103$B	ICHmw3/103$B	IDFdk5/Rt07	MSdk/103$B	
ESSFwm1/Rt07	ICHmk1/Rt07	ICHmw4/103$B	IDFdk5/Rt08	MSdk/Rt07	

Table D-2: Avalanche Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Avalanche Priority Ecosystem Crosswalk					
ESSFdc1/Vh	ESSFdkw/Vs12	ESSFwh1/Vh01.1	ESSFwm1/Vs12	ICHdm/Vh01	ICHmw4/Vs01.1
ESSFdc1/Vh02	ESSFdkw/Vs13	ESSFwh1/Vh01.2	ESSFwm1/Vs13	ICHdm/Vh01.1	ICHmw4/Vs01.2
ESSFdc1/Vh02.1	ESSFdkw/Vt	ESSFwh1/Vh02	ESSFwm1/Vt	ICHdm/Vh01.2	ICHmw4/Vs02
ESSFdc1/Vh10	ESSFmh/Vh	ESSFwh1/Vh02.1	ESSFwm2/Vh	ICHdm/Vh10	ICHmw4/Vs04
ESSFdc1/Vh11	ESSFmh/Vh01	ESSFwh1/Vh02.2	ESSFwm2/Vh01	ICHdm/Vh11	ICHmw4/Vs10
ESSFdc1/Vs	ESSFmh/Vh01.1	ESSFwh1/Vh03	ESSFwm2/Vh01.1	ICHdm/Vs	ICHmw4/Vs10.1
ESSFdc1/Vs02	ESSFmh/Vh01.2	ESSFwh1/Vh11	ESSFwm2/Vh01.2	ICHdm/Vs01	ICHmw4/Vs10.2
ESSFdc1/Vs03	ESSFmh/Vh02	ESSFwh1/Vs	ESSFwm2/Vh02	ICHdm/Vs01.1	ICHmw4/Vs11
ESSFdc1/Vs10	ESSFmh/Vh03	ESSFwh1/Vs01	ESSFwm2/Vh02.1	ICHdm/Vs01.2	ICHmw4/Vs13
ESSFdc1/Vs10.1	ESSFmh/Vh04	ESSFwh1/Vs01.1	ESSFwm2/Vh02.2	ICHdm/Vs02	ICHmw4/Vs14
ESSFdc1/Vs10.2	ESSFmh/Vh10	ESSFwh1/Vs01.2	ESSFwm2/Vh10	ICHdm/Vs10	ICHmw4/Vt
ESSFdc1/Vs12	ESSFmh/Vh11	ESSFwh1/Vs02	ESSFwm2/Vh11	ICHdm/Vs10.1	ICHmw5/Vh
ESSFdc1/Vt	ESSFmh/Vs	ESSFwh1/Vs03	ESSFwm2/Vs	ICHdm/Vs10.2	ICHmw5/Vh01
ESSFdc2/Vh	ESSFmh/Vs01	ESSFwh1/Vs04	ESSFwm2/Vs01	ICHdm/Vs11	ICHmw5/Vh01.1
ESSFdc2/Vs	ESSFmh/Vs01.1	ESSFwh1/Vs10	ESSFwm2/Vs01.1	ICHdm/Vs13	ICHmw5/Vh01.2
ESSFdc2/Vt	ESSFmh/Vs01.2	ESSFwh1/Vs10.1	ESSFwm2/Vs01.2	ICHdm/Vs14	ICHmw5/Vh03
ESSFdcp/Vh	ESSFmh/Vs02	ESSFwh1/Vs10.2	ESSFwm2/Vs02	ICHdm/Vt	ICHmw5/Vh10

Avalanche Priority Ecosystem Crosswalk

ESSFdcp/Vs	ESSFmh/Vs10	ESSFwh1/Vs11	ESSFwm2/Vs03	ICHdw1/Vh	ICHmw5/Vh11
ESSFdcp/Vt	ESSFmh/Vs10.1	ESSFwh1/Vs12	ESSFwm2/Vs10	ICHdw1/Vs	ICHmw5/Vs
ESSFdcw/Vh	ESSFmh/Vs10.2	ESSFwh1/Vt	ESSFwm2/Vs10.1	ICHdw1/Vt	ICHmw5/Vs01
ESSFdcw/Vh02	ESSFmh/Vs11	ESSFwh2/Vh	ESSFwm2/Vs10.2	ICHmk1/Vh	ICHmw5/Vs01.1
ESSFdcw/Vh02.1	ESSFmh/Vs12	ESSFwh2/Vh01	ESSFwm2/Vs13	ICHmk1/Vh01	ICHmw5/Vs01.2
ESSFdcw/Vh10	ESSFmh/Vs14	ESSFwh2/Vh01.1	ESSFwm2/Vt	ICHmk1/Vh01.1	ICHmw5/Vs02
ESSFdcw/Vh10.1	ESSFmh/Vt	ESSFwh2/Vh01.2	ESSFwm3/Vh	ICHmk1/Vh01.2	ICHmw5/Vs04
ESSFdcw/Vh10.2	ESSFmm1/Vh	ESSFwh2/Vh02	ESSFwm3/Vh01	ICHmk1/Vh11	ICHmw5/Vs10
ESSFdcw/Vh11	ESSFmm1/Vs	ESSFwh2/Vh02.1	ESSFwm3/Vh01.1	ICHmk1/Vs	ICHmw5/Vs10.1
ESSFdcw/Vs	ESSFmm1/Vt	ESSFwh2/Vh02.2	ESSFwm3/Vh01.2	ICHmk1/Vs02	ICHmw5/Vs10.2
ESSFdcw/Vs03	ESSFmm3/Vh	ESSFwh2/Vh03	ESSFwm3/Vh02	ICHmk1/Vs10	ICHmw5/Vs11
ESSFdcw/Vs10	ESSFmm3/Vs	ESSFwh2/Vh11	ESSFwm3/Vh02.1	ICHmk1/Vs10.1	ICHmw5/Vs12
ESSFdcw/Vt	ESSFmm3/Vt	ESSFwh2/Vs	ESSFwm3/Vh02.2	ICHmk1/Vs10.2	ICHmw5/Vs14
ESSFdk1/Vh	ESSFmmp/Vh	ESSFwh2/Vs01	ESSFwm3/Vh10	ICHmk1/Vs11	ICHmw5/Vt
ESSFdk1/Vh01	ESSFmmp/Vs	ESSFwh2/Vs01.1	ESSFwm3/Vh11	ICHmk1/Vs14	ICHvk1/Vh
ESSFdk1/Vh01.1	ESSFmmp/Vt	ESSFwh2/Vs01.2	ESSFwm3/Vs	ICHmk1/Vt	ICHvk1/Vs
ESSFdk1/Vh01.2	ESSFmmw/Vh	ESSFwh2/Vs02	ESSFwm3/Vs01	ICHmk4/Vh	ICHvk1/Vt
ESSFdk1/Vh02	ESSFmmw/Vs	ESSFwh2/Vs03	ESSFwm3/Vs01.1	ICHmk4/Vh01	ICHwk1/Vh
ESSFdk1/Vh02.1	ESSFmmw/Vt	ESSFwh2/Vs04	ESSFwm3/Vs01.2	ICHmk4/Vh01.1	ICHwk1/Vs
ESSFdk1/Vh02.2	ESSFvc/Vh	ESSFwh2/Vs10	ESSFwm3/Vs02	ICHmk4/Vh01.2	ICHwk1/Vt
ESSFdk1/Vh10	ESSFvc/Vs	ESSFwh2/Vs10.1	ESSFwm3/Vs03	ICHmk4/Vh03	ICHxw/Vh
ESSFdk1/Vh10.1	ESSFvc/Vt	ESSFwh2/Vs10.2	ESSFwm3/Vs10	ICHmk4/Vh11	ICHxw/Vs
ESSFdk1/Vh10.2	ESSFvcp/Vh	ESSFwh2/Vs11	ESSFwm3/Vs10.1	ICHmk4/Vs	ICHxw/Vt
ESSFdk1/Vh11	ESSFvcp/Vs	ESSFwh2/Vs13	ESSFwm3/Vs10.2	ICHmk4/Vs01	ICHxwa/Vh
ESSFdk1/Vh12	ESSFvcp/Vt	ESSFwh2/Vt	ESSFwm3/Vs13	ICHmk4/Vs01.1	ICHxwa/Vs
ESSFdk1/Vs	ESSFvcw/Vh	ESSFwh3/Vh	ESSFwm3/Vt	ICHmk4/Vs01.2	ICHxwa/Vt
ESSFdk1/Vs02	ESSFvcw/Vs	ESSFwh3/Vh01	ESSFwm4/Vh	ICHmk4/Vs02	IDFdm2/Vh
ESSFdk1/Vs03	ESSFvcw/Vt	ESSFwh3/Vh01.1	ESSFwm4/Vh01	ICHmk4/Vs04	IDFdm2/Vs
ESSFdk1/Vs10	ESSFwc2/Vh	ESSFwh3/Vh01.2	ESSFwm4/Vh01.1	ICHmk4/Vs10	IDFdm2/Vt
ESSFdk1/Vs11	ESSFwc2/Vs	ESSFwh3/Vh02	ESSFwm4/Vh01.2	ICHmk4/Vs10.1	IMAun/Vh
ESSFdk1/Vs12	ESSFwc2/Vt	ESSFwh3/Vh02.1	ESSFwm4/Vh02	ICHmk4/Vs10.2	IMAun/Vs
ESSFdk1/Vs13	ESSFwc4/Vh	ESSFwh3/Vh02.2	ESSFwm4/Vh02.1	ICHmk4/Vs11	IMAun/Vt
ESSFdk1/Vt	ESSFwc4/Vh01	ESSFwh3/Vh03	ESSFwm4/Vh02.2	ICHmk4/Vs12	MSdk/Vh
ESSFdk2/Vh	ESSFwc4/Vh01.1	ESSFwh3/Vh10	ESSFwm4/Vh10	ICHmk4/Vs14	MSdk/Vh01
ESSFdk2/Vh01	ESSFwc4/Vh02	ESSFwh3/Vh11	ESSFwm4/Vs	ICHmk4/Vt	MSdk/Vh01.1
ESSFdk2/Vh01.1	ESSFwc4/Vh02.1	ESSFwh3/Vs	ESSFwm4/Vs01	ICHmk5/Vh	MSdk/Vh01.2
ESSFdk2/Vh01.2	ESSFwc4/Vh11	ESSFwh3/Vs01	ESSFwm4/Vs01.1	ICHmk5/Vs	MSdk/Vh10
ESSFdk2/Vh02	ESSFwc4/Vs	ESSFwh3/Vs01.1	ESSFwm4/Vs01.2	ICHmk5/Vt	MSdk/Vh11
ESSFdk2/Vh02.1	ESSFwc4/Vs01	ESSFwh3/Vs01.2	ESSFwm4/Vs02	ICHmw1/Vh	MSdk/Vs
ESSFdk2/Vh02.2	ESSFwc4/Vs01.1	ESSFwh3/Vs02	ESSFwm4/Vs03	ICHmw1/Vs	MSdk/Vs02
ESSFdk2/Vh10	ESSFwc4/Vs02	ESSFwh3/Vs03	ESSFwm4/Vs10	ICHmw1/Vt	MSdk/Vs10
ESSFdk2/Vh11	ESSFwc4/Vs03	ESSFwh3/Vs04	ESSFwm4/Vs10.1	ICHmw2/Vh	MSdk/Vs10.1
ESSFdk2/Vs	ESSFwc4/Vs10	ESSFwh3/Vs10	ESSFwm4/Vs10.2	ICHmw2/Vh01	MSdk/Vs10.2

Avalanche Priority Ecosystem Crosswalk					
ESSFdk2/Vs01	ESSFwc4/Vs10.1	ESSFwh3/Vs10.1	ESSFwm4/Vs11	ICHmw2/Vh01.1	MSdk/Vs11
ESSFdk2/Vs01.1	ESSFwc4/Vs12	ESSFwh3/Vs10.2	ESSFwm4/Vs13	ICHmw2/Vh03	MSdk/Vs12
ESSFdk2/Vs01.2	ESSFwc4/Vt	ESSFwh3/Vs11	ESSFwm4/Vt	ICHmw2/Vh11	MSdk/Vs14
ESSFdk2/Vs02	ESSFwcp/Vh	ESSFwh3/Vs13	ESSFwmp/Vh	ICHmw2/Vs	MSdk/Vt
ESSFdk2/Vs03	ESSFwcp/Vs	ESSFwh3/Vt	ESSFwmp/Vs	ICHmw2/Vs01	MSdm1/Vh
ESSFdk2/Vs10	ESSFwcp/Vt	ESSFwm1/Vh	ESSFwmp/Vt	ICHmw2/Vs01.1	MSdm1/Vs
ESSFdk2/Vs10.1	ESSFwcw/Vh	ESSFwm1/Vh01	ESSFwmw/Vh	ICHmw2/Vs02	MSdm1/Vt
ESSFdk2/Vs10.2	ESSFwcw/Vh01	ESSFwm1/Vh01.1	ESSFwmw/Vh01	ICHmw2/Vs04	MSdw/Vh
ESSFdk2/Vs11	ESSFwcw/Vh01.1	ESSFwm1/Vh01.2	ESSFwmw/Vh01.1	ICHmw2/Vs10	MSdw/Vh01
ESSFdk2/Vs12	ESSFwcw/Vh01.2	ESSFwm1/Vh02	ESSFwmw/Vh01.2	ICHmw2/Vs10.1	MSdw/Vh01.1
ESSFdk2/Vt	ESSFwcw/Vh02	ESSFwm1/Vh02.1	ESSFwmw/Vh02	ICHmw2/Vs11	MSdw/Vh01.2
ESSFdkp/Vh	ESSFwcw/Vh02.1	ESSFwm1/Vh02.2	ESSFwmw/Vh02.1	ICHmw2/Vs12	MSdw/Vh10
ESSFdkp/Vs	ESSFwcw/Vh02.2	ESSFwm1/Vh03	ESSFwmw/Vh02.2	ICHmw2/Vs14	MSdw/Vh11
ESSFdkp/Vt	ESSFwcw/Vh10	ESSFwm1/Vh10	ESSFwmw/Vh10	ICHmw2/Vt	MSdw/Vh12
ESSFdkw/Vh	ESSFwcw/Vh11	ESSFwm1/Vh11	ESSFwmw/Vh11	ICHmw3/Vh	MSdw/Vs
ESSFdkw/Vh01	ESSFwcw/Vs	ESSFwm1/Vs	ESSFwmw/Vs	ICHmw3/Vs	MSdw/Vs02
ESSFdkw/Vh01.1	ESSFwcw/Vs01	ESSFwm1/Vs01	ESSFwmw/Vs01	ICHmw3/Vt	MSdw/Vs10
ESSFdkw/Vh01.2	ESSFwcw/Vs01.1	ESSFwm1/Vs01.1	ESSFwmw/Vs01.1	ICHmw4/Vh	MSdw/Vs10.1
ESSFdkw/Vh02	ESSFwcw/Vs01.2	ESSFwm1/Vs01.2	ESSFwmw/Vs01.2	ICHmw4/Vh01	MSdw/Vs10.2
ESSFdkw/Vh02.1	ESSFwcw/Vs03	ESSFwm1/Vs02	ESSFwmw/Vs03	ICHmw4/Vh01.1	MSdw/Vs11
ESSFdkw/Vh02.2	ESSFwcw/Vs10	ESSFwm1/Vs03	ESSFwmw/Vs10	ICHmw4/Vh01.2	MSdw/Vs12
ESSFdkw/Vh10	ESSFwcw/Vs10.2	ESSFwm1/Vs04	ESSFwmw/Vs10.2	ICHmw4/Vh03	MSdw/Vs13
ESSFdkw/Vh11	ESSFwcw/Vt	ESSFwm1/Vs10	ESSFwmw/Vs12	ICHmw4/Vh10	MSdw/Vs14
ESSFdkw/Vh12	ESSFwh1/Vh	ESSFwm1/Vs10.1	ESSFwmw/Vs13	ICHmw4/Vh11	MSdw/Vt
ESSFdkw/Vs	ESSFwh1/Vh01	ESSFwm1/Vs10.2	ESSFwmw/Vt	ICHmw4/Vs	
ESSFdkw/Vs03	ESSFdkw/Vs12	ESSFwm1/Vs11	ICHdm/Vh	ICHmw4/Vs01	

Table D-3: Cottonwood Floodplain Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Cottonwood Floodplain Priority Ecosystem Crosswalk					
ICHdm/Fm	ICHmk4/Fm01	ICHmw4/Fm01	ICHxwa/Fm	IDFdm2/Fm01	IDFxx2/Fm02
ICHdm/Fm01	ICHmk4/Fm02	ICHmw4/Fm02	ICHxwa/Fm01	IDFdm2/Fm02	IDFxx2/Fm07
ICHdm/Fm02	ICHmk5/Fm	ICHmw4/Fm04	IDFdh/Fm	IDFdm2/Fm07	MSdk/Fm
ICHdm/Fm04	ICHmk5/Fm01	ICHmw5/Fm	IDFdh/Fm05	IDFxk/Fm	MSdk/Fm01
ICHdw1/Fm	ICHmk5/Fm02	ICHmw5/Fm01	IDFdk5/Fm	IDFxk/Fm01	MSdk/Fm02
ICHdw1/Fm01	ICHmw1/Fm	ICHmw5/Fm02	IDFdk5/Fm01	IDFxk/Fm02	MSdm1/Fm
ICHdw1/Fm02	ICHmw2/Fm	ICHmw5/Fm04	IDFdk5/Fm02	IDFxk/Fm07	MSdm1/Fm02
ICHdw1/Fm04	ICHmw2/Fm01	ICHvk1/Fm	IDFdk5/Fm07	IDFxx1/Fm	MSdw/Fm
ICHmk1/Fm	ICHmw2/Fm02	ICHwk1/07	IDFdm1/Fm	IDFxx1/Fm01	MSdw/Fm01
ICHmk1/Fm01	ICHmw2/Fm04	ICHwk1/Fm	IDFdm1/Fm01	IDFxx1/Fm05	MSdw/Fm02
ICHmk1/Fm02	ICHmw3/Fm	ICHxw/Fm	IDFdm1/Fm05	IDFxx2/Fm	
ICHmk4/Fm	ICHmw4/Fm	ICHxw/Fm01	IDFdm2/Fm	IDFxx2/Fm01	

Table D-4: Grassland/Brushland Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Grassland/Brushland Priority Ecosystem Crosswalk					
ESSFdc1/Ga	ESSFwcw/Ag	ICHmw1/Gs	IDFdk5/Ga03$2	IDFdm2/Gg10$2.3	IDFxx2/Ga06
ESSFdc1/Gb	ESSFwcw/Ag01	ICHmw2/Ga	IDFdk5/Gb	IDFdm2/Gg10$3.3	IDFxx2/Gb
ESSFdc1/Gg	ESSFwcw/Gg	ICHmw2/Gb	IDFdk5/Gb01	IDFdm2/Gg12	IDFxx2/Gb04
ESSFdc1/Gs	ESSFwcw/Gg16	ICHmw2/Gb03	IDFdk5/Gg	IDFdm2/Gg12$2.3	IDFxx2/Gg
ESSFdcp/Ag	ESSFwm1/Ga	ICHmw2/Gg	IDFdk5/Gg01	IDFdm2/Gg12$2.4	IDFxx2/Gg01
ESSFdcp/Ag01	ESSFwm1/Gb	ICHmw2/Gg11	IDFdk5/Gg01$2.2	IDFdm2/Gg12$2.6	IDFxx2/Gg01$2.2
ESSFdcp/Ag03	ESSFwm1/Gb20	ICHmw2/Gs	IDFdk5/Gg02	IDFdm2/Gs	IDFxx2/Gg01$3.1
ESSFdcp/Gg	ESSFwm1/Gg	ICHmw3/Ga	IDFdk5/Gg02$2.2	IDFdm2/Gs12	IDFxx2/Gg02
ESSFdcw/Ag	ESSFwm1/Gg14	ICHmw3/Gb	IDFdk5/Gg02$2.3	IDFxk/Ga	IDFxx2/Gg02$2.2
ESSFdcw/Ag01	ESSFwm1/Gs	ICHmw3/Gg	IDFdk5/Gg02$3.2	IDFxk/Ga01	IDFxx2/Gg02$2.3
ESSFdcw/Ag03	ESSFwm2/Ga	ICHmw3/Gs	IDFdk5/Gg10	IDFxk/Ga01.1	IDFxx2/Gg02$3.2
ESSFdcw/Ga	ESSFwm2/Gb	ICHmw4/Ga	IDFdk5/Gg10$2.1	IDFxk/Ga01.2	IDFxx2/Gg10
ESSFdcw/Gb	ESSFwm2/Gg	ICHmw4/Gb	IDFdk5/Gg10$2.3	IDFxk/Ga02	IDFxx2/Gg10$2.1
ESSFdcw/Gg	ESSFwm2/Gs	ICHmw4/Gb03	IDFdk5/Gg12	IDFxk/Ga02.1	IDFxx2/Gg10$2.3
ESSFdcw/Gs	ESSFwm3/Ag	ICHmw4/Gg	IDFdk5/Gg12$2.3	IDFxk/Ga02.2	IDFxx2/Gg10$3.3
ESSFdk1/Ag	ESSFwm3/Ag01	ICHmw4/Gg11	IDFdk5/Gg12$2.4	IDFxk/Ga03	IDFxx2/Gg15
ESSFdk1/Ag01	ESSFwm3/Ga	ICHmw4/Gs	IDFdk5/Gg12$2.6	IDFxk/Ga03$2	IDFxx2/Gg15$2.1
ESSFdk1/Ga	ESSFwm3/Gb	ICHmw5/Ga	IDFdk5/Gs	IDFxk/Gb	IDFxx2/Gg15$2.2
ESSFdk1/Gb	ESSFwm3/Gg	ICHmw5/Gb	IDFdm1/Ga	IDFxk/Gb01	IDFxx2/Gg15$2.3
ESSFdk1/Gb20	ESSFwm3/Gg14	ICHmw5/Gg	IDFdm1/Ga03	IDFxk/Gg	IDFxx2/Gg15$2.4
ESSFdk1/Gg	ESSFwm3/Gg16	ICHmw5/Gg11	IDFdm1/Ga03$2	IDFxk/Gg01	IDFxx2/Gg15$2.5
ESSFdk1/Gg14	ESSFwm3/Gs	ICHmw5/Gg11$2.1	IDFdm1/Gb	IDFxk/Gg02	IDFxx2/Gg15$2.6
ESSFdk1/Gg16	ESSFwm4/Ag	ICHmw5/Gg11$2.4	IDFdm1/Gb03	IDFxk/Gg02$2.2	IDFxx2/Gg15$2.7
ESSFdk1/Gg17	ESSFwm4/Ag01	ICHmw5/Gs	IDFdm1/Gb04	IDFxk/Gg02$2.3	IDFxx2/Gg15a
ESSFdk1/Gg33	ESSFwm4/Ga	ICHxw/Ga	IDFdm1/Gg	IDFxk/Gg02$3.2	IDFxx2/Gg15b
ESSFdk1/Gs	ESSFwm4/Gb	ICHxw/Gb	IDFdm1/Gg02	IDFxk/Gg10	IDFxx2/Gs
ESSFdk2/Ga	ESSFwm4/Gg	ICHxw/Gb03	IDFdm1/Gg02$2.3	IDFxk/Gg10$2.1	IDFxx2/Gs12
ESSFdk2/Gb	ESSFwm4/Gg14	ICHxw/Gb05	IDFdm1/Gg11	IDFxk/Gg10$2.3	IDFxx2/Gs13
ESSFdk2/Gb20	ESSFwm4/Gg16	ICHxw/Gb06	IDFdm1/Gg11$2.1	IDFxk/Gg12	IMAun/Ag
ESSFdk2/Gg	ESSFwm4/Gs	ICHxw/Gg	IDFdm1/Gg11$2.4	IDFxk/Gg12$2.3	IMAun/Ag01
ESSFdk2/Gs	ESSFwmp/Ag	ICHxw/Gg11	IDFdm1/Gg11$3.1	IDFxk/Gg12$2.4	MSdk/Ga
ESSFdkp/Ag	ESSFwmp/Ag01	ICHxw/Gs	IDFdm1/Gg12	IDFxk/Gg12$2.6	MSdk/Gb
ESSFdkp/Ag01	ESSFwmp/Gg	ICHxwa/Ga	IDFdm1/Gg12$2.5	IDFxk/Gs	MSdk/Gb01
ESSFdkp/Gg	ESSFwmp/Gg16	ICHxwa/Gb	IDFdm1/Gg12.1	IDFxx1/Ga	MSdk/Gg
ESSFdkp/Gg14	ESSFwmw/Ag	ICHxwa/Gb03	IDFdm1/Gg13	IDFxx1/Ga03	MSdk/Gg14
ESSFdkp/Gg16	ESSFwmw/Ag01	ICHxwa/Gb05	IDFdm1/Gg13$2.2	IDFxx1/Ga03$2	MSdk/Gs
ESSFdkw/Ag	ESSFwmw/Gg	ICHxwa/Gb06	IDFdm1/Gg13$2.3	IDFxx1/Gb	MSdm1/Ga
ESSFdkw/Ag01	ESSFwmw/Gg14	ICHxwa/Gg	IDFdm1/Gg13$2.5	IDFxx1/Gb04	MSdm1/Gb
ESSFdkw/Gb20	ESSFwmw/Gg16	ICHxwa/Gg11	IDFdm1/Gg18	IDFxx1/Gb05	MSdm1/Gb21
ESSFdkw/Gg	ICHdm/Ga	ICHxwa/Gs	IDFdm1/Gs	IDFxx1/Gg	MSdm1/Gg

Grassland/Brushland Priority Ecosystem Crosswalk					
ESSFdkw/Gg14	ICHdm/Gb	IDFdh/Ga	IDFdm2/Ga	IDFxx1/Gg01	MSdm1/Gg11
ESSFdkw/Gg16	ICHdm/Gb03	IDFdh/Ga03	IDFdm2/Ga01	IDFxx1/Gg02	MSdm1/Gg11$2.1
ESSFdkw/Gg17	ICHdm/Gg	IDFdh/Ga03$2	IDFdm2/Ga01.1	IDFxx1/Gg02$2.3	MSdm1/Gg11$2.4
ESSFdkw/Gg33	ICHdm/Gg11	IDFdh/Gb	IDFdm2/Ga01.2	IDFxx1/Gg10	MSdm1/Gg11$3.1
ESSFmh/Ga	ICHdm/Gs	IDFdh/Gb03	IDFdm2/Ga02	IDFxx1/Gg11	MSdm1/Gg18
ESSFmh/Gb	ICHdw1/Ga	IDFdh/Gb04	IDFdm2/Ga02.1	IDFxx1/Gg11$2.1	MSdm1/Gs
ESSFmh/Gb21	ICHdw1/Gb	IDFdh/Gg	IDFdm2/Ga02.2	IDFxx1/Gg11$2.4	MSdm1/Gs06
ESSFmh/Gg	ICHdw1/Gb03	IDFdh/Gg01	IDFdm2/Ga03	IDFxx1/Gg13	MSdm1/Gs06$3.2
ESSFmh/Gg11	ICHdw1/Gg	IDFdh/Gg02	IDFdm2/Ga03$2	IDFxx1/Gg13$2.2	MSdw/Ga
ESSFmh/Gg11$2.4	ICHdw1/Gg11	IDFdh/Gg02$2.3	IDFdm2/Gb	IDFxx1/Gg13$2.3	MSdw/Gb
ESSFmh/Gs	ICHdw1/Gs	IDFdh/Gg10	IDFdm2/Gb02	IDFxx1/Gg13$2.5	MSdw/Gb01
ESSFwc2/Ga	ICHmk1/Ga	IDFdh/Gg11	IDFdm2/Gb04	IDFxx1/Gg26	MSdw/Gb04
ESSFwc2/Gb	ICHmk1/Gb	IDFdh/Gg11$2.1	IDFdm2/Gg	IDFxx1/Gs	MSdw/Gg
ESSFwc2/Gg	ICHmk1/Gb21	IDFdh/Gg11$2.4	IDFdm2/Gg01	IDFxx2/Ga	MSdw/Gg12
ESSFwc2/Gs	ICHmk1/Gg	IDFdh/Gg13	IDFdm2/Gg01$2.2	IDFxx2/Ga01	MSdw/Gg12$2.3
ESSFwc4/Ga	ICHmk1/Gg11	IDFdh/Gg13$2.2	IDFdm2/Gg01$3.1	IDFxx2/Ga01.1	MSdw/Gg12$2.4
ESSFwc4/Gb	ICHmk1/Gg11$2.1	IDFdh/Gg13$2.3	IDFdm2/Gg02	IDFxx2/Ga01.2	MSdw/Gg12$2.6
ESSFwc4/Gg	ICHmk1/Gg11$2.4	IDFdh/Gg13$2.5	IDFdm2/Gg02$2.2	IDFxx2/Ga02	MSdw/Gg14
ESSFwc4/Gs	ICHmk1/Gs	IDFdh/Gg26	IDFdm2/Gg02$2.3	IDFxx2/Ga02.1	MSdw/Gg17
ESSFwcp/Ag	ICHmw1/Ga	IDFdh/Gs	IDFdm2/Gg02$3.2	IDFxx2/Ga02.2	MSdw/Gs
ESSFwcp/Ag01	ICHmw1/Gb	IDFdk5/Ga	IDFdm2/Gg10	IDFxx2/Ga03	
ESSFwcp/Gg	ICHmw1/Gg	IDFdk5/Ga03	IDFdm2/Gg10$2.1	IDFxx2/Ga03$2	

Table D-5: High Elevation Meadow/Parkland Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

High Elevation Meadow/Parkland Priority Ecosystem Crosswalk					
ESSFdcp/Af	ESSFdcp/Af	ESSFmmp/Ag	ESSFvcp/Az	ESSFwcp/Sc03	ESSFwmw/Aff
ESSFdcp/Aff	ESSFdkp/Afm	ESSFdkp/Afm	ESSFvcp/Sc	ESSFwcp/Sk	ESSFwmw/Afm
ESSFdcp/Afm	ESSFdkp/Afr	ESSFmmp/Ah	ESSFmmp/Ah	ESSFwcw/Af	ESSFwmw/Afr
ESSFdcp/Afr	ESSFdkp/Afs	ESSFmmp/Am	ESSFvcp/Sc01	ESSFvcp/Sc01	ESSFwmw/Afs
ESSFdcp/Afs	ESSFdkp/Ag	ESSFmmp/As	ESSFvcp/Sc02	ESSFwcw/Aff	ESSFwcw/Aff
ESSFdcp/Ag	ESSFdkp/Ag01	ESSFmmp/At	ESSFvcp/Sc03	ESSFwcw/Afm	ESSFwmw/Ag
ESSFdcp/Ag01	ESSFdkp/Ah	ESSFmmp/Az	ESSFvcp/Sk	ESSFwcw/Afr	ESSFwmw/Ag01
ESSFdcp/Ag03	ESSFdkp/Am	ESSFmmp/Sc	ESSFvcw/Af	ESSFwcw/Afs	ESSFwmw/Ah
ESSFdcp/Ah	ESSFdkp/As	ESSFmmp/Sc01	ESSFvcw/Aff	ESSFwcw/Ag	ESSFwmw/Am
ESSFdcp/Am	ESSFdkp/At	ESSFmmp/Sc02	ESSFvcw/Afm	ESSFwcw/Ag01	ESSFwmw/As
ESSFdcp/As	ESSFdkp/Az	ESSFmmp/Sc03	ESSFvcw/Afr	ESSFwcw/Ah	ESSFwmw/At
ESSFdcp/At	ESSFdkp/Sc	ESSFmmp/Sk	ESSFvcw/Afs	ESSFwcw/Am	ESSFwmw/Az
ESSFdcp/Az	ESSFdkp/Sc01	ESSFmmw/Af	ESSFvcw/Ag	ESSFwcw/As	ESSFwmw/Sc
ESSFdcp/Sc	ESSFdkp/Sc02	ESSFmmw/Aff	ESSFvcw/Ah	ESSFwcw/At	ESSFwmw/Sc01
ESSFdcp/Sc01	ESSFdkp/Sc03	ESSFmmw/Afm	ESSFvcw/Am	ESSFwcw/Az	ESSFwmw/Sc02
ESSFdcp/Sc02	ESSFdkp/Sk	ESSFmmw/Afr	ESSFvcw/As	ESSFwcw/Sc	ESSFwmw/Sc03

High Elevation Meadow/Parkland Priority Ecosystem Crosswalk					
ESSFdcp/Sc03	ESSFdkw/Af	ESSFmmw/Afs	ESSFvcw/At	ESSFwcw/Sc01	ESSFwmw/Sk
ESSFdcp/Sk	ESSFdkw/Aff	ESSFmmw/Ag	ESSFvcw/Az	ESSFwcw/Sc02	IMAun/Af
ESSFdcw/Af	ESSFdkw/Afm	ESSFmmw/Ah	ESSFvcw/Sc	ESSFwcw/Sc03	IMAun/Aff
ESSFdcw/Aff	ESSFdkw/Afr	ESSFmmw/Am	ESSFvcw/Sc01	ESSFwcw/Sk	IMAun/Afm
ESSFdcw/Afm	ESSFdkw/Afs	ESSFmmw/As	ESSFvcw/Sc02	ESSFwmp/Af	IMAun/Afr
ESSFdcw/Afr	ESSFdkw/Ag	ESSFmmw/At	ESSFvcw/Sc03	ESSFwmp/Aff	IMAun/Afs
ESSFdcw/Afs	ESSFdkw/Ag01	ESSFmmw/Az	ESSFvcw/Sk	ESSFwmp/Afm	IMAun/Ag
ESSFdcw/Ag	ESSFdkw/Ah	ESSFmmw/Sc	ESSFwcp/Af	ESSFwmp/Afr	IMAun/Ag01
ESSFdcw/Ag01	ESSFdkw/Am	ESSFmmw/Sc01	ESSFwcp/Aff	ESSFwmp/Afs	IMAun/Ah
ESSFdcw/Ag03	ESSFdkw/As	ESSFmmw/Sc02	ESSFwcp/Afm	ESSFwmp/Ag	IMAun/Am
ESSFdcw/Ah	ESSFdkw/At	ESSFmmw/Sc03	ESSFwcp/Afr	ESSFwmp/Ag01	IMAun/As
ESSFdcw/Am	ESSFdkw/Az	ESSFmmw/Sk	ESSFwcp/Afs	ESSFwmp/Ah	IMAun/At
ESSFdcw/As	ESSFdkw/Sc	ESSFvcp/Af	ESSFwcp/Ag	ESSFwmp/Am	IMAun/Az
ESSFdcw/At	ESSFdkw/Sc01	ESSFvcp/Aff	ESSFwcp/Ag01	ESSFwmp/As	IMAun/Sc
ESSFdcw/Az	ESSFdkw/Sc02	ESSFvcp/Afm	ESSFwcp/Ah	ESSFwmp/At	IMAun/Sc01
ESSFdcw/Sc	ESSFdkw/Sc03	ESSFvcp/Afr	ESSFwcp/Am	ESSFwmp/Az	IMAun/Sc02
ESSFdcw/Sc01	ESSFdkw/Sk	ESSFvcp/Afs	ESSFwcp/As	ESSFwmp/Sc	IMAun/Sc03
ESSFdcw/Sc02	ESSFmmp/Af	ESSFvcp/Ag	ESSFwcp/At	ESSFwmp/Sc01	IMAun/Sk
ESSFdcw/Sc03	ESSFmmp/Aff	ESSFvcp/Ah	ESSFwcp/Az	ESSFwmp/Sc02	
ESSFdcw/Sk	ESSFmmp/Afm	ESSFvcp/Am	ESSFwcp/Sc	ESSFwmp/Sc03	
ESSFdkp/Af	ESSFmmp/Afr	ESSFvcp/As	ESSFwcp/Sc01	ESSFwmp/Sk	
ESSFdkp/Aff	ESSFmmp/Afs	ESSFvcp/At	ESSFwcp/Sc02	ESSFwmw/Af	

Table D-6: Huckleberry Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Huckleberry Priority Ecosystem Crosswalk					
ESSFdc1/102	ESSFmh/Ro10	ESSFwh1/103	ESSFwm1/Ro10	ESSFwmw/103	ICHmw4/Ro10
ESSFdc1/Ro10	ESSFmh/Vs12	ESSFwh1/104	ESSFwm1/Vs12	ESSFwmw/Ro10	ICHmw4/Vs13
ESSFdc1/Vs12	ESSFmm1/02	ESSFwh1/Ro10	ESSFwm1/Vs13	ESSFwmw/Vs12	ICHmw5/112
ESSFdcw/Ro10	ESSFmm3/103	ESSFwh1/Vs12	ESSFwm2/102	ESSFwmw/Vs13	ICHmw5/Ro10
ESSFdk1/Ro10	ESSFwc2/02	ESSFwh2/102	ESSFwm2/104	ICHdm/Ro10	ICHmw5/Vs12
ESSFdk1/Vs12	ESSFwc2/03	ESSFwh2/103	ESSFwm2/Ro10	ICHdm/Vs13	MSdk/Vs12
ESSFdk1/Vs13	ESSFwc4/102	ESSFwh2/104	ESSFwm2/Vs13	ICHdw1/Ro10	MSdw/Vs12
ESSFdk2/Ro10	ESSFwc4/103	ESSFwh2/Ro10	ESSFwm3/102	ICHmk4/Ro10	MSdw/Vs13
ESSFdk2/Vs12	ESSFwc4/Ro10	ESSFwh2/Vs13	ESSFwm3/104	ICHmk4/Vs12	
ESSFdkw/Ro10	ESSFwc4/Vs12	ESSFwh3/103	ESSFwm3/Ro10	ICHmw2/112	
ESSFdkw/Vs12	ESSFwcw/102	ESSFwh3/Ro10	ESSFwm3/Vs13	ICHmw2/Ro10	
ESSFdkw/Vs13	ESSFwcw/Ro10	ESSFwh3/Vs13	ESSFwm4/Ro10	ICHmw2/Vs12	
ESSFmh/103	ESSFwh1/102	ESSFwm1/103	ESSFwm4/Vs13	ICHmw4/111	

Table D-7: Open Forest Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Open Forest Priority Ecosystem Crosswalk					
ICHdm/102	ICHmk4/102	ICHxwa/102	IDFdm1/102	IDFxx1/102	MSdm1/102
ICHdm/103	ICHmk4/103	ICHxwa/103	IDFdm1/103	IDFxx1/103	MSdm1/103
ICHdw1/102	ICHmk5/102	IDFdh/102	IDFdm2/102	IDFxx2/102	MSdw/102
ICHdw1/103	ICHmk5/103	IDFdh/103	IDFdm2/103	IDFxx2/103	MSdw/103
ICHmk1/102	ICHxw/102	IDFdk5/102	IDFxk/102	MSdk/102	
ICHmk1/103	ICHxw/103	IDFdk5/103	IDFxk/103	MSdk/103	

Table D-8: Riparian Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Riparian Priority Ecosystem Crosswalk					
ESSFdc1/112a	ESSFwc4/Fh	ICHdw1/Fl02	ICHmw4/Fa	IDFdk5/Ff	IDFxx1/Fh
ESSFdc1/Fa	ESSFwc4/Fl	ICHdw1/Fl04	ICHmw4/Ff	IDFdk5/Ff01	IDFxx1/Fl
ESSFdc1/Ff	ESSFwc4/Fm	ICHdw1/Fl06	ICHmw4/Fh	IDFdk5/Ff01a	IDFxx1/Fl03
ESSFdc1/Ff01	ESSFwh1/111a	ICHdw1/Fm	ICHmw4/Fl	IDFdk5/Ff01b	IDFxx1/Fl06
ESSFdc1/Ff01a	ESSFwh1/Fa	ICHdw1/Fm01	ICHmw4/Fl01	IDFdk5/Fh	IDFxx1/Fm
ESSFdc1/Fh	ESSFwh1/Ff	ICHdw1/Fm02	ICHmw4/Fl02	IDFdk5/Fl	IDFxx1/Fm01
ESSFdc1/Fl	ESSFwh1/Fh	ICHdw1/Fm04	ICHmw4/Fl04	IDFdk5/Fl01	IDFxx1/Fm05
ESSFdc1/Fl05	ESSFwh1/Fl	ICHmk1/07	ICHmw4/Fm	IDFdk5/Fl02	IDFxx2/112a
ESSFdc1/Fm	ESSFwh1/Fl01	ICHmk1/Fa	ICHmw4/Fm01	IDFdk5/Fl03	IDFxx2/Fa
ESSFdc2/Fa	ESSFwh1/Fl02	ICHmk1/Ff	ICHmw4/Fm02	IDFdk5/Fl05	IDFxx2/Ff
ESSFdc2/Ff	ESSFwh1/Fm	ICHmk1/Ff01	ICHmw5/Fa	IDFdk5/Fl06	IDFxx2/Ff01
ESSFdc2/Fh	ESSFwh2/112a	ICHmk1/Ff01a	ICHmw5/Ff	IDFdk5/Fm	IDFxx2/Ff01a
ESSFdc2/Fl	ESSFwh2/Fa	ICHmk1/Fh	ICHmw5/Ff01	IDFdk5/Fm01	IDFxx2/Ff01b
ESSFdc2/Fm	ESSFwh2/Ff	ICHmk1/Fl	ICHmw5/Ff01a	IDFdk5/Fm02	IDFxx2/Fh
ESSFdk1/111a	ESSFwh2/Fh	ICHmk1/Fl01	ICHmw5/Fh	IDFdk5/Fm07	IDFxx2/Fl
ESSFdk1/Fa	ESSFwh2/Fl	ICHmk1/Fl02	ICHmw5/Fl	IDFdm1/112	IDFxx2/Fl01
ESSFdk1/Ff	ESSFwh2/Fl01	ICHmk1/Fl04	ICHmw5/Fl01	IDFdm1/Fa	IDFxx2/Fl03
ESSFdk1/Fh	ESSFwh2/Fm	ICHmk1/Fl05	ICHmw5/Fl02	IDFdm1/Ff	IDFxx2/Fl06
ESSFdk1/Fl	ESSFwh3/112a	ICHmk1/Fm	ICHmw5/Fl04	IDFdm1/Ff01	IDFxx2/Fm
ESSFdk1/Fl01	ESSFwh3/Fa	ICHmk1/Fm01	ICHmw5/Fl05	IDFdm1/Ff01a	IDFxx2/Fm01
ESSFdk1/Fl05	ESSFwh3/Ff	ICHmk1/Fm02	ICHmw5/Fm	IDFdm1/Ff01b	IDFxx2/Fm02
ESSFdk1/Fm	ESSFwh3/Fh	ICHmk4/112	ICHmw5/Fm01	IDFdm1/Fh	IDFxx2/Fm07
ESSFdk2/112a	ESSFwh3/Fl	ICHmk4/Fa	ICHmw5/Fm02	IDFdm1/Fl	MSdk/111a
ESSFdk2/Fa	ESSFwh3/Fl01	ICHmk4/Ff	ICHmw5/Fm04	IDFdm1/Fl01	MSdk/112a
ESSFdk2/Ff	ESSFwh3/Fm	ICHmk4/Fh	ICHvk1/Fa	IDFdm1/Fl03	MSdk/Fa
ESSFdk2/Fh	ESSFwm1/Fa	ICHmk4/Fl	ICHvk1/Ff	IDFdm1/Fl05	MSdk/Ff
ESSFdk2/Fl	ESSFwm1/Ff	ICHmk4/Fl01	ICHvk1/Fh	IDFdm1/Fm	MSdk/Ff01
ESSFdk2/Fl01	ESSFwm1/Fh	ICHmk4/Fl02	ICHvk1/Fl	IDFdm1/Fm01	MSdk/Ff01a
ESSFdk2/Fl05	ESSFwm1/Fl	ICHmk4/Fl04	ICHvk1/Fl01	IDFdm1/Fm05	MSdk/Fh
ESSFdk2/Fm	ESSFwm1/Fl01	ICHmk4/Fl05	ICHvk1/Fm	IDFdm2/112a	MSdk/Fl
ESSFmh/112a	ESSFwm1/Fl05	ICHmk4/Fm	ICHwk1/07	IDFdm2/Fa	MSdk/Fl01
ESSFmh/Fa	ESSFwm1/Fm	ICHmk4/Fm01	ICHwk1/Fa	IDFdm2/Ff	MSdk/Fl02

Riparian Priority Ecosystem Crosswalk					
ESSFmh/Ff	ESSFwm2/112a	ICHmk4/Fm02	ICHwk1/Ff	IDFdm2/Ff01	MSdk/Fl04
ESSFmh/Ff01	ESSFwm2/Fa	ICHmk5/112	ICHwk1/Fh	IDFdm2/Ff01a	MSdk/Fm
ESSFmh/Ff01a	ESSFwm2/Ff	ICHmk5/Fa	ICHwk1/Fl	IDFdm2/Ff01b	MSdk/Fm01
ESSFmh/Fh	ESSFwm2/Fh	ICHmk5/Ff	ICHwk1/Fl02	IDFdm2/Fh	MSdk/Fm02
ESSFmh/Fl	ESSFwm2/Fl	ICHmk5/Fh	ICHwk1/Fm	IDFdm2/Fl	MSdm1/113a
ESSFmh/Fl01	ESSFwm2/Fm	ICHmk5/Fl	ICHxw/Fa	IDFdm2/Fl01	MSdm1/Fa
ESSFmh/Fl02	ESSFwm3/112a	ICHmk5/Fm	ICHxw/Ff	IDFdm2/Fl03	MSdm1/Ff
ESSFmh/Fl04	ESSFwm3/Fa	ICHmk5/Fm01	ICHxw/Fh	IDFdm2/Fl05	MSdm1/Ff01
ESSFmh/Fl05	ESSFwm3/Ff	ICHmk5/Fm02	ICHxw/Fl	IDFdm2/Fl06	MSdm1/Ff01a
ESSFmh/Fm	ESSFwm3/Fh	ICHmw1/07	ICHxw/Fl06	IDFdm2/Fm	MSdm1/Fh
ESSFmm1/Fa	ESSFwm3/Fl	ICHmw1/Fa	ICHxw/Fm	IDFdm2/Fm01	MSdm1/Fl
ESSFmm1/Ff	ESSFwm3/Fm	ICHmw1/Ff	ICHxw/Fm01	IDFdm2/Fm02	MSdm1/Fl01
ESSFmm1/Fh	ESSFwm4/Fa	ICHmw1/Fh	ICHxwa/Fa	IDFdm2/Fm07	MSdm1/Fl05
ESSFmm1/Fl	ESSFwm4/Ff	ICHmw1/Fl	ICHxwa/Ff	IDFxk/113a	MSdm1/Fm
ESSFmm1/Fm	ESSFwm4/Fh	ICHmw1/Fm	ICHxwa/Fh	IDFxk/Fa	MSdm1/Fm02
ESSFmm3/Fa	ESSFwm4/Fl	ICHmw2/Fa	ICHxwa/Fl	IDFxk/Ff	MSdw/111a
ESSFmm3/Ff	ESSFwm4/Fm	ICHmw2/Ff	ICHxwa/Fl06	IDFxk/Ff01	MSdw/Fa
ESSFmm3/Fh	ICHdm/Fa	ICHmw2/Fh	ICHxwa/Fm	IDFxk/Ff01a	MSdw/Ff
ESSFmm3/Fl	ICHdm/Ff	ICHmw2/Fl	ICHxwa/Fm01	IDFxk/Fh	MSdw/Ff01
ESSFmm3/Fm	ICHdm/Fh	ICHmw2/Fl01	IDFdh/Fa	IDFxk/Fl	MSdw/Ff01a
ESSFvc/Fa	ICHdm/Fl	ICHmw2/Fl02	IDFdh/Ff	IDFxk/Fl01b	MSdw/Fh
ESSFvc/Ff	ICHdm/Fl01	ICHmw2/Fl04	IDFdh/Ff01	IDFxk/Fl02	MSdw/Fl
ESSFvc/Fh	ICHdm/Fl02	ICHmw2/Fl06	IDFdh/Ff01a	IDFxk/Fl03	MSdw/Fl01
ESSFvc/Fl	ICHdm/Fl04	ICHmw2/Fm	IDFdh/Ff01b	IDFxk/Fl06	MSdw/Fl02
ESSFvc/Fm	ICHdm/Fm	ICHmw2/Fm01	IDFdh/Fh	IDFxk/Fm	MSdw/Fl04
ESSFwc2/Fa	ICHdm/Fm01	ICHmw2/Fm02	IDFdh/Fl	IDFxk/Fm01	MSdw/Fl05
ESSFwc2/Ff	ICHdm/Fm02	ICHmw2/Fm04	IDFdh/Fl03	IDFxk/Fm02	MSdw/Fm
ESSFwc2/Fh	ICHdm/Fm04	ICHmw3/Fa	IDFdh/Fl06	IDFxk/Fm07	MSdw/Fm01
ESSFwc2/Fl	ICHdw1/Fa	ICHmw3/Ff	IDFdh/Fm	IDFxx1/Fa	MSdw/Fm02
ESSFwc2/Fm	ICHdw1/Ff	ICHmw3/Fh	IDFdh/Fm01	IDFxx1/Ff	
ESSFwc4/112a	ICHdw1/Fh	ICHmw3/Fl	IDFdh/Fm05	IDFxx1/Ff01	
ESSFwc4/Fa	ICHdw1/Fl	ICHmw3/Fm	IDFdk5/111a	IDFxx1/Ff01a	
ESSFwc4/Ff	ICHdw1/Fl01	ICHmw4/114	IDFdk5/Fa	IDFxx1/Ff01b	

Table D-9: Rock Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Rock Priority Ecosystem Crosswalk					
ESSFdc1/102	ESSFmm1/Rt	ESSFwh3/Rt07.2	ICHdw1/Ro	ICHvk1/Rc	IDFxk/102a
ESSFdc1/Rc	ESSFmm3/102	ESSFwm1/102	ICHdw1/Ro05	ICHvk1/Ro	IDFxk/Rc
ESSFdc1/Ro	ESSFmm3/Rc	ESSFwm1/Rc	ICHdw1/Ro05.1	ICHvk1/Rt	IDFxk/Ro
ESSFdc1/Ro06	ESSFmm3/Ro	ESSFwm1/Ro	ICHdw1/Ro09	ICHwk1/Rc	IDFxk/Ro01
ESSFdc1/Ro06.1	ESSFmm3/Rt	ESSFwm1/Ro06	ICHdw1/Ro09.1	ICHwk1/Ro	IDFxk/Ro01.1
ESSFdc1/Ro06.2	ESSFmmp/Rc	ESSFwm1/Ro07	ICHdw1/Ro09.2	ICHwk1/Ro09/02	IDFxk/Ro01.2
ESSFdc1/Ro08	ESSFmmp/Ro	ESSFwm1/Ro10	ICHdw1/Ro10	ICHwk1/Rt	IDFxk/Ro02

Rock Priority Ecosystem Crosswalk					
ESSFdc1/Ro10	ESSFmmp/Rt	ESSFwm1/Ro11	ICHdw1/Rt	ICHxw/102	IDFxk/Ro05
ESSFdc1/Ro11	ESSFmmw/Rc	ESSFwm1/Rt	ICHdw1/Rt01	ICHxw/Rc	IDFxk/Ro05.1
ESSFdc1/Rt	ESSFmmw/Ro	ESSFwm1/Rt01	ICHdw1/Rt02	ICHxw/Ro	IDFxk/Rt
ESSFdc1/Rt01	ESSFmmw/Rt	ESSFwm1/Rt02	ICHdw1/Rt03	ICHxw/Ro05	IDFxk/Rt01
ESSFdc1/Rt07	ESSFvc/02	ESSFwm1/Rt07	ICHdw1/Rt06	ICHxw/Ro05.1	IDFxk/Rt04
ESSFdc2/102	ESSFvc/Rc	ESSFwm1/Rt07.1	ICHdw1/Rt08	ICHxw/Ro09	IDFxx1/102
ESSFdc2/Rc	ESSFvc/Ro	ESSFwm1/Rt07.2	ICHmk1/102	ICHxw/Ro09.1	IDFxx1/Rc
ESSFdc2/Ro	ESSFvc/Rt	ESSFwm1/Rt20	ICHmk1/Rc	ICHxw/Ro09.2	IDFxx1/Ro
ESSFdc2/Ro06	ESSFvcp/Rc	ESSFwm1/Rt21	ICHmk1/Ro	ICHxw/Rt	IDFxx1/Ro01
ESSFdc2/Ro06.1	ESSFvcp/Ro	ESSFwm2/102	ICHmk1/Ro05	ICHxw/Rt01	IDFxx1/Ro01.1
ESSFdc2/Ro06.2	ESSFvcp/Rt	ESSFwm2/Rc	ICHmk1/Ro05.1	ICHxw/Rt02	IDFxx1/Ro01.2
ESSFdc2/Ro11	ESSFvcw/Rc	ESSFwm2/Ro	ICHmk1/Ro09	ICHxw/Rt03	IDFxx1/Ro04
ESSFdc2/Rt	ESSFvcw/Ro	ESSFwm2/Ro06	ICHmk1/Ro09.1	ICHxw/Rt06	IDFxx1/Ro04.1
ESSFdc2/Rt11	ESSFvcw/Rt	ESSFwm2/Ro06.1	ICHmk1/Ro09.2	ICHxwa/102	IDFxx1/Ro04.2
ESSFdc2/Rt20	ESSFwc2/02	ESSFwm2/Ro10	ICHmk1/Rt	ICHxwa/Ro	IDFxx1/Rt
ESSFdcp/Rc	ESSFwc2/Rc	ESSFwm2/Ro11	ICHmk1/Rt01	ICHxwa/Ro05	IDFxx1/Rt01
ESSFdcp/Ro	ESSFwc2/Ro	ESSFwm2/Ro12	ICHmk1/Rt02	ICHxwa/Ro05.1	IDFxx1/Rt04
ESSFdcp/Ro06	ESSFwc2/Rt	ESSFwm2/Rt	ICHmk1/Rt03	ICHxwa/Ro09	IDFxx1/Rt06
ESSFdcp/Ro06.1	ESSFwc4/102	ESSFwm2/Rt01	ICHmk1/Rt07	ICHxwa/Ro09.1	IDFxx2/102
ESSFdcp/Ro06.2	ESSFwc4/Rc	ESSFwm2/Rt02	ICHmk1/Rt07.1	ICHxwa/Ro09.2	IDFxx2/Rc
ESSFdcp/Rt	ESSFwc4/Ro	ESSFwm2/Rt07	ICHmk1/Rt07.2	ICHxwa/Rt	IDFxx2/Ro
ESSFdcw/102	ESSFwc4/Ro06	ESSFwm2/Rt07.1	ICHmk1/Rt08	ICHxwa/Rt01	IDFxx2/Ro01
ESSFdcw/Rc	ESSFwc4/Ro10	ESSFwm2/Rt07.2	ICHmk4/102	ICHxwa/Rt02	IDFxx2/Ro01.1
ESSFdcw/Ro	ESSFwc4/Ro11	ESSFwm2/Rt21	ICHmk4/102a	ICHxwa/Rt03	IDFxx2/Ro01.2
ESSFdcw/Ro06	ESSFwc4/Ro12	ESSFwm3/102	ICHmk4/Rc	ICHxwa/Rt06	IDFxx2/Ro02
ESSFdcw/Ro06,2	ESSFwc4/Rt	ESSFwm3/Rc	ICHmk4/Ro	ICHxwa/Rt08	IDFxx2/Ro03
ESSFdcw/Ro06.1	ESSFwc4/Rt01	ESSFwm3/Ro	ICHmk4/Ro05	IDFdh/102	IDFxx2/Rt
ESSFdcw/Ro10	ESSFwc4/Rt02	ESSFwm3/Ro06	ICHmk4/Ro05.1	IDFdh/Rc	IDFxx2/Rt01
ESSFdcw/Ro11	ESSFwc4/Rt07	ESSFwm3/Ro06.1	ICHmk4/Ro09	IDFdh/Ro	IDFxx2/Rt04
ESSFdcw/Rt	ESSFwc4/Rt07.1	ESSFwm3/Ro10	ICHmk4/Ro09.1	IDFdh/Ro01	IMAun/Rc
ESSFdcw/Rt01	ESSFwc4/Rt21	ESSFwm3/Ro11	ICHmk4/Ro09.2	IDFdh/Ro01.1	IMAun/Ro
ESSFdk1/102	ESSFwcp/Rc	ESSFwm3/Ro12	ICHmk4/Ro10	IDFdh/Ro01.2	IMAun/Rt
ESSFdk1/Rc	ESSFwcp/Ro	ESSFwm3/Rt	ICHmk4/Rt	IDFdh/Ro04	MSdk/102
ESSFdk1/Ro	ESSFwcp/Ro06	ESSFwm3/Rt01	ICHmk4/Rt01	IDFdh/Ro04.1	MSdk/Rc
ESSFdk1/Ro06	ESSFwcp/Ro10	ESSFwm3/Rt02	ICHmk4/Rt02	IDFdh/Ro04.2	MSdk/Ro
ESSFdk1/Ro07	ESSFwcp/Ro11	ESSFwm3/Rt07	ICHmk4/Rt03	IDFdh/Rt	MSdk/Ro01
ESSFdk1/Ro10	ESSFwcp/Rt	ESSFwm3/Rt07.1	ICHmk4/Rt07	IDFdh/Rt01	MSdk/Ro01.1
ESSFdk1/Ro11	ESSFwcw/102	ESSFwm3/Rt07.2	ICHmk4/Rt07.1	IDFdh/Rt04	MSdk/Ro01.2
ESSFdk1/Rt	ESSFwcw/Rc	ESSFwm3/Rt21	ICHmk4/Rt07.2	IDFdh/Rt06	MSdk/Ro05
ESSFdk1/Rt01	ESSFwcw/Ro	ESSFwm4/102	ICHmk4/Rt08	IDFdk5/102	MSdk/Ro05.1
ESSFdk1/Rt07	ESSFwcw/Ro06	ESSFwm4/102a	ICHmk4/Rt20	IDFdk5/Rc	MSdk/Ro09
ESSFdk1/Rt07.1	ESSFwcw/Ro06.1	ESSFwm4/Rc	ICHmk5/102	IDFdk5/Ro	MSdk/Ro11
ESSFdk1/Rt07.2	ESSFwcw/Ro10	ESSFwm4/Ro	ICHmk5/Rc	IDFdk5/Ro01	MSdk/Rt

Rock Priority Ecosystem Crosswalk					
ESSFdk1/Rt20	ESSFwcw/Ro11	ESSFwm4/Ro06	ICHmk5/Ro	IDFdk5/Ro01.1	MSdk/Rt01
ESSFdk1/Rt21	ESSFwcw/Ro12	ESSFwm4/Ro06.1	ICHmk5/Rt	IDFdk5/Ro01.2	MSdk/Rt02
ESSFdk2/102	ESSFwcw/Rt	ESSFwm4/Ro09	ICHmw1/02	IDFdk5/Ro02	MSdk/Rt03
ESSFdk2/Rc	ESSFwcw/Rt01	ESSFwm4/Ro09.1	ICHmw1/Rc	IDFdk5/Ro05	MSdk/Rt04
ESSFdk2/Ro	ESSFwcw/Rt21	ESSFwm4/Ro09.2	ICHmw1/Ro	IDFdk5/Ro05.1	MSdk/Rt07
ESSFdk2/Ro06	ESSFwh1/102	ESSFwm4/Ro10	ICHmw1/Rt	IDFdk5/Rt	MSdk/Rt07.1
ESSFdk2/Ro07	ESSFwh1/Rc	ESSFwm4/Ro11	ICHmw2/102	IDFdk5/Rt01	MSdk/Rt07.2
ESSFdk2/Ro10	ESSFwh1/Ro	ESSFwm4/Ro12	ICHmw2/Rc	IDFdk5/Rt03	MSdk/Rt08
ESSFdk2/Ro11	ESSFwh1/Ro06	ESSFwm4/Rt	ICHmw2/Ro	IDFdk5/Rt04	MSdk/Rt20
ESSFdk2/Rt	ESSFwh1/Ro06.1	ESSFwm4/Rt01	ICHmw2/Ro05	IDFdk5/Rt06	MSdm1/102
ESSFdk2/Rt01	ESSFwh1/Ro09	ESSFwm4/Rt02	ICHmw2/Ro05.1	IDFdk5/Rt07	MSdm1/Rc
ESSFdk2/Rt07	ESSFwh1/Ro09.1	ESSFwm4/Rt07	ICHmw2/Ro09	IDFdk5/Rt07.1	MSdm1/Ro
ESSFdk2/Rt07.1	ESSFwh1/Ro09.2	ESSFwm4/Rt07.1	ICHmw2/Ro09.1	IDFdk5/Rt07.2	MSdm1/Ro01
ESSFdk2/Rt07.2	ESSFwh1/Ro10	ESSFwm4/Rt07.2	ICHmw2/Ro10	IDFdk5/Rt08	MSdm1/Ro01.1
ESSFdk2/Rt20	ESSFwh1/Rt	ESSFwm4/Rt21	ICHmw2/Rt	IDFdm1/102	MSdm1/Ro01.2
ESSFdk2/Rt21	ESSFwh1/Rt01	ESSFwmp/Rc	ICHmw2/Rt01	IDFdm1/Rc	MSdm1/Ro05
ESSFdkp/Rc	ESSFwh1/Rt02	ESSFwmp/Ro	ICHmw2/Rt02	IDFdm1/Ro	MSdm1/Ro05.1
ESSFdkp/Ro	ESSFwh1/Rt03	ESSFwmp/Rt	ICHmw2/Rt03	IDFdm1/Ro01	MSdm1/Ro09
ESSFdkp/Rt	ESSFwh1/Rt07	ESSFwmw/102	ICHmw3/02	IDFdm1/Ro01.1	MSdm1/Ro09.1
ESSFdkw/102	ESSFwh1/Rt07.1	ESSFwmw/Rc	ICHmw3/Rc	IDFdm1/Ro01.2	MSdm1/Ro09.2
ESSFdkw/Rc	ESSFwh1/Rt07.2	ESSFwmw/Ro	ICHmw3/Ro	IDFdm1/Ro04	MSdm1/Ro11
ESSFdkw/Ro	ESSFwh2/102	ESSFwmw/Ro06	ICHmw3/Rt	IDFdm1/Ro04.1	MSdm1/Rt
ESSFdkw/Ro06	ESSFwh2/Rc	ESSFwmw/Ro06.1	ICHmw4/102	IDFdm1/Ro04.2	MSdm1/Rt01
ESSFdkw/Ro07	ESSFwh2/Ro	ESSFwmw/Ro06.2	ICHmw4/Rc	IDFdm1/Ro05	MSdm1/Rt02
ESSFdkw/Ro10	ESSFwh2/Ro06	ESSFwmw/Ro07	ICHmw4/Ro	IDFdm1/Ro05.1	MSdm1/Rt03
ESSFdkw/Ro11	ESSFwh2/Ro06.1	ESSFwmw/Ro10	ICHmw4/Ro05	IDFdm1/Rt	MSdm1/Rt07
ESSFdkw/Rt	ESSFwh2/Ro09	ESSFwmw/Ro11	ICHmw4/Ro05.1	IDFdm1/Rt01	MSdm1/Rt07.1
ESSFdkw/Rt01	ESSFwh2/Ro09.1	ESSFwmw/Ro12	ICHmw4/Ro09	IDFdm1/Rt04	MSdm1/Rt07.2
ESSFdkw/Rt07	ESSFwh2/Ro09.2	ESSFwmw/Rt	ICHmw4/Ro09.1	IDFdm1/Rt06	MSdm1/Rt08
ESSFdkw/Rt20	ESSFwh2/Ro10	ESSFwmw/Rt01	ICHmw4/Ro09.2	IDFdm1/Rt07	MSdw/102
ESSFdkw/Rt21	ESSFwh2/Rt	ESSFwmw/Rt20	ICHmw4/Ro10	IDFdm1/Rt07.1	MSdw/Rc
ESSFmh/102	ESSFwh2/Rt01	ESSFwmw/Rt21	ICHmw4/Rt	IDFdm1/Rt07.2	MSdw/Ro
ESSFmh/Rc	ESSFwh2/Rt02	ICHdm/102	ICHmw4/Rt01	IDFdm2/102	MSdw/Ro01
ESSFmh/Ro	ESSFwh2/Rt03	ICHdm/102a	ICHmw4/Rt02	IDFdm2/Rc	MSdw/Ro01.1
ESSFmh/Ro06	ESSFwh2/Rt07	ICHdm/Rc	ICHmw4/Rt03	IDFdm2/Ro	MSdw/Ro01.2
ESSFmh/Ro06.1	ESSFwh2/Rt07.1	ICHdm/Ro	ICHmw5/102	IDFdm2/Ro01	MSdw/Ro05
ESSFmh/Ro06.2	ESSFwh2/Rt07.2	ICHdm/Ro05	ICHmw5/Rc	IDFdm2/Ro01.1	MSdw/Ro05.1
ESSFmh/Ro09	ESSFwh3/102	ICHdm/Ro05.1	ICHmw5/Ro	IDFdm2/Ro01.2	MSdw/Ro09
ESSFmh/Ro09.1	ESSFwh3/Rc	ICHdm/Ro09	ICHmw5/Ro05	IDFdm2/Ro02	MSdw/Ro09.1
ESSFmh/Ro09.2	ESSFwh3/Ro	ICHdm/Ro09.1	ICHmw5/Ro05.1	IDFdm2/Ro03	MSdw/Ro11
ESSFmh/Ro10	ESSFwh3/Ro06	ICHdm/Ro09.2	ICHmw5/Ro09	IDFdm2/Ro05	MSdw/Rt
ESSFmh/Ro11	ESSFwh3/Ro06.1	ICHdm/Ro10	ICHmw5/Ro09.1	IDFdm2/Ro05.1	MSdw/Rt01
ESSFmh/Rt	ESSFwh3/Ro09	ICHdm/Rt	ICHmw5/Ro09.2	IDFdm2/Rt	MSdw/Rt02

Rock Priority Ecosystem Crosswalk					
ESSFmh/Rt01	ESSFwh3/Ro09.1	ICHdm/Rt01	ICHmw5/Ro10	IDFdm2/Rt01	MSdw/Rt03
ESSFmh/Rt02	ESSFwh3/Ro09.2	ICHdm/Rt02	ICHmw5/Rt	IDFdm2/Rt03	MSdw/Rt04
ESSFmh/Rt03	ESSFwh3/Ro10	ICHdm/Rt03	ICHmw5/Rt01	IDFdm2/Rt04	MSdw/Rt07
ESSFmh/Rt07	ESSFwh3/Rt	ICHdm/Rt06	ICHmw5/Rt02	IDFdm2/Rt06	MSdw/Rt07.1
ESSFmh/Rt07.1	ESSFwh3/Rt01	ICHdm/Rt07	ICHmw5/Rt03	IDFdm2/Rt07	MSdw/Rt07.2
ESSFmh/Rt07.2	ESSFwh3/Rt02	ICHdm/Rt07.1	ICHmw5/Rt07	IDFdm2/Rt07.1	MSdw/Rt08
ESSFmm1/02	ESSFwh3/Rt03	ICHdm/Rt07.2	ICHmw5/Rt07.1	IDFdm2/Rt07.2	MSdw/Rt20
ESSFmm1/Rc	ESSFwh3/Rt07	ICHdm/Rt08	ICHmw5/Rt07.2	IDFdm2/Rt08	
ESSFmm1/Ro	ESSFwh3/Rt07.1	ICHdw1/Rc	ICHmw5/Rt08	IDFxk/102	

Table D-10: Wetland Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Wetland Priority Ecosystem Crosswalk					
ESSFdc1/112b	ESSFmh/Ws08.2	ESSFwh3/Wf12	ICHdw1/Ws06	ICHmw5/Ww	IDFdm2/Ws07.2
ESSFdc1/Wb	ESSFmh/Ws13	ESSFwh3/Wf13	ICHdw1/Ws10	ICHvk1/06	IDFdm2/Ww
ESSFdc1/Wb07	ESSFmh/Ww	ESSFwh3/Wm	ICHdw1/Ww	ICHvk1/Wb	IDFxk/113b
ESSFdc1/Wb16	ESSFmm1/07	ESSFwh3/Wm01	ICHmk1/Wb	ICHvk1/Wf	IDFxk/Wb
ESSFdc1/Wf	ESSFmm1/Wb	ESSFwh3/Wm16	ICHmk1/Wb16	ICHvk1/Wf05	IDFxk/Wf
ESSFdc1/Wf01	ESSFmm1/Wf	ESSFwh3/Ws	ICHmk1/Wf	ICHvk1/Wf11	IDFxk/Wf01
ESSFdc1/Wf03	ESSFmm1/Wm	ESSFwh3/Ws08.1	ICHmk1/Wf01/08	ICHvk1/Wm	IDFxk/Wf02
ESSFdc1/Wf04	ESSFmm1/Ws	ESSFwh3/Ws08.2	ICHmk1/Wf02	ICHvk1/Ws	IDFxk/Wm
ESSFdc1/Wf09	ESSFmm1/Ww	ESSFwh3/Ws13	ICHmk1/Wf05	ICHvk1/Ws06	IDFxk/Wm01
ESSFdc1/Wf13	ESSFmm3/Wb	ESSFwh3/Ww	ICHmk1/Wf07	ICHvk1/Ww	IDFxk/Wm02
ESSFdc1/Wm	ESSFmm3/Wf	ESSFwm1/Wb	ICHmk1/Wf11	ICHwk1/08	IDFxk/Wm04
ESSFdc1/Wm01	ESSFmm3/Wm	ESSFwm1/Wf	ICHmk1/Wm	ICHwk1/Wb	IDFxk/Wm05
ESSFdc1/Wm16	ESSFmm3/Ws	ESSFwm1/Wf01	ICHmk1/Wm01	ICHwk1/Wf	IDFxk/Wm06
ESSFdc1/Ws	ESSFmm3/Ww	ESSFwm1/Wf02	ICHmk1/Wm02	ICHwk1/Wf05	IDFxk/Wm07
ESSFdc1/Ws04	ESSFmmp/Wa	ESSFwm1/Wf03	ICHmk1/Wm04	ICHwk1/Wf06	IDFxk/Wm12
ESSFdc1/Ws08	ESSFmmw/Wa	ESSFwm1/Wf04	ICHmk1/Wm05	ICHwk1/Wm	IDFxk/Wm14
ESSFdc1/Ws08.1	ESSFmmw/Wb	ESSFwm1/Wf11	ICHmk1/Wm06	ICHwk1/Wm01	IDFxk/Ws
ESSFdc1/Ws08.2	ESSFmmw/Wf	ESSFwm1/Wf12	ICHmk1/Wm09	ICHwk1/Wm06	IDFxk/Ws04
ESSFdc1/Ws13	ESSFmmw/Wm	ESSFwm1/Wf13	ICHmk1/Wm15	ICHwk1/Wm09	IDFxk/Ww
ESSFdc1/Ww	ESSFmmw/Ws	ESSFwm1/Wm	ICHmk1/Ws	ICHwk1/Wm51	IDFxx1/Wb
ESSFdc2/Wb	ESSFmmw/Ww	ESSFwm1/Wm01	ICHmk1/Ws02	ICHwk1/Ws	IDFxx1/Wf
ESSFdc2/Wb16	ESSFvc/05	ESSFwm1/Wm16	ICHmk1/Ws04	ICHwk1/Ws02	IDFxx1/Wm
ESSFdc2/Wf	ESSFvc/Wb	ESSFwm1/Ws	ICHmk1/Ws06	ICHwk1/Ww	IDFxx1/Wm01
ESSFdc2/Wf01	ESSFvc/Wf	ESSFwm1/Ws08	ICHmk1/Ws07	ICHxw/113	IDFxx1/Wm03
ESSFdc2/Wf02	ESSFvc/Wf03/06	ESSFwm1/Ws13	ICHmk1/Ws07.1	ICHxw/Wb	IDFxx1/Wm04
ESSFdc2/Wf03	ESSFvc/Wm	ESSFwm1/Ww	ICHmk1/Ws07.2	ICHxw/Wf	IDFxx1/Wm05
ESSFdc2/Wf04	ESSFvc/Ws	ESSFwm2/112b	ICHmk1/Ws10	ICHxw/Wf01	IDFxx1/Wm06
ESSFdc2/Wf06	ESSFvc/Ww	ESSFwm2/Wa	ICHmk1/Ww	ICHxw/Wf05	IDFxx1/Wm07
ESSFdc2/Wf07	ESSFvcp/Wa	ESSFwm2/Wa02	ICHmk4/Wb	ICHxw/Wm	IDFxx1/Wm12
ESSFdc2/Wf08	ESSFvcw/Wa	ESSFwm2/Wb	ICHmk4/Wf	ICHxw/Wm01	IDFxx1/Wm14
ESSFdc2/Wf09	ESSFvcw/Wb	ESSFwm2/Wf	ICHmk4/Wf01	ICHxw/Wm02	IDFxx1/Ws

Wetland Priority Ecosystem Crosswalk					
ESSFdc2/Wf12	ESSFvcw/Wf	ESSFwm2/Wf01	ICHmk4/Wf02	ICHxw/Wm04	IDFxx1/Ww
ESSFdc2/Wf13	ESSFvcw/Wm	ESSFwm2/Wf03	ICHmk4/Wf05	ICHxw/Wm05	IDFxx2/112b
ESSFdc2/Wm	ESSFvcw/Ws	ESSFwm2/Wf04	ICHmk4/Wf11	ICHxw/Wm06	IDFxx2/Wb
ESSFdc2/Wm01	ESSFvcw/Ww	ESSFwm2/Wf11	ICHmk4/Wm	ICHxw/Wm09	IDFxx2/Wf
ESSFdc2/Wm09	ESSFwc2/09	ESSFwm2/Wf12	ICHmk4/Wm01	ICHxw/Ws	IDFxx2/Wf01
ESSFdc2/Wm16	ESSFwc2/Wb	ESSFwm2/Wf13	ICHmk4/Wm02	ICHxw/Ws01	IDFxx2/Wm
ESSFdc2/Ws	ESSFwc2/Wf	ESSFwm2/Wm	ICHmk4/Wm04	ICHxw/Ws06	IDFxx2/Wm01
ESSFdc2/Ws02	ESSFwc2/Wf03	ESSFwm2/Wm01	ICHmk4/Wm05	ICHxw/Ws10	IDFxx2/Wm02
ESSFdc2/Ws08.1	ESSFwc2/Wf04	ESSFwm2/Wm16	ICHmk4/Wm06	ICHxw/Ww	IDFxx2/Wm03
ESSFdc2/Ws08/112	ESSFwc2/Wf11	ESSFwm2/Ws	ICHmk4/Wm15	ICHxwa/113	IDFxx2/Wm04
ESSFdc2/Ws13	ESSFwc2/Wf13	ESSFwm2/Ws08.1	ICHmk4/Ws	ICHxwa/Wb	IDFxx2/Wm05
ESSFdc2/Ww	ESSFwc2/Wm	ESSFwm2/Ws08.2	ICHmk4/Ws02	ICHxwa/Wf	IDFxx2/Wm06
ESSFdcp/Wa	ESSFwc2/Ws	ESSFwm2/Ws13	ICHmk4/Ws03	ICHxwa/Wf01	IDFxx2/Wm07
ESSFdcw/Wa	ESSFwc2/Ww	ESSFwm2/Ww	ICHmk4/Ws06	ICHxwa/Wf05	IDFxx2/Wm12
ESSFdcw/Wb	ESSFwc4/112b	ESSFwm3/112b	ICHmk4/Ws07	ICHxwa/Wm	IDFxx2/Wm14
ESSFdcw/Wf	ESSFwc4/Wa	ESSFwm3/Wa	ICHmk4/Ws07.1	ICHxwa/Wm01	IDFxx2/Ws
ESSFdcw/Wf01	ESSFwc4/Wa01	ESSFwm3/Wa02	ICHmk4/Ww	ICHxwa/Wm02	IDFxx2/Ww
ESSFdcw/Wf03	ESSFwc4/Wa01.1	ESSFwm3/Wb	ICHmk5/112b	ICHxwa/Wm04	IMAun/Wa
ESSFdcw/Wf04	ESSFwc4/Wa01.2	ESSFwm3/Wf	ICHmk5/Wb	ICHxwa/Wm05	MSdk/111b
ESSFdcw/Wf12	ESSFwc4/Wa03	ESSFwm3/Wf01	ICHmk5/Wf	ICHxwa/Wm06	MSdk/112
ESSFdcw/Wf13	ESSFwc4/Wb	ESSFwm3/Wf03	ICHmk5/Wm	ICHxwa/Wm09	MSdk/Wb
ESSFdcw/Wm	ESSFwc4/Wf	ESSFwm3/Wf04	ICHmk5/Ws	ICHxwa/Ws	MSdk/Wb15
ESSFdcw/Wm01	ESSFwc4/Wf01	ESSFwm3/Wf11	ICHmk5/Ww	ICHxwa/Ws01	MSdk/Wf
ESSFdcw/Wm16	ESSFwc4/Wf03	ESSFwm3/Wf12	ICHmw1/Wb	ICHxwa/Ws06	MSdk/Wf01
ESSFdcw/Ws	ESSFwc4/Wf04	ESSFwm3/Wf13	ICHmw1/Wf	ICHxwa/Ws10	MSdk/Wf06
ESSFdcw/Ws08.2	ESSFwc4/Wf11	ESSFwm3/Wm	ICHmw1/Wf05	ICHxwa/Ww	MSdk/Wf07
ESSFdcw/Ws13	ESSFwc4/Wf12	ESSFwm3/Wm01	ICHmw1/Wf11	IDFdh/Wb	MSdk/Wf08
ESSFdcw/Ww	ESSFwc4/Wf13	ESSFwm3/Wm16	ICHmw1/Wm	IDFdh/Wf	MSdk/Wf11
ESSFdk1/111b	ESSFwc4/Wm	ESSFwm3/Ws	ICHmw1/Ws	IDFdh/Wm	MSdk/Wm
ESSFdk1/Wb	ESSFwc4/Wm01	ESSFwm3/Ws08.1	ICHmw1/Ww	IDFdh/Wm01	MSdk/Wm02
ESSFdk1/Wb15	ESSFwc4/Wm16	ESSFwm3/Ws08.2	ICHmw2/114	IDFdh/Wm03	MSdk/Wm04
ESSFdk1/Wb16	ESSFwc4/Ws	ESSFwm3/Ws13	ICHmw2/Wb	IDFdh/Wm04	MSdk/Wm05
ESSFdk1/Wf	ESSFwc4/Ws13	ESSFwm3/Ww	ICHmw2/Wf	IDFdh/Wm05	MSdk/Wm15
ESSFdk1/Wf01	ESSFwc4/Ww	ESSFwm4/Wa	ICHmw2/Wf01	IDFdh/Wm06	MSdk/Wm16
ESSFdk1/Wf02	ESSFwcp/Wa	ESSFwm4/Wa02	ICHmw2/Wf05	IDFdh/Wm07	MSdk/Ws
ESSFdk1/Wf03	ESSFwcp/Wa01	ESSFwm4/Wb	ICHmw2/Wm	IDFdh/Wm12	MSdk/Ws02
ESSFdk1/Wf04	ESSFwcp/Wa01.1	ESSFwm4/Wf	ICHmw2/Wm01	IDFdh/Wm14	MSdk/Ws03
ESSFdk1/Wf11	ESSFwcp/Wa01.2	ESSFwm4/Wf01	ICHmw2/Wm02	IDFdh/Ws	MSdk/Ws06
ESSFdk1/Wf12	ESSFwcp/Wa03	ESSFwm4/Wf03	ICHmw2/Wm04	IDFdh/Ww	MSdk/Ws07
ESSFdk1/Wf13	ESSFwcw/Wa	ESSFwm4/Wf04	ICHmw2/Wm05	IDFdk5/111b	MSdk/Ws07.1
ESSFdk1/Wm	ESSFwcw/Wa01	ESSFwm4/Wf11	ICHmw2/Wm06	IDFdk5/Wb	MSdk/Ws07.2
ESSFdk1/Wm01	ESSFwcw/Wa01.1	ESSFwm4/Wf12	ICHmw2/Wm09	IDFdk5/Wf	MSdk/Ww
ESSFdk1/Wm16	ESSFwcw/Wa01.2	ESSFwm4/Wf13	ICHmw2/Wm15	IDFdk5/Wf01	MSdm1/Wb

Wetland Priority Ecosystem Crosswalk					
ESSFdk1/Ws	ESSFwcw/Wa03	ESSFwm4/Wm	ICHmw2/Ws	IDFdk5/Wf02	MSdm1/Wb16
ESSFdk1/Ws03	ESSFwcw/Wb	ESSFwm4/Wm01	ICHmw2/Ws01	IDFdk5/Wf05	MSdm1/Wf
ESSFdk1/Ws08	ESSFwcw/Wf	ESSFwm4/Wm16	ICHmw2/Ws02	IDFdk5/Wm	MSdm1/Wf01
ESSFdk1/Ws13	ESSFwcw/Wf01	ESSFwm4/Ws	ICHmw2/Ws06	IDFdk5/Wm01	MSdm1/Wf02
ESSFdk1/Ww	ESSFwcw/Wf03	ESSFwm4/Ws08.2	ICHmw2/Ws10	IDFdk5/Wm02	MSdm1/Wf04
ESSFdk2/112b	ESSFwcw/Wf04	ESSFwm4/Ws13	ICHmw2/Ww	IDFdk5/Wm04	MSdm1/Wf05
ESSFdk2/Wb	ESSFwcw/Wf12	ESSFwm4/Ww	ICHmw3/08	IDFdk5/Wm05	MSdm1/Wf07
ESSFdk2/Wb15	ESSFwcw/Wf13	ESSFwmp/Wa	ICHmw3/10	IDFdk5/Wm06	MSdm1/Wf11
ESSFdk2/Wf	ESSFwcw/Wm	ESSFwmp/Wa02	ICHmw3/Wb	IDFdk5/Wm07	MSdm1/Wm
ESSFdk2/Wf01	ESSFwcw/Wm01	ESSFwmw/Wa	ICHmw3/Wf	IDFdk5/Wm12	MSdm1/Wm01
ESSFdk2/Wf02	ESSFwcw/Wm16	ESSFwmw/Wa02	ICHmw3/Wf/09	IDFdk5/Wm14	MSdm1/Wm02
ESSFdk2/Wf03	ESSFwcw/Ws	ESSFwmw/Wb	ICHmw3/Wf05	IDFdk5/Wm15	MSdm1/Wm04
ESSFdk2/Wf04	ESSFwcw/Ws08	ESSFwmw/Wf	ICHmw3/Wf11	IDFdk5/Ws	MSdm1/Wm05
ESSFdk2/Wf11	ESSFwcw/Ws08.2	ESSFwmw/Wf01	ICHmw3/Wm	IDFdk5/Ws03	MSdm1/Wm09
ESSFdk2/Wf12	ESSFwcw/Ws13	ESSFwmw/Wf03	ICHmw3/Wm02	IDFdk5/Ws04	MSdm1/Wm15
ESSFdk2/Wf13	ESSFwcw/Ww	ESSFwmw/Wf04	ICHmw3/Wm09	IDFdk5/Ws07	MSdm1/Wm16
ESSFdk2/Wm	ESSFwh1/111b	ESSFwmw/Wf12	ICHmw3/Ws	IDFdk5/Ws07.1	MSdm1/Ws
ESSFdk2/Wm01	ESSFwh1/Wb	ESSFwmw/Wf13	ICHmw3/Ww	IDFdk5/Ws07.2	MSdm1/Ws02
ESSFdk2/Wm16	ESSFwh1/Wf	ESSFwmw/Wm	ICHmw4/Wb	IDFdk5/Ww	MSdm1/Ws04
ESSFdk2/Ws	ESSFwh1/Wf01	ESSFwmw/Wm01	ICHmw4/Wf	IDFdm1/Wb	MSdm1/Ws06
ESSFdk2/Ws03	ESSFwh1/Wf03	ESSFwmw/Wm16	ICHmw4/Wf01	IDFdm1/Wf	MSdm1/Ws07.1
ESSFdk2/Ws08	ESSFwh1/Wf04	ESSFwmw/Ws	ICHmw4/Wf05	IDFdm1/Wf01	MSdm1/Ws07.2
ESSFdk2/Ws13	ESSFwh1/Wf11	ESSFwmw/Ws08.2	ICHmw4/Wm	IDFdm1/Wf05	MSdm1/Ws07/113b
ESSFdk2/Ww	ESSFwh1/Wf12	ESSFwmw/Ws13	ICHmw4/Wm01	IDFdm1/Wm	MSdm1/Ww
ESSFdkp/Wa	ESSFwh1/Wf13	ESSFwmw/Ww	ICHmw4/Wm02	IDFdm1/Wm01	MSdw/111b
ESSFdkw/Wa	ESSFwh1/Wm	ICHdm/112	ICHmw4/Wm04	IDFdm1/Wm02	MSdw/112
ESSFdkw/Wb	ESSFwh1/Wm01	ICHdm/Wb	ICHmw4/Wm05	IDFdm1/Wm03	MSdw/Wb
ESSFdkw/Wf	ESSFwh1/Wm15	ICHdm/Wf	ICHmw4/Wm15	IDFdm1/Wm04	MSdw/Wb15
ESSFdkw/Wf03	ESSFwh1/Wm16	ICHdm/Wf01	ICHmw4/Ws	IDFdm1/Wm05	MSdw/Wb16
ESSFdkw/Wf04	ESSFwh1/Ws	ICHdm/Wf05	ICHmw4/Ws01	IDFdm1/Wm06	MSdw/Wf
ESSFdkw/Wf12	ESSFwh1/Ws08.1	ICHdm/Wm	ICHmw4/Ws06	IDFdm1/Wm07	MSdw/Wf01
ESSFdkw/Wf13	ESSFwh1/Ws08.2	ICHdm/Wm01	ICHmw4/Ws10	IDFdm1/Wm12	MSdw/Wf02
ESSFdkw/Wm	ESSFwh1/Ws13	ICHdm/Wm02	ICHmw4/Ww	IDFdm1/Wm14	MSdw/Wf05
ESSFdkw/Wm16	ESSFwh1/Ww	ICHdm/Wm04	ICHmw5/113	IDFdm1/Wm15	MSdw/Wf06
ESSFdkw/Ws	ESSFwh2/112b	ICHdm/Wm05	ICHmw5/Wb	IDFdm1/Ws	MSdw/Wf07
ESSFdkw/Ws13	ESSFwh2/Wb	ICHdm/Wm06	ICHmw5/Wb16	IDFdm1/Ws04	MSdw/Wf08
ESSFdkw/Ww	ESSFwh2/Wf	ICHdm/Wm15	ICHmw5/Wf	IDFdm1/Ww	MSdw/Wf11
ESSFmh/112b	ESSFwh2/Wf01	ICHdm/Ws	ICHmw5/Wf01	IDFdm2/112b	MSdw/Wm
ESSFmh/Wb	ESSFwh2/Wf03	ICHdm/Ws01	ICHmw5/Wf04	IDFdm2/Wb	MSdw/Wm01
ESSFmh/Wb16	ESSFwh2/Wf04	ICHdm/Ws06	ICHmw5/Wf05	IDFdm2/Wf	MSdw/Wm02
ESSFmh/Wf	ESSFwh2/Wf11	ICHdm/Ws10	ICHmw5/Wf11	IDFdm2/Wf01	MSdw/Wm04
ESSFmh/Wf01	ESSFwh2/Wf12	ICHdm/Ww	ICHmw5/Wm	IDFdm2/Wf02	MSdw/Wm05
ESSFmh/Wf02	ESSFwh2/Wf13	ICHdw1/113	ICHmw5/Wm01	IDFdm2/Wf05	MSdw/Wm06

Wetland Priority Ecosystem Crosswalk					
ESSFmh/Wf03	ESSFwh2/Wm	ICHdw1/Wb	ICHmw5/Wm02	IDFdm2/Wm	MSdw/Wm15
ESSFmh/Wf04	ESSFwh2/Wm01	ICHdw1/Wf	ICHmw5/Wm04	IDFdm2/Wm01	MSdw/Wm16
ESSFmh/Wf05	ESSFwh2/Wm16	ICHdw1/Wf01	ICHmw5/Wm05	IDFdm2/Wm02	MSdw/Ws
ESSFmh/Wf09	ESSFwh2/Ws	ICHdw1/Wf05	ICHmw5/Wm06	IDFdm2/Wm03	MSdw/Ws02
ESSFmh/Wf11	ESSFwh2/Ws08.1	ICHdw1/Wm	ICHmw5/Wm09	IDFdm2/Wm04	MSdw/Ws03
ESSFmh/Wf12	ESSFwh2/Ws08.2	ICHdw1/Wm01	ICHmw5/Wm15	IDFdm2/Wm05	MSdw/Ws04
ESSFmh/Wf13	ESSFwh2/Ws13	ICHdw1/Wm02	ICHmw5/Ws	IDFdm2/Wm06	MSdw/Ws06
ESSFmh/Wm	ESSFwh2/Ww	ICHdw1/Wm04	ICHmw5/Ws01	IDFdm2/Wm07	MSdw/Ws07
ESSFmh/Wm01	ESSFwh3/112b	ICHdw1/Wm05	ICHmw5/Ws02	IDFdm2/Wm12	MSdw/Ws07.1
ESSFmh/Wm16	ESSFwh3/Wb	ICHdw1/Wm06	ICHmw5/Ws04	IDFdm2/Wm14	MSdw/Ws07.2
ESSFmh/Ws	ESSFwh3/Wf	ICHdw1/Wm09	ICHmw5/Ws06	IDFdm2/Ws	MSdw/Ww
ESSFmh/Ws04	ESSFwh3/Wf01	ICHdw1/Wm15	ICHmw5/Ws07	IDFdm2/Ws03	
ESSFmh/Ws06	ESSFwh3/Wf03	ICHdw1/Ws	ICHmw5/Ws07.1	IDFdm2/Ws04	
ESSFmh/Ws08	ESSFwh3/Wf04	ICHdw1/Ws01	ICHmw5/Ws07.2	IDFdm2/Ws07	
ESSFmh/Ws08.1	ESSFwh3/Wf11	ICHdw1/Ws02	ICHmw5/Ws10	IDFdm2/Ws07.1	

Table D-11: Whitebark and Limber Pine Priority Ecosystem Crosswalk to TEI Ecosystem Codes based on BECv12

Whitebark and Limber Pine Priority Ecosystem Crosswalk					
ESSFdc1/102	ESSFdk1/102	ESSFmh/102	ESSFwc4/102	ESSFwm1/102	ESSFwmw/103
ESSFdc1/103	ESSFdk1/103	ESSFmm3/102	ESSFwc4/103	ESSFwm1/103	IDFxk/102
ESSFdc1/Ro08	ESSFdk1/104	ESSFmm3/103	ESSFwcp/Sk	ESSFwm2/102	IDFxk/Ro
ESSFdc2/102	ESSFdk2/101	ESSFmm3/104	ESSFwcw/102	ESSFwm2/103	MSdk/102
ESSFdc2/103	ESSFdk2/102	ESSFmmp/Sk	ESSFwh1/102	ESSFwm2/104	MSdk/Ro
ESSFdcp/Ro08	ESSFdk2/103	ESSFmmw/Sk	ESSFwh1/103	ESSFwm3/102	MSdw/102
ESSFdcp/Sk	ESSFdk2/104	ESSFvc/02	ESSFwh2/102	ESSFwm3/103	MSdw/Ro
ESSFdcw/102	ESSFdkp/Sk	ESSFvcp/Sk	ESSFwh2/103	ESSFwm4/102	
ESSFdcw/103	ESSFdkw/102	ESSFvcw/Sk	ESSFwh3/102	ESSFwmp/Sk	
ESSFdcw/Ro08	ESSFdkw/103	ESSFwc2/02	ESSFwh3/103	ESSFwmw/102	

Appendix E: Expert Input on Ecosystem Mapping and Modelling of Priority Ecosystems for Wildlife Habitat Stewardship

The following information was compiled by Madrone Environmental Services Ltd. through feedback provided at a series of three workshops (January/ February 2022) and based on review of project related reports and supporting information. Workshop attendees and contributors included several Ministry staff as well as subject matter experts from various consulting companies as provided below:

- Anna McIndoe - FLNR – Wildlife Habitat Specialist
- Deepa Filatow - ENV - Provincial Bioterrain Specialist
- Jackie Churchill - ENV - Ecosystem Mapping Ecologist
- Tony Button - ENV - Ecosystem Information Specialist
- Gillian Harvey - ENV - Spatial Information Analyst
- Tania Tripp - Madrone Environmental Services Ltd. - Senior Wildlife Biologist
- Jen McEwen - Madrone Environmental Services Ltd.- Ecologist
- Anna Jeffries - Madrone Environmental Services Ltd. - GIS Analyst
- Eric Hagen - Madrone Environmental Services Ltd. - Biologist
- Ben Andrew - B.A. Blackwell & Associates Ltd. - Senior Ecologist
- Bob Green - B.A. Blackwell & Associates Ltd. - Senior Ecologist
- Kristi Iverson - Iverson & Mackenzie Biological Consulting Ltd.- Ecologist
- Sally Leigh-Spencer - Ecologic Consulting - Senior Wildlife Biologist
- Adrian DeGroot - Drosera Consulting - Vegetation Ecologist
- Del Meidinger - Meidinger Ecological Consultants Ltd. - Senior Ecologist

A high-level summary of the results of this consultation including considerations for mapping and modelling priority ecosystems is provided in Section 7 (Table 14). A detailed review of the benefits of each priority ecosystem for wildlife, as well as a description of mapping challenges, requirements and recommendations is provided below. Appendix E-1 provides a general summary of T4W priority wildlife species habitat requirements for the Kootenay Boundary Region.

High Elevation Meadow and Parkland Ecosystems

High elevation meadow ecosystems consist of herbaceous moisture-loving herb and sedge dominant plant assemblages on wetter sites in the alpine and subalpine forest areas. Parkland ecosystems include a high-elevation mosaic of stunted tree clumps referred to as krummholtz, and herb or dwarf shrub-dominated openings. Dominant structural stages include 2a (herbaceous leading meadows), 2b (forb leading sites), 2d (dwarf shrub dominated; typically mountain heathers of the Family *Ericaceae*), 3a/3b (short and tall shrub units), and 3d (dwarf/stunted tree sites). Parkland ecosystems occupy a transition zone niche below the alpine and above the treeline. In the KBR, these ecosystems occur within the IMA and associated parkland units in the ESSFdkp, dcp, vcp, wcp, wmp and mmp.

Detailed classification coding for alpine and parkland ecosystems are presently limited in BC. In general, high elevation meadows are indicated by the nBEC code "Am" (meadows occurring within the Alpine group). Other high elevation and parkland units are also coded within nBEC that provides a high-level classification. A list of high elevation ecosystems and their associated ecosystem codes is provided in Appendix D (Table D-5); a product of crosswalk efforts by Provincial and Regional ecologists based on the TEI Ecosystem Codes List/BECv12 ecosystem units. Additional or updated land management handbooks and guidebooks with coding specific to the CMA, IMA and BAFA and their associated parkland units is recommended.

Alpine grasslands are especially important as forage for Bighorn sheep. While rich herbaceous meadows in the alpine and parkland provide forage during the late spring through fall for a multitude of species including Grizzly bear, ungulates and small mammals. Many high elevation ecosystems provide security in the form of dense brush, a priority ecosystem discussed later. High elevation open habitat such as grasslands, meadows, dwarf shrub, and sparsely vegetated ecosystems can also provide security for wildlife in providing good visibility of approaching predators. These wide open alpine and parkland areas are selected by caribou and other ungulates for use during the rutting season. Where these ecosystems remain undisturbed, the natural "back country" conditions provide high use travel corridors.

High elevation ecosystems within the parkland and alpine provide critical habitat to many wildlife species during different times of the year and life stages. They are of importance to a wide variety of species in the region, including red-listed species, as well as several blue-listed terrestrial species ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework[24]; including Mountain Goats, Grizzly Bear, Wolverine, and American Marten (Table E-1).

One of the biggest threats to the high elevation ecosystems is climate change. Using draft climate projections for the 2041-2060 period developed for the province (Mackenzie and Mahony 2021) and modeled for the KBR[25], many of the BEC units in the KBR, including the alpine and parkland units, are

[24] cf_primer.pdf (gov.bc.ca) and Implementing conservation actions - Province of British Columbia (gov.bc.ca)

[25] Biogeoclimatic projections provided by C. Mahony to A. McIndoe via email, 31 January 2022

expected to see changes in the next 30 years. In most cases, due to changes in temperature and precipitation (including snowfall), forests may establish at higher elevations, encroaching into the parkland. As there are more frost-free days at these upper elevations, vegetation can establish in areas that were previously unoccupied such as non-vegetated parkland and alpine. The result is predicted to result in an overall reduction in the amount of alpine and increase in parkland ecosystems with an increase in the upper elevation of the treeline.

Mapping Challenges

One of the challenges noted for mapping high elevation alpine and parkland units is that the ecosystems change at a finer scale than at lower elevations, making mapping more difficult. There are also limitations with the current classification for mapping these ecological units, particularly for the rock-based units where all rock types are classified as Alpine Fellfield (Af), whereas at lower elevations, they can be described as rock outcrop, cliff and talus. Some subclasses have been described for alpine fellfield but there is currently no subclass field within the TEI Long Table found within the Contractor Package (TEI Unit 2020). However, there may be limitations to mapping to the subclass level as those units may require field plots and verification to confirm. Site associations have been described for alpine grasslands in the Kootenay Boundary, but classification for other ecosystems within the Alpine Group is limited to the Realm/Group/Class (R/G/C) level (e.g., Am).

Another challenge for mapping these units is gathering field data. Access to high elevation units typically requires a helicopter, which can be a limitation due to the high cost. There can also be challenges associated with finding appropriate locations for drop/pick up spots for the helicopter and identifying safe transect routes. The purpose of the mapping project may also place priority on sampling in lower elevation units.

Further, the majority of ecosystem mapping in BC is focused on lower elevation, agriculture and forest lands. Therefore, high elevation areas are often excluded from mapping. This has the added consequence of partial mapping without context to the full landscape of ecosystem values and limits wildlife stewardship planning.

Mapping Requirements

High elevation ecosystems are best mapped at a 1:10,000 scale or better using colour imagery to allow for better distinction between grassland, meadow and heath ecosystems. The use of stereo (3D) imagery is preferred but mapping can be done using 2D, colour imagery with a 25 m Digital Elevation Model (DEM).

Recommendations

Despite limitations in the current classification for alpine and parkland units, high elevation ecosystems can still be mapped to a level of detail within the current classification system for most applications such as wildlife habitat models. It is recommended that a standard way of assigning subclasses be created and approved by the Province to ensure consistency amongst mapping practitioners, such as use of a User Defined Field. High elevation ecosystems can be queried from existing mapping either by selecting the parkland and alpine BEC units or by the associated ecosystem codes (i.e. mapcodes and nBEC).

These priority ecosystems are best mapped through visual interpretation. Attempts to model high elevation ecosystems have proved challenging as demonstrated in previous PEM projects through poor predictive ability. Modeled ecosystem mapping such as PEM refer to these priority ecosystems as requiring exceptions mapping.

Avalanche Tracks

Avalanche tracks are often shrub dominated due to periodic to frequent snow and rockslides that prevent coniferous forest establishment. Moisture is plentiful for much of the growing season within avalanche tracks as the shape of these ecosystems lends to a natural channeling of snowmelt and drainage. Lower relief sections of avalanche tracks, often referred to as run-outs, may support rich herbaceous growth depending on the substrate source material, texture and soil.

Avalanche tracks can occur from valley bottoms up to the highest elevations within a given watershed. They are linear in shape that occur in a wide variety of sizes and are highly variable in vegetation composition; from completely barren rock to lush vegetation. The length and size of these features is a result of factors such as geomorphology, parent material, slope, snowpack, and frequency and magnitude of the events.

Depending on the vegetation composition of the site, these features can have very important benefits to wildlife. For example, warm aspect slopes with herbaceous dominant vegetation can provide critical early spring forage for grizzly bears that have recently emerged from hibernation. Herbaceous avalanche tracks with forbs and graminoids are rich forage sites for a plethora of wildlife from large ungulates down to small, burrowing mammals. The floral diversity found under certain conditions can also be important to local populations of invertebrates such as butterflies, beetles and bees.

In the late summer and early fall, shrub dominant avalanche sites can provide abundant berry crops for a wide variety of wildlife to forage. High elevation avalanche tracks in the parkland and alpine can provide important forage when the lower elevation forage is no longer available (seasonal, elevational forage migration). Management of activities adjacent to avalanche tracks is specified in some general wildlife measures for grizzly bears wildlife habitat areas in the KBR. Avalanche tracks can also provide security habitat in two important ways: as long, open corridors with high visibility of potential approaching predators, and as dense, tall shrubs for visual screening to hide from predators.

These ecosystems are important to a number of regional important species, including ones that are ranked as highest priority (ranked as 1 or 2 on a scale of 6) in the BC Conservation Framework, including Mountain Goat, Grizzly Bear, Wolverine, and the interior subspecies of Northern Goshawk

(*Accipiter gentilis atricapillus*) (Table E-1). A list of ecosystem codes associated with avalanche ecosystems by BEC units in the KBR is provided in Appendix D (Table D-2).

Mapping Challenges

Although predominately linear, avalanche tracks come in many widths and lengths. Short avalanche track runs as well as narrow, long runs can be too small to "pull out" in the mapping (i.e., under 10% of the polygon or below the size threshold for the scale of focus of the mapping). Where these features are of priority for wildlife habitat planning for species such as Grizzly bear, additional funds should be ensured to capture these ecosystems to the level of detail specified in the project plan.

One of the challenges for mapping avalanche tracks is distinguishing between the initiation zone (non-avalanche) and the chute and run-out zones. This often results in decision making around whether the alpine should be included or not. There can be a lot of variation between mappers in how they choose to delineate these features. As well, once trees re-establish within an old avalanche track, it can become difficult to distinguish if the site should remain a treed avalanche site or be classified as a forested site series. In general, if the forest appears 'established' (structural stage greater or equal to "5" young forest), a site series is assigned. The site is no longer considered to be providing the type of avalanche vegetation values that are associated with earlier seral conditions. In addition, because interpretation of these ecosystems is challenging, attribution can be expensive.

Mapping Requirements

The use of LiDAR is preferred for delineating avalanche tracks as it allows the mapper to distinguish where the initiation zone is, that is not otherwise obvious from imagery alone. Using recent colour imagery is also necessary for distinguishing between deciduous and coniferous shrub, and/or structural stage (herbaceous versus shrub-dominated). Terrain data is also helpful as geoscientists are trained in identification of slides and terrain hazards. A scale of 1:10,000 is appropriate for mapping, but ability to zoom to 1:5,000 would allow further differentiation between herb and shrub-dominated communities where it may otherwise be challenging. Linework and attribution can be done without field work if imagery and input data sources provide enough information for mappers.

Recommendations

Similar to some of the other priority ecosystems, avalanche tracks have been prioritized in ecosystem mapping projects, and some site associations have been described in the current classification. As such, these areas can easily be queried in existing data using the nBEC coding and/or potentially within the terrain data fields (i.e., where the Geoprocess = A (snow avalanche) or R (rapid mass movement)). Improving the coverage of bioterrain mapping is key to capturing areas that are being affected by avalanches. It's important to understand that there is limited reliability with existing mapping as many smaller features are likely to be missed due to the scale of the mapping (often 1:20,000) and will only be captured at a finer scale. It is recommended that the Province confirms an agreed-upon definition of avalanche tracks across disciplines in order to help provide clarity around initiation zones, as the ecological definition may vary from the terrain definition.

Riparian

Riparian ecosystems link water to land. They are the areas that border streams, lakes and wetlands and can be a blend of streambed, water, trees, shrubs and grasses[26]. These areas are not only important for fish and fish habitat, but they are also important for biodiversity and wildlife. Riparian ecosystems provide food, shelter, water, and breeding sites for birds, mammals, amphibians, and reptiles. The assemblage of species dependent on a riparian ecosystem will depend on type and size of the watercourse adjacent to it (wetland, river, stream, lake, or pond), as well as the habitat within it (diversity of tree species, availability of nest and perch sites, frequency of flooding, etc.).

Although wetlands can be included in the definition of riparian areas, they have been identified as a separate priority ecosystem that is discussed in the next section. This section refers primarily to non-wetland ecosystems that are regularly flooded by river or lake waters where there is deposition of fluvial or lacustrine materials (Mackenzie 2012; Mackenzie and Moran 2004). Low benches experience longer (20-40 days) and more powerful flooding than middle benches (<25 days) and can support vegetation tolerant of extended flooding and erosion such as willows and alders. Middle bench ecosystems have similar shrub species to low bench but can support a canopy of deciduous trees. High bench ecosystems have event less frequent flooding than middle bench ecosystems, allowing for the establishment of conifers (MacKillop et al. 2018) and are described in the regional field guides.

As with high elevation ecosystem networks, riparian zones provide travel corridors for wildlife. Well worn wildlife trails that parallel rivers are often used by ecosystem mappers during field verification, which allows for ample opportunities to document evidence of use by local wildlife species. Riparian ecosystems are typically associated with high productivity in the form of rapid seral stage development and tree growth. These rich growing sites tend to have high shrub densities that provide abundant forage for ungulates to browse while also providing security screening. Riparian ecosystems are also associated with some of the highest avian biodiversity during the breeding season. These ecosystems provide a wide range of habitat niches for ground and shrub-nesting birds as well as plentiful prey for insectivorous birds and bats.

Riparian ecosystems are a priority because they are of high importance to numerous wildlife species. They are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for at least 22 species representing amphibians, reptiles, birds and mammals (Table E-1). Many red and blue-listed Ecological Communities are also associated with riparian ecosystems; especially forested

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[26] https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/aquatic-habitat-management/riparian-areas-regulation

floodplain ecosystems in old seral stages[27]. A list of ecosystem codes associated with riparian ecosystems is provided in Appendix D (Table D-8).

Mapping Challenges

Floodplain ecosystems are maintained by a combination of annual flooding, erosion, and deposition, but are also geomorphically dynamic in that the site conditions are regularly modified (Mackenzie and Moran 2004). Because of their dynamic nature, floodplain ecosystems are challenging to map and existing mapping is outdated relatively quickly.

Mapping Requirements

The use of LiDAR is preferred for delineating enduring features, active floodplains, scarps, ravines, and terraces. Using recent colour imagery is also necessary for classification of the floodplain units (low shrub, tall shrub, unvegetated). For example, areas that were exposed gravel a few years ago may now have fewer flood events, resulting in the establishment of willows. A scale of 1:5,000 is necessary for detailed mapping of smaller streams and drainages.

Recommendations

Like wetlands, floodplain riparian areas have been prioritized in mapping projects with classification describing both non-forested and forested floodplain areas. As such, these areas can easily be queried in existing data using the mapped site series (forested or non-forested) and/or the surficial materials (Fluvial). However, it's important to understand that riparian areas may be poorly captured by the mapping and are often inconsistently mapped with disconnected polygons. In areas where riparian ecosystems are prioritized for mapping and mapping exists, it may be worth the effort to remap using new imagery and LiDAR with the original linework as reference.

Wetlands

Wetlands are defined as ecosystems developed under high water tables or other increased moisture conditions. They can include fens, bogs, swamps, marshes and shallow open water, meadows, and shrub-carrs. Wetlands are usually composed of shrub or graminoid vegetation, but sometimes may be forested or have open tree cover (Mackenzie and Moran 2004). Wetlands and related ecosystems provide ecosystem services disproportionate to their limited extent in the landscape. They are valuable ecosystems with many functions: the majority of wildlife and fish species in the Province use these ecosystems for part of their life history and some are entirely dependent upon them; they support large populations of economically important fur-bearers; wetlands and related ecosystems provide some of the highest-quality range for livestock; and they are an integral component of hydrological systems and good water quality (Mackenzie and Moran 2004).

[27] BC Species & Ecosystems Explorer - Province of British Columbia (gov.bc.ca)

Wildlife uses of wetlands are as diverse as wetland types. While marshes and shallow waters support the highest wildlife populations, bogs and other wetland types each support their own distinctive wildlife communities. Some basic features that may influence a wetland's wildlife habitat value include: presence of water, structural diversity and cover, abundant forage, high prey densities, and rarity in the landscape (especially in drier climates, water and aquatic habitats are especially valuable for wildlife).

High structural complexity within wetlands generally increases their value to wildlife by providing nesting cover and foraging habitat for a wider variety of species occupying the greater abundance/variety of ecological niches. Forage species such as sedges, and horsetails form an important component of bear diets; willows and other shrubs are browsed by moose, and emergent aquatics are foraged on by waterfowl and other species (Mackenzie and Moran 2004).

The most heavily used wetlands are marshes, with their high productivity and adjacency to water, followed by swamps, fens, and bogs (Mackenzie and Moran 2004). However, all of these habitats are vital for wetland-dependent species and important for upland species that use wetlands and their associated riparian areas for food, water, and cover.

Wetlands are identified as high use for species ranked as highest priority (ranked as 1 or 2 on a scale of 6) in the BC Conservation Framework, including Grizzly Bear, Wolverine, Great Blue Heron (*herodias* subspecies), Rocky Mountain Tailed Frog, Great Basin Spadefoot, Western Toad, Painted Turtle, Silver-haired Bat, Townsend's Big-eared Bat, California Myotis, Hoary Bat, Long-eared Myotis, and Northern Myotis (Table E-1). Many of the species mentioned are listed under the Federal *Species at Risk Act*, the provincial Conservation Data Centre, as well as the B.C. *Forest and Range Practices Act*. Many red and blue-listed Ecological Communities are also associated with wetland ecosystems (BC CDC 2022). A list of ecosystem codes associated with wetland ecosystems by BEC units in the KBR is provided in Appendix D (Table D-10).

<u>Mapping Challenges</u>

For many of the priority ecosystems, limitations within the classification makes them more difficult to capture. However, for wetlands (excluding high elevation wetlands) the opposite is true. There are several wetlands classified throughout the Province in either *Wetlands of British Columbia* (Mackenzie and Moran 2004) or within the regional field guides. The classification is detailed, describing the different wetland types down to the site association level based on the dominant plant communities. The challenge with mapping wetlands is that classification of wetlands to the site association level requires field confirmation. Therefore, in most cases, wetlands can only be mapped with confidence to the R/G/C level (e.g., as a wetland fen (Wf), but not a water sedge - beaked sedge fen (Wf01)) unless field verified. Forested wetlands, particularly horsetail sites, are difficult to pull out from imagery and the transition from upland to wetland can be subtle. Wetlands at higher elevations are not well classified.

<u>Mapping Requirements</u>

A SIL 3 (26-50% verification of the polygons) is recommended for classification of wetlands to the site association level. Wetlands can be mapped at a 1:10,000 scale but 1:5,000 is best for capturing small features. The use of 3D (stereo) colour imagery for mapping is preferred to differentiate between vegetation types, but delineation can accurately be done using high resolution 2D colour imagery. For capturing forested wetlands, LiDAR is required as the LiDAR shows the surface shape, including depression areas where wetlands are likely to occur that are not easily detected from the imagery. Some wetlands may also be found in the Fresh Water Atlas (FWA) that are not easily picked up on the imagery, due to forest cover, shade or cloud cover. This input data source is a helpful source when mapping wetlands.

Recommendations

Fortunately, wetlands are one of the few priority ecosystems that have been prioritized within ecosystem mapping projects. In many cases, wetlands have been mapped within TEM projects at a finer scale (1:5,000) and to a smaller minimum polygon size (0.25 ha or less depending on agreed to methods for each map product) than the overall project. As a result, wetlands can be queried from existing data. Although some very small wetlands may be missed, there is relatively high confidence that most of these ecosystems will be represented in the data. As noted, these can easily be pulled using the site series or R/G/C fields within the TEI Long Table found within the Contractor Package (TEI Unit 2020). Alternatively, information within the soils/terrain fields may also be used for queries of existing data. For example, wetlands are typically mapped as having an organic surficial material and are imperfectly to very poorly drained. In addition, the hydrogeomorphic system and subsystem information, as described in the Describing Terrestrial Ecosystems in the Field (DTEIF) manual (BC Ministry of Forests and Range and Ministry of Environment 2015) and as captured on field forms, can assist classification.

For TEM projects, field sampling typically aims for equal distribution across all BEC units and all ecosystem types. One possibility for future TEM projects would be to focus the field sampling on the mapped wetlands, with fewer plots in lower priority areas. This would allow the mappers to gain a better understanding and knowledge of the wetlands in the area by classifying to the site association level. This will also provide confidence in assigning a site association to wetlands that were not field verified.

Some wetlands, especially marshes and alkali meadows are very dynamic and will change quickly with changing weather and/or climate. For these wetlands, mapping to the class level may be acceptable.

Old and Ancient Forest

Old and ancient forests are natural stands of forest, dominated by large or old trees, and their associated ecological communities. These ecosystems are characterized by their complex and heterogeneous structure formed by a wide diversity of tree sizes including large trees, multiple canopy layers, snags, and large woody debris (Franklin and Spies 1991; Franklin et al. 2002). Old forest, regardless of species composition, can be differentiated from younger forests by their structure (Franklin and Spies 1991), as young forests are more uniform. When an ecosystem become and old or ancient forest depends on the species composition, site conditions, and disturbance history (Franklin and Spies 1991).

Old and ancient forest are important for the ecosystem services (Sutherland et al. 2016) as well as the social-cultural benefits they provide (Blicharska and Mikusiński 2014). Their complex structure promotes habitat diversity, and maintaining this structural complexity is a principle in managing forest biodiversity (Lindenmayer et al. 2006). Additionally, these ecosystems store considerable amounts of carbon compared to younger forests (Law et al. 2001; Sutherland et al. 2016) and can help ecosystem resiliency by buffering the effects of climate change (Betts et al. 2018; Frey et al. 2016).

Large old trees provide key structure for old and ancient forest ecosystems, such as cavities, large branches, and vertical and horizontally complex canopy, which supports ecosystem function (Franklin et al., 2002; Lindenmayer et al. 2012, Lindenmayer et al. 2014). However, not all old trees are large. Some old and ancient forests can have relatively small, stunted trees that persist in harsh growing conditions such as sub-alpine ecosystems or nutrient poor sites. Gap-phase dynamics are the typical primary disturbance mechanism in old growth ecosystems (Lertzman et al. 1996; Daniels and Gray 2006), though other disturbance processes such as bark beetles are also known to contribute to their structural diversity (Parish et al. 1999).

Old and Ancient Forest ecosystems are a Priority Ecosystem because they are of high importance as critical habitat to numerous wildlife species. They are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for many species (Table E-1). There is an extensive list of red and blue-listed forested Ecological Communities due to the lack of old seral stage representation within most low elevation BEC units in the region.

Mapping Challenges

Old and ancient forests are difficult to map because structural stage can be difficult to interpret and classify using photo interpretation methods. Forest age is often used as a proxy for structural stage to identify older forests. However, stand ages in BC's spatial forest inventory data (i.e., Vegetation Resources Inventory) can be inaccurate, particularly for stands over 200 years (Old Growth Technical Advisory Panel, 2021). Forest age can still provide an estimate of structural class and complexity, however field verified structural characteristics would be preferred for identifying old and ancient forest. Age is a forest attribute, as is structure, however a stands structural characteristics are what determine the habitats it will provide along with other ecosystem services, and therefore is what is key conservation planning.

Mapping Requirements

To have a higher confidence in old and ancient forest mapping, a SIL 3 (26-50% verification of the polygons) is recommended for classification to the site association level. Recent field data that provides information on the structural stage will be necessary to confirm seral units. Old and ancient forests should be mapped at a 1:10,000 scale to increase accuracy, and the use of 3D (stereo) colour imagery and/or LiDAR will help capture the variations in the structure (mature versus old growth). However, delineation may accurately be done using high resolution 2D colour imagery. Field plots with age and structural stage data will also help relate validate structural stages assigned by mappers and differentiate between old and ancient forests.

Recommendations

Full field plots with stand age and structural stage should be completed to calibrate mapping of old and ancient forests. Field data will help mappers differentiate old and ancient forest polygons and help mappers delineate the spectrum of structural stages. Focusing the majority of the field sampling on the mapped mature, old, and ancient forest, with fewer plots in lower priority areas could allow mappers to gain a better grasp of the differences between older forest types give them more confidence in assigning a structural stage in polygons without field verification.

Open Forest

Open forests are drier than average, due to factors such as upper-slope positions, warm aspects, steep sites, or dry, shallow, or coarse-textured soils. Their occurrence on the landscape is often dependent upon the BEC unit they occur in (e.g., not all BEC units will have open forest). Some open forest ecosystems can produce decent growing conditions and merchantable timber, while others can take a long time to develop through the various seral stages and remain quite stunted even in their old forest seral climax.

Open forests of the lowland BEC units such as the IDF tend to be associated with interior Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*). A number of wildlife species in the KBR are adapted to living in this type of open forest habitat, including Flammulated Owl, and Lewis' Woodpecker. The open nature of these forests creates a diversity of vegetation assemblages in the understorey that is unique to open forest areas with distinct flowering species such as balsamroot (*Balsamorhiza* sp.) and many native grasses. These units blend the benefits of forest and grassland habitats that are beneficial to wildlife by providing nesting opportunities for birds in snags and live trees, while also providing open spaces for foraging on insects and seeds from the grasses. Many species of ungulates favour these sites for the high value grazing. These areas are also ideal for grazing domestic horses, cattle, and sheep.

Open forests along ridges, typically classified as the 02 "dry" forested site series in most BEC units, provide a different set of features for wildlife. These open, forested ridges rarely have more than a 15% canopy cover due to a mosaic of rock outcrops, talus, and shallow soils. These sites are often associated with cave formations. Some may be small cracks and crevices that extend deep into the rock and can be ideal for snake denning.

Most open forest on ridges and upper-slope positions are not rare due to their lower resource values and often hazardous terrain and challenging accessibility. In contrast, open forest ecosystems in the lower landscape positions are more likely to be converted to range (forest cover removed), or restocked with a higher tree stem density following harvesting; thus replacing the natural open forest ecosystems. Loss of open forest ecosystems that are associated with native grass understories also contribute to overall loss of grassland habitat.

Open forest ecosystems are a priority because they are of high importance to wildlife species that depend on them for specific seasons and life requisites. They are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for over 20 species (Table E-1). A list of ecosystem codes associated with open forests by BEC units in the KBR is provided in Appendix D (Table D-7).

Mapping Challenges

A challenge for mappers when interpreting open forest from other ecosystem types, is deciding the point at which an open forest becomes a closed forest. There is not a clear definition regarding the threshold for percent closure, and definitions vary among the disciplines (e.g., forestry versus ecology). However, in general, open forest ecosystems are associated with crown closures/canopy cover of less than 30%, but more often less than 15% canopy cover.

Mapping Requirements

Because open forests are associated with certain tree species, having colour imagery would allow the mapper to differentiate target tree species from other coniferous species. In addition, VRI would be a valuable tool for mapping open forests as it provides information about tree species as well as the soil moisture, nutrients, age, and canopy closure.

LiDAR is preferred to visually capture the structure of the forest and the canopy closure. However, caution should be applied in how LiDAR interprets canopy closure compared to VRI crown closure and in-field plots conducted under the canopy (canopy cover). Field data is collected by looking up at the canopy which provides a very different perspective from aerial views. Typically, LiDAR canopy closures are much higher than values assigned by visual interpretation from above or below the canopy by mappers. It is important to learn to gauge the values produced through these different methods of interpretation.

A scale of 1:10,000 would be necessary for detailed mapping of these forests. Soils data would be beneficial to provide the mappers with information about the soil texture and depth, as open forests tend to occur on shallow soils.

Recommendations

The definition of open forest varies across the disciplines, making them challenging to identify. It will be necessary to determine the threshold for percent closure that determines whether a forest is open or closed for these ecosystems to be assessed. This is especially true in the Kootenay Boundary, and consultation with the Regional Ecologist has confirmed several site series are considered open forest (Appendix D, Table D-7). Open forests, due to their naturally low shrub cover, are susceptible to encroachment by invasive species. Therefore, open forest areas may provide stewardship opportunities as restoration efforts may be required.

Whitebark and Limber Pine

Whitebark pine (*Pinus albicaulis*) is a five-needled pine restricted in Canada to high elevations in the mountains of BC and Alberta (COSEWIC 2010). Whitebark pine generally occurs on thin, rocky, cold soils. This species is Endangered in Canada (COSEWIC 2010; SARA Schedule 1 2012) due to their loss from white pine blister rust, mountain pine beetle, climate change and fire exclusion. Negative effects from these factors result in death of the trees which cannot be reversed. Delayed age at maturity, low dispersal rate and reliance on Clark's nutcracker (*Nucifraga columbiana*) for successful dispersal and reproduction (BC CDC 2020) contribute to whitebark pine's high risk of extirpation in Canada (COSEWIC 2010). In BC, a predictive model is being developed for whitebark pine (M. Murray, pers. comm. 2021) [28].

Limber pine (*Pinus flexilis*) is another five-needled species of pine that occurs in BC. It is found in montane and subalpine habitats within the foothills of the Rocky Mountains. A recent study using occurrence data in a distribution model for limber pine found that its presence was most strongly determined by dolomitic carbonate, limestone and calcareous and undivided sedimentary rocks (Keefer 2020). This species is also positively associated with shrublands and south or southwest facing slopes, and negatively associated with coniferous forest and high summer solar radiation (Keefer 2020).

Limber pine is considered a "keystone" species as the seeds provide important food for bears, small mammals and birds, and the trees themselves provide shelter for other species (COSEWIC 2014). Limber pine is Endangered in Canada (COSEWIC) and blue-listed in BC (BC CDC 2022) due to being imminently and severely threatened by white pine blister rust, mountain pine beetle and climate change (COSEWIC 2014). Other factors that put this species at risk include a low population density, restricted distribution, and narrow habitat preferences (Keefer 2020).

These ecosystems are important to species ranked as highest priority (ranked as 1 or 2 on a scale of 6) in the BC Conservation Framework. Specific species that are associated with this ecosystem include Grizzly Bear, American Marten, and Flammulated Owl (Table E-1). A list of ecosystem codes associated with whitebark and limber pine ecosystems by BEC units in the KBR is provided in Appendix D (Table D-11).

Mapping Challenges

[28] Murray, M. Email to A. McIndoe. 31 March 2021

Both limber and whitebark pine occupy very small areas and are documented as having patchy distribution. Obtaining reliable data is also challenging due to accessibility from the types of habitats where they occur including steep slopes and subalpine areas. Mapping at a scale of 1:5,000 will likely be necessary to pull out small patches of these species from the landscape. Limber and whitebark pine are similar and may occur in the same habitats. Because limber pine is even more difficult to map and not classified in the field guides, capturing whitebark pine may result in capturing areas with potential for limber pine.

Mapping Requirements

One of the key inputs that should be obtained prior to initiating distribution mapping of whitebark pine or limber pine is existing plot data. This includes plot data held by the Province and externally, such as from the US or Alberta. As noted above, a model is in development that rates the habitat suitability for limber pine (Keefer 2020) in the eastern portion of the KBR. A predictive model is also in development for whitebark pine and the BC Whitebark and Limber Pine Seed Orchard working group meets monthly to discuss and share historical facts, best practices, technical support and information[29]. Recent colour imagery is also key as these species are very susceptible to pathogens and climate change so older imagery sources will not be reliable if there has been recent mortality. Therefore, communication with experts is key. Use of plot data and local knowledge would help to prioritize mapping efforts for these species in the KBR.

Regional Mapping Initiatives

Mapping of these ecosystems will rely on modelling being done by the Crown Managers Partnership. The Hi5 Working Group is in the process of completing a restoration strategy for whitebark and limber pine in the CCE, including piloting a modelling approach for whitebark pine restoration in a portion of the CCE. The range of these ecosystems is in a limited area of the region. The critical habitat mapping is relied on at this time at a broad-scale of potential. The region is considering expanding the critical habitat model to the rest of the region if field verification indicates the existing product is useful, and has a high level of likelihood of occurrence (e.g., performs well when field verified). It may be necessary to modify the existing modelling methods to determine if certain site attributes enable an improved level of differentiations between predicted and observed.

Recommendations

Increased field data is key to learning more about these species and their ecological requirements so that the models can be updated and do a better job at predicting where they may occur. Therefore, when field crews are sampling for ecosystem projects in areas where these species may occur, they should be trained in identification of these species. If observed, a GPS point should be collected and included in a mapping project using the TEI Symbol points feature class found within the Contractor

[29] https://whitebarkpine.ca/about/partners/

Package (TEI Unit 2020). The point feature method is especially useful when the observations are for singular or scattered trees that comprise <10% of the polygon.

There are some ecosystem mapping codes available for use when occurrence of whitebark pine is >10% of the polygon. However, there is no standard code for mapping limber pine. It is recommended that a standard code or way of mapping limber pine be developed by the Province to ensure consistency from mapping practitioners. There are some codes, however, for whitebark pine, including the Whitebark pine – juniper – kinnikinnick rock outcrop unit "Ro05". Other forested and krummholz ecosystems in certain BEC units have been confirmed by the Region as supporting this species (Appendix D, Table D-11). For example, the 102-site series in 21 BEC units[30] is considered to have a high correlation with individual or clusters of Whitebark pine. Therefore, these site series and mapcodes can be queried from existing mapping to help identify areas that are associated with these species.

Aspen-dominated

Trembling aspen (*Populus tremuloides*) ecosystems include pure stands, where aspen is prevailingly even aged, and where it occurs in later successional stages. These stands may contain shade-tolerant conifers. Aspen can be a pioneer species or occur as self-perpetuating stands without major disturbance. Aspen can form dense stands, but can also be described in some cases as open forest. As mentioned for open forest ecosystems, the diverse grasses, forbs and shrubs that grow in these areas provide valuable forage for ungulates. They are also highly valued by cattle ranchers for grazing their livestock.

Many migratory and resident birds nest in aspen-dominated ecosystems. As well, a study on cavity nesting communities in the Interior of BC found that "Aspen was the critical nesting tree…There was overwhelming selection for quaking aspen (*Populus tremuloides*); 95% of 1,692 cavity nests were in aspen, which comprised only 15% of trees available" (Martin et al. 2004).

Porcupines feed on aspen leaves and twigs in spring and summer and bark in winter, and beaver utilize it for food and dam-building materials. Aspen forests have about twice the density and diversity of insects as pure conifer stands, and consequently attract insectivores such as bats (Simard et al. 2001).

Aspen leaves, particularly those on suckers, are highly nutritious and provide summer food for moose, elk, and deer. They typically contain much higher forage value than conifer stands.

Aspen dominated ecosystems are identified here as a Priority Ecosystems because they are of high importance to numerous wildlife species for specific seasons and life requisites. They are ranked as

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[30]Subzone/variants identified by the Region include: ESSFdc1, ESSFdc2, ESSFdcw, ESSFdk1, ESSFdk2, ESSFdkw, ESSFmh, ESSFmm3, ESSFwc4, ESSFwcw, ESSFwh1, ESSFwh2, ESSFwh3, ESSFwm1, ESSFwm2, ESSFwm3, ESSFwm4, ESSFwmw, IDFxk, MSdk, MSdw

highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for Williamson's Sapsucker, Northern Goshawk, and North American Racer (Table E-1). A list of ecosystem codes associated with aspen-dominated ecosystems by BEC units in the KBR is provided in Appendix D (Table D-1).

Mapping Challenges

The biggest challenge for mapping seral versions of forested units, which include aspen-dominated sites, is how this information can be included in the mapping. In Land Management Handbook #65 (DeLong et al. 2011), seral units are numbered according to the site series association but followed by a "$" to designate a seral status. Some units are then further assigned a number for the structural stage it typically represents, a stand composition modifier and a running number to designate the seral vegetation community (DeLong et al. 2011). For example, the Trembling Aspen – Birch-leaved spirea – Huckleberry unit in the BWBSwk1 is assigned a code of 101$6B.1. However, the current TEI Long Table found within the Contractor Package (TEI Unit 2020) only allows a maximum of 5 characters within the site series field. This leads to difficulty for the mapper when attempting to attribute those ecosystems, and a decision on which values within the codes are most important to assign. This can lead to inconsistencies in how these units are attributed across mapping projects – how they were assigned in one project might not be how they were assigned in another.

There is a Seral field in the TEI Long Table (TEI Unit 2020) that can be used, but is still limiting in solving this mapping challenge. It is the intent to include a new field to the long table specific to Ecosystem Code (ECOC_S) in future updates to the TEIS standard. In the meantime, clear guidance is required on how to map seral ecosystems in a way that the information is captured; whether it is with a $ symbol in the seral field or if the $ symbol is added to the site series field (i.e., 103$).

Mapping Requirements

Having VRI for the mapping area would be highly beneficial as information regarding the leading tree species could be queried from that data. In some cases, the polygon linework in VRI could be copied and used for the ecosystem mapping product. At minimum, it could be used as a reference for mappers. Colour imagery is also required to accurately pull out deciduous leading species from the landscape.

Recommendations

Because aspen-dominated sites can be found across the landscape, it will be necessary to filter the existing data to only include the habitat types where they've been prioritized. For example, pulling out all of the areas in VRI that have aspen will include moist, receiving and floodplain sites as well as dry, upland sites. Pulling out site names from the provincial code list (TEI Unit 2022) where Aspen is leading will also capture two ecosystem types. For example, the current classification includes the rock talus site associations Aspen – Juniper- Rocktripe (Rt07) and the Aspen – Douglas maple – Saskatoon (Rt08), and flood site associations Aspen - Snowberry – Roses (Ff04), Aspen - Dogwood - Nootka rose (Ff05) and Aspen - Dogwood – Sarsaparilla (Fm07). As mentioned above, clear direction from the Province on how to assign approved seral codes that are incompatible with the TEI Long Table or, changes to the TEI Long Table to allow for more characters, is necessary.

Cottonwood Floodplain Forests

Cottonwood floodplain areas are specific riparian ecosystems. These broadleaf tree-dominated sites occur as middle bench ecosystems (nBEC code “Fm”), where the frequency of flooding has reduced, allowing for the establishment of cottonwood.

These rich, fast-growing sites are high in plant and wildlife species diversity. The shrubs in the understory shade streams and provide browse and cover for larger mammals. The foliage, twigs, and buds of the trees are used for food. Insects are typically abundant in these riparian forests during the spring that provide a critical prey source for breeding birds and bats. Large, old cottonwoods are prone to heart rot resulting in hollow trunks. The dead limbs and trunk cavities provide habitat for a wide variety of birds and mammals, including black bears, which can hibernate up in dry, hollow sections.

Great Blue Heron colonies have been documented in these ecosystems, placing their nests as high amongst the branches of the tallest cottonwoods. A number of woodpecker species use these deciduous sites for nesting and foraging. Cottonwoods are the tree species most often associated with known nesting sites of Western Screech Owls (for the interior subspecies).

Due to factors such as their naturally limited distribution, location on flat, fertile land where people like to settle and lack of mature and old seral stage representation, cottonwood ecosystems are at risk in British Columbia. All Cottonwood Riparian Forested ecosystems are either red- and blue-listed Ecological Communities in the region (BC CDC 2022). These ecosystems are listed regardless of current conditions (all structural stages) in order to prioritize them for conservation and restoration. One of the oldest known Cottonwood stands in the province occurs in the ICHmk4 near Morrissey, with individual cottonwood trees that are more than 450 years old (MacKillop et al. 2018, LMH 71).

Cottonwood Floodplain Forests are a Priority Ecosystem in the Kootenay Boundary region because they are of high importance as critical habitat to a number of wildlife species. Some red- and blue-listed terrestrial wildlife require these specific ecosystems to fulfill critical life requisites. For example, these sites are used as primary cavity excavation sites for woodpeckers that have the added benefit of providing secondary nesting sites for owls, or roosting by bats. These ecosystems are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for Grizzly Bear, Lewis’ Woodpecker, Western Screech-owl, Great Blue Heron and Silver Haired Bat (Table E-1). A list of ecosystem codes associated with cottonwood floodplains by BEC units in the KBR is provided in Appendix D (Table D-3).

<u>Mapping Challenges</u>

The challenges for mapping cottonwood floodplains are similar to those identified for riparian areas. However, there is likely to be less frequent modification in comparison to low bench and active floodplain areas and linework may have more accuracy over time. One change may be where the middle bench transitions to the high bench (or vice versa) due to the amount of flooding and disturbance experienced. As the river shifts, middle bench areas may experience even less frequent flooding, allowing for the establishment of conifers. The result is that the middle bench floodplain is now the high bench floodplain. The opposite can be true as well where more frequent flooding in areas that were considered high bench may result in conifer death, leaving cottonwood as the dominant species. Low bench floodplain areas can also become middle bench over time.

Mapping Requirements

Because cottonwood is a deciduous species, having colour imagery is necessary for identification. LiDAR is preferred for delineating enduring features. Mapping at a scale of 1:5,000 is also preferred to allow for more refined linework.

Recommendations

Several cottonwood-dominated site associations have been identified in the Province and the Region, and these codes can be used to query these ecosystems specifically within the existing data (Appendix D, Table D-3). As cottonwood ecosystems occur as middle bench ecosystems, the queries can also include middle bench ecosystems. The output of these queries would require assessment by an ecologist using imagery to determine the accuracy of the mapping. As recommended with the riparian areas mapping, it may be worthwhile investing in updates to the linework using new imagery and LiDAR to capture these ecosystems.

Grasslands

Grassland ecosystems are graminoid-dominated associations that occur on deep soils, but sites are dry because of very rapid soil drainage, insolation and/or lack of precipitation (Mackenzie 2012). Shrubs, if present, are sparse (<10%). The grassland category includes valley bottom, low elevation, mid- and high elevation grasslands, including alpine grasslands. Although they are physiognomically similar, the environmental factors driving the development of low and high elevation grasslands are different (Mackenzie 2012). Grasslands at lower elevations develop where conditions are too dry for tree establishment due to a semi-arid climate or because sites within forested zones are too dry and warm. At these higher elevations, grasslands are typically small pocket ecosystems that are restricted to steep, warm-aspect sites. More extensive and widespread higher-elevation grasslands occur within the Elk Valley, where they are often associated with coal deposits. Higher-elevation grasslands also occur in the Flathead valley (MacKillop et al. 2018).

Alpine grasslands occur as a result of the cold winters and growing-season frosts. Alpine grasslands are uncommon and occur in the ESSF woodland and parkland, and in the IMA where cold-air pooling or growing-season frosts, rather than excessive aridity, prevent tree establishment. In southern British Columbia, these grasslands are dominated by timber oatgrass (MacKillop et al. 2018).

Grasslands, along with brushlands, shrub-steppe, and alkaline/saline meadows form a very important part of the regional landscape by providing forage and habitat for wildlife, as well as rangeland for livestock. Low elevation grasslands provide important forage throughout the year for provincially significant populations of Rocky Mountain bighorn sheep, elk, and mule deer. During the spring and summer, mid- to high elevation grasslands are heavily utilized forage habitat by ungulates. High elevation grasslands are of particularly high importance to Mountain Goats throughout the year, especially in the spring for social groups of nannies and their kids.

Grasslands are ecologically, socially, and economically important ecosystems in the region, the Province and throughout Canada. In BC, grassland ecosystems are considered at-risk ecological communities because they are naturally uncommon and their condition is threatened by a number of factors including urban and rural development, overgrazing by wildlife and livestock, introduction of invasive species, off-road vehicle use and loss of natural fire patterns (MacKillop et al. 2018). The majority of native grasslands in the region are either red- or blue-listed Ecological Plant Communities (BC CDC 2022).

Grasslands are a Priority Ecosystem in the Kootenay Boundary region where they provide critical habitat during the breeding season as well as year-round for many regionally significant, and red- and blue-listed terrestrial wildlife species. Many species require grasslands to fulfill critical habitat requirements for nesting, burrowing, and foraging. These ecosystems are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for Mountain Goat, Long-billed Curlew, Lewis' Woodpecker, Common Nighthawk, Great Basin Spadefoot, Western Rattlesnake, North American Racer, Rubber Boa, Western Skink, Gopher Snake, Silver Haired Bat, Townsend's Big-eared Bat, California Myotis, and Hoary Bat (Table E-1).

A list of ecosystem codes associated with grassland ecosystems by BEC units in the KBR is provided in Appendix D (Table D-4). Grassland codes typically consist of two letters, starting with an upper-case "G" for grassland followed by a lowercase letter, followed by two numbers to indicate the specific grassland species type and plant assemblage (species composition and site conditions). Grassland associations described in the region include: Low to mid elevation Gg plant communities, Mid- to high elevation communities such as Gg16 (Rough fescue – Sulphur buckwheat – Sandwort), Alkaline/saline meadow class (Ga), and Alpine grassland class (Ag). Although several grassland plant communities have been described for the region, it is cautioned that others may occur that have not yet been described.

Mapping Challenges

One of the challenges for mappers is determining whether an ecosystem is a grassland or a brushland as many of the seral grasslands described for the Kootenays[31] have a significant (>10%) cover of brush (e.g., antelope-brush or big sagebrush). In these cases, understanding the site factors that are driving the ecosystems is important as brushlands are associated with shallower soils, which can be queried as a specific code in the bioterrain attribute fields. In addition, mapping seral versions of units can be challenging due to the limitations within the TEI Long Table fields found within the Contractor Package (TEI Unit 2020). This can lead to these ecosystems being inconsistently mapped. Another challenge when mapping grassland ecosystems is distinguishing between a sedge-

[31] See LMH71, LMH75 for descriptions of seral grasslands

dominated alkali meadow (Grassland Group) and a sedge-dominated wetland (Wetland Realm). Mapping grasslands to the site association level requires field confirmation of the plant species. In most cases, grasslands can only be mapped with confidence to the R/G/C level (e.g., as a grassland (Gg) but not a Bluebunch wheatgrass – Baslamroot grassland (Gb02)) unless field verified. Therefore, without accurate soils mapping or field plots, there's potential for inaccuracy when mapping grasslands.

Mapping Requirements

To have a higher confidence in the grassland mapping, a SIL 3 (26-50% verification of the polygons) is recommended for classification to the site association level. Recent field data that provides information on the current condition (e.g., level of disturbance and percent cover of invasive species) will be necessary to confirm seral units. Grasslands should be mapped at a 1:5,000 scale for further accuracy, and the use of 3D (stereo) colour imagery and/or LiDAR will help capture the variations in the structure (grassland versus brushland). However, delineation can accurately be done using high resolution 2D colour imagery. Soils data will also help distinguish between grasslands and brushlands as grasslands are associated with deep soils whereas brushlands have shallow soils.

Recommendations

Several grassland site associations have been identified in the Province and the Region, and these codes can be used to query these ecosystems specifically within the existing data. These can also be queried from the R/G/C fields, where populated. When existing data is being evaluated for use, it will be important to evaluate the data based on the project BAPID as older projects will require crosswalking of old codes to the current coding. There is higher confidence in the lower elevation mapping, which should also be considered.

For TEM projects, field sampling typically aims for equal distribution across all BEC units and all ecosystem types. One possibility for future TEM projects would be to focus the field sampling on the mapped grasslands, with fewer plots in lower priority areas. This would allow the mappers to gain a better understanding and knowledge of the grassland types and ecological drivers in the area to classify to the site association level. This will also give them more confidence to assign a site association to other grasslands that were not field verified.

Brushland

Brushland ecosystems are dryland shrub-dominated ecosystems that occur at low elevations outside of semi-arid climates but where conditions are too dry or warm for tree establishment (Mackenzie 2012). Soils are well-drained and often shallow. Shrubs are drought-tolerant, and of moderate stature including saskatoon (*Amelanchier alnifolia*), juniper (*Juniperus* spp.), cherries (*Prunus* spp.) and snowberry (*Symphoricarpus* spp.). These ecosystems can include disclimax brush ecosystems where vegetation competition, rather than environmental factors, maintains the non-forested state (Mackenzie 2012). High elevation brush is described as a separate priority ecosystem.

Brushlands form a very important part of the regional landscape by providing forage and habitat for wildlife, as well as rangeland for livestock. Low elevation brushlands provide important forage throughout the year for provincially significant populations of Rocky Mountain bighorn sheep, elk, and mule deer. Shrub species associated with brushland provide nesting opportunities for migratory birds, as well as security cover and shade for smaller, ground-dwelling wildlife species, and substrates are often conducive to burrowing.

Brushlands are a Priority Ecosystem in the Kootenay Boundary region with low elevation brushland ecosystems ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for Long-billed Curlew, Lewis' Woodpecker, Common Nighthawk, Great Basin Spadefoot, Western Rattlesnake, North American Racer, Rubber Boa, Western Skink, Gopher Snake, Silver Haired Bat, Townsend's Big-eared Bat, California Myotis, and Hoary Bat (Table E-1). The majority of natural, low elevation brushland ecosystems in the region are either red- or blue-listed Ecological Plant Communities (BC CDC 2022). A list of ecosystem codes associated with brushland ecosystems by BEC units in the KBR is provided in Appendix D (Table D-4). Brushland classes of grassland plant communities include units such as Gb20 (Saskatoon – Soopolallie – Juniper) and Shrub-steppe Classes (Gs).

Mapping Challenges

Although brushlands are distinctive to identify, it can be challenging to determine whether the brushland is the result of environmental factors (naturally occurring) or the result of non-environmental factors (disclimax). Within the vegetation disclimax class, a subclass for shrub-dominated ecosystems has been identified but cannot be assigned in the mapping as there is no subclass field in the TEI Long Table found within the Contractor Package (TEI Unit 2020).

Mapping Requirements

Mapping can be done at a scale of 1:20,000 or better. LiDAR or 3D imagery would allow the mapper to determine the height of the shrubs for classification and structural stage determination, but these are not requirements for mapping as it can be done in 2D. Soils data can help confirm natural brushlands from disclimax brush as natural brushlands are associated with shallow soils.

Recommendations

Brushland ecosystems, both natural and disclimax, can be captured by the current classification and queried within the existing data using the site series or the R/G/C fields, where populated. Some site associations for brushland ecosystems have recently been classified within the Region (TEI Unit 2022) and these can also be queried. When existing data is being evaluated for use, it will be important to evaluate the data based on the project BAPID as older projects will require crosswalking old codes to the current coding. Also, each polygon mapped as disclimax vegetation (Xv) will require further analysis to determine if it is shrub-dominated. Going forward it is recommended that a standard way of assigning subclasses be created and approved by the province to ensure consistency amongst mapping practitioners and allow them to map to the subclass level if it is possible to do so. This may include the creation of a User Defined Field or inclusion of a subclass field within the TEI Long Table.

Mid to High Elevation Brush

Mid to high elevation brush ecosystems are predominately mapped in the ESSF, parkland units and upper elevations of the MS BEC units and are exposed to higher precipitation, colder temperatures, and wind exposure than lower elevation brushlands. Due to these factor plant assemblages generally consist of heartier shrub species such as tree regen in combination with *Vaccinium* sp., false azalea, rhododendron, black twinberry, and highbush-cranberry.

High elevation brushland is often applied to capture site conditions that appear to be 1) a natural shrub dominated site (not disclimax), 2) a disclimax site where the source of disturbance is not clear via imagery and where avalanche has been ruled out, or 3) VRI indicates the site as not satisfactorily restocked (NSR). The first two cases are more common in the subalpine and are often referred to as subalpine shrubland. The VRI NSR noted high elevation sites resulted from forest harvesting and due to unknown reasons (not obvious via interpretation of imagery) are not returning to a forested condition (stuck in the shrub seral stage).

Although these ecosystems are not rare, they provide incredibly high value summer and fall forage for Moose, Mule Deer, White-tailed Deer, Rocky Mountain Elk, and Rocky Mountain Bighorn Sheep. In Wildlife Habitat Models based on ecosystem mapping, high elevation brush sites are assumed to provide Class 1 (High) and 2 (Moderately High) summer/fall forage values for the species mentioned.

<u>Previous Mapping Initiatives</u>

Broad Ecosystem Units that capture mid- to high elevation "brush" have been applied using BEI at 1:250,000 scale and include:

- "SU" Subalpine Shrub/Grassland - described in BEI as "Typically high elevation, northern habitat, characterized by dense shrubs and bunchgrasses, both intermixed and occasionally dominated by scrub birch, willows and Altai fescue"
- "MS" Montane Shrub/Grassland - described as "Typically a varied mixture of shrubs, thickets and herbaceous openings found in steep breaks along lower river valleys
- "AV" Avalanche Track

Unfortunately, none of these units is an ideal fit for mapping at more refined scales such as 1:20,000. In previous VRIBEM products, used to model moose winter forage, a generic "BR" brush map code has been applied to assist in capturing vegetation types that are considered to provide static winter forage. In the Skeena region and Northeast region VRIBEM product, Brush "BR" is applied to "Sites that remain in an early seral condition of shrub. In the VRI, these sites are indicated as not satisfactory restocked, as they have not reached a free to grow condition of a re-establishing forest." The code "BR" for Brush was used as the ecosystem unit to identify these sites. It was assigned a generic "Not Forested" due to the static disclimax condition following previous disturbance (fire, clearing, etc.). A generic structural stage 3b (tall shrub) is assigned to these sites, but likely varies from sparse shrub cover to dense tall shrub and thick regeneration.

Mapping Challenges

Mid to high elevation brush ecosystems are challenging to map by the very nature of the uncertainty of fit. At this time, there is no clear guidance on how to map these specific units consistently (i.e., no site modifiers, stand composition, etc.). In addition, ecosystem codes associated with high elevation brushland ecosystems are varied and inconsistently applied. Due to the variety of ways in which high elevation shrub sites have been labeled to date, it is challenging to query the coding. Also, in some cases these sites have previously been included as shrub dominated avalanche tracks in past mapping projects as it can be challenging to distinguish these sites from brushy avalanche tracks (Vs).

Mapping Requirements

Mid to high elevation brush ecosystems should be mapped at 1:20,000 scale or finer. The use of colour imagery allows the differentiation between deciduous and coniferous species and can allow for distinction between brush and avalanche track ecosystems. For example, if conifers are dominant on steep slopes, especially where an avalanche source is identified, “Vt” with a structural stage 3b or 4 would be appropriate.

Recommendations

For use in application of wildlife habitat models, the key ingredients to capture for these sites is the structural stage value (3, 3a, or 3b). Based on assumptions related to slope, aspect, structural stage and BEC unit, these sites can be queried and rated appropriately.

It is recommended that field surveys take place where high elevation brush sites have been identified to determine the site conditions and species assemblages and to note evidence of wildlife use; specifically the level of browse.

Huckleberry-Associated Ecosystems

There are many species of *Vaccinium* in BC with black huckleberry (*Vaccinium membranaceum*) being the focus within the KBR. Black huckleberry is present throughout much of BC and in a wide range of BEC zones, montane ecosystems in the Cascade Range and Kootenay regions support particularly abundant populations (Cocksedgeet al. 2009; Klinkenberg 2019). Similar to other *Vaccinium* species, black huckleberry favours moist, well-drained, and acidic soil that is high in organic matter and low in calcium and available nutrients (Barney et al., 2006).

Black huckleberry is an understory species primarily occurring in coniferous forests on well-drained mountain slopes (Haeussler and Coates, 1986; Cocksedge et al., 2009). Black huckleberry is a dominant understory species in all stages of forest succession and can be found in both shaded old-growth forests and in cleared areas with full sun exposure (Anzinger, 2002).

In southeastern B.C., black huckleberry is typically found in dry to moist forests and clearings at moderate to high elevations in the montane and subalpine zones (Haeussler and Coates, 1986; Cocksedge et al., 2009). Abundance is also associated with areas of moderate to high snowfall as deep snowpacks insulate plants from extreme cold and desiccation by heavy winter frosts (Haeussler and Coates, 1986; Proctor et al., 2017). Huckleberry habitat occurrence models in the Kootenay Region have indicated that huckleberry patches are most likely to occur between 1500-2000 m in the Kootenay Region (Proctor et al., 2017).

Several site series include huckleberry as a dominant species (e.g., ESSFwm3/102: Bl – Huckleberry – Bear-grass). These can be identified by searching through the TEI Ecosystems Codes (TEI Unit 2022) and then queried from the existing data. A list of ecosystem codes associated with huckleberry-dominated ecosystems by BEC units in the KBR is provided in Appendix D (Table D-6). However, there are other factors affecting whether huckleberry grow at a given site, and presence of the plant does not equal berry production.

Black huckleberry is a keystone plant species that provides food and shelter for wildlife, particularly grizzly bear (*Ursus arctos*) and is an important cultural resource for Indigenous peoples (Shores et al. 2019). Black huckleberry provides food and cover for several mammals, birds, pollinators, and insect herbivores (Shores et al., 2019).

In particular, black huckleberry is an extremely valuable and high energy food source for grizzly bears and black bears (McLellan and Hovey, 1995; Holden et al, 2012). Bears are reliant upon huckleberries as a critical diet component during late summer and early fall in the Kootenay Region; grizzly bear habitat selection, abundance, mortality, reproductive success, and dispersal are all associated with huckleberry availability (Spencer et al. 2020).

Huckleberry also provides browse for several ungulates, including elk (Edge et al., 1988), moose (Pierce, 1984), white-tailed deer(Kingery et al, 1996), and bighorn sheep (Demarchi, 2004). Several bird and small mammal species also utilize huckleberry patches as a source of food and cover. Blue (Beer, 1943), ruffed (King, 1969), and spruce grouse (Pendergast et al. 1970), in addition to a variety of songbird species (Simonin,2000) consume flowers, fruit, and foliage.

Black huckleberry populations are under pressure in the Kootenay Region due to many factors, particularly fire suppression, backcountry road construction, commercial forestry, recreational and commercial berry harvesting and climate change (Spencer et al. 2020).

The impacts of climate change on huckleberry production include shifts in distribution, phenology, and consequently, in access and availability to wildlife and people (Holden et al., 2012; Prevéy et al, 2020). Species distribution models developed by Prevéy et al. (2020) predict that the current range of huckleberry will contract significantly, particularly at lower elevations and in more xeric ecosystems, while climate suitability at higher elevations and northern latitudes may increase where sufficient soil development to support huckleberry patches occurs. The velocity of this shift, however, may be dependent on ecosystem characteristics such as soil and forest stand development (Prevéyet al, 2020).

Climate change is also predicted to modify the distribution of suitable habitat in British Columbia and alter the timing of flowering and fruiting (Prevéy et al., 2020). Warmer and drier conditions caused by climate change may also increase the probability of fire, which may increase abundance and berry production when fires are of low to moderate intensity (Prevéy et al., 2020), but have the potential to damage rhizome networks and hinder regeneration if intense or frequent fires occur.

Regional Initiatives

Approximately 40-70% of the Kootenay Region has been identified as potential black huckleberry habitat based on biogeoclimatic data (Hobby and Keefer, 2010). Some areas may support large huckleberry populations that are not productive, indicating that presence does not necessarily imply berry production (Hobby and Keefer, 2010). Predictive models associating site characteristics with huckleberry patch occurrence and utilization of patches by grizzly bears have been developed for the Kootenay Region (Proctor et al., 2017), but there is an ongoing need for predictive tools that can be used by resource managers to predict productive huckleberry patches at the site level in the Kootenay Region (Hobby and Keefer, 2010).

Techniques using remote sensing imagery have been developed to map the distribution of black huckleberry at local and regional scales based on the plant's seasonal colour change to bright red in late summer and early autumn (Shores et al, 2019). Remote sensing imagery is particularly useful in areas where forest cover is low and could be used to map changes in distribution due to disturbance, monitor changes in phenology and range due to climate change, and identify critical habitat for huckleberry dependent species. Using satellite imagery collected in different seasons, huckleberry can be mapped through modelling with high accuracy (~80% based on field surveys) (Shores et. al. 2019).

High-resolution (≤ 1 m) single-date aerial imagery methods are useful for spatially detailed mapping and monitoring in areas where the objective is to understand the range and distribution of huckleberry patches, or to quantify the abundance of huckleberry in a region. Alternatively, landscape satellite (Landsat) imagery has broad spatial and high temporal resolution and allows for the tracking of huckleberry distribution at the landscape scale and for monitoring long-term changes in distribution (Shores et al., 2019).

Canopy cover <30% has been identified as the most important factor associated with huckleberry patches important to grizzly bears (Proctor et al., 2017), and MacHutchon (2017) determined that an open canopy is likely more important to patch development and berry production than forest structural stage. In an effort to better understand where huckleberry patches are occurring, and what factors increase patch productivity and usefulness to grizzly bears as a food source, Proctor et al. (2017) developed a model associating geophysical, ecological, soil, climate, and topographical variables with huckleberry patches known to be used by bears. Their huckleberry patch model found that the most important predictors for patches utilized by grizzly bears were low canopy cover, low coarse fragment content in soil, low slope angle, high winter snowpack, and a cool (north–east) aspect (Proctor et al., 2017).

In addition, they found that cut blocks were a poor predictor for huckleberry patches, as was slash burning, whereas fires other than slash burning increased the probability of huckleberry patch establishment. Additional models designed by Proctor et al. (2017) to predict grizzly bear population processes determined that huckleberry patch availability was the most influential predictor of grizzly bear habitat selection, density, and fitness.

Mapping Challenges

A challenge identified using remote sensing imagery to map the distribution of black huckleberry at local and regional scales by Shores et al. (2019) was that other, non-target plants also turn red seasonally. Having vegetation plot data helped the researchers determine that those species are generally not dominant in the understorey and confirmed that huckleberry shrubs cover a greater percentage of the land than any of the other species in the study area. Therefore, reliability in the huckleberry mapping from the model is based on the amount of field data available to support the accuracy. The modelling also requires access to a particular type of imagery, collected in different seasons and over several years. Comparison of all the imagery can be quite time consuming, and best done for small study areas. This type of mapping will also only capture huckleberry where there is low forest cover; therefore, it will not capture huckleberry that occurs in the understorey of a closed forest (Spencer et al. 2020).

Mapping Requirements

As noted, mapping ecosystems associated with huckleberry requires high-resolution, remote sensing imagery from multiple years in different seasons, including late summer when the leaves of the huckleberry plants are red. Vegetation plot data is extremely valuable to inform the accuracy of the mapping. Although 3D imagery isn't necessary, it can provide the mapper with information that is useful (including aspect, drainage, canopy height, etc.). Crown closure information from VRI or LiDAR (where available) can also be helpful in predicting where huckleberries are more likely to occur.

Recommendations

Due to the complexity to map huckleberry-associated ecosystems and the fact that experts are currently working on models to identify huckleberry across the landscape, it is recommended that providing support and/or resources to expand the existing work into the Region will be most beneficial. Collecting vegetation plot data and providing it to the experts can help inform the model and improve the final outputs. Therefore, it will be important to learn which key attributes are required for the modelling to ensure that the information needed is collected. Existing plot data, including WHR plots, and other data sources available may also be valuable for this work.

To support the continued validation of huckleberry modelling, any field verification efforts for ecosystem mapping during the summer and fall should collect berry presence and abundance data specific to the data input required in the regional models. Collaboration and coordination of efforts between field crews and projects is recommended.

Cliff, Rock Outcrops and Talus

This priority ecosystem type includes sites with thin and discontinuous soil that have an abundance of exposed rock. Vegetation cover is low and typically dominated by xerophytes (Mackenzie 2012). Cliffs are defined as vertical rock sites, with small pockets of soil that may support vascular vegetation. Rock outcrops include bluffs and knobs of bedrock with limited soil development and high cover of exposed rock. Talus consists of active and inactive talus (large rocks) and scree (smaller rocks and more soil) that occur at the base of rock outcroppings or escarpments. Stable talus slopes may have some cover of deciduous trees or shrubs whereas unstable sites may have species that are tolerant of mobile substrates (Mackenzie 2012).

Some cliffs provide suitable ledges and formations for birds to nest on or attach nest structures to. Examples include Peregrine Falcon, Golden Eagle, and Cliff Swallows. Cliffs and rock outcrops also provide requisite escape terrain as security habitat for Mountain Goats. These features can also provide vertical foraging zones where the heat attracts insects at night. Bats can often be seen foraging along cliffs during dusk.

Talus and rock outcrops can provide critical access to hibernacula as well as security habitat for snakes, and other rock dwelling wildlife species. Reptiles can't produce their own body heat and rely on the temperature around them to maintain body heat, this is known as thermoregulation. Where these features are on warm-facing slopes, they provide important opportunities for reptiles to thermoregulate using direct heat from the sun and indirect heat from the rocks to warm themselves.

Rock outcrops, talus, and cliffs also provide important breeding habitat for additional species at risk such as white-throated swift, black swift, and Townsend's big-eared bat (MacKillop et al. 2018).

Non-vegetated (<10%) cliffs, rock outcrops and talus are a Priority Ecosystem group in the Kootenay Boundary Region. This group of non-vegetated ecosystems are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for Wolverine (hunting of small mammal colonies, travel corridors, and denning potential), Mountain Goat, Western Rattlesnake, North American Racer, Rubber Boa, Western Skink, Gopher Snake, and multiple bat species (Table E-1).

No cliff, rock outcrop or talus ecosystems are red- or blue-listed in the region (BC CDC 2022). Non-vegetated ecosystem codes associated with these sites include the nBEC codes: Rc (Rock Cliff), Ro (Rock Outcrop), and Rt (Rock Talus) (Mackenzie 2012). These codes are used regardless of BEC unit. A list of ecosystem codes associated with rock-dominated ecosystems including cliffs, rock outcrops and talus, by BEC units in the KBR is provided in Appendix D (Table D-9).

Although these enduring features are unlikely to have their structure altered in obvious ways by climate change, they will likely be susceptibility to temperature and moisture changes that could alter the temperature statis for successful hibernacula for bats and snakes.

Mapping Challenges

Exposed rock ecosystems can be relatively easy to map. It is when these become obscured by tree cover that they become more challenging. Cliffs within the forest canopy are likely to be missed by mappers, or they may be too small to capture as a separate feature. Rock outcrops may occur as small, isolated units within a larger forested polygon. Stable talus slopes may now support shrub or tree growth, which make these units difficult to map in some cases. Previous standards included a "brushy talus" code that could be mapped wherever these shrub-dominated talus slopes occurred, but this coding is absent from the current classification.

Mapping Requirements

Ecosystem mappers can capture most of these ecosystems at a scale of 1:20, using 2D imagery. However, mapping at a finer scale like 1:10,000 will help capture smaller features that may otherwise be missed and provide higher confidence in the mapping. Mapping in stereo (3D) may also help pull out small cliffs from the landscape as it will capture extreme changes in altitude. It can also help identify natural, rocky clearings when they occur in heavily disturbed areas. LiDAR is preferred for helping mappers determine size of talus.

Recommendations

The current non-forested classification (Mackenzie 2012) describes these rock ecosystems and provides codes that can be mapped in a TEI project (TEI Unit 2022). In addition, some rock outcrop and talus site associations have been identified. These codes can be queried from the existing mapping to identify areas mapped as rock (Appendix D, Table D-9). They can also be queried from the Realm/Group/Class fields, where populated (Terrestrial Realm, Rock Group).

Ecosystem modifiers, typically assigned based on TRIM/DEM models, may also help pull out areas from existing mapping, particularly areas that are very steep and could contain smaller cliffs that make up less than 10% of the polygon. For example, the q and z modifiers indicate slopes that are >100%. Other ecosystem modifiers can indicate where ecosystem occur on very shallow soils or dry soils, in gullies (often associated with exposed rock), or on ridges (exposed rock outcrops) (RIC 1998).

For some species, it is important to differentiate talus by the size of the rocks, which can vary greatly; from large boulders the size of small cars down to dime-sized pieces of rock and smaller. Rock size information is best captured in the bioterrain portion of TEM attribution.

In the absence of a "brushy talus" ecosystem code, using the structural stage fields will be key to capture when deciduous trees and shrubs have established on stable talus slopes. Other options can include the use of point features.

Caves

Caves are underground chambers that vary in size and length but have continuous air flow. That means that true caves have both entry and exit ports, though they may be inaccessible to people. The ability for air to move through caves is critical for their use and function as hibernacula for bats, and limits carbon dioxide buildup. Because they are subsurface, caves have limited fluctuations in temperature, but tend to remain humid and moist throughout the year.

The stable temperatures and humidity of a cave limit the need for energy fluctuations from the species using them. This lower energy demand has particular use for small mammals like bats which are homeothermic and enter states of torpor and hibernation. Many bat species reduce their metabolic requirements by entering a hibernation state during the winter months. Being able to suspend from cave roofs and walls and the persistent darkness in caves allow bats to remain relatively hidden while they hibernate. Caves provide an opportunity for bats to avoid danger and reduce energy during the winter when their food supply is substantially reduced in temperate climates.

Caves provide critical habitat to a number of species and are therefore identified as a Priority Ecosystem in the region. They are ranked as highest priority (ranks of 1 or 2 out of 6) in the BC Conservation Framework for many species of bats (Table E-1).

<u>Mapping Challenges</u>

Caves are often impossible to identify from aerial imagery. The only real indicator of where they can or do occur is from mapped karst formations. Portals to caves may be small and cryptic, regardless of the size of the associated cavern, so they are a challenge to identify in the field. The presence of a cave also does not necessarily equate to suitable for hibernation as shallow widely open caves may have ranging temperature changes. This means that a mapped cave may need field verification to determine if it is adequate for hibernation for target species. This results in very limited information available for wildlife biologists to find potential hibernacula for bats. Caves are even harder to identify using remote sensing technologies. Often, biologists rely on radio telemetry to locate bat hibernacula, but telemetry studies are often done on a small scale, are often limited to a small number of bats tracked per year and are very costly. There is currently no ecosystem mapping code for caves due to their general lack of mappability, and there is no clear direction on field crew requirements if caves are observed.

<u>Mapping Requirements</u>

To identify areas that may have caves, LiDAR would be required as this provides a “picture” of the earth’s surface. Mapping at a scale of 1:5,000 or less would be necessary but would be still be limited as some portals will be smaller than the LiDAR resolution, even if potential for use by wildlife exists.

Other input data sources including provincial karst mapping[32] can be used to focus on areas for mapping. Mapping or identifying these features on the landscape would best be done by a professional geoscientist but could be done by a professional biologist who is knowledgeable (qualified) in caves formation and local geology of the area being mapped. It is more typical for the biologist to provide the bioterrain mapper with a description of the wildlife habitat requirements and ask them to include point features during preliminary mapping for where they think there could be potential.

Recommendations

During field surveys to verify mapping, cave features should be captured as point features. Because caves cannot be picked out during ecosystem mapping, efforts to locate or identify caves will have to be done as a specific task. If ecosystem mapping is being done for a study area that has karst potential, field crews should be informed prior to field work on what to do if a cave is encountered. One potential would be for crews to collect a GPS location for the cave, complete a Site Visit Form (FS1333) and collect digital photographs. At minimum, a GPS location, photographs and a brief description of the cave should be collected. The information can be used to inform Wildlife Habitat Ratings. These sites are best captured in the mapping as a point features. Attribute fields in the bioterrain portion of TEM may also be well suited to capture these features at the polygon level.

[32] Recreation Karst Inventory (WHSE_FOREST_VEGETATION.REC_KARST_INV_SVW) and Reconnaissance Karst Potential Mapping (WHSE_LAND_USE_PLANNING.RKPM_KARST_POTENTIAL_AREA_SP)

Table E-1: KBR Wildlife Focal Species[33], FRPA Applicability, Conservation Framework Priority, and Association with Priority Ecosystems.

Note: Refer to below list by species with habitat requirement highlights specific to the KBR.

				Montane, Subalpine and Alpine Ecosystems			*Interior Moist/Wet Ecosystems*			*Interior Dry Ecosystems*			*Other Priority Ecosystems*				
Species	**FRPA-Identified Wildlife under the IWMS (no red-listed)**	**FRPA - WHF Order Applies**	**Conservation Framework – Highest Priority**	**Whitebark and Limber Pine**	**Avalanche Path Derived**	**High Elevation**	**Wetlands**	**Riparian Areas**	**Cottonwood Floodplain Forests**	**Aspen Dominated**	**Grasslands & Brushlands**	**Open Forests**	**Brush**	**Old and Ancient Forests**	**Huckleberry-associated Ecosystems**	**Cliff, Rock outcrops & Talus**	**Caves**
Grizzly Bear	x	x	2	x	x	x	x	x	x			x		x	x		
Cougar			4			x		x		x	x	x		x		x	x
Wolverine, *luscus* subspecies	x		2		x	x	x	x				x		x		x	
Bighorn Sheep	x	x	3		x	x					x	x				x	
Moose	x	x	6		x		x	x	x	x		x	x		x		
Mule Deer	x	x	6		x	x	x	x	x	x	x	x	x	x	x	x	
White-tailed Deer	x	x	6					x	x	x	x	x	x				
Elk	x	x	5		x	x	x	x	x		x	x	x	x	x		
Mountain Goat	x	x	1		x	x		x			x	x		x		x	x
Marten			2	x				x				x		x			
Lynx			4					x		x				x		x	
Flammulated Owl	x	x	2	x				x				x		x			
Long-billed Curlew	x		2								x						
Lewis' Woodpecker	x	x	2					x	x		x	x					
Western Screech-Owl, *macfarlanei* subspecies	x	x	1					x	x			x					
Williamson's Sapsucker	x	x	2					x		x		x		x			
Common Nighthawk			2								x	x					
Great Blue Heron, *herodias* subspecies	x	x	2				x	x	x								
Northern Goshawk, *atricapillus* subspecies			1		x			x		x		x		x			
Rocky Mountain Tailed Frog	x		2				x	x									

[33] Within the mandate of Together for Wildlife (T4W), wildlife is defined as terrestrial vertebrates and invertebrates that are provincially yellow or blue listed, in addition to plant communities, habitats or habitat features that support life requisites of these species.

				Montane, Subalpine and Alpine Ecosystems			*Interior Moist/Wet Ecosystems*			*Interior Dry Ecosystems*			*Other Priority Ecosystems*				
Species	**FRPA-Identified Wildlife under the IWMS (no red-listed)**	**FRPA - WHF Order Applies**	**Conservation Framework – Highest Priority**	**Whitebark and Limber Pine**	**Avalanche Path Derived**	**High Elevation**	**Wetlands**	**Riparian Areas**	**Cottonwood Floodplain Forests**	**Aspen Dominated**	**Grasslands & Brushlands**	**Open Forests**	**Brush**	**Old and Ancient Forests**	**Huckleberry-associated Ecosystems**	**Cliff, Rock outcrops & Talus**	**Caves**
Great Basin Spadefoot	x		1				x				X	x					
Coeur d'Alene Salamander	x		2					x				x		x			
Western Toad			2				x	x				x					
Western Rattlesnake	x		2								x	x				x	
North American Racer	x		2					x		x	x	x				x	
Rubber Boa			1					x			x	x				x	
Western Skink			1					x			x	x				x	
Painted Turtle - Intermountain - Rocky Mountain Population			2				x	x									
Gopher Snake, *deserticola* subspecies	x		2								x	x				x	
Silver-haired Bat		x	2				x	x	x		x	x		x			
Townsend's Big-eared Bat		x	2				x	x			x	x				x	x
Big Brown Bat		x	6				x	x			x	x		x			
Californian Myotis		x	2				x	x			x	x		x			
Hoary Bat		x	2				x	x			x	x		x			
Fringed Myotis	x	x	3					x			x	x		x		x	x
Little Brown Myotis		x	5				x	x			x	x		x		x	x
Long-eared Myotis		x	2				x	x								x	x
Long-legged Myotis		x	4											x		x	x
Northern Myotis		x	2				x							x			x
Yuma Myotis		x	6				x	x				x		x		x	x

Appendix E-1: Summary of Wildlife Species Habitat Requirements for the Kootenay Boundary Region

Summaries for KBR Wildlife Species Habitat Requirements[34]

Prepared by: Liam Brennan, Co-op Student, University of British Columbia

For: Together for Wildlife

Grizzly Bear

- Interior grizzlies breed in subalpine meadows.
- Occupies boreal forests, subalpine meadows, alpine meadows.
- Riparian/Wetlands areas important for feeding on non-fibrous plants
- Average home range of males: 450km^2

Cougar

- Occur where ungulates are found, often semi open habitat in the interior.
- Preference for areas with no human disturbance, with suitable cover (dense vegetation/rocky ledges/cliffs)
- Den near water, in cave/rock ledge or secluded area protected by roots or windfall.

Wolverine, *luscus* subspecies

- Limited to mountainous region in Southern portion of province
- Prey abundance is key habitat characteristic
- Occupying conifer-dominated habitat, alpine and fresh emergent wetland habitats
- Will occupy alpine meadows, shrublands, grasslands
- Uses all seral stages of the forest

Bighorn Sheep, *canadensis* subspecies

- Alpine tundra, health, grasslands, and meadows are all important sheep habitat (mainly in summer)
- Shrub grass steppe and open dry forests important for wintering populations
- Usually in areas of low precipitation

Moose

- Associated with wetlands, consumer emergent vegetation in lakes
- Also, may visit alpine shrubland
- Associated with shrubby, early seral habitats with some more mature trees for cover

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34 Sources used for the species summaries: https://www.cosewic.ca/index.php/en-ca/, https://linnet.geog.ubc.ca/biodiversity/efauna/, https://www.allaboutbirds.org/guide/ , Stevens & Lofts, 1988, Stevens, 1995.

Mule Deer

- Use steep, south-facing slopes in winter
- Will occupy wetland, avalanche tracks, dry, average, wet, riparian and parkland forests.
- Forested habitat, need of cover
- Prefer open coniferous habitat in early seral stages

White-tailed Deer

- No alpine habitat usage
- Agricultural, riparian, dry forest
- Shrub- herb stage of dry forests
- Need for cover more important than habitat class

Rocky Mountain Elk

- Forage in a variety of habitat including ponderosa pine, Douglas fir, lodgepole pine forests, Engelmann spruce, trembling aspen, deciduous, riparian forests, subalpine wet meadows, avalanche shrubland, and boreal and southern bunchgrass steppe.
- Open area interspersed with patches of trees or dense shrubs

Mountain Goat

- Use of all habitat is constrained by proximity to rocky cliffs or bluffs; old-growth forest is used for protection from winter storms
- Steep rocky terrain is used for escape cover
- Utilized most alpine subzones including rocky, talus, tundra, heath, alpine grassland, alpine/subalpine meadows and krummholtz.

Marten

- Uses late seral stages of a forest, needs wildlife trees, slash piles and coarse woody debris. Dry, average, wet, riparian and parkland forests all used.
- In general, mature coniferous forests are ideal habitat
- Avoids alpine areas

Lynx

- Occupies rocky and talus zones along with dry, average, wet, riparian and parkland forests
- Typically associated with extensive tracts of boreal forest with rocky outcroppings, bogs and thickets
- Boreal white spruce, boreal spruce – trembling aspen mixed forest, black spruce – tamarack bogs, young dense stands of lodgepole pine, sub-climax alder – black spruce forests and willow thickets are all important habitat
- Successional, closed conifer habitats allow for a close approach onto snow show hare – the primary prey item.
- Avoids Alpine Areas

Flammulated Owl

- Occupies Old Growth Forest on mountain sides
- Dry, mature open forests of ponderosa pine or other large coniferous trees interspersed with oaks or aspen.
- Douglas Fir, Limber and yellow pine allow attracts this species.
- May favor burned areas, especially those with snags because the flammulated owl is a cavity nester

Long Billed Curlew

- Occupies grasslands, agricultural areas and shrubland steppe ecosystems
- Often occupies grasslands with sparse, short grass

Lewis' Woodpecker

- Use logged and burned areas often in ponderosa pine open forests. High standing snag densities are a very important habitat quality as they are used for cavity nesting.
- Lewis' woodpeckers may also use deciduous groves near lakes and streams, open forest, orchards rural and residential gardens.

Western Screech Owl

- Prefer mixed deciduous-coniferous woods near water.
- Cavity nester will use nesting boxes.
- Common trees used include cottonwood, aspen, alder, water birch, oak and bigleaf maple.

Williamson's Sapsucker

- Nests in coniferous and mixed woodlands in mountains, especially forests with pine, larch, fir, Douglas fir and aspen.
- Not known to nest in moist forests such red cedar or western hemlock.
- Cavity nesters

Common Nighthawk

- A bird of open or semi habitat
- Including, logged forest, recently burned forest, woodland clearings, prairies, plains, grasslands, open forests, and rock outcrops
- Forages almost exclusively for aerial insects at dawn and dusk, high insect density likely important quality of good habitat

Great Blue Heron, *herodias* subspecies

- Uses a variety of freshwater habitats from lakes, streams and/or marshes to forage for fish and amphibians
- May also forage in grasslands and agricultural fields
- Nests in trees near foraging areas, usually away from human disturbances

Northern Goshawk

- Breeds in large tracts of coniferous forests, heavily affected by logging
- Forages in more open areas
- Mature, old growth forest with more than 60% canopy cover
- Nests are often built near clearing in the forest such as forest trail and are often near lakes or streams.

Rocky Mountain Tailed Frog

- Cold cascading streams, shaded by old-growth forest; sensitive to steam disturbance such as algal growth
- Adult frogs use mature riparian forests to forage for invertebrates on the forest floor

Great Basin Spadefoot Toad

- Will occupy lakes, shrub grass steppe (BG, PP, IDF) and dry and average forests.
- All habitat must be close to permanent or temporary water
- Sensitive ranch cattle and lakeside development

Coeur D'Alene Salamander

- Needs cool, humid sites; mature/old growth areas
- Logging may have devastated much of population

Western Toad

- Breeding occurs in shallow lakes and ponds often with a sandy or silty bottom substrate.
- In the summer, foraging takes place in forests, forest openings, shrubby areas, marshes, and other open and wooded habitats.

Western Rattlesnake

- Forested (dry / average) areas or shrub grass steppe but must be associated with rocky or talus area
- Needs rocky fissures, talus or caves for den sites

North American Racer

- Arid valleys in Southeastern B.C.
- Overwinter in communal rock dens
- Forage in grasslands and lowlands

Rubber Boa

- Often found with decaying logs / rubble and sandy, well-drained soil
- Can be found in woodlands, grasslands, coniferous forests, dry pine forests and juniper woods
- Frequently associated with lakes and streams
- Frequently in associated with rocky, talus areas

Western Skink

- Found in variety of habitats, including woodlands, grasslands, and dry hillsides (especially those that are south facing).
- Can be very abundant along riverbanks
- Found in bunchgrass, interior Douglas fir and interior cedar-hemlock bio geoclimatic zones.

Painted Turtle

- Low elevation lakes and ponds
- Loose soil for digging nests
- Offshore basking sites
- Sensitive to lakeshore development

Gopher Snake, *deserticola* subspecies

- Forested areas, shrub/grass steppe, agricultural areas
- Must be associated with rocky / talus areas for denning
- Needs sizable rodent populations

Silver Haired Bat

- Associated mainly with forests and sometimes grasslands, near water
- In the Okanagan Valley, cottonwood trees appear to be important for roosting
- Hunts in clearings, above treetops and over water

Townsend's Big- eared Bat

- Uses caves and old mine shafts for hibernation, vulnerable to human disturbance
- Dry grasslands, coniferous and deciduous forests – wide variety of habitats
- Foraging areas include insect-rich riparian areas and wetlands

Big Brown Bat

- Strong affinity for buildings
- In the Okanagan, colonies found in rock crevices and dead ponderosa pine tree snags
- Inhabits a variety of habitats from arid grasslands to interior forests, from sea level to 1070 meters.
- Roosts used during the daytime – hollow trees, buildings, close to water

California Myotis

- Wide range of habitat tolerance, from arid grassland to wet forest
- Will forage over Douglas fir forests, ponderosa pine parkland, bodies of water.
- Require day roost in crevice like places, allow trees, loose bark or under buildings.

Hoary Bat

- Forested and agricultural habitats, orchards
- Forage above fields, rivers, lakes, and forest clearings
- Roost along in both coniferous and deciduous trees, often in orchards

Fringed Myotis

- Arid habitats – ponderosa pine parkland, forest, sagebrush steppe.
- May forage close to forested or riparian areas.
- Nighttime roosts often in caves, mines, tunnels or buildings

Little Brown Myotis

- Forage over water, agricultural habitats, urban/suburban and forested areas.
- Roosting may occur in man-made structures or cliffs and outcroppings
- Hibernates in caves and abandoned mines

Long Eared Myotis

- Roosts in rock fissures, caves, under loose bark or in hallow trees
- Forages with coniferous forest canopy (Douglas fir, Ponderosa Pine, Engelmann spruce-subalpine fir0 and over small forest lakes
- Roosts during the day in snags and buildings

Long–legged Myotis

- Coniferous forests, usually in mountainous areas
- Day roost in abandoned building, cracks in ground, cliff faces or beneath bark of tree
- Hibernates in caves and mines

Northern Myotis

- Hunts over forest clearings and small ponds
- Has been found in Revelstoke National Park in Western Red-Cedar, Hemlock at 700m.

Western Small-footed Myotis

- Roosts in rock fissures, caves, under loose bark or hallow trees.
- Occupies sage brush steppe and ponderosa pine parkland, in association with cliffs and talus
- Forages along cliffs and rocky slopes
- Day roosts in talus

Yuma Myotis

- Open coniferous forests near water
- Forage over still or moving water
- Maternity roosts are almost entirely in manmade structures but occasionally will be caves, mines, and crevices