Yellowstone to Yukon Conservation Initiative

wildsight

SELKIRK GEOSPATIAL RESEARCH CENTRE

Creston Valley Green Map Project Final Report

By YANN TROUTET

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Contents

The Selkirk Geospatial Research Centre (SGRC) at Selkirk College is a leading-edge research centre specializing in geospatial technologies to aid in solving critical issues pertaining to environmental and socio-economic challenges. Through partnerships with non-profit organizations, businesses and industries, the SGRC assists to create Geospatial based solutions in the Kootenays.

Wildsight works locally, regionally and globally to protect biodiversity and encourage sustainable communities in Canada's Columbia and Rocky Mountain regions. Wildsight interacts with industry, scientists and all levels of government, including First Nations, to shape and influence land-use decision and steward change on the ground.

Wildsight Creston Valley Branch:
https://wildsight.ca/branches/creston-valley/

The Yellowstone to Yukon Conservation Initiative (Y2Y) is a joint Canada-U.S. not-for-profit organization that connects and protects habitat from Yellowstone to Yukon so people and nature can thrive.

Abstract

Relying on the GIS-based concept of suitability analysis, this project combines data from 28 geospatial datasets to identify areas of high potential for conservation and ecological restoration work in the Creston Valley.

Acknowledgements

The Creston Valley Green Map project is a collaborative project between Wildsight's Creston Valley Branch and the Selkirk Geospatial Research Centre. The project is funded by Wildsight and the Yellowstone to Yukon Conservation Initiative. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the view of Wildsight or the Yellowstone to Yukon Conservation Initiative.

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Executive Summary

The Creston Valley is located in southeastern British-Columbia. It stretches from Kootenay Lake to the USA border and is flanked in the East and West by the Purcell and Selkirk Mountain Ranges, respectively. Harbouring a number of species at risk, the valley holds important wetlands as well as winter habitats and crucial travel corridors for elk, moose, caribou and grizzly bears.

The mild climate, abundant spring rains and fertile soils support a thriving farming business in the Creston Valley. The wider area also provides timber to two local sawmills and the Creston Community Forest. Growing human populations and expanding communities are putting pressure on wildlife habitats and regional biodiversity. In order to preserve the region's rich biodiversity and threatened species, the maintenance of critical habitats and the co-existence of humans and wildlife need to be facilitated.

Wildsight's Creston Valley Branch strives to inform and influence land-use planning processes in the Creston Valley. There is a need for robust, objective mapping products to help guide this work.

The goal of the Creston Valley Green Map Project is to help preserve the exceptional biodiversity of the Creston Valley. The first steps in reaching this are to characterise the valley's habitats, to evaluate their relative importance and to highlight areas where conservation and ecological restoration efforts could most effectively support this goal. The project aims to help decision makers take steps to preserve the most critical habitat areas in the Creston Valley.

To evaluate the appropriateness of any given area for conservation, the project relies on a GIS-based process known as *suitability analysis*. In this case, the process incorporates 19 layers describing the natural features of the study area, and 9 layers detailing social factors relevant to the analysis. Incorporating local ecological knowledge and expert judgment, each dataset is used to rank the conservation value of the study area's terrestrial ecosystems. The data is compiled according to the six following themes:

1) Habitat Rarity
2) Under-representation in Conservation Areas (Gap Analysis)
3) Wildlife Habitat Value
4) Forest and Floral Attributes
5) Human Footprint
6) Geotechnical and Wildfire Risks (soil stability, flooding, urban interface wildfires, etc.)

The theme results are further aggregated into a single map that highlights *hotspots* of high natural value and areas where social factors could constrain conservation. A connectivity model then uses these results to identify potential pathways along which conservation efforts could prove particularly effective for building ecological resilience in the face of climatic changes. Finally, a multi-factored visibility analysis is performed to help inform future landscape-based management decisions.

The preparation of the Creston Valley Green Map involved the inventory, examination and assessment of a considerable number of geospatial datasets describing the Creston Valley's social and ecological fabric.

Results compiled according to the project's six themes provide detailed insights into the factors that may justify enhanced conservation efforts in given locations within the study area. Among the major findings are the following:

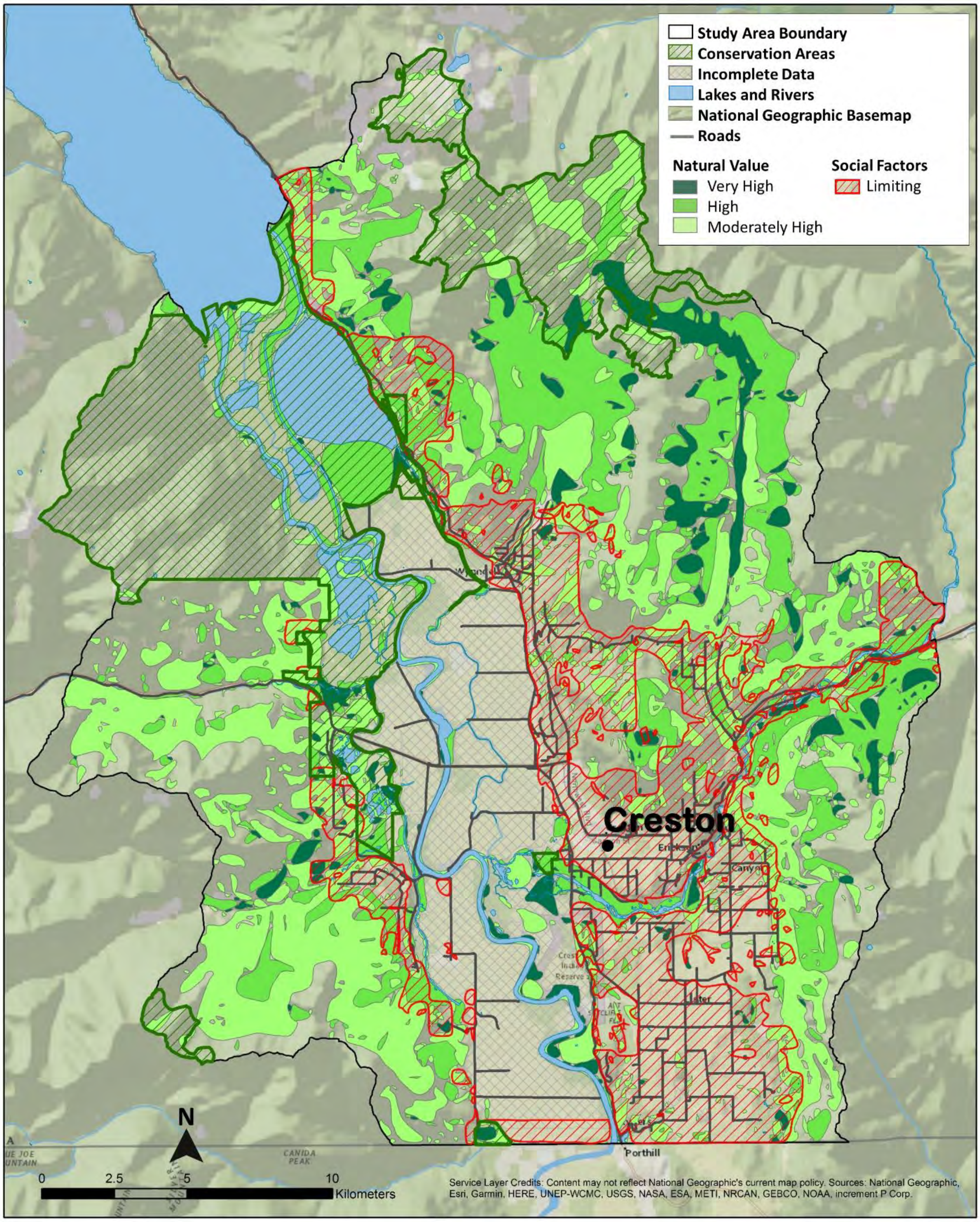
- Rare habitats in the Creston Valley are associated with low altitude riparian areas. Ridgetop ecosystems were also identified as being rare, though with lower 'rarity values'.
- Mid-slope *Dry Interior Cedar Hemlock* habitats tend to be the ones that are the least well represented in existing conservation areas.
- High-ranking wildlife habitat is found extensively in the valley bottom, with high-value areas located mostly in wetlands along the Kootenay River, notably on Lower Kootenay Band land.
- Alpine ecosystems within the study offer caribou winter habitats that enjoy a high level of legal protection, owing to the *No Harvest* designation adopted as *general wildlife measures* under the Forest and Ranges Practices Act of BC.
- High-value forest and floral attributes are found in dense concentration in the Arrow Creek watershed and on the west-facing slopes overlooking Duck Lake.
- Riparian sites in the valley bottom offer strings of small high-value polygons very near human populations.
- Community watersheds are deemed areas of high compatibility with conservation.
- When considering conservation in relation to Geotechnical and Wildfire Risks, large, high-ranking areas are found in the more intact portions of the valley's floodplains and along the lower reaches of the Goat River.

The aggregation of the theme results provides an overall picture of the high-ranking candidate areas for conservation in the Creston Valley. Key findings are that:

- The largest areas of high natural value in the study area are found in
  - the upper reaches of the Arrow Creek and Duck Creek watershed,
  - the northwest-facing slopes of Mount Thompson and
  - the northern flanks of the Corn Creek watershed.
- Riparian areas account for most of the valley bottom's high-ranking natural hotspots; these are concentrated along the lower reaches of the Goat River and Summit Creek as well as on the east bank of the Kootenay River, on Lower Kootenay Band lands.
- Creston and Wynndel form the larger areas of very high social constraints.

- Areas of high social constraints affect the Lister Plateau, the upper sections of the Goat River, the area of West Creston and most of the lower, west-facing slopes between Creston and Kuskonook.
- Goat Mountain forms an isolated 'island' surrounded by areas of high social constraints.

The following map is copied from the concluding sections of this report.



Hotspots of high natural value and areas of siginficant human footprint as they relate to the potential for enhanced conservation and ecological restoration efforts in the Creston Valley

Creston Valley is located at the crossroads of significant, known wildlife and climate connectivity corridors. Modeling ecological connectivity was one of the intended results of the project. By including expert knowledge and by modelling internal and cross-valley connectivity, the project mapped five major corridors connecting important habitats within and around the study area.

The Creston Valley Green Map Project is intended as a platform to spark and inform further conversations with local stakeholders, knowledge holders and decision makers, whose input will help define future iterations of this map, and help shape a vision for evidence-based conservation in the Creston Valley by taking a proactive approach.

As of October 2018, the recommendations for future work are the following:

- To consider spot-check field validations to document and assess the quality of the analysis results;
- To consult with biologists and ecologists to evaluate the need for process review or further analysis;
- To solicit and integrate added local and traditional ecological knowledge;
- To present and discuss the results with stakeholders and decision makers;
- To identify promising sites for the implementation of field-based conservation efforts.

1. Creston Valley Green Map Project Overview

1.1 Introduction

The Creston Valley is located in southeastern British-Columbia. It stretches from the Kootenay Lake in the North to the US border in the South, and is flanked in the East by the Purcell Mountain Range and in the West by the Selkirks (see figure 1). The Creston Valley is one of the most diverse parts of the Columbia Basin, where 74% of all terrestrial species in B.C and 61% of all bird species in Canada can be found (Huck, 2006). The valley provides habitat for great blue herons, bald and golden eagles, trumpeter swans and more than 100 species of songbirds. Harbouring several species at risk, the valley also holds important winter habitats in the wetlands and crucial travel corridors for elk, moose, caribou and grizzly bears.

The mild climate, abundant spring rains and fertile soils support a thriving farming business in the Creston Valley. The valley bottom and the Lister plateau produce lush grasslands for dairy farms, and also sustain hay, grain and vegetables growers. Orchards and vineyards benefit from the excellent conditions offered by the valley's higher terraces and west-facing slopes. The wider area also provides timber to two local sawmills and the Creston Community Forest.

Growing human populations and expanding communities are putting pressure on wildlife habitats and regional biodiversity. In order to preserve the region's rich biodiversity and threatened species, maintenance of critical habitats and co-existence of humans and wildlife need to be facilitated.

1.2 Problem Statement

Wildsight's Creston Valley Chapter (https://wildsight.ca/branches/creston-valley/) advocates for the conservation of biological diversity and strives to inform and influence land-use planning processes in the Creston Valley. Robust, objective mapping products are needed to help guide this work.

1.3 Goal and Objectives

The goal of this project is to help preserve the exceptional biodiversity of the Creston Valley. The first steps in reaching this goal are 1) to characterise the valley's habitats, 2) to evaluate their importance for biodiversity, 3) to evaluate the performance/gaps of existing protected areas and 4) to delineate the extent of the areas that hold the most potential as candidates for future conservation and/or restoration efforts.

By producing a Green Map of the valley, the project aims to assist decision makers in taking the necessary steps to preserve the most critical habitat areas in the Creston Valley.

What is a Green Map®?

A Green Map is a locally-made map highlighting sustainable resources of a particular geographic area. Since virtually all decisions about each Green Map are made locally by the mapmakers in the community being charted, the mapmaking process and final products vary widely in terms of goals, content, and design. Green Map projects create perspective-changing community 'portraits' which act as comprehensive inventories for decision-making. Each map has its own unique style, validity, and audience, and many Green Mapmakers work in multiple formats over time, charting specific themes, piloting new concepts and continually creating compelling new perspectives on familiar places.

Both the mapmaking process and the resulting Green Maps have tangible effects that:

- Strengthen local-global sustainability networks;
- Expand the demand for healthier, greener choices;
- Help successful initiatives spread to even more communities.

Green Map® System promotes inclusive participation in sustainable community development worldwide, using mapmaking as a medium. Mapmaking teams pair Green Map System's adaptable tools and universal iconography with local knowledge and leadership as they chart green-living, ecological, social and cultural resources. Green Map System has been developed collaboratively since 1995, and the movement has spread to over 950 cities, towns and villages in 65 countries. Over 550 unique, vibrant Green Maps have been published to date, and another 450 are interactive Open Green Maps. Hundreds more have been created in classrooms and workshops by youth and adults.

For more information: http://www.greenmap.org

Wildsight intends to use the project's output maps to:

- work with the Regional District of Central Kootenay (RDCK) to aid in planning future developments;
- develop a sustainability plan for the Creston Valley;
- help preserve crucial habitat types by supporting education, land acquisition and provincial legislation projects.

2. Study Area

In defining the study area for the Creston Valley Green Map project, the guiding principles laid out by Wildsight included two criteria that can be addressed by terrain analysis using GIS software: 1) visibility form the valley bottom and 2) major ridgelines/watershed boundaries.

Figure 1 presents the results of a 'viewshed' analysis that was performed to identify the areas that are visible from the bottom of the Creston Valley. Using the Canadian Digital Elevation Model (DEM), the 800 meter elevation contour line was chosen as a 'viewpoint'. The results of the analysis were used to select the watersheds and sub-watersheds that would be included in the study area. The final study area boundary more or less captures the watersheds that are mostly visible from the valley bottom.

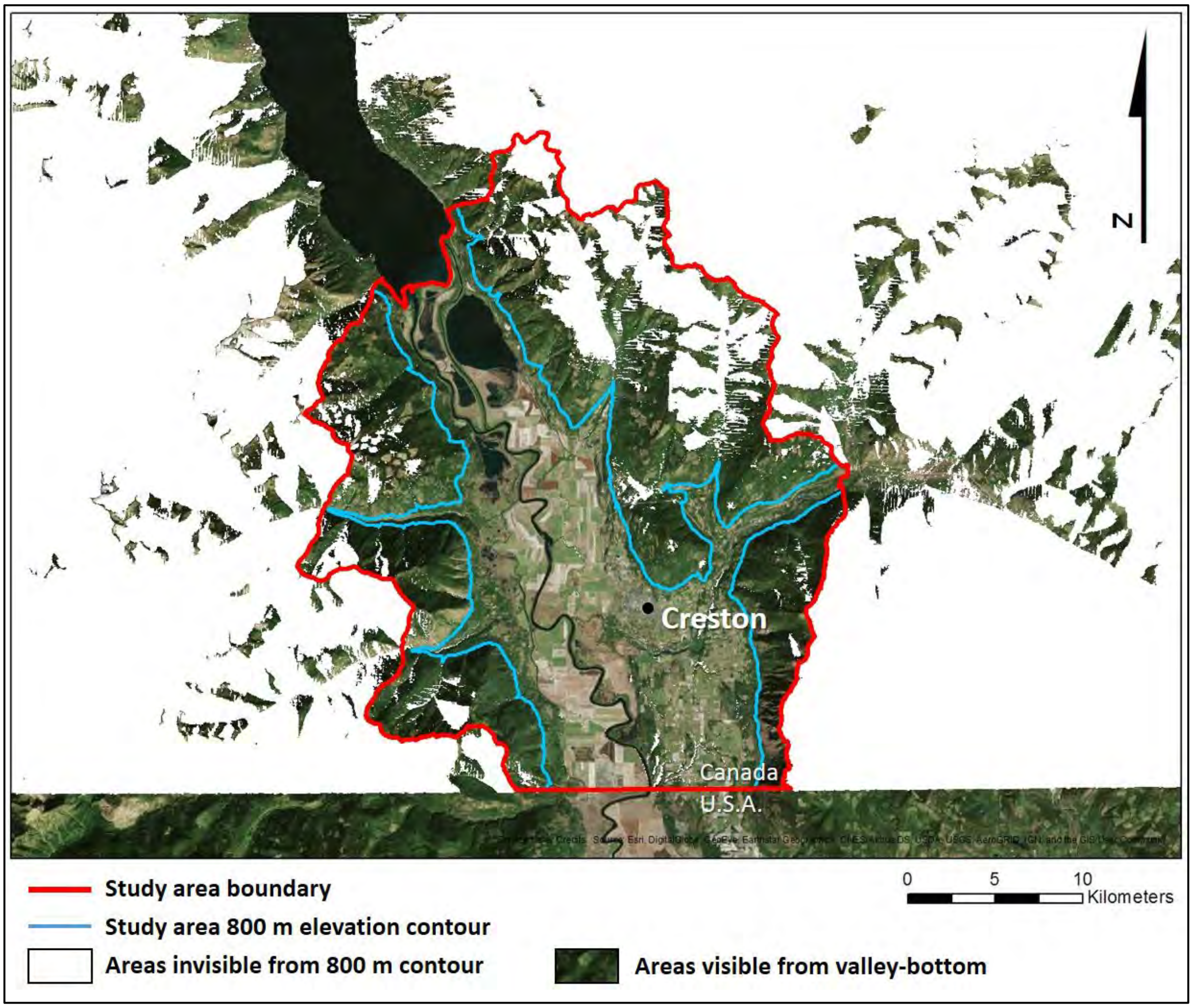


Figure 1: The study area chosen for the Creston Valley Green Map project captures the watersheds and sub-watersheds that are mostly visible from the bottom of the Creston Valley.

The study area boundaries displayed in figure 1 follow the limits of the major watersheds of the Creston Valley. For the Goat River, Summit Creek and Corn Creek, watershed subdivisions were selected following prominent ridgelines that bound the areas that are mostly visible from the valley bottom. Finally, a small portion of the lower part of Buckworth Creek is included in accordance with the limits of Wildsight's original proposed study area.

The background imagery in Figure 2 provides a snapshot of the land cover types (forest, water, crops) and land-use patterns (cutblocks, agriculture, etc.) that occur in and around the study area. The natural shading of the different hill aspects give the viewer an appreciation of the area's topography.

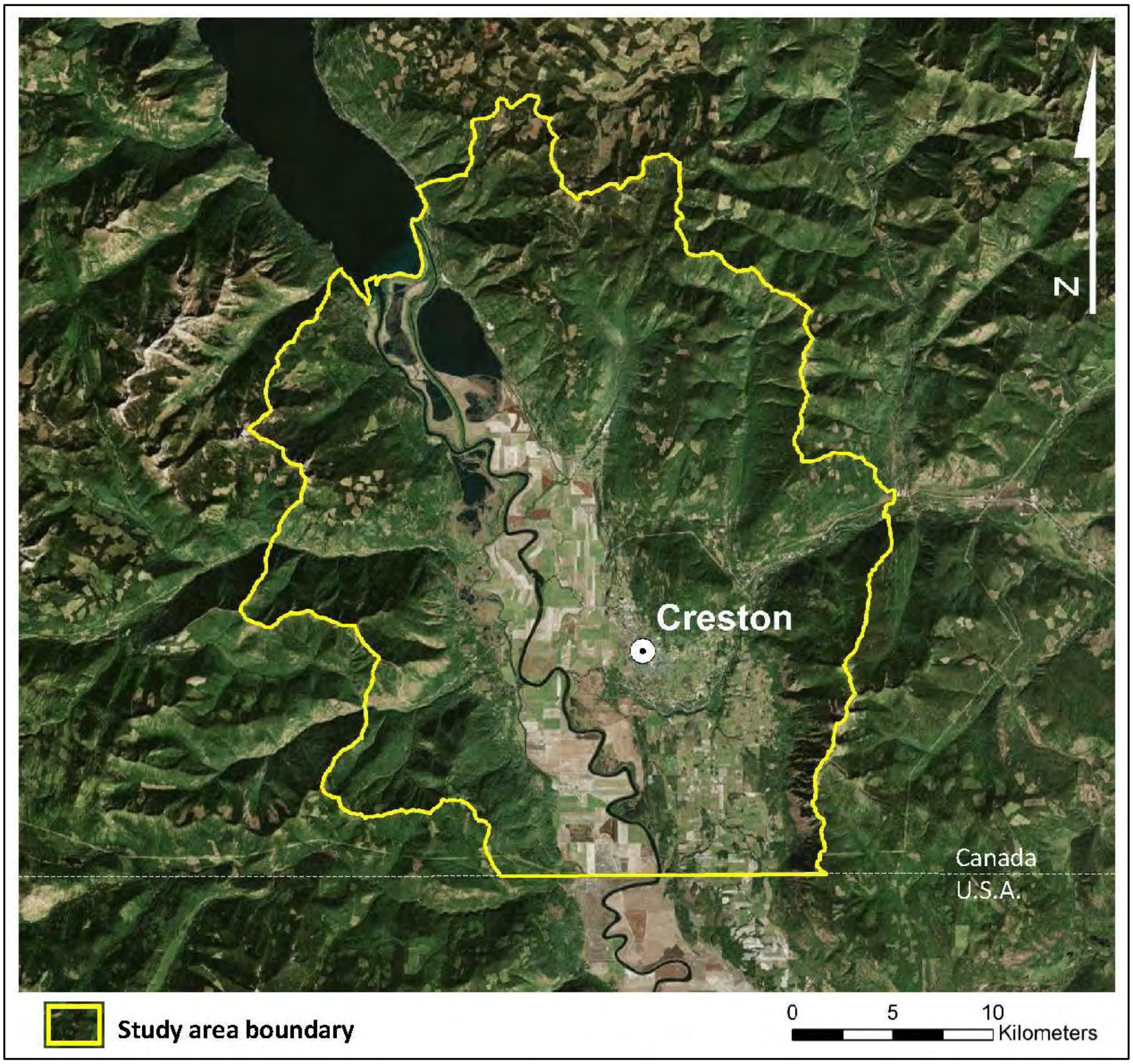


Figure 2: Study area boundary relative to Landsat 8 imagery of the Creston Valley and surroundings.

Figure 3 gives place names used in this document. The background map is the standard basemap provided by National Geographic for viewing and mapping purposes in GIS software.

Figure 3:
National Geographic basemap and place names used in this document.

3. Methodological Approach

The methodological approach that was favoured for the Creston Valley Green Map Project relies on the principles of *suitability analysis*.

> **"**Suitability analysis in a GIS context is a geographic or GIS-based process used to determine the appropriateness of a given area for a particular use. The basic premise of GIS suitability analysis is that each aspect of the landscape has intrinsic characteristics that are to some degree either suitable or unsuitable for the activities being planned. Suitability is determined through systematic, multi-factor analysis of the different aspects of the terrain. Model inputs include a variety of physical, cultural, and economic factors. The results are often displayed on a map that is used to highlight areas from high to low suitability." (https://en.wikipedia.org/wiki/Suitability_analysis)

3.1 Themes and Datasets

Many publicly available databases can help identify and describe habitat types in BC. The production of the Creston Valley Green Map incorporated 19 layers describing the natural features of the study area and 9 layers detailing social factors relevant to the suitability analysis. The data was compiled according to six themes. Table 1 lists these themes along with the underlying data layers.

Table 1: Creston Valley Green Map analysis themes and underlying data layers.

Natural Features	
Rarity	**Wildlife**
• Biogeoclimatic Ecosystem Classification (BEC) unit province-wide rarity • Predictive Ecosystem Mapping (PEM) site series local rarity • Vegetation Resources inventory (VRI) Leading tree species local rarity	• Ungulate Winter Ranges • Occurrences of Blue-listed animal species • Occurrences of Red-listed animal species • 'Cost of travel' to nearest water source
Conservation Areas Gap Analysis	**Forest and Floral Attributes**
• Biogeoclimatic Ecosystem Classification (BEC) unit under-representation in the provincial network of conservation areas • Biogeoclimatic Ecosystem Class (BEC) under-representation in the local network of conservation areas • Under-representation of Leading Tree species type (VRI) in the local network of conservation areas	• Forest cover • Logging (1966 -2016) (VRI) • Forest site series (PEM) and stands (VRI) of interest • Whitebark pine stands (VRI) and habitat suitability • Blue- and Red-listed plant occurrences • Blue- and Red-listed ecosystems • Site Index (VRI) • Projected Age (VRI) • Old-Growth Management Areas
Social Factors	
Human Footprint	**Risk Factors**
• Roads density • Building density • Community watersheds • Water licenses • Private property ownership type	• Wildfire fuel treatment priorities • Erosion and flooding risks • Terrain instability • Surface material modifying processes (VRI)

Infographics inspired by the contents of Table 1 are provided in Appendix 3.

3.2 Pixel-based Thematic Data Analysis

In order to be able to summarize each theme's result in a single map, the individual data layers were first converted to pixel-based (raster) layers, where cell sizes equal 25m by 25m on the ground. Ranking the value of each individual cell in a layer could sometimes be performed using strictly numerical operations. For example, this was the case when estimating the rarity of any given feature or their level of under-representation in conservation areas, based on the percentage of the land base that they occupy within the extent of the study area. Other times, the features were ranked by relying on expert judgment or local ecological knowledge, according to their estimated value for conservation. In both cases, this procured numeric values to all the pixels in the layers. The data was then standardised to ensure that each layer had an equal weight in the analysis. For each theme, a simple summation of the data layer was performed to obtain an overall theme raster layer.

3.3 Aggregated Theme Maps

To display the theme results on simplified maps, each theme's aggregated raster was classified into seven classes using the natural breaks in the distribution of the pixel values. The top three high-ranking classes were then used to convert the raster data to polygons. Areas of less than 1 hectare in size were merged with neighbouring polygons using ArcGIS's "Eliminate" tool. The resulting polygon's boundaries were smoothed for more pleasant display. Finally, the location of these polygons is shown over a background map, with the top three classes displayed using a colour ramp of increasingly hot colours (see fig. 7 or 11 as examples).

3.4 Final Map Production

For the purpose of designing a single *Green Map* product, the data from the six themes had to be compiled into a single visual representation. Therefore, the theme data was further aggregated into the two main data categories: *Natural Features* and *Social Factors*.

The *Natural Features* map is intended as a visual output that highlights hotspots of high natural value within the study area. The *Social Factors* map aims to show where social considerations could likely constrain the efficacy of conservation efforts.

Different combinations of the Natural Features and Social Factors map allow us to examine the overall analysis results using a single visual output.

3.5 Connectivity Modeling

Based on the principles of 'circuit theory', connectivity modeling requires a layer that maps out areas of high 'resistance' and high 'conductance' on the surface of the target landscape.

With this in mind, the pixel values of the *Natural* and *Social* data outputs were intersected (i.e. area where *Social Factors* constrain conservation, resulting in the output layer having lower pixel values). This produced a layer in which each 25m by 25m pixel on the ground has a value that reflects it's 'conductance' in the modeling process. This output raster was used as the 'conductance surface' to run models that identify potential pathways along which conservation efforts could prove particularly effective for building ecological resilience in the face of a changing world.

Connectivity modeling was performed both for cross-valley connectivity and for internal connectivity. In addition, expert knowledge obtained from the *West Kootenay Resilience Project* (westkootenayresilience.org) was factored into the model to include areas proposed as linkages and refugia for adaptation to climate change.

3.6 Viewscape Modeling

As a complement to the ecological and social factors taken into consideration in producing the maps, a multi-layered *viewshed analysis* was performed to highlight the cumulative visibility of all parts of the study area. This process sums up the output results of distinct viewshed maps produced for a variety of viewpoints. Though not a contributing factor for the Green Map analysis, this exercise creates a worthwhile reference layer to help inform future landscape-based management decisions regarding the development of the Creston Valley.

4. Analysis and Results

The following sections of this report provide a brief rationale for each of the project's themes. Details are given on the ways that data were processed for each layer. A map of the analysis result is also provided for each layer. The main results are discussed briefly. Finally, an overall map is shown for each data theme.

4.1 Under-representation of Ecosystems in Existing Conservation Areas (Gap Analysis)

Rationale

One of the justifications for creating protected areas is that they help conserve a representative sample of the land's ecological diversity. For instance, if a given ecosystem occupies 3% of the land base of BC, then we would expect it to also occupy 3% of the land base of the province's protected area network.

A *Gap Analysis* can help identify how well a network of conservation areas performs at providing a representative sample of the land's diverse ecosystems.

Using the classic concept of *Gap Analysis*, it is possible to identify ecological features that are under-represented (or over-represented) in a given network of protected areas.

For the Creston Valley Green Map Project, conservation areas are defined as being any one of the following categories:

- Provincially-protected areas;
- National Parks;
- Conservation areas held by NGO's (such as the Creston Wildlife Management Area);
- Ungulate Winter Ranges recognised under the Forest and Range Practices Act;
- Conservation areas listed by the province as *Other managed areas* (such as the Darkwoods property, held by the Nature Conservancy of Canada).

Using the conservation areas listed above, gap analysis was performed on *BEC (version 10) Units** and *VRI Leading Species type***

* *BEC Units* : Units of the province's *Biogeoclimatic Ecosystem Classification* map

** *VRI Leading Species* : The dominant tree species of each polygon in the area's Vegetation Resources Inventory map

In British-Columbia's *Biogeoclimatic Ecosystem Classification* (BEC), the ecosystem class is a result of the interactions between climate and soil that determine the vegetation potential on a site. It is important to note that this denotes the ecological capacity of any given site, but does not necessarily represent what is actually found on the ground. There are 213 different BEC Site Series types in BC, six of which can be found in the Creston Valley.

Our first gap analysis identified which BEC Unit types (of all units in the province) are most under-represented in existing conservation areas at the provincial scale. The result of this analysis highlights the areas on which decision makers could focus conservation designations in order for protected areas to provide a better sample of BC's natural heritage. These results are shown in figure 4.

Similarly, a gap analysis at the local scale reveals interesting results. This highlights the features that might be common locally, but not well represented in the local conservation areas (see fig. 5). This information might encourage local decision makers to attempt to close these gaps with local-scale conservation efforts.

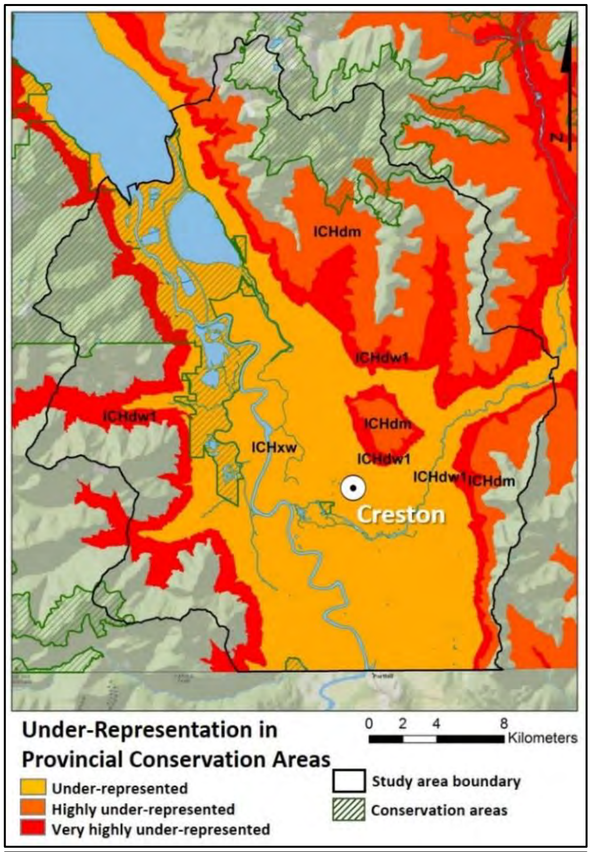


Figure 4:
Under-representation of Biogeoclimatic (BEC) units in the province's network of conservation areas

When protected areas and BEC units are considered at the scale of the province, the gap analysis reveals that the ICHdw1 (Interior Cedar Hemlock, Dry Warm, West Kootenay variant) is the most under-represented of the study area's units.

ICHdm (Interior Cedar Hemlock, Dry Mild) is the second most under-represented BEC unit type.

The valley-bottom BEC unit (ICHxw) is also under-represented at the provincial scale, but less so than its two valley-side neighbours.

According to this gap analysis, higher-altitude ecosystems are well represented in the province-wide network of conservation areas.

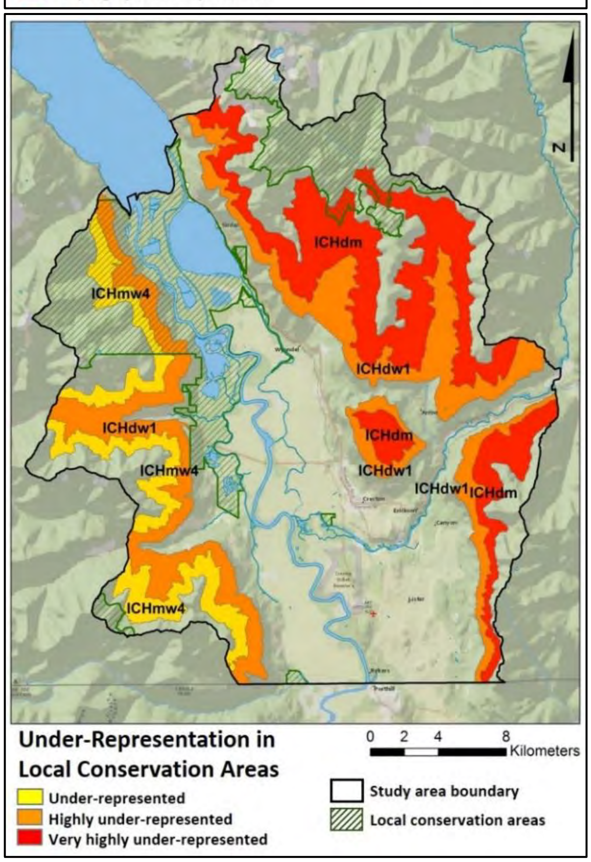


Figure 5:
Under-representation of Biogeoclimatic (BEC) units in the local network of conservation areas

When only the extent of the study area in considered, then a different portrait of under-representation is obtained.

Locally, the conservation areas (most notably the Creston Wetlands Management Area) represent significant samples of valley-bottom habitats. Accordingly, these habitats can not be considered under-represented by the network of local conservation areas. On the other hand, the local conservation areas perform poorly to represent west-facing, mid-slope habitats in the Creston Valley.

In comparison to BEC units, Vegetation Resources Inventory (VRI) data is much more finely detailed. VRI is a photo-interpreted vegetation inventory geared mostly toward forestry applications. If we consider the first *Leading Tree Species* of the VRI polygons, there are 13 different categories in the study area. Based on how little or how much land these categories occupy, we can once again compute the rarity of this valuable ecological attribute relevant to forest stands. These results are given in figure 6.

A gap analysis was also performed to identify the types of local tree stands that are under-represented in the local conservation area network (fig. 6).

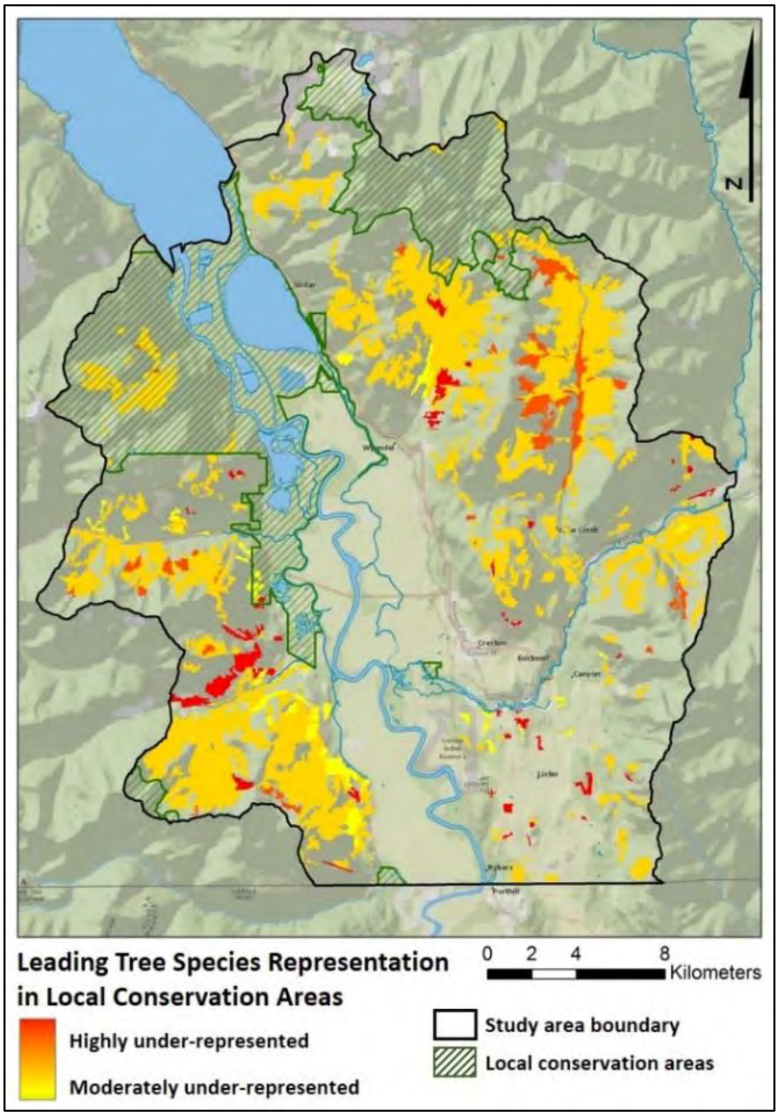


Figure 6:
Under-representation of *Leading Tree Species* in local conservation areas

The forests of the study area are dominated by any one of 13 Leading Tree Species.

Of this total, 5 stand types are well represented in the local conservation areas:
True Fir, Western White Pine, Spruce, Poplar, Lodgepole Pine, and Western Red Cedar.

Seven types are under represented:
Yellow Pine, Douglas Fir, Paper Birch, Larch, Hemlock, Trembling Aspen.

One type (forests dominated by Grand Fir) is not represented at all.

By scaling and aggregating the values of the three layers presented above, we obtain a generalized value for how well the BEC and VRI units are represented in the local and provincial conservation areas. This result is given in figure 7.

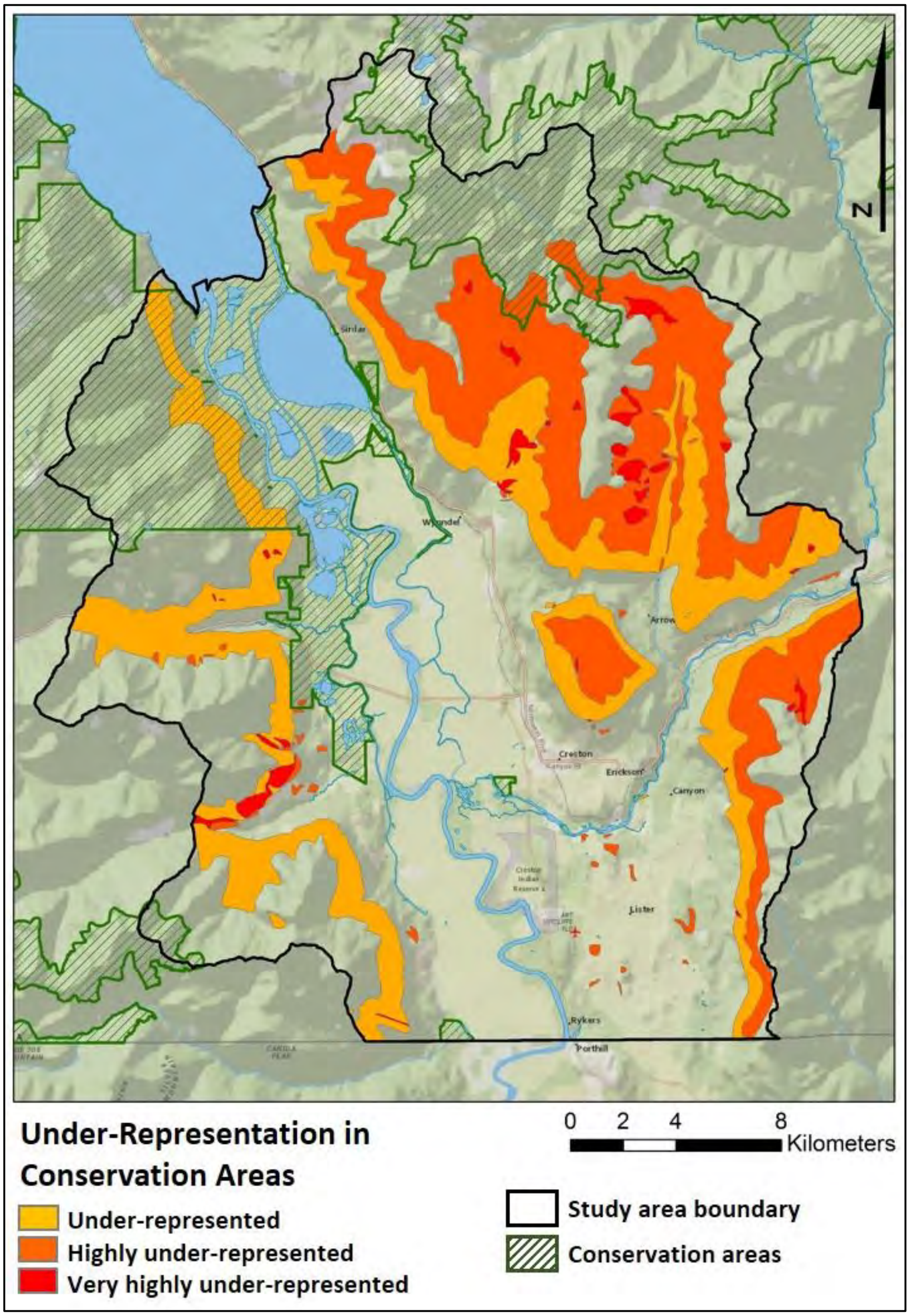


Figure 7:
THEME MAP
Conservation Areas Gap Analysis

According to our gap analysis, the Creston Valley has certain types of forest that we do not find many examples of in existing conservation areas. These tend to be situated at mid-slope and are concentrated in the 'Dry Interior Cedar Hemlock' units (ICHdm and ICHdw) of BC's Biogeoclimatic map system.

4.2 Rarity

Rationale

Habitat rarity is an oft-discussed subject in conservation biology. Rare habitats are usually thought to be the most threatened in the face of various pressures. Because of their limited extent, they are more likely to disappear as a cause of disturbance. This makes them inherently valuable for conservation.

> "Focused protection of rare ecological associations helps to maximize our conservation return on investment. These are places where many conservation goals can often be achieved at once."
>
> Nature Conservancy of Canada
> http://www.natureconservancy.ca/en/blog/last-places-on-earth-1.html)

For the Creston Valley Green Map project, *rarity* was computed from three classic sources of ecological data for British-Columbia.

Firstly, the province's 2017 *Biogeoclimatic Ecosystem Classification* (BEC, version 10) was analyzed.

In BEC, the ecosystem class is a result of the interactions between climate and soil that determine the vegetation potential on a site. It is important to note that this denotes the ecological capacity of any given site, but does not necessarily represent what is actually found on the ground. There are 213 different BEC Site Series types in BC, six of which can be found in the Creston Valley. Based on how common these are at the provincial level, we can rank these six units for their province-wide rarity. The results of this are presented in figure 8.

Secondly, the results of a *Predictive Ecological Mapping* (PEM) project that was done for the Kootenay Lake area were interpreted. This type of mapping is done at a very fine scale to model the ecosystems that would be expected to occur given the climatic and biophysical attributes of the land. At the scale of the study area, there are 85 different PEM Site Series descriptors. Considering the PEM Site Series, we can once again perform an analysis to map those that are 'rare', but this will then produce results at a much finer scale. See figure 9 for results.

Finally, Vegetation Resources Inventory (VRI) data was used. VRI is a photo-interpreted vegetation inventory geared mostly toward forestry applications. If the first Leading Tree Species of the VRI polygons is used, there are 13 different categories in the study area. Based on how little or how much land these categories occupy, once again the rarity of this valuable ecological attribute relevant to forest stands can be computed. These results are given in figure 10.

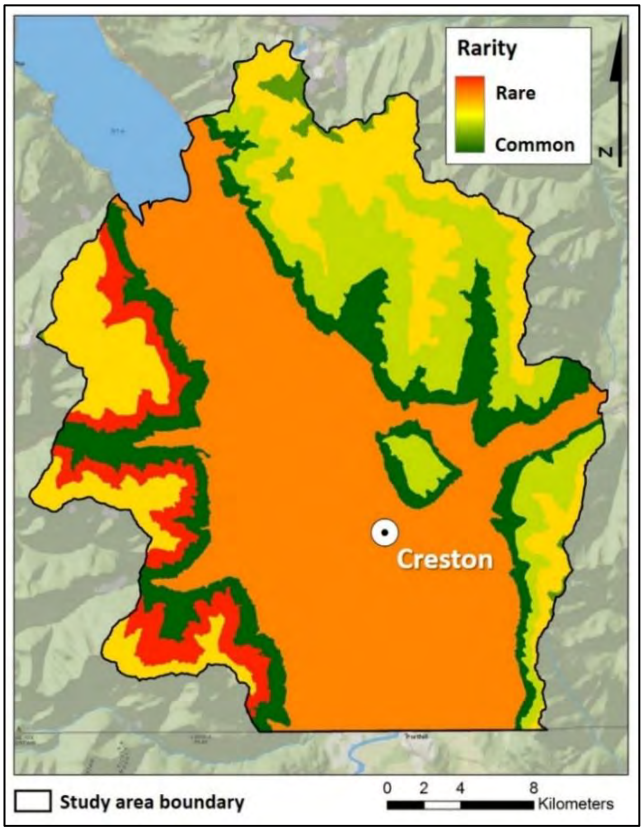


Figure 8:
Biogeoclimatic Ecosystem Classification (BEC) Units
Province-wide rarity

Based on the analysis, out of the 6 BEC units that occur in the study area, the one that covers the least surface area at the provincial scale is: ICHmw4 (Interior Cedar – Hemlock, Moist Warm, Ymir variant)

The location of this rare BEC unit is shown in red in the opposite map.

The next rarest unit at the provincial scale is ICHxw (Interior Cedar – Hemlock, Very Dry Warm). This unit describes the ecosystem that would be expected to be present under natural conditions in the valley bottom. It is displayed in orange on the opposite map.

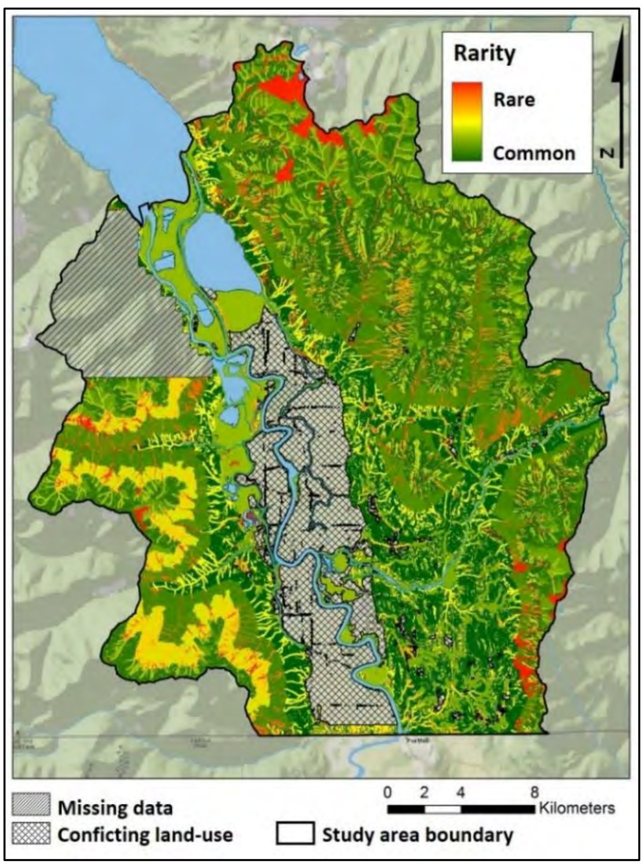


Figure 9:
Predictive Ecosystem Mapping (PEM)
Site Series - local rarity

There are 85 PEM Site Series types occurring in the study area. Of this number, 66 cover less than 1% of the study area.

As a general rule, these rare types are associated with high altitude or riparian areas. The steep talus field of the Skimmerhorn area are also appropriately recognised as being an unusual type of ecosystem.

Notes:

- The agricultural lands of the valley bottom do not have an associated Site Series code in the dataset.
- The Darkwoods property, located in the north-west portion of the study area, was not part of the same PEM project. We have been unable to obtain the PEM data for the Darkwoods property.

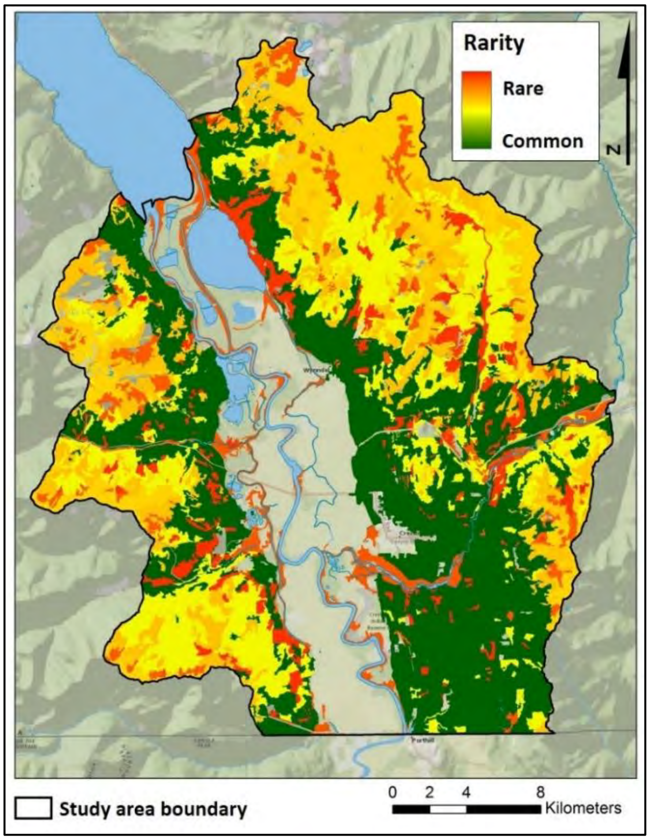


Figure 10:
Vegetation Resources Inventory (VRI)
Leading Species - local rarity

The most common dominant tree species identified in the VRI dataset for the Creston Valley is the Douglas Fir. Areas deemed to be dominated by this species are displayed in green in the opposite map.

The most uncommon stands in the study area are the one dominated by Grand Fir. Closely following are the Western White Pine stands, the Western Red Cedar stands, the Trembling Aspen stands and the Paper Birch stands.

The three data layers shown in figure 8, 9 and 10 have been converted into pixel-based layers (raster layers) where pixel sizes equate to 25m by 25m cells on the ground. If the three layers are then combined, a generalized view of rarity, based on vegetation and biophysical attributes in the Creston Valley can be obtained. This result can in turn be classed into simplified groups for better display (fig. 11).

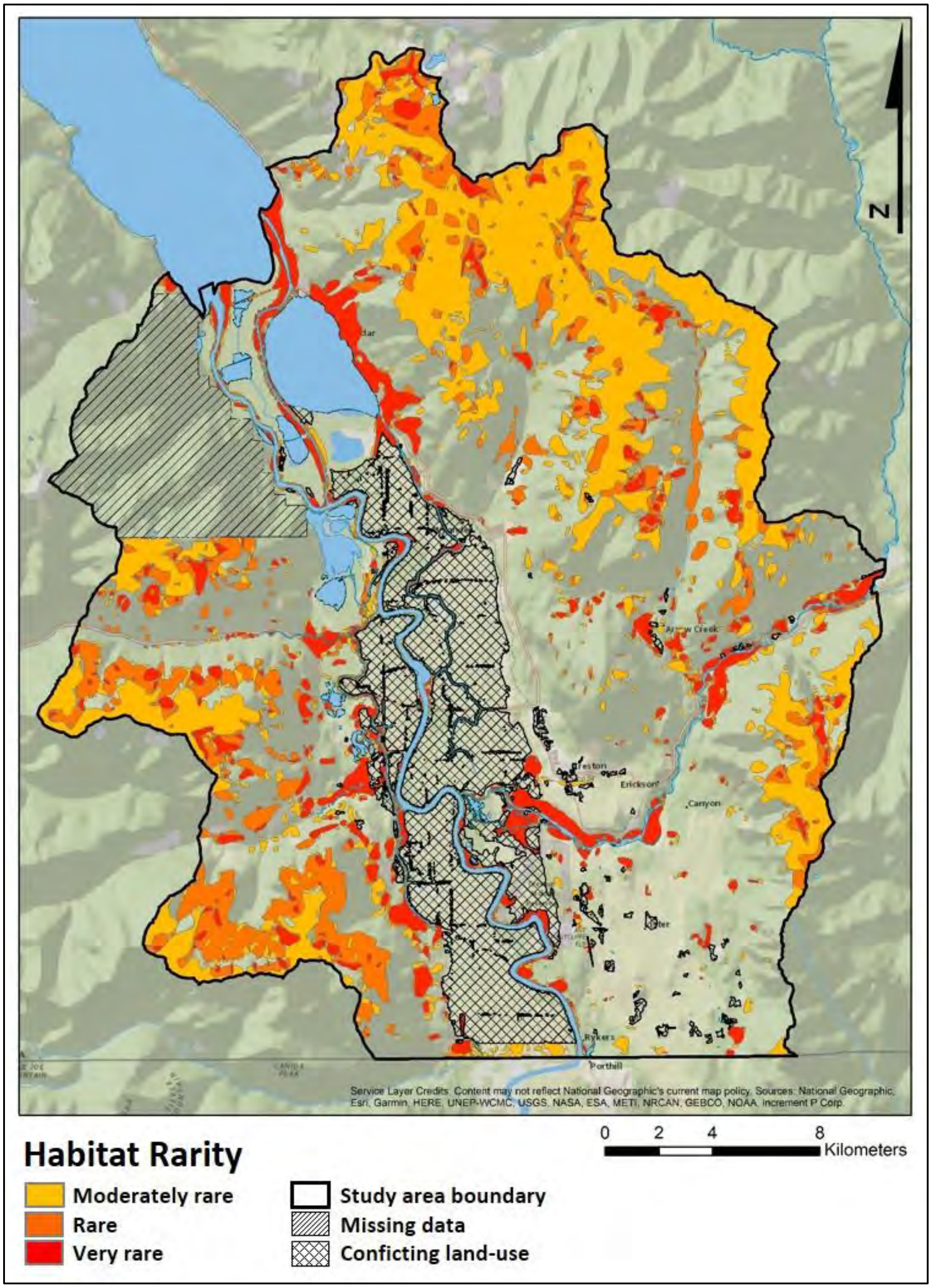


Figure 11:
THEME MAP
Hotspots of Habitat Rarity

The most extensive rare habitats in the Creston Valley are associated with low altitude riparian areas, most notably around Duck Lake, Corn Creek and the Goat River.

Ridgetop ecosystems also show up as being rare, though with lower 'rarity values'.

Not surprisingly, the high-altitude alpine ecosystems of the Wooden Shoe Lake area boast high levels of rarity in the context of our study area.

Finally, some isolated mid-slope forest stands can also be considered rare. These occur more commonly in the western half of the study area.

4.3 Wildlife Values

Rationale

With remarkable wetland networks, varied forest ecosystems, hospitable winter climates and a location found at the crossroads of significant wildlife movement corridors, the Creston Valley offers unique values for quality wildlife habitats.

As is the case in many of BC's valley bottoms, these quality habitats have been deeply affected by human development. Identifying remaining wildlife habitat and prime wildlife-habitat features can help inform balanced land management decisions.

For the Wildlife theme, data was obtained for the locations of species of management concern. This includes occurrences of animal species at risk (fig. 12 and 13) and important ungulate winter habitats (fig. 14). Given the dry summer climate of the study area, a layer modeling access to water sources was also included in the analysis (fig. 15).

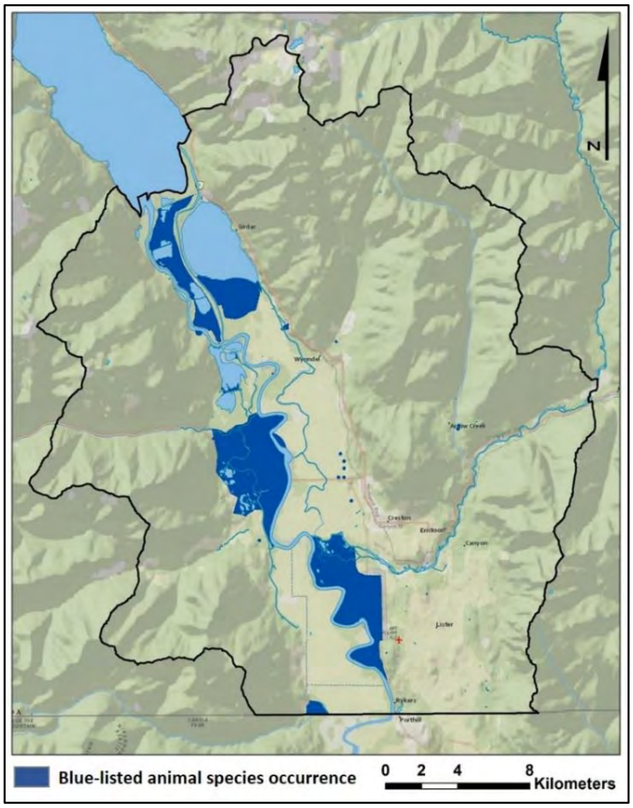


Figure 12:
Blue-listed species

The Conservation Data Centre of BC publishes the locations of occurrences of BC-listed *Species at Risk* (http://maps.gov.bc.ca/ess/hm/cdc/).

Localized animal occurrences were selected from the dataset. In the opposite map, some of the more punctual locations were given buffers.

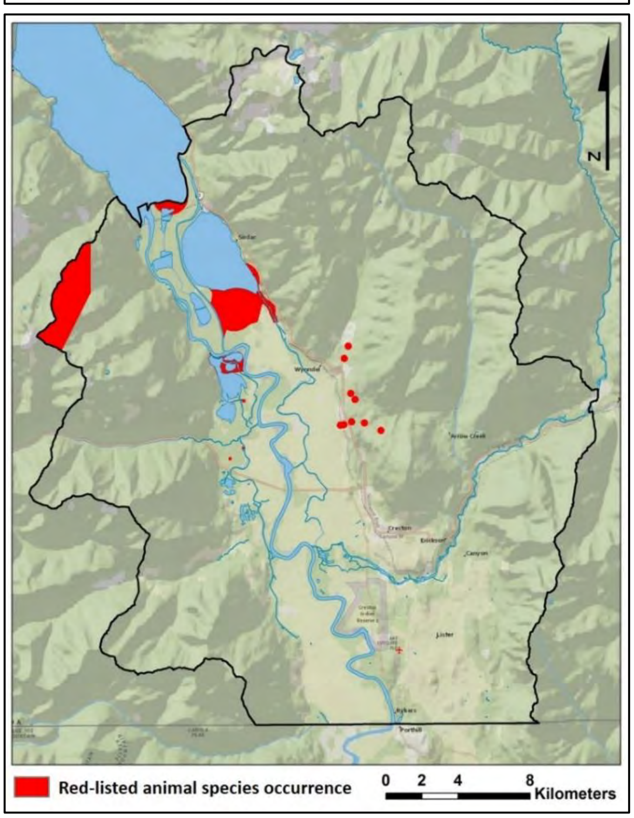


Figure 13:
Red-listed species

The Conservation Data Centre (CDC) of BC publishes the locations of occurrences of BC-listed *Species at Risk* (http://maps.gov.bc.ca/ess/hm/cdc/).

Localized animal occurrences were selected from the dataset.

Of note, CDC data points are sometimes randomized and buffered to obscure the exact location of the known occurrence. This is intended to reduce the risk posed by human collectors, etc.

To make the data points more relevant for the suitability analysis, some of the more punctual locations were also given buffers as part of the project to highlight their surrounding habitat.

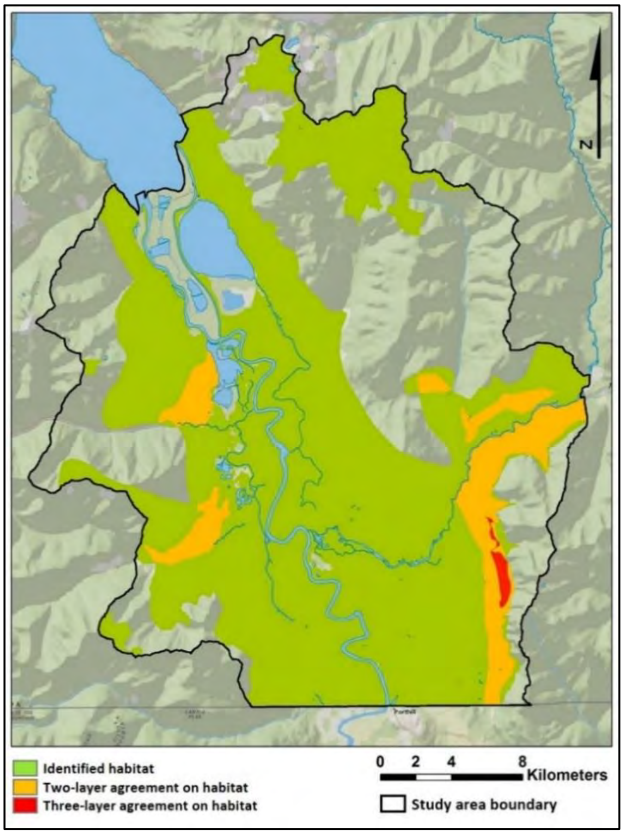


Figure 14:
Ungulate Habitat

Ungulates are a valued taxonomic group, primarily due to their value to hunters. Protecting their known habitats is a classic application of conservation. In addition, the health of certain ungulate populations is often considered a valid proxy for more general ecosystem health.

The data presented in the map opposite is the result of combining three separate datasets. A general habitat suitability map was used as a background over which were superimposed more targeted areas deemed to offer high quality conditions for game animal. Added to this are the legal Ungulate Winter Ranges recognised by BC's Forest and Range Practices Act.

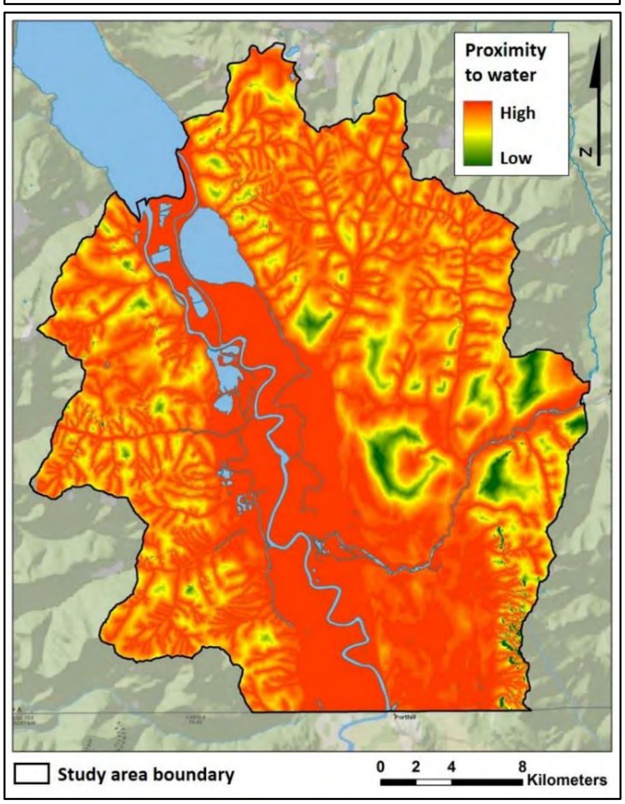


Figure 15:
'Cost of Travel' to nearest water source

Access to water sources is important to most wildlife species. A layer was created taking into account the combined 'cost' of distance and slope to model the expenditure required to move from any given location in the study area to the nearest source of water (stream, river, wetland or lake found inside or outside of the study area).

By aggregating the values given to the layers presented in figure 12-15, a generalized result for the wildlife habitat value offered by different parts of the Creston Valley Green Map study area can be obtained. Figure 16 presents the locations of highest value.

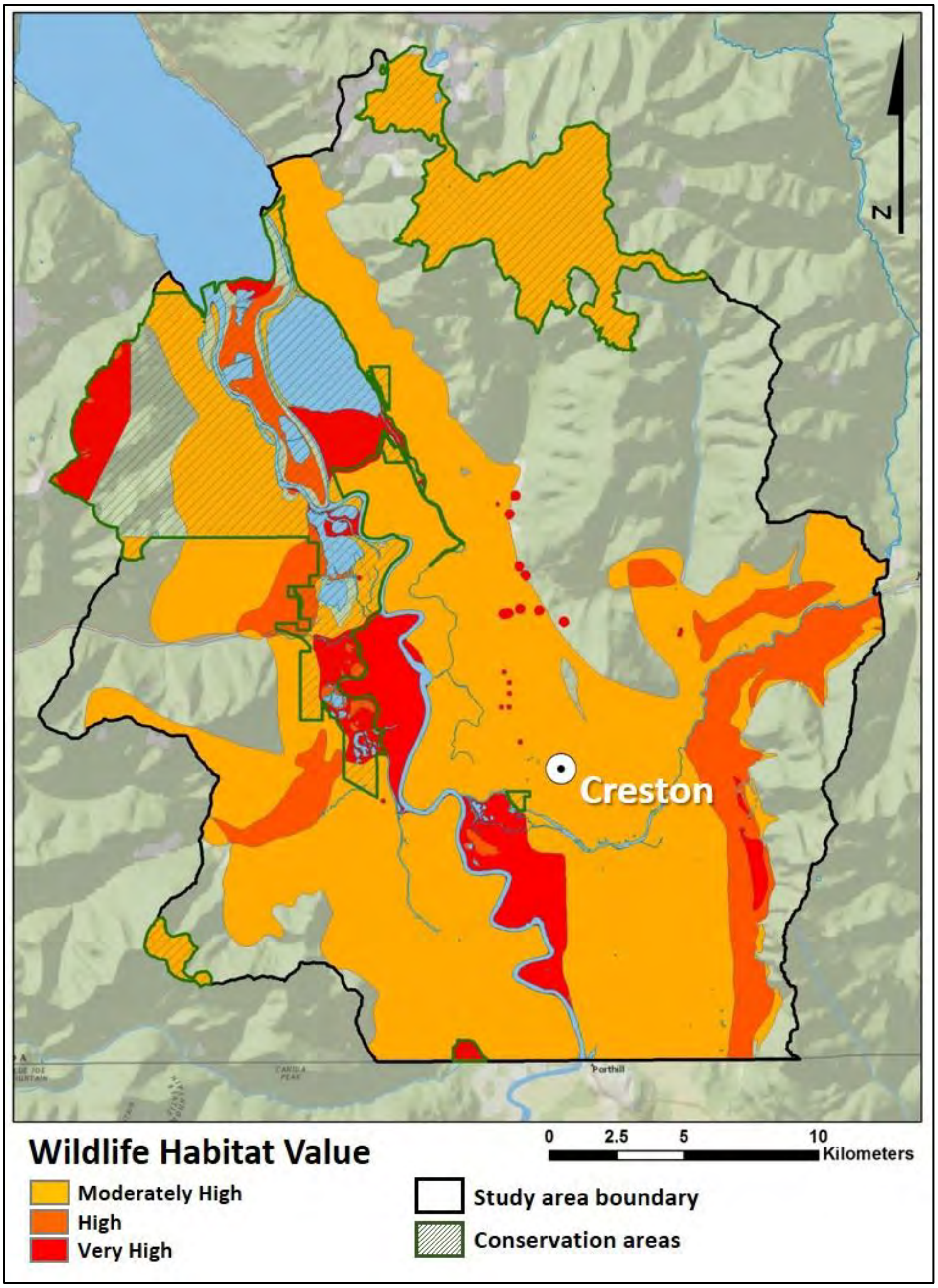


Figure 16:
THEME MAP
Location of high-value areas for Wildlife

As a general rule, the highest concentration of good wildlife habitat in the study area is found in the valley-bottom.

According to the aggregation of the data sources, the most extensive high-value areas for wildlife are found in the low-lying areas (mostly wetlands) along the Kootenay River.

Caribou winter habitats also register as important areas.

Finally, steep low-altitude slopes offer habitat for the valley's ungulate populations.

4.4 Forest and Floral Attributes

Rationale

Under the ecological conditions offered by the Creston valley, most undisturbed sites would be expected to support mature forests. In local popular culture and scientific circles, the language and values associated with high quality habitat often refer to concepts such as old-growth or intact forests. The presence of flora of interest is also a common justification for conservation.

Several available datasets enable us to identify forest features that are of social or ecological interest. The geographical distribution of such features can hence be highly relevant to conservation planning in a region such as the Creston Valley.

Several sources of detailed information have been compiled to describe the characteristics of the study area's forest cover.

Personal communications with Greg Utzig (co-author, West Kootenay Resilience Project) and Jim Smith (Forester, Creston Community Forest) have underscored forest management issues that can be informed by GIS-based investigations. As a result, a number a forest stands of interest have been singled out as having high value for this theme analysis (fig. 18). More in-depth work with forest ecologists in the future may be worth pursuing in order for the project to address meaningful forest management questions more deeply.

Figures 17 to 25 give snapshots of the datasets used for this theme analysis.

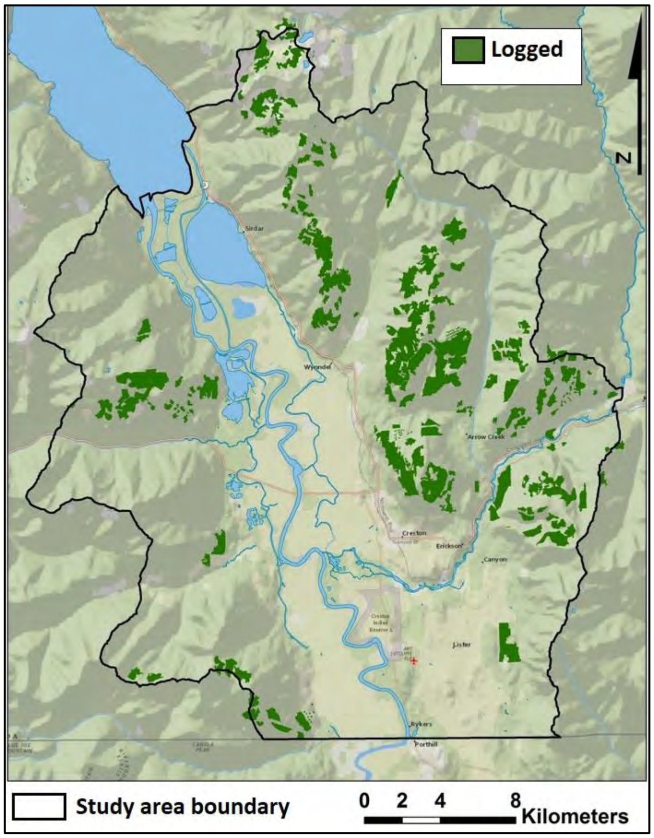


Figure 17:
Areas logged during the period 1966-2016

Recently logged forests have usually lost a significant portion of their value for short to mid-term conservation.

Logged areas were attributed a negative value in the suitability analysis.

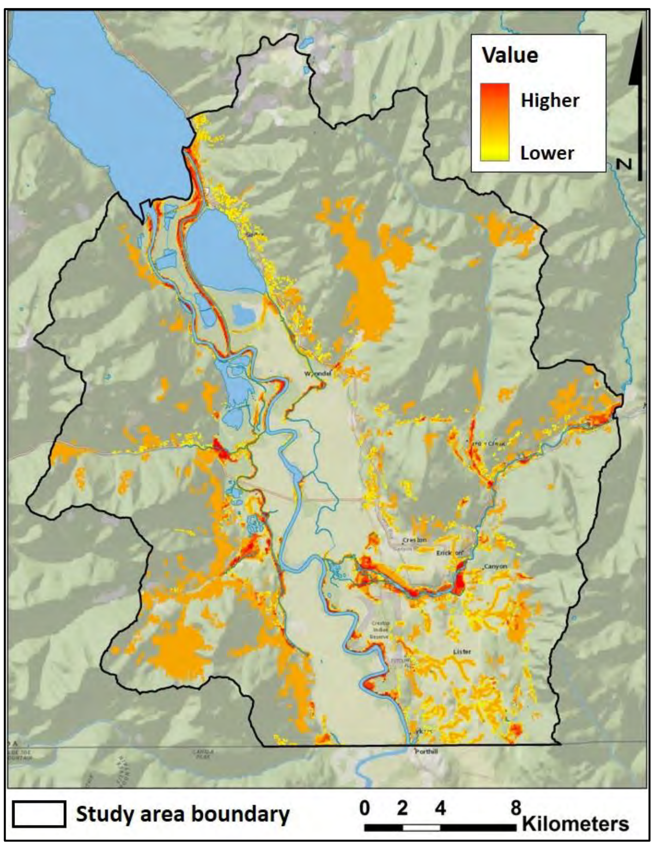


Figure 18:
Predicted (PEM) Cottonwood-dominated Site Series, Cottonwood-dominated (VRI) stands, Predicted ICHxw 102* and ICHxw 103 Site series and Deciduous (broadleaf) forest stands**

Expert advice was obtained as to the forest stands of particular interest for conservation in the Creston Valley. Each sub-layer was given an intrinsic value.

Output values are higher where different sub-layers coincide. Most of the high-value results (displayed in red) are found along low-altitude riparian areas.

**ICHxw103: Douglas Fir - Yellow Pine – Oregon-grape – Pinegrass*
***ICHxw102: Douglas Fir - Yellow Pine – Oceanspray – Bluebunch wheatgrass*

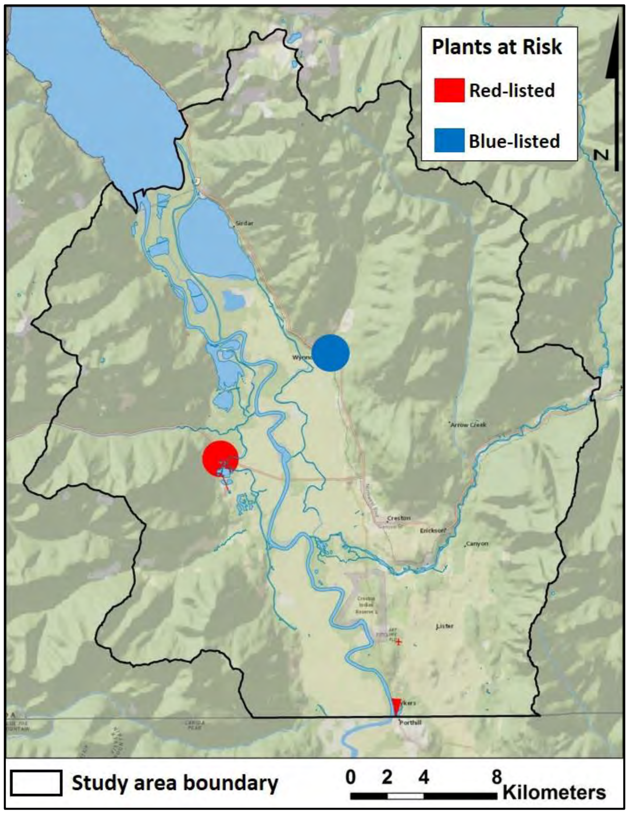


Figure 19:
Blue-listed and Red-listed plant occurrences

The Conservation Data Centre of BC publishes the locations of occurrences of Blue-Listed and Red-listed *Species at Risk* (http://maps.gov.bc.ca/ess/hm/cdc/).

Plant occurrences were selected from the dataset.

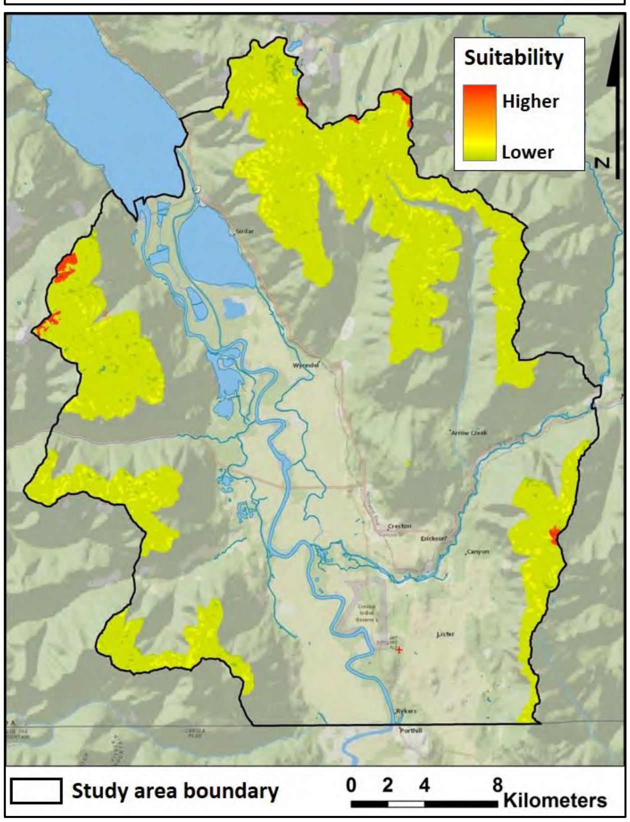


Figure 20:
Whitebark Pine stands and habitat

The Whitebark Pine is a federally listed species at risk.

Known occurrences of the species were extracted from the Vegetation Resources Inventory (VRI) dataset (displayed in red).

A habitat suitability layer for this species was also used to indicate the presence of potential habitat (displayed with increasing quality from green to yellow) for this endangered species

Only very small sections of the study area currently support Whitebark Pine, but most ridge-top area offer habitat that could be favourable for this species.

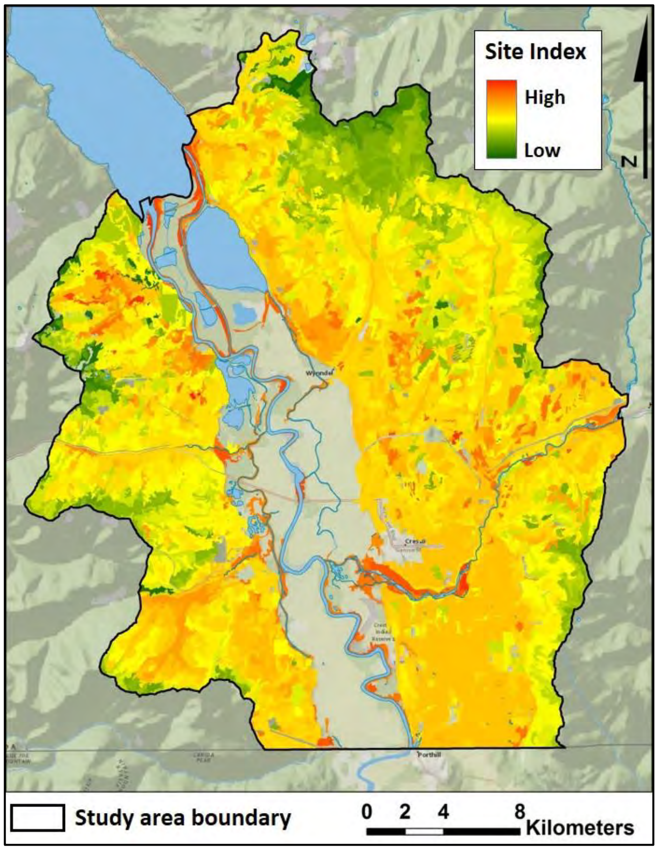


Figure 21 :
Vegetation Resources Inventory (VRI) Site Index

In VRI, the Site Index is an estimate of site productivity for tree growth.

Site productivity is a strong predictor of biodiversity and is therefore a valuable index that can be used to inform a suitability analysis in support of biodiversity conservation.

The opposite map shows high-productivity sites in hot (red) tones. Unfortunately, the VRI dataset does not estimate the potential productivity of areas that are currently used for large agricultural productions. These would likely be classed as highly productive areas.

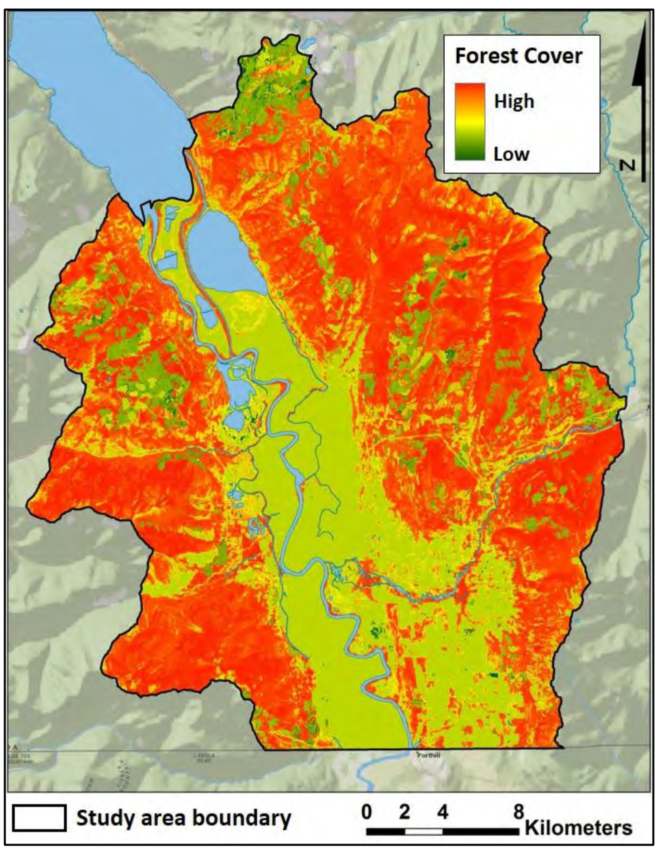


Figure 22:
Forest Cover

The use of satellite imagery enables highly detailed mapping of forest cover over large areas. Using repeat measurements, change detection methods can be used to describe forest change over time.

The opposite map shows a highly detailed and standardized forest cover layer. Areas where forest loss was detected during the period 2000-2016 were given lower values in the output layer.

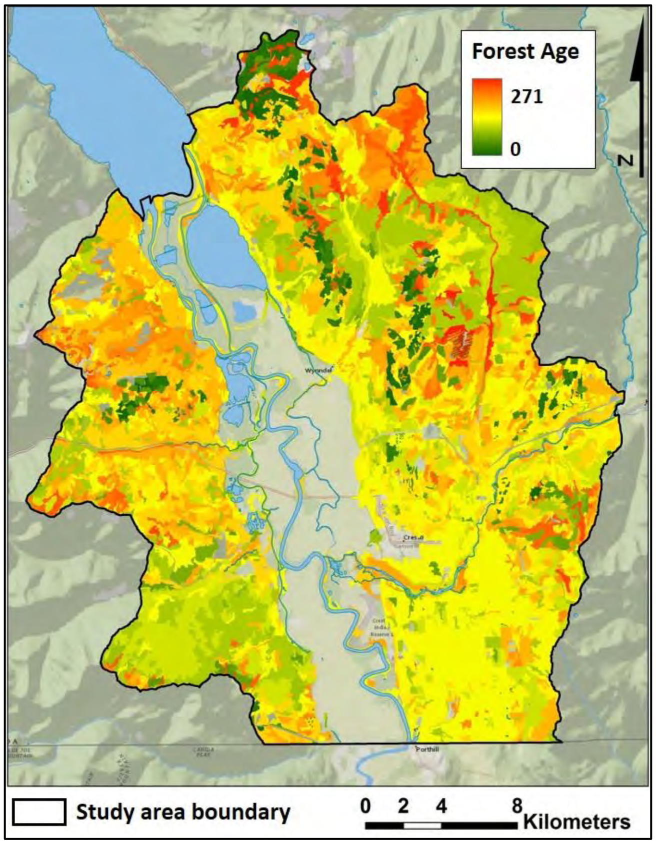


Figure 23:
Projected Age

The Vegetation Resources Inventory (VRI) dataset provides a *Projected Age* value for each of the inventory's polygons. As an indication of forest maturity, this attribute was incorporated in the theme analysis.

Several areas of high projected age are found in the Arrow Creek watershed. The upper reaches of the Duck Creek watershed also show a concentration of older forests.

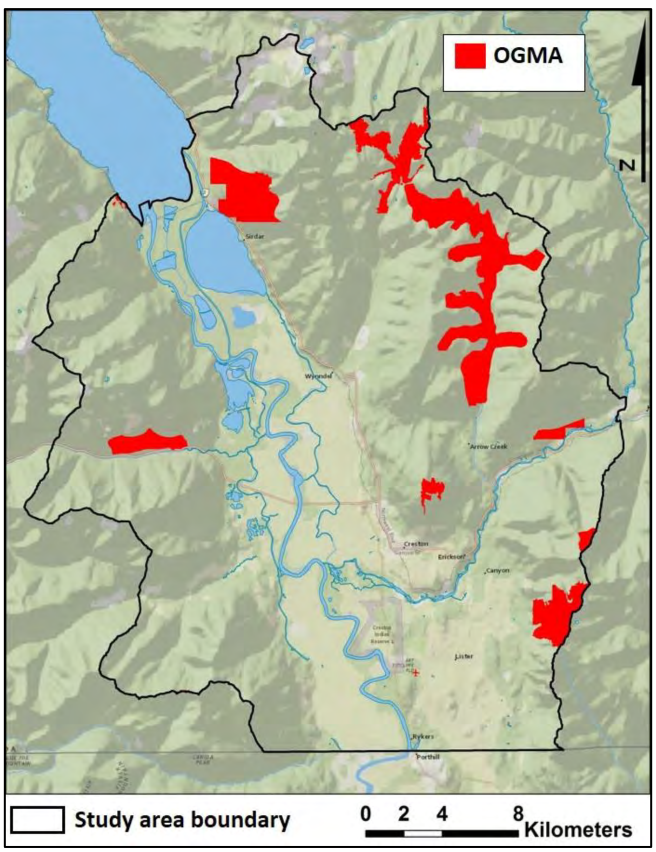


Figure 24:
Old-Growth Management Areas (OGMA)

The values associated with old forests are generally viewed as important in both popular culture and scientific circles. For this reason, the provincial government recognises and designates *Old-Growth Management Areas* (OGMAs).

The map opposite shows the location of proposed non-legal OGMAs in the study area.

It is interesting to contrast these proposed areas with the areas of high *Projected Age* (figure 22) used for planning forestry operations.

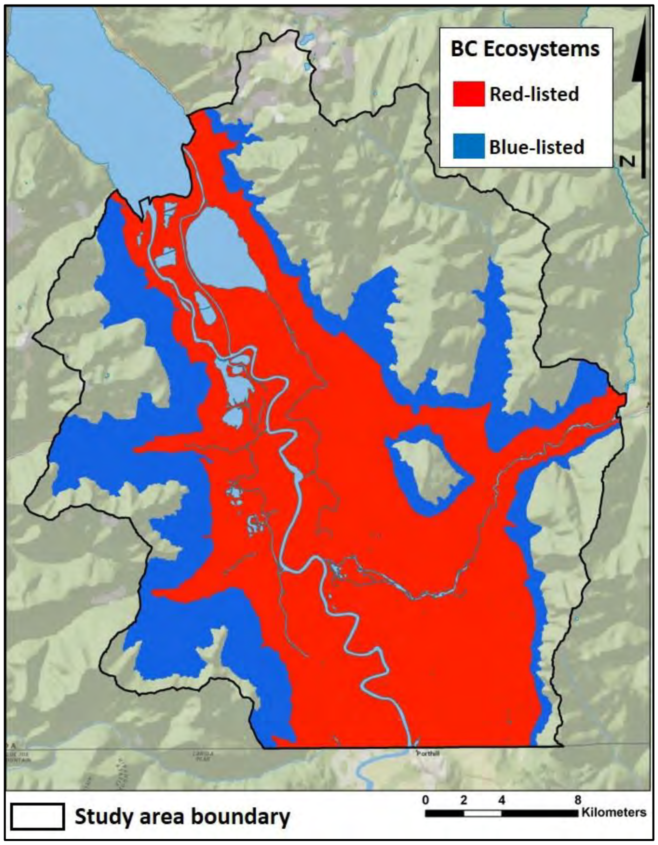


Figure 25: Listed Ecosystems

In addition to publishing rare species occurrences, the Conservation Data Centre of BC publishes the lists of "Ecosystems at Risk" (based on Biogeoclimatic Ecosystem Classification unit delineations).

In the Creston valley, the valley-bottom communities are red-listed, which underscores the importance of preserving and restoring valley-bottom habitats in the *big picture* of conservation in BC.

The neighbouring lower-altitude slopes are blue-listed.

The cumulative value obtained from the layers illustrated in figures 17 to 25 provides an indication of the particular values that are associated with forest and floral attributes in the study area. The overall result was classified. Top values areas are presented in figure 26.

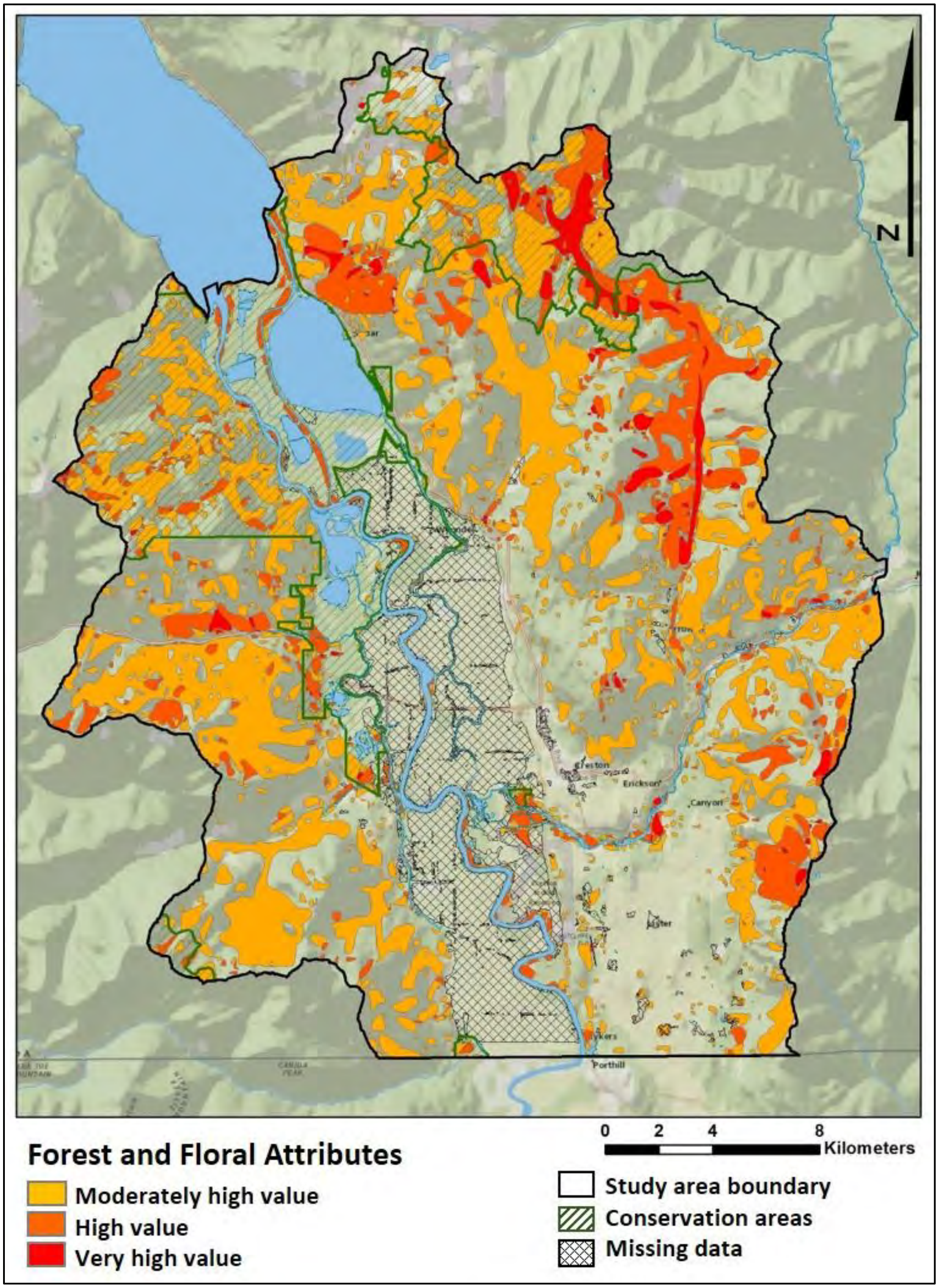


Figure 26:
THEME MAP
Aggregated Forest and Floral Attributes theme values

As a general observation, the forest and floral attributes found in the Arrow Creek watershed (north-eastern portion of the study area) show a high concentration of top value polygons. Of note, the upper reaches of this watershed are currently protected under a *No Harves*t restriction linked to caribou habitat.

The west-facing slopes overlooking Duck Lake are the next most extensive high-value area according to these theme results.

Riparian sites in the valley bottom offer strings of small, high value polygons very near human populations.

In the map, "Missing data" delineates zones that have artificially low scores because the Vegetation Resources Inventory ignores most agricultural areas.

4.5 Human Footprint

Rationale

The Creston Valley has been inhabited for generations. Humans have built infrastructure that support the social and economic development of the valley's communities.

Conservation measures can be a tool to help preserve values such as clean water in community watersheds or around water licence locations. On the other hand, some of the 'harder' land cover modifications, such as buildings and roads are significant constraints to conservation measures. Putting these potentials and constraints in perspective can help orient conservation efforts more efficiently.

Figure 27 to 31 provide snapshots of the layers used to evaluate the impact of the human land use on potential constraints or, inversely, justifications, for conservation. A blue-to-red colour ramp was chosen to display the layer cell values; hotter tones indicate areas of higher value for conservation.

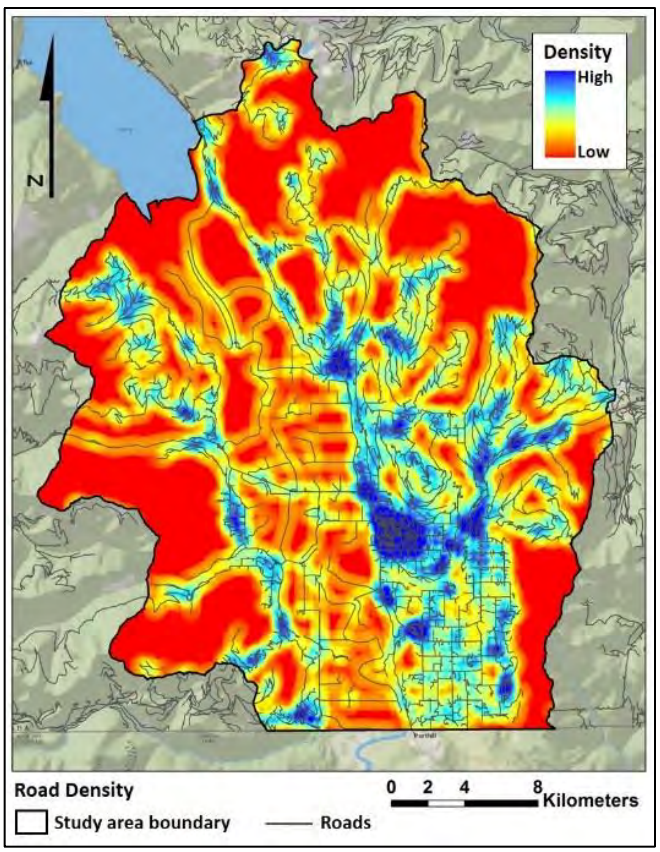


Figure 27:
Road Density

In conservation ecology, the density of roads on the landscape is a classic metric to model habitat intactness. This has been computed for the study area.

The Teetzel area offers the largest and most unbroken swath of roadless terrain in the study area. The upper reaches of the Duck Creek and Arrow Creek watershed are also rather intact. Of note, significant portions of the Darkwood property and Creston Wetlands Management Area are affected by roads.

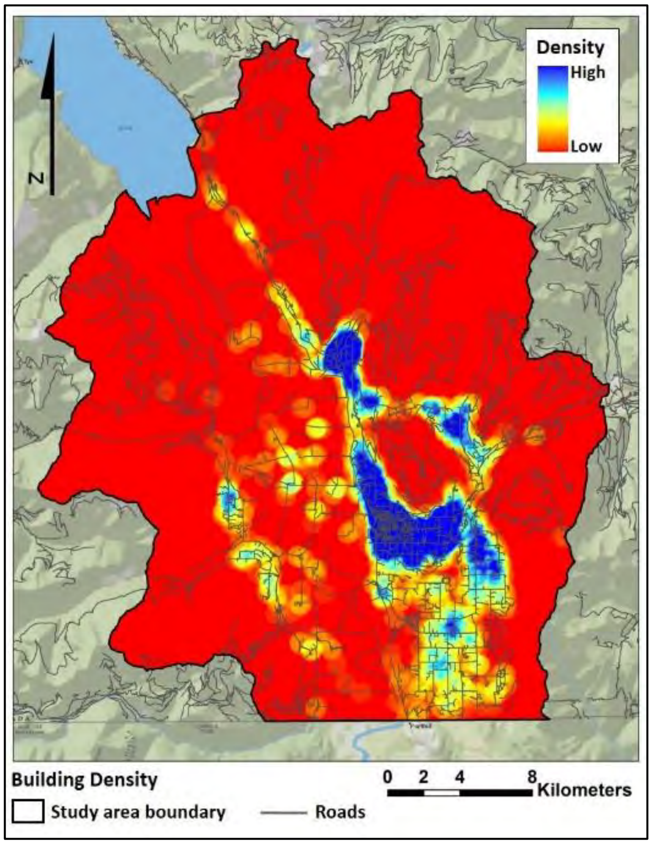


Figure 28:
Building Density

Much like road density, the density of built structures per surface area is an important factor in characterizing the human footprint on a landscape.

Creston and Wynndel are clearly identified as the most urbanized areas. Canyon, Arrow Creek, Lister and West Creston also show concentrations of built areas.

Note: known 'extraction sites' (from TRIM data) have been included as points in this density analysis.

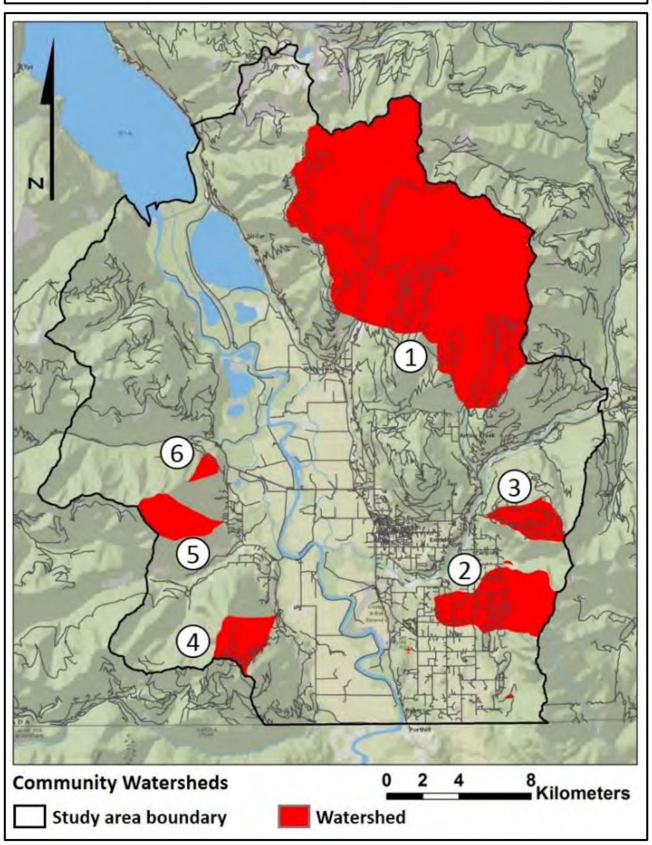


Figure 29:
Community Watersheds

A community watershed is defined under the Forest & Range Practices Act (FRPA) as all or part of the drainage area that is upslope of the lowest point from which water is diverted for human consumption by a licensed waterworks.

The Creston Valley has 6 such areas:

1. Arrow/Duck Creeks
2. Orde/Lister Creek
3. Sullivan Creek
4. Urmston Creek
5. Teetzel Creek
6. *Unnamed creek*

Conservation is one of the tools available to land managers to help preserve water quality in community watersheds for human use.

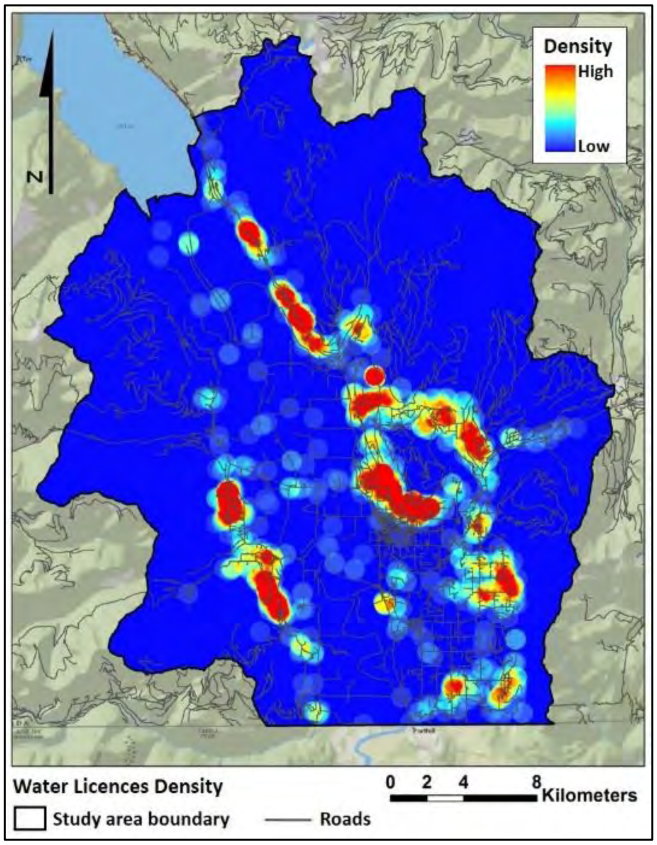


Figure 30:
Water Licenses Density

Areas found in proximity to water licenses are worth conserving for the preservation of water quality for human use.

Density of Water License points (including water diversion points) was computed for the study area.

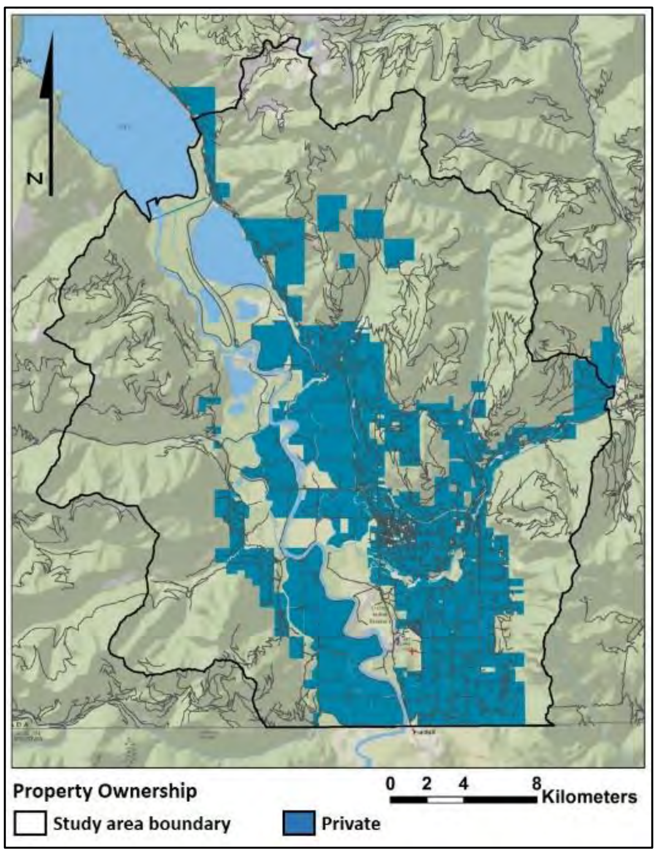


Figure 31:
Property Ownership Type

Ownership type can be interesting to consider for conservation advocacy.

For the purpose of the numerical analysis of the anthropogenic constraints, a negative value was given to properties whose owner type is listed as "private" in BC's Parcel Fabric.

Of note, a number of properties are of "unknown" ownership in the dataset. The Darkwoods property, located in the north-western part of the study area, is privately owned by the Nature Conservancy of Canada. It is by far the most significant example of the lots of "unknown" ownership type.

The cumulative value obtained from the layers shown in figures 27 to 31 highlights areas where there are added justifications for conservation based on the current state of human use of the landscape. Figure 31 presents the top-value classes.

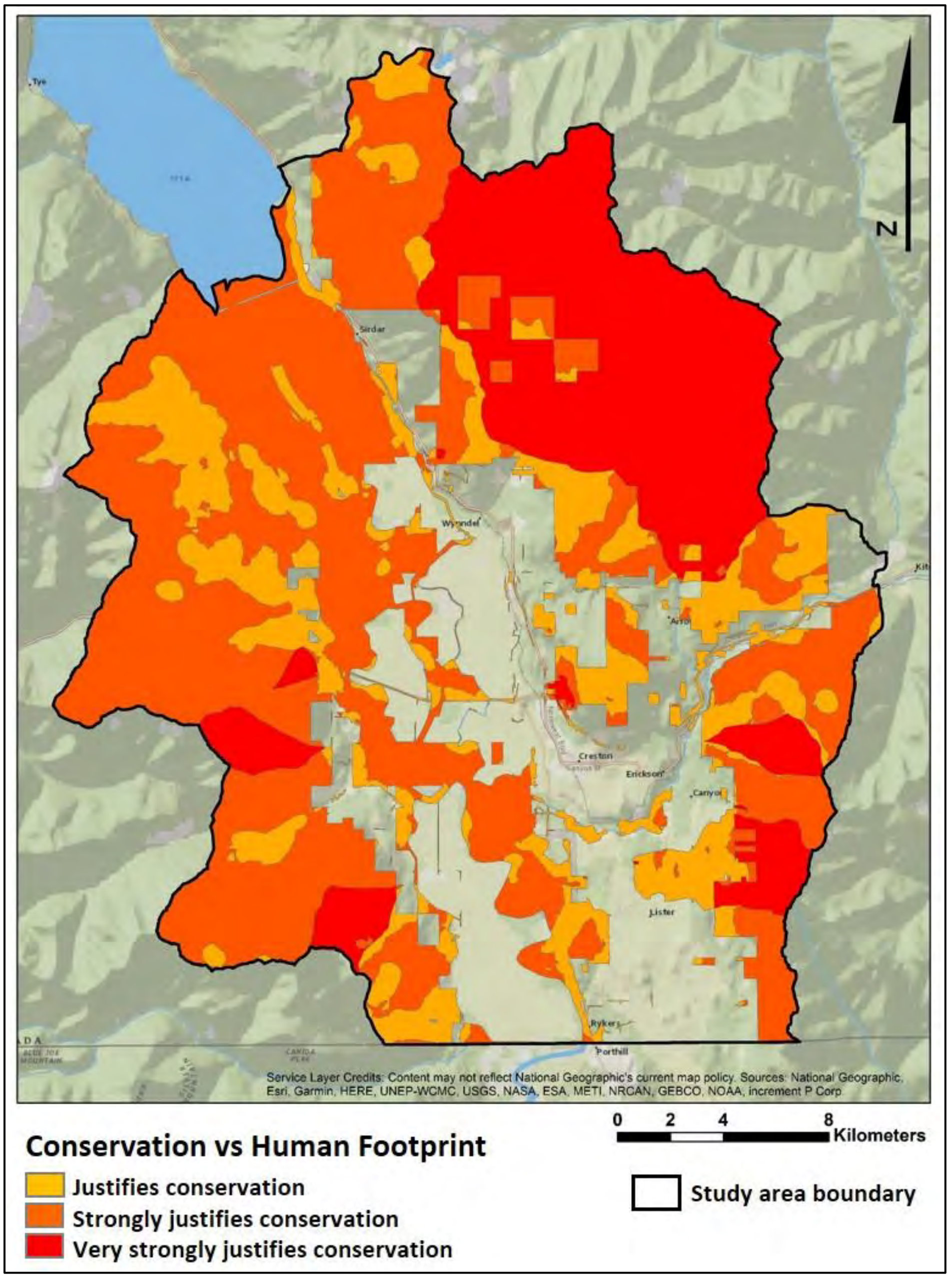


Figure 32:
THEME MAP
Conservation in relation to the Human Footprint

Considering the human footprint in the study area, our analysis highlights those areas where conservation measures could prove to be helpful for better land use management.

The presence of community watershed has an important influence on this output. The upper Arrow/Duck Creek watersheds are by far the largest areas highlighted by this analysis.

4.6 Geotechnical and Wildfire Risks

Rationale

Conservation measures can help build resilience and manage areas where geotechnical risks (soil instability, risk of erosion from flowing water, floodplains) are known to be present. Implementing such measures can help meet both conservation and public safety management objectives.

In many areas, wildfire risk is becoming an increasingly problematic result of past land management decisions. The most critical areas may now require aggressive treatment and active management. While this can also help to build resilience in the face of climate change, it can be perceived as contrary to conventional conservation approaches.

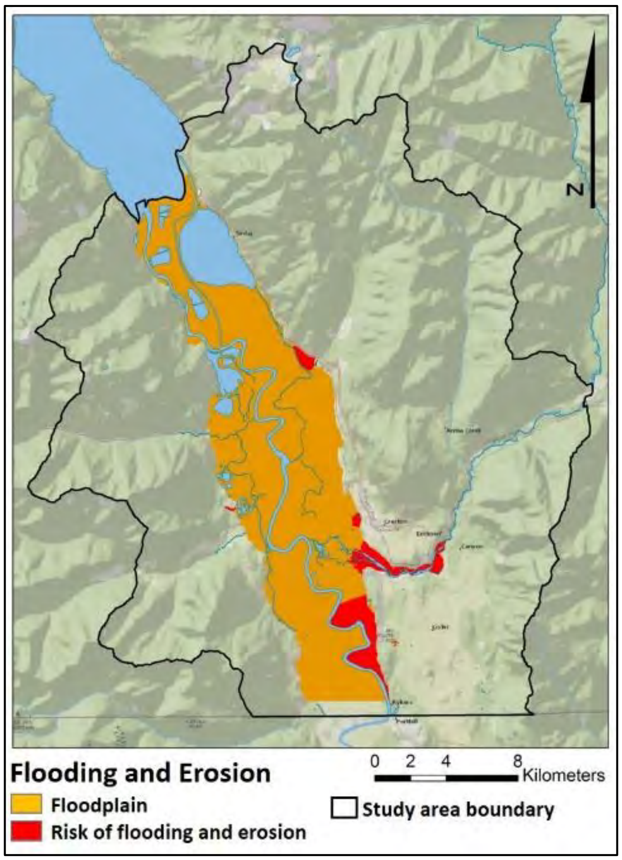


Figure 33:
Flooding and Erosion Risks

The Creston Valley's original floodplain ecosystems have been largely converted to agricultural lands. Today, the Kootenay River is heavily controlled by a complex system of dykes and dams.

None-the-less, risk management warrants adapting land management decisions in floodplains. Similarly, areas prone to erosion are worth managing accordingly.

Preserving the structural function played by vegetation and natural landforms is an effective way to build resiliency in the face of these risks. Concurrently, floodplains and riparian areas are known to offer exceptionally rich and diverse habitats. Conserving such areas is therefore beneficial in multiple ways.

Identifying and assigning a value to floodplains and erosion-prone areas can help highlight areas where conservation is appropriately used as a decision-making tool for land use.

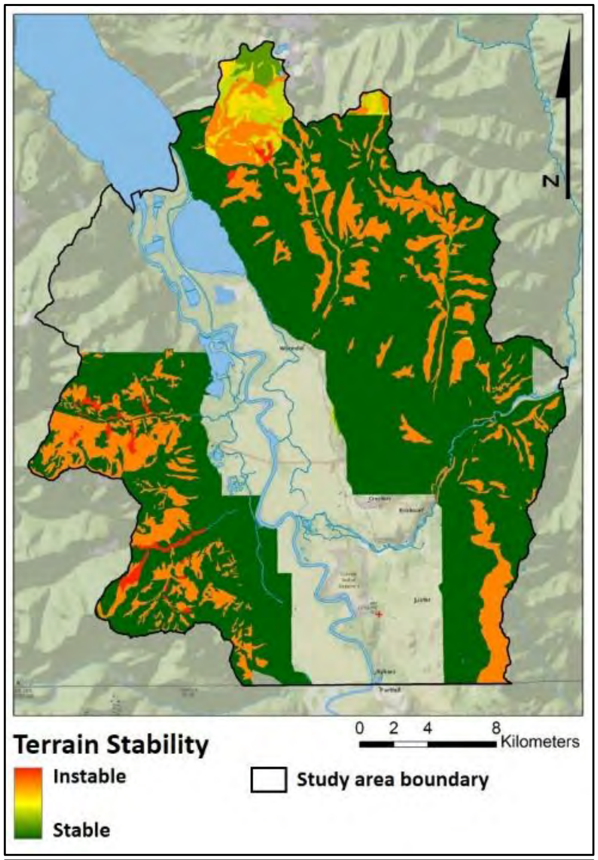


Figure 34:
Terrain Stability

Areas of higher terrain instability are often found on steep slopes, particularly along steep streambeds. Preserving the natural vegetation cover can help safeguard against mass wasting in and downstream of such areas. In many cases, it also helps maintain healthy riparian habitats. Hence, conservation proves to be an appropriate, desirable and useful land-use strategy in areas of instable terrain.

For the purpose of the analysis, increasingly high values were assigned to areas belonging to any one of 7 levels of terrain instability classes.

Areas of higher instability are mostly found in the Summit and Corn Creek watersheds.

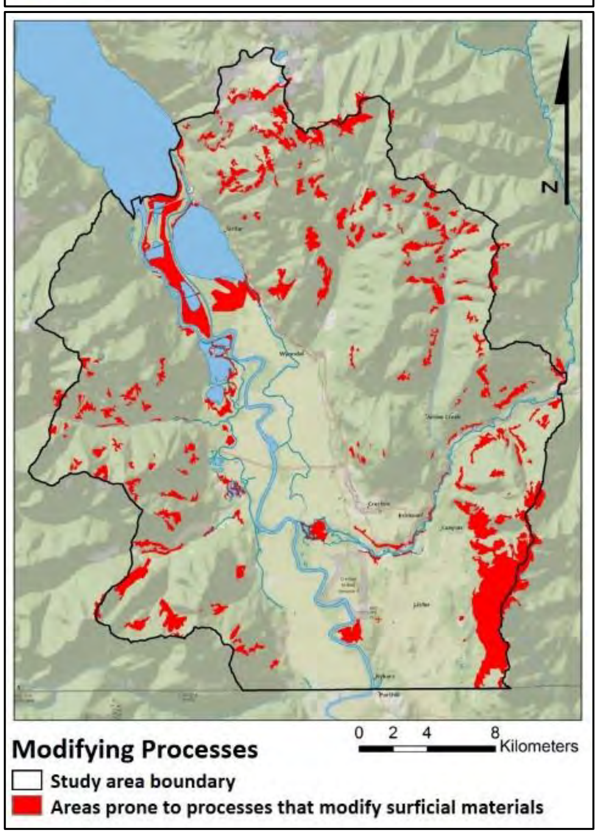


Figure 35:
Processes Modifying Surface Materials

The Vegetation Resources Inventory (VRI) attributes include information related to soil sensitivity to natural mechanisms of weathering that result in the modification of surficial materials and landforms.

The dynamic nature of these processes may encourage land planners to consider conservation approaches to mitigate potential geotechnical risks.

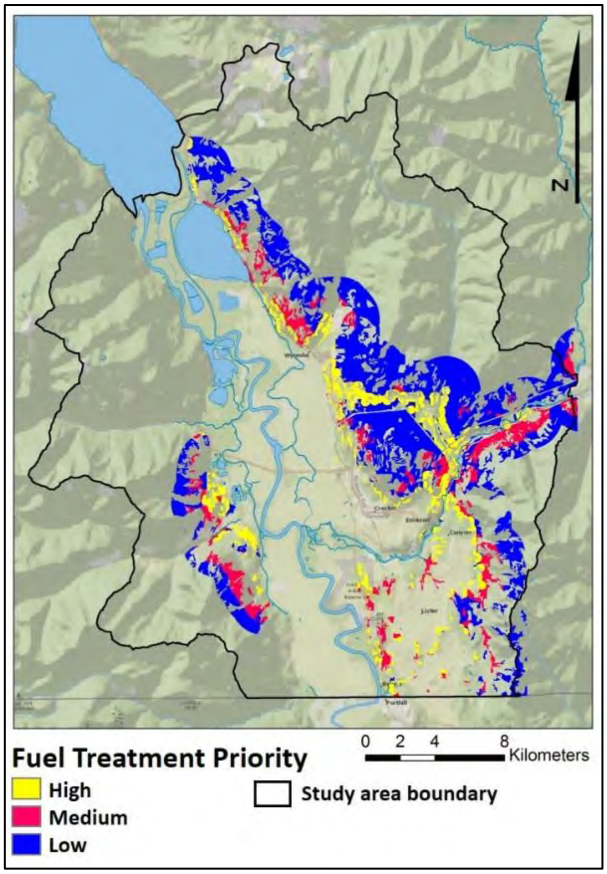


Figure 36:
Wildfire Fuel Treatment Priority

In certain circumstances, wildfire fuel treatment can be done to promote conservation values. It is of particular relevance to assist in the anticipated transition of the Creston Valley to a grassland-dominated landscape. However, in most cases, fuel treatment strategies will likely be perceived as contrary to conventional conservation initiatives in densely forested environments.

Given that this particular layer is specifically designed to address public safety needs, the high-priority areas were given negative values in the theme analysis. Areas requiring treatment are given lower value to highlight their potential as candidates for aggressive intervention (logging, burning, fuel removal, etc.) rather than as candidates for more conventional conservation efforts.

The summed values of the four *risks* layers above provide a generalized value for the theme. According to this analysis, some parts of the study area receive added support for conservation based on the known geotechnical and wildfire risks present in the Creston Valley. Figure 37 gives the classified results.

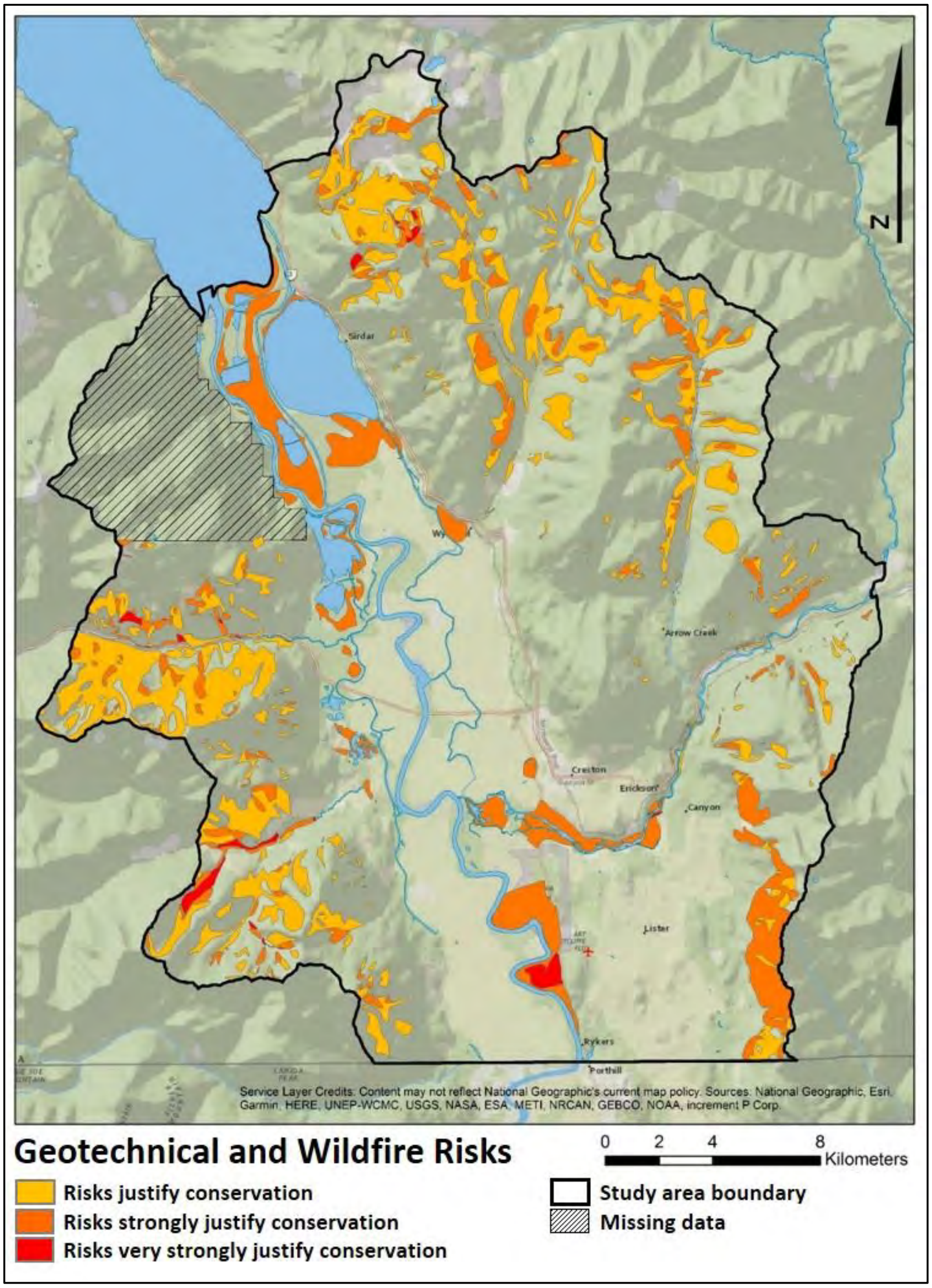


Figure 37:
THEME MAP
Conservation in relation to Geotechnical and Wildfire Risks

The map opposite shows areas where some known risks could be addressed in part by conservation measures.

Large, high-ranking areas are found in the more intact portions of the valley.

The fast-flowing waters of the Goat River justify appropriate management of its lower reaches. The steep talus slopes of the Skimmerhorn area are also delineated.

Finally, the analysis suggests that some of the steeper streambeds of the higher-elevation forested areas could benefit from conservation measures as well.

4.7 Connectivity and Resilience to Climate Change

Rationale

Landscape fragmentation is increasingly recognized as a significant threat to the maintenance of biodiversity. Accordingly, it is now known that creating protected areas alone will not ensure the long term survival of many species.

It is essential that some level of connectivity be maintained between core areas of habitat in order to enable species dispersion, seasonal movements and gene flow across populations. In addition to addressing fragmentation, this need is made even more urgent by the pressures brought on by climate change, shifting species ranges and transitioning ecosystems.

Recent advances in ecology and GIS have given rise to the development of 'connectivity modelling'. As part of a continent-wide study (Carroll et al. 2018), the Selkirk and Purcell Mountain ranges have been identified as prime pathways of 'climate connectivity'.

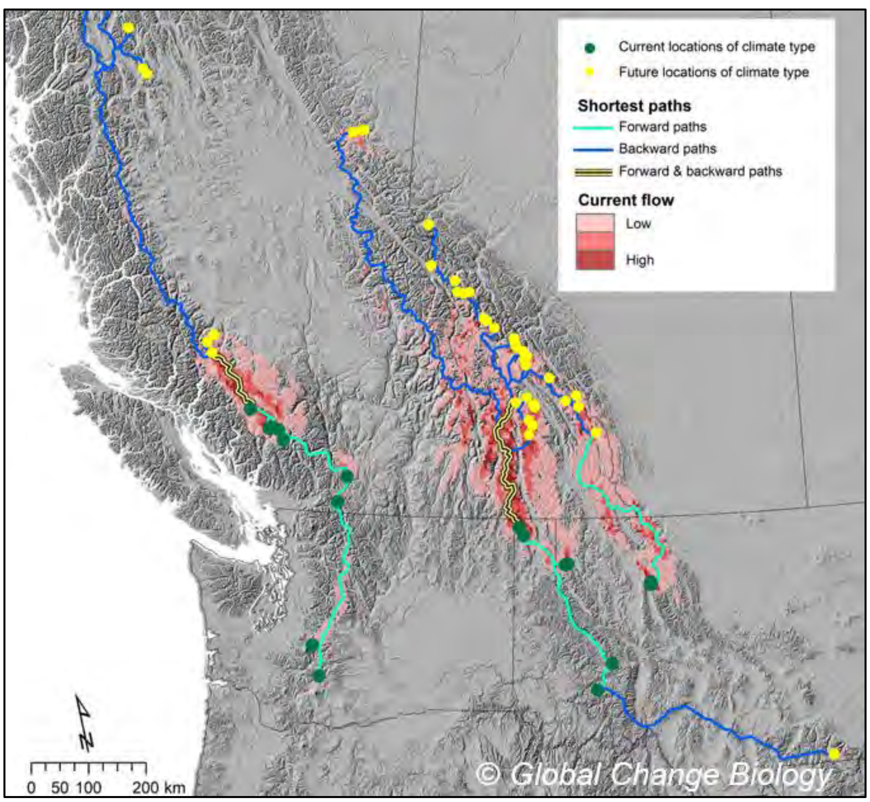


Figure 38: Recent climate-connectivity modeling analysis results suggest strong 'current flow' potential along the Purcell Trench.

Source: Carroll et al 2018
http://conservationcorridor.org/2018/08/climate-corridors-of-north-america/

Being a land passage between the Selkirk and Purcell mountains, the Creston Valley offers potentially important wildlife corridors, notably for grizzly bears (Proctor et al. 2015) which can arguably be considered an ‘umbrella’ species.

The Creston Valley is also one of the most significant low altitude South-to-North corridors in southeastern BC, offering much-needed pathways for shifting species ranges in response to climate change (http://www.westkootenayresilience.org/).

Having been deeply modified by human occupation, the valley’s ecosystems suffer considerable levels of fragmentation.

Identifying existing and potential pathways to enhance ecological connectivity in the study area is one of the desired outcomes of the Creston Valley Green Map Project.

For the purpose of the project, the need for enhanced connectivity has been framed in three ways:

- South-to-North and Upslope connectivity as it relates to climate change resiliency and refugia;
- Cross-valley connectivity as it relates to animal movements and gene flow;
- Internal connectivity to alleviate isolation of high value conservation patches within the study area.

Various projects have already addressed connectivity issues in the Creston Valley. Personal communications with project-leads (Yellowstone to Yukon initiative, Dr Michael Proctor, Greg Utzig) promise to provide valuable inputs for the analysis. Further contacts with such specialists could prove very valuable in widening and deepening the project’s scope in the future.

For finer-scale planning, software relying on ‘circuit theory’ has been used to model connectivity based on the outputs of the Creston Valley Green Map theme analyses.

The *West Kootenay Climate Change Vulnerability and Resilience Project* (Holt et al. 2012, Utzig & Holt 2012) proposes conservation and linkage areas that could be managed in ways that increase ecosystem resilience in the West Kootenay in the face of climate change (fig. 39). These intend to highlight areas of highest potential for maintaining and restoring south-north connectivity and upland refugia.

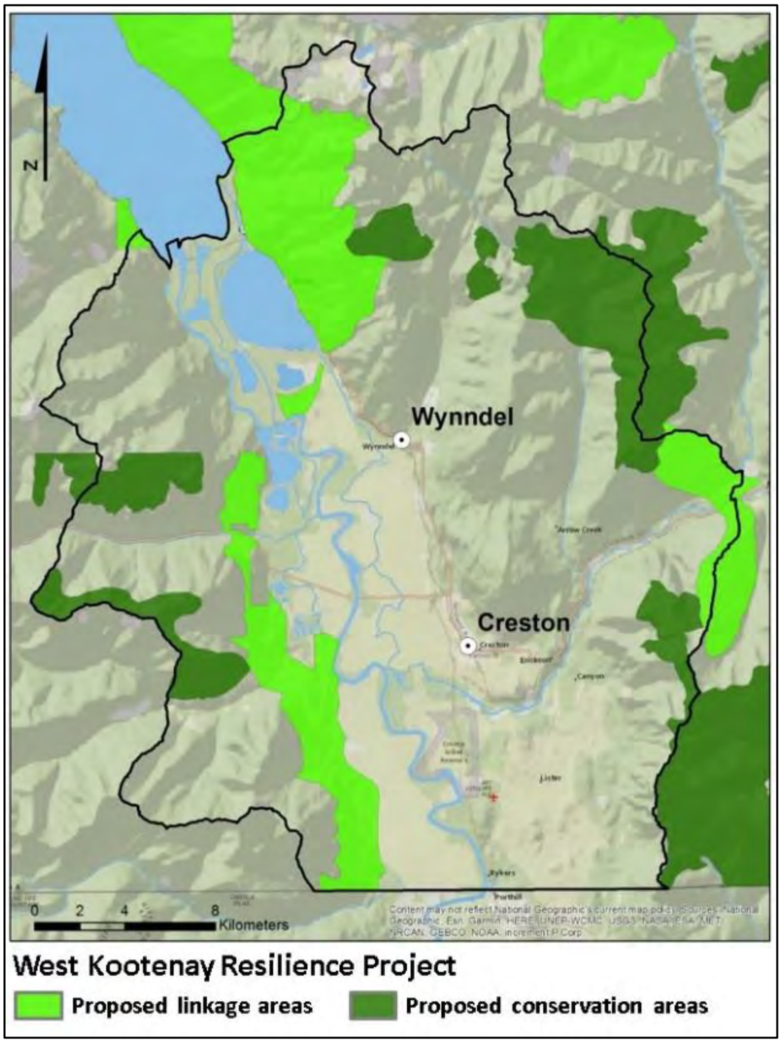


Figure 39:
Expert-knowledge of required linkage and resilience-based conservation areas

The *West Kootenay Climate Change Vulnerability and Resilience Project* (http://www.westkootenayresilience.org/) proposes conservation and linkage areas that could be managed in ways that increase ecosystem resilience in the West Kootenay in the face of climate change.

The opposite polygons were used as inputs for the "Connectivity and Resilience" theme of the current project.

As part of the Creston Valley Green Map project, the theme analyses results described above can be further aggregated to produce a finely detailed pixel-based map of the potential 'value' of:

1) the *Natural Features* found within the study area and
2) the *Social Factors* that can either constrain or support conservation in the study area.

The graphic results of these aggregations are shown in figure 40.

Natural Features

- **Conservation Gap Analysis**
- **Rarity**
- **Wildlife**
- **Forest and Flora Attributes**

Social Factors

- **Human Footprint**
- **Risk Factors**

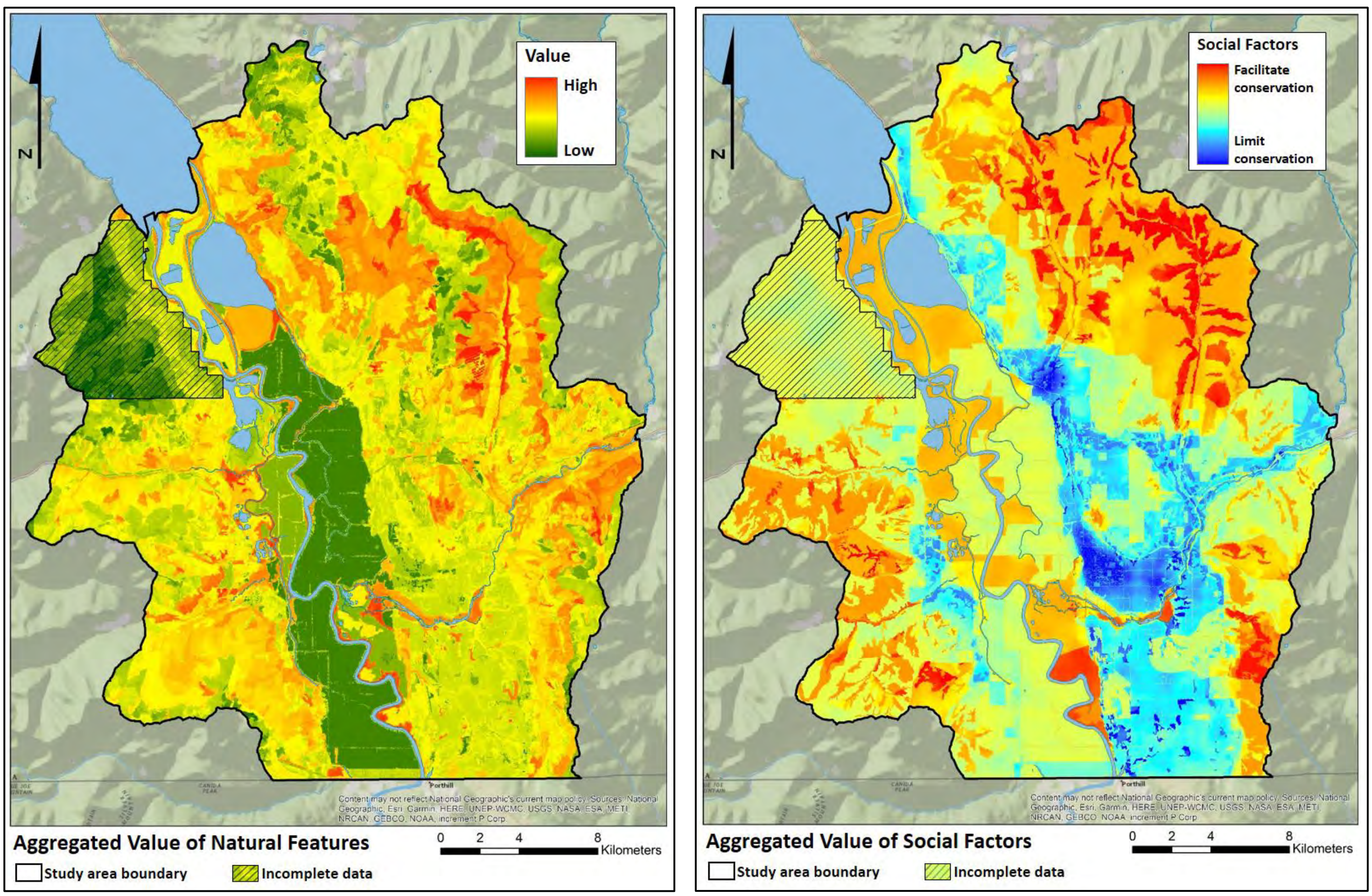


Figure 40: Finely-detailed pixel-based layers were produced to summarize the value of 1) the natural features in the study area and 2) the social factors than can constrain or help support conservation initiatives in the study area.

In order to identify potential corridors in the study area, the *Natural* and *Social* layer values were combined to produce a map used as a ‘conductance surface’ for circuit-based connectivity modeling (fig. 41).

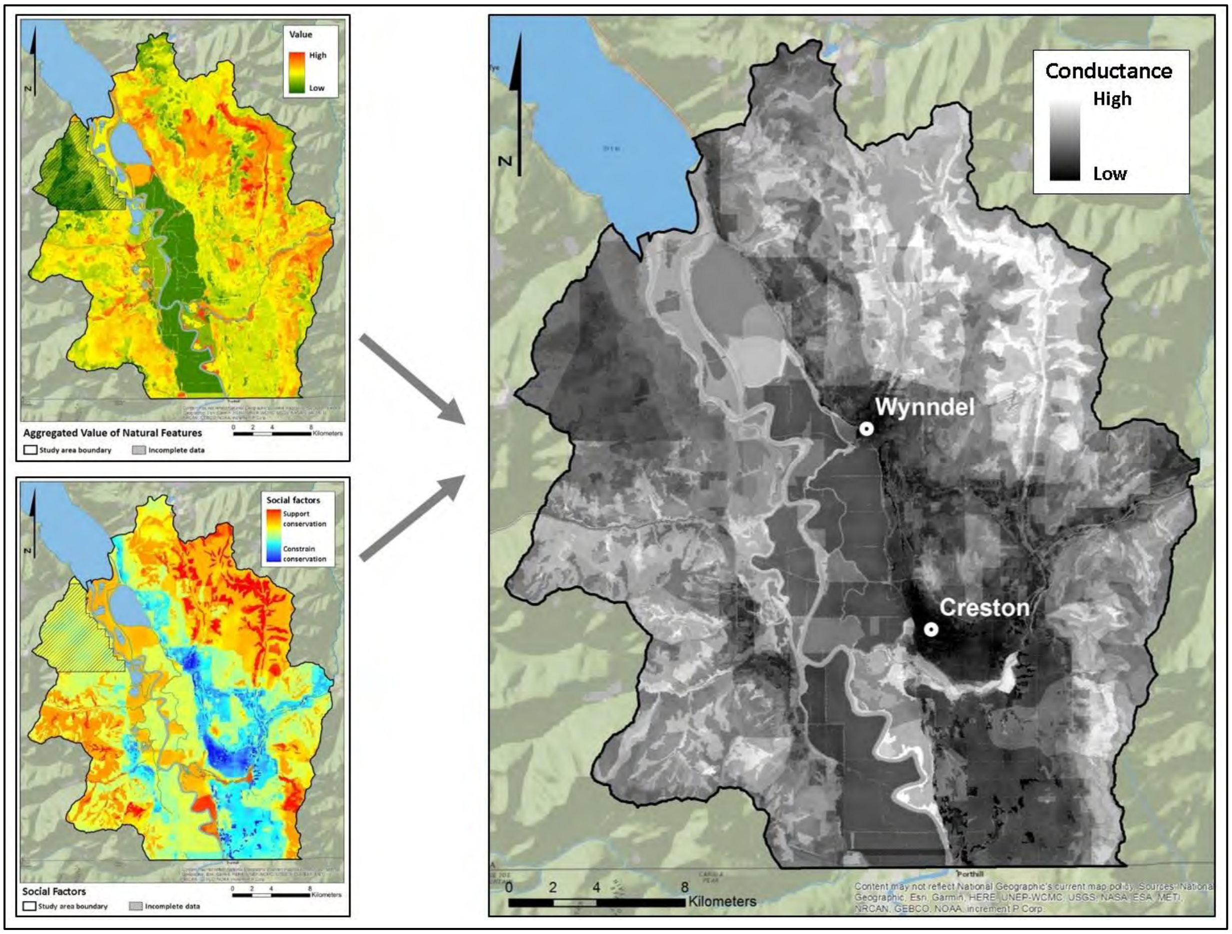


Figure 41: The combined values of the *natural features* and *social factors* layers provide the conductance surface that can be employed to model ecological connectivity across and within the study area.

Using a total of 27 'nodes' located in 2 terrestrial buffer areas on either side of the study area, a cumulative *current* map was produced to illustrate the pathways of highest cross-valley connectivity given the conductance surface (fig. 42).

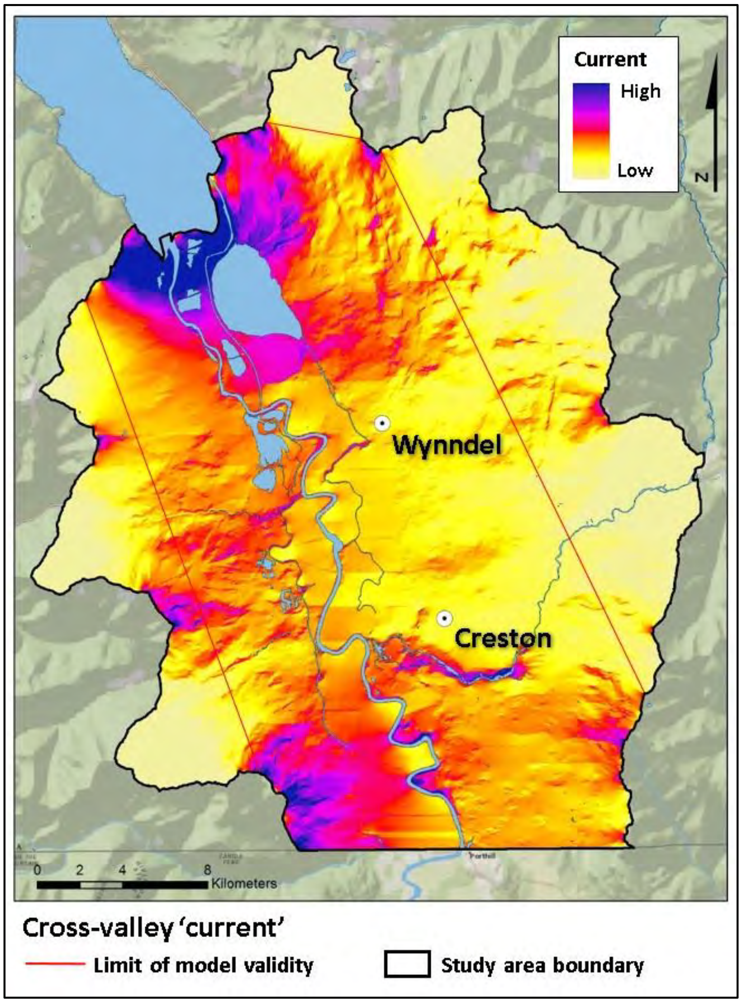


Figure 42:
Cross-valley current

Based on circuit-theory, this cross-valley current model uses the combination of the natural and social layer values as an indication of potential ecological 'conductance' in the study area.

Areas of high 'current' in the model suggest that these pathways offer higher-quality attributes for restoring ecological connectivity between both sides of the Creston Valley.

Note:
The irregular boundary of the study area creates some artifacts in the model. The 'current' values should only be considered for the central portion of the study area (between the red lines on the map).

Many assumptions must be taken into account when interpreting any kind of connectivity map based on circuit theory. Most notably, understanding the criteria leading to the creation of the conductance surface is of critical importance. With this caution in mind, areas of high 'current' displayed in figure 42 can be cautiously interpreted as areas where conservation or restoration efforts will be the most effective at enhancing cross-valley ecological connectivity.

For further analysis, the *Natural Features* value can be summarized in classes. The top-ranking areas can then be considered *Natural Value Hotspots* from the perspective of the Creston Valley Green Map analysis (fig. 43).

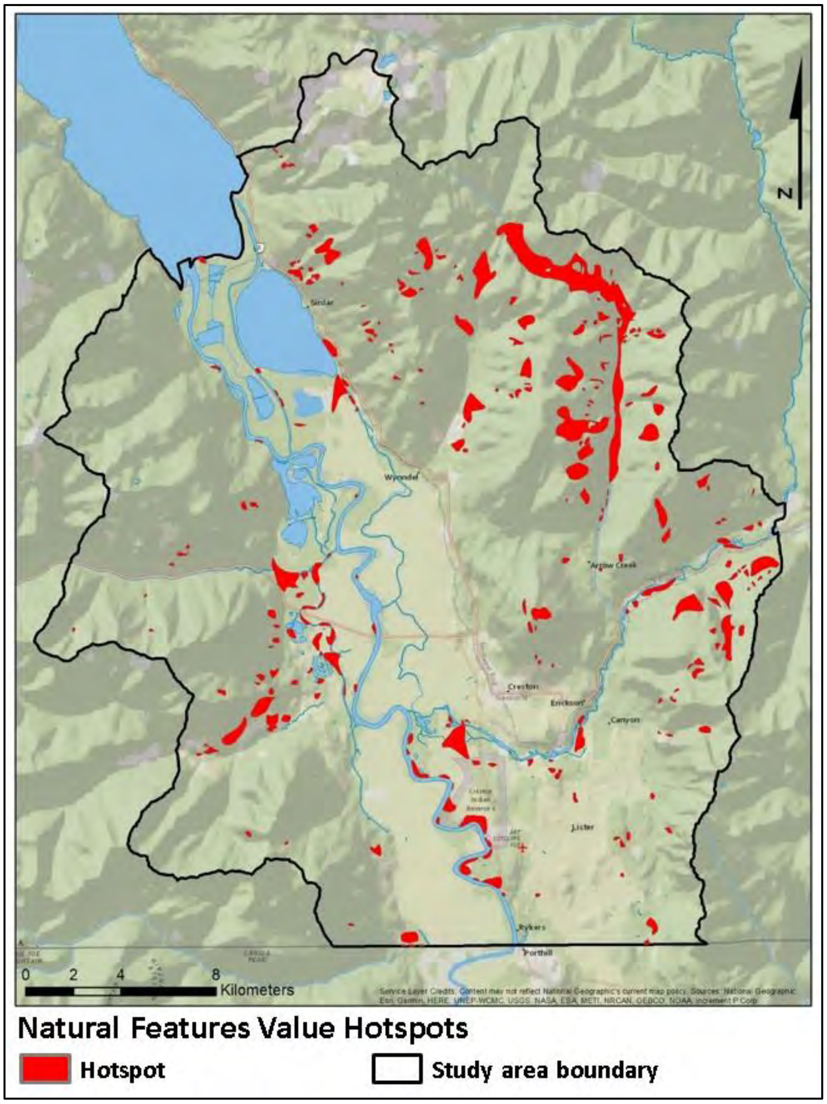


Figure 43:
Natural Value Hotspots obtained from the Creston Valley Green Map analysis results

Areas of high hotspot density are concentrated

- in the upper reaches of the Arrow Creek watershed;
- on the east-facing slopes to the northwest of West Creston;
- on the north-facing slopes of Mt Thompson;
- along the Goat River;
- along the east side of the Kootenay River upstream of its confluence with the Goat River;
- on the west-facing slopes above Duck Lake.

Using the study area's *Natural Value Hotspots* as 'nodes' can in turn help to better understand the potential pathways along which connectivity between these hotspots can be most effectively enhanced.

The analysis identified 249 hotspots in the study area. Figure 44 shows the pathways of highest internal connectivity between these hotspots, given the conductance surface.

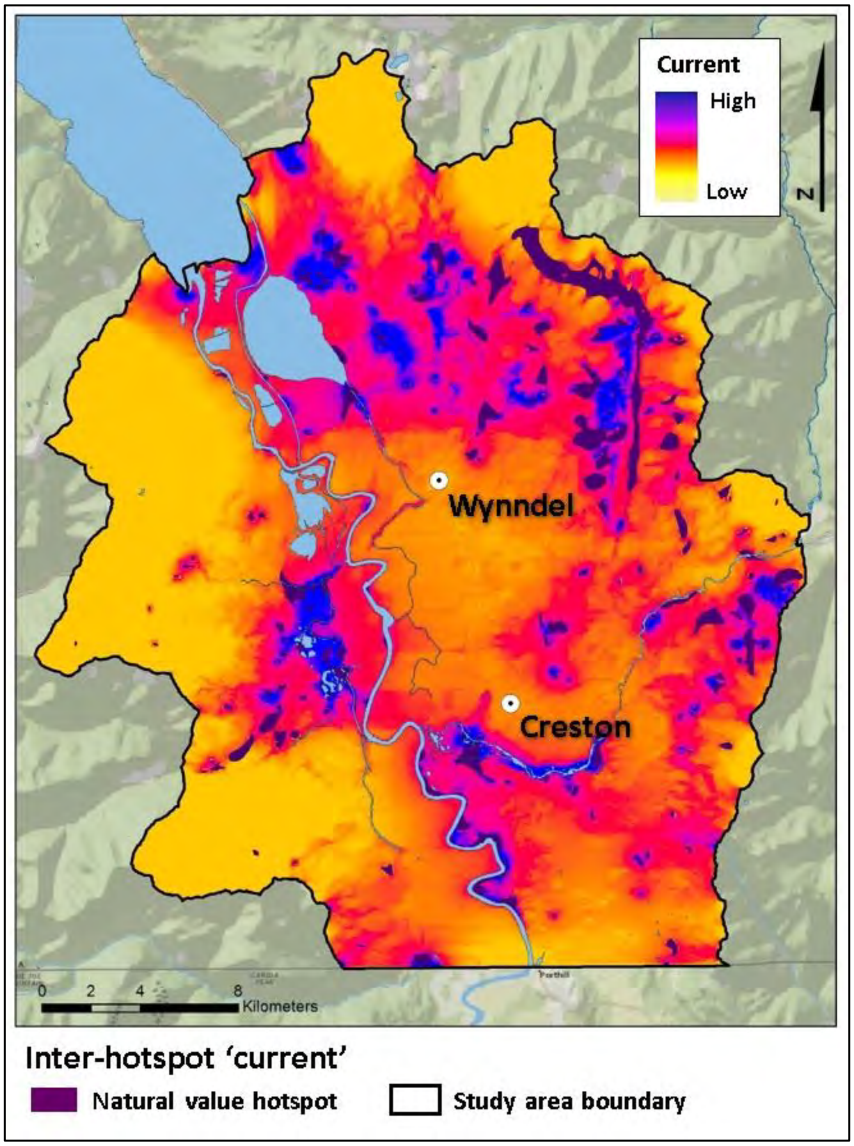


Figure 44: Connectivity between Creston Valley Green Map Hotspots

As opposed to the cross-valley connectivity model, this model finds the most promising pathways for ecological connections between the *Natural Value Hotspots* revealed by the project.

Areas of high internal connectivity help connect the Duck Lake area to the upper portions of the Arrow Creek watershed. Similarly, this mode reveals interesting connections between the hotspots of the West Creston area and those of Mount Thompson, notably along the lower Goat river.

Note:
The irregular boundary of the study area creates artifacts in the model. The current values in the lobes are artificially low.

The aggregation of the three previous connectivity layers provides an overall picture of the corridors that might hold the highest potential for maintaining and restoring ecological connectivity in the Creston Valley (fig. 45).

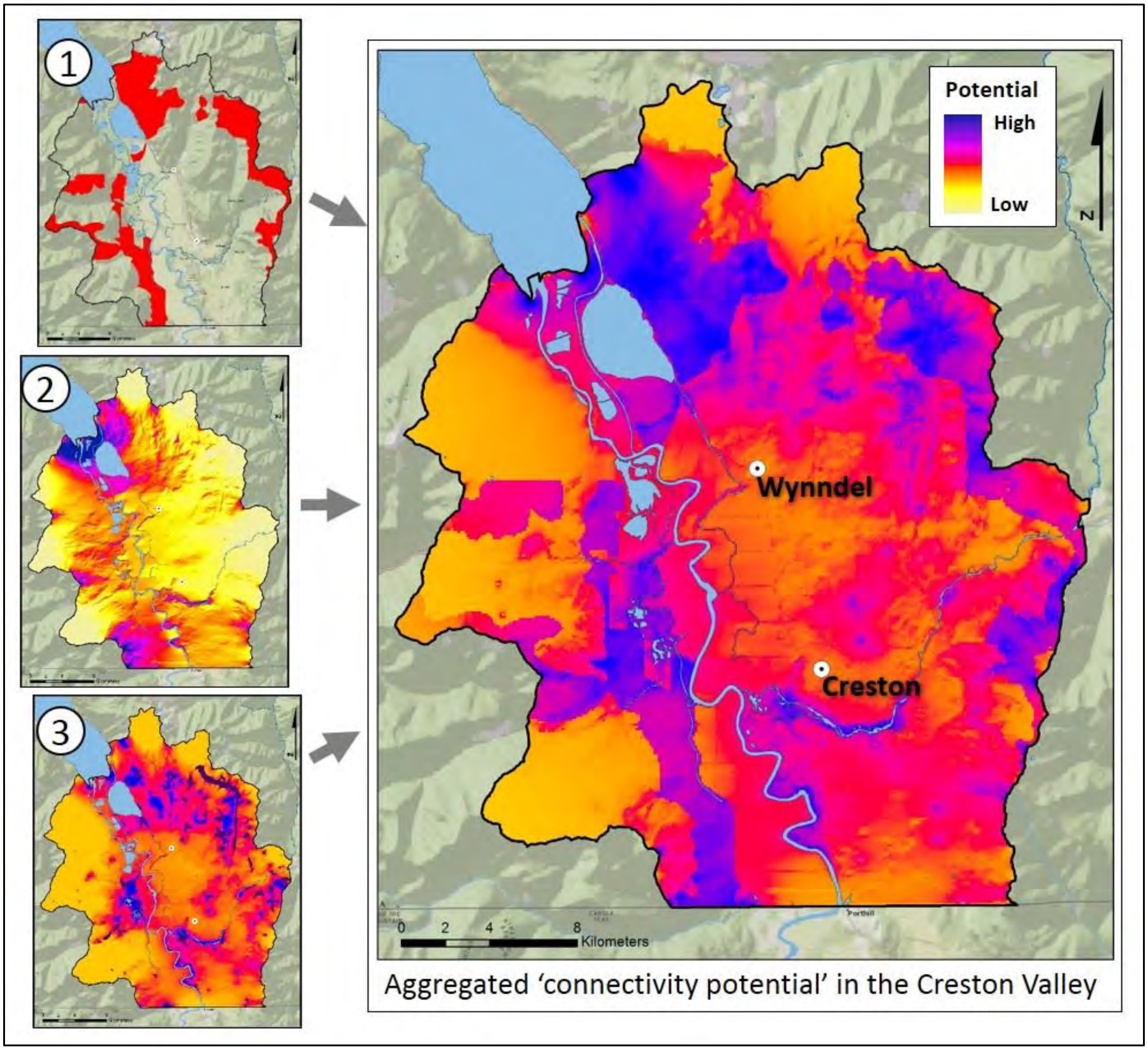
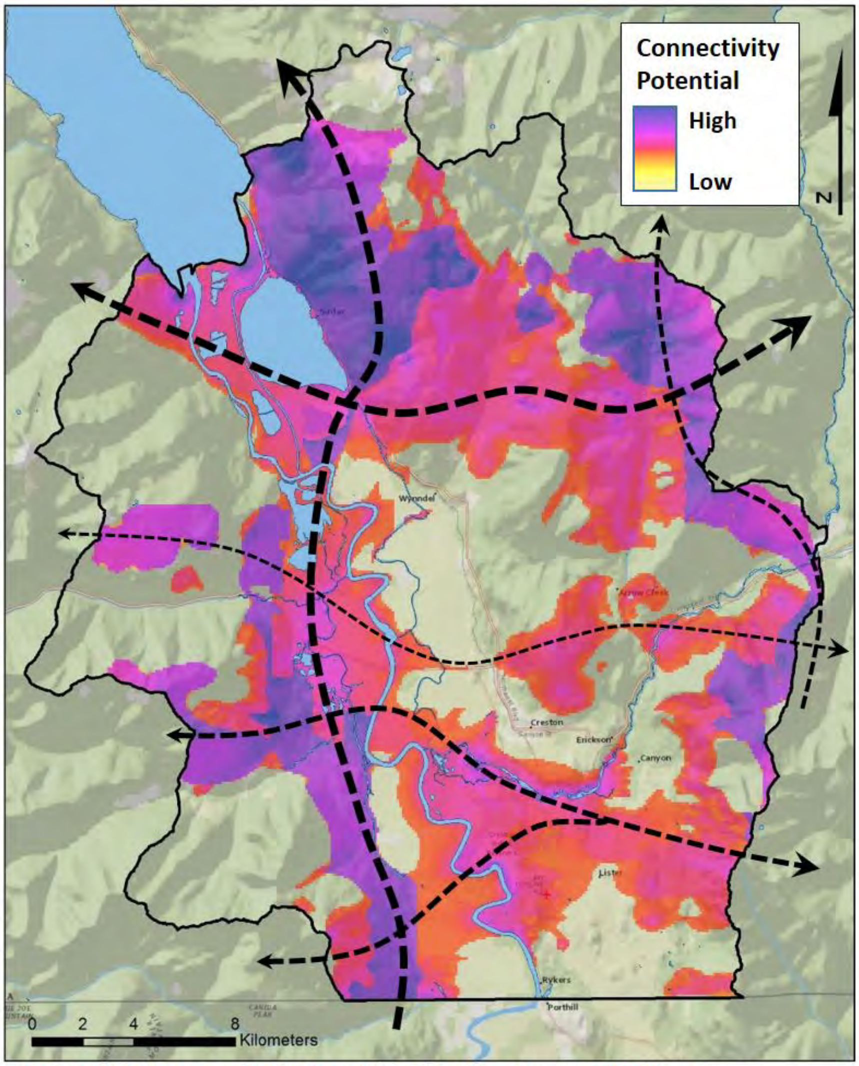


Figure 45: Overall connectivity potential in the Creston Valley can be obtained from the aggregated values for:

1) expert-based proposed linkage and conservation areas,
2) modelled cross-valley connectivity and
3) modelled internal hotspot connectivity.

Focussing on the top classes of the 'connectivity potential' map, potential ecological corridors in the Creston Valley (fig. 46) can be identified:

- A major corridor running south-to-north
- A major east-west corridor crossing the northern half of the study area (Duck Lake – Upper Arrow)
- A double corridor crossing the southern half of the study area (Corn Creek/Porthill - Skimmerhorn)
- A narrow east-west corridor across the central part of the study area (Summit – Goat)
- South-to-north connectivity across the Goat River (Thompson – Upper Arrow)



Potential 'Connectivity Corridors' in the Creston Valley

Study area boundary

Figure 46:
Major potential ecological corridors in the Creston Valley

Figure 47 shows a coarsely georeferenced screenshot of a map modified from Proctor et al. (2015) for the study area. Of note, the GIS datasets for this were requested but not obtained, so were not included as added factors in this project's connectivity analysis or wildlife habitat mapping.

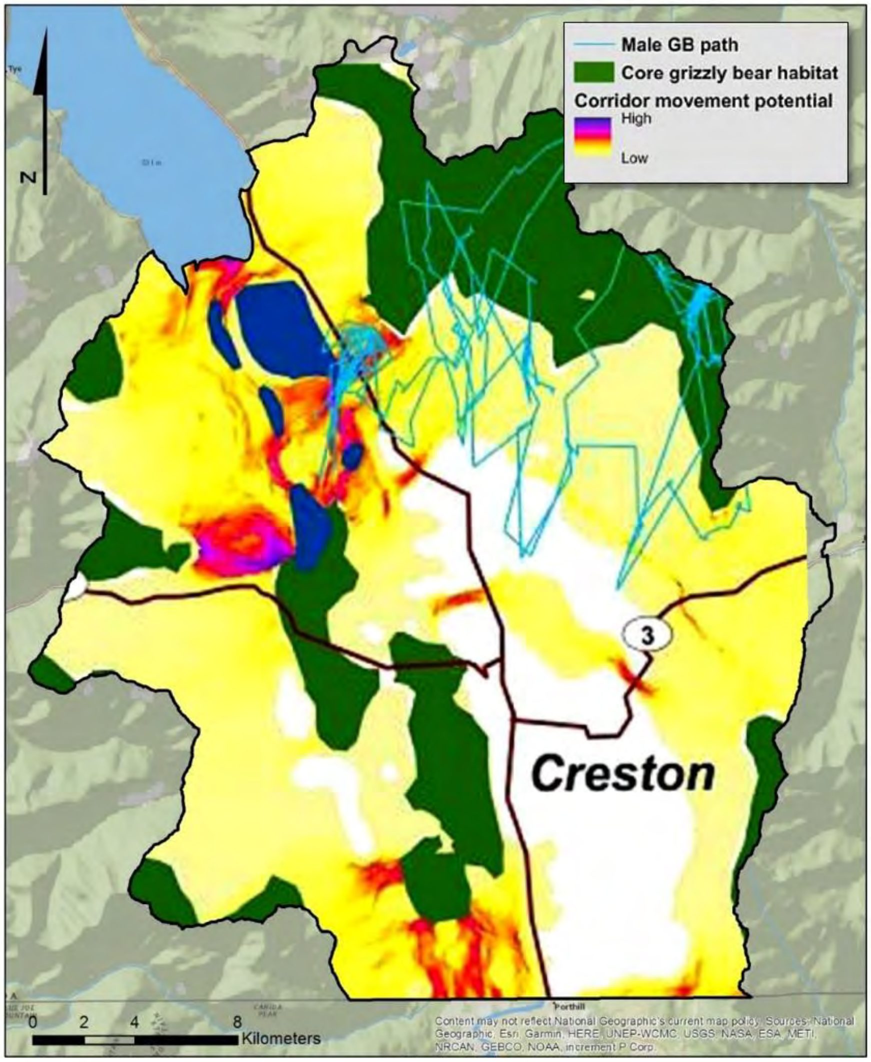


Figure 47:
Core grizzly bear habitat and corridor movement potential in the study area

Source:
Proctor, M. F., S. E. Nielsen, W. F. Kasworm, C. Servheen, T. G. Radandt, A. G. MacHutchon, and M. S. Boyce. 2015. Grizzly bear connectivity mapping in the Canada-US trans-border region. Journal of Wildlife Management 79:544–558.
https://wildlife.onlinelibrary.wiley.com/doi/full/10.1002/jwmg.862

4.8 Viewscape Analysis

Rationale

Carved deeply by massive ancient glaciers, the Creston Valley stands out by its relatively wide and flat valley bottom.

Made very open by its predominantly agricultural land use, the valley offers innumerable vistas with sweeping views of Kootenay Lake, the valley's expansive wetland network and soaring valley sides, reaching all the way up to the alpine peaks of the Purcell and Selkirk ranges.

The viewscapes of the Creston Valley shape the relationship that residents and visitors develop with the land. They contribute to the sense of place and are therefore important assets, worth evaluating and considering in land management decisions.

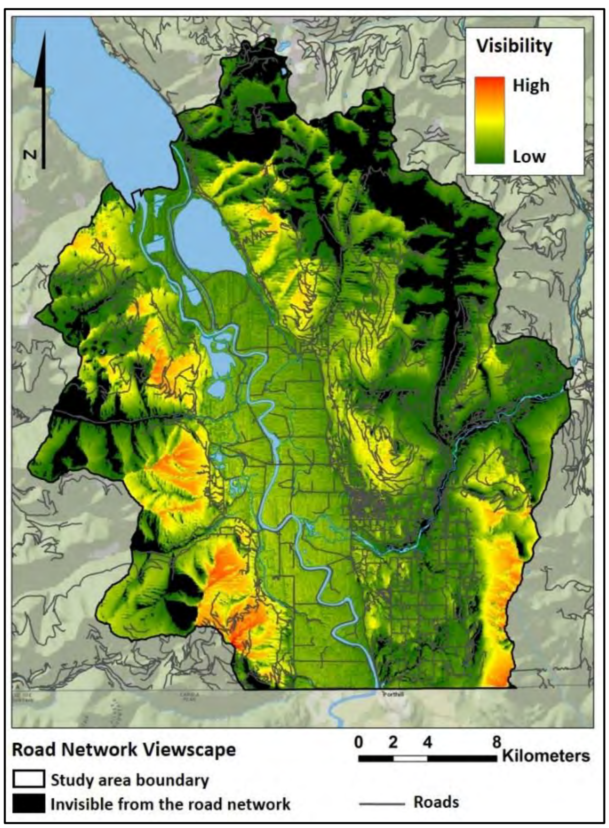


Figure 48:
Visibility of the land as seen from BC Atlas Road Network

In GIS, a visibility analysis uses a Digital Elevation Model (DEM) where pixels give the altitude of the land. This is used to compute areas of unobstructed views

A cumulative visibility value was computed for the study area's landscapes with the road network (including tracks and forestry roads) as an aggregated viewpoint.

Areas displayed in red are those that are visible from the highest number of different road segments.

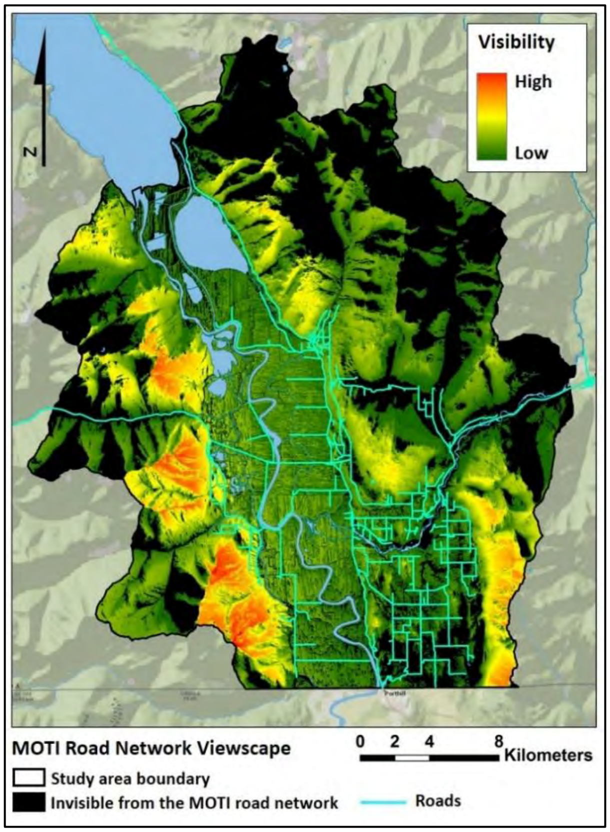


Figure 49:
Visibility from MOTI Road Network

Because the Ministry of Transportation and Infrastructure (MOTI) network sees much more use, it is reasonable to want to give added weight to this particular viewscape in the analysis.

Here again, the layer gives the cumulative visibility of the landscape as seen only from the MOTI road network.

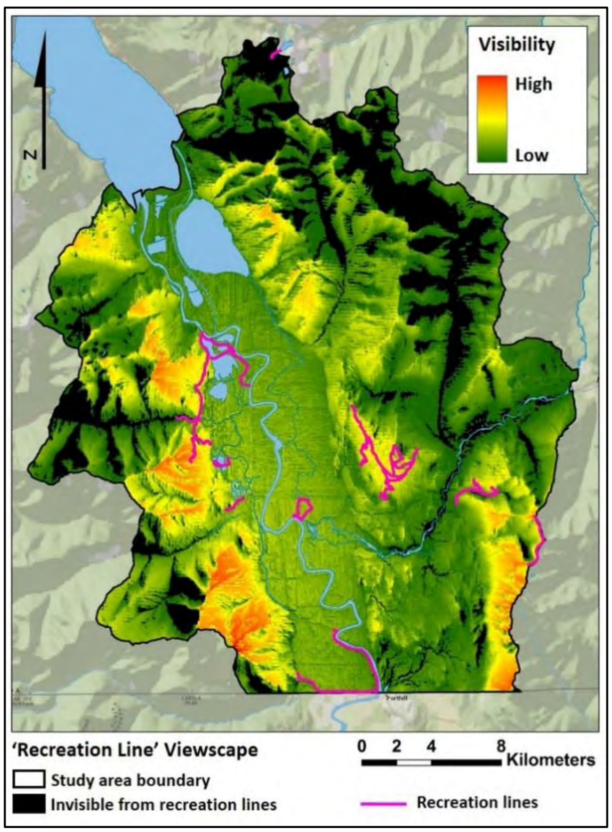


Figure 50:
Visibility from known "Recreation Line" features

The purple lines are from a combination of trail dataset sources.

This map shows the cumulative visibility of all pixels in the study area, using points every 50 meters along these trails as viewpoints.

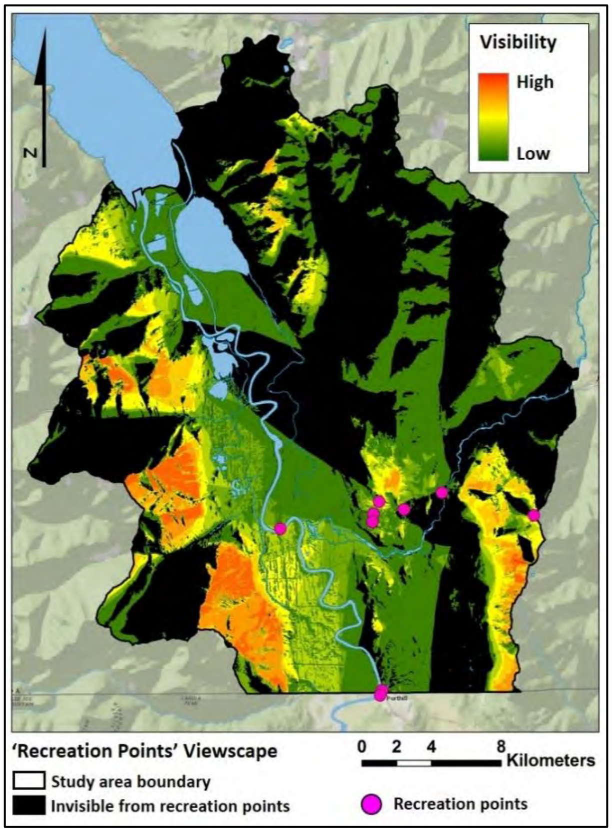


Figure 51:
Visibility from Known "Recreation Point" features

The points shown in purple are from the DataBC's recreation dataset. This map shows the number of these points that are visible for each of the cells (pixels) of the study area.

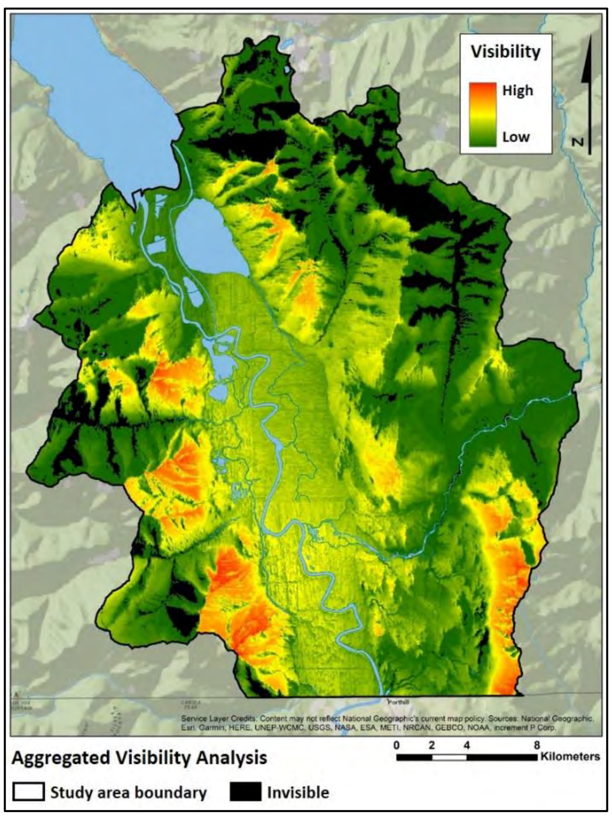


Figure 52:
Aggregated Viewscape values

By combining the visibility values of the above maps (figures 48 to 51), we obtain a single aggregated value layer.

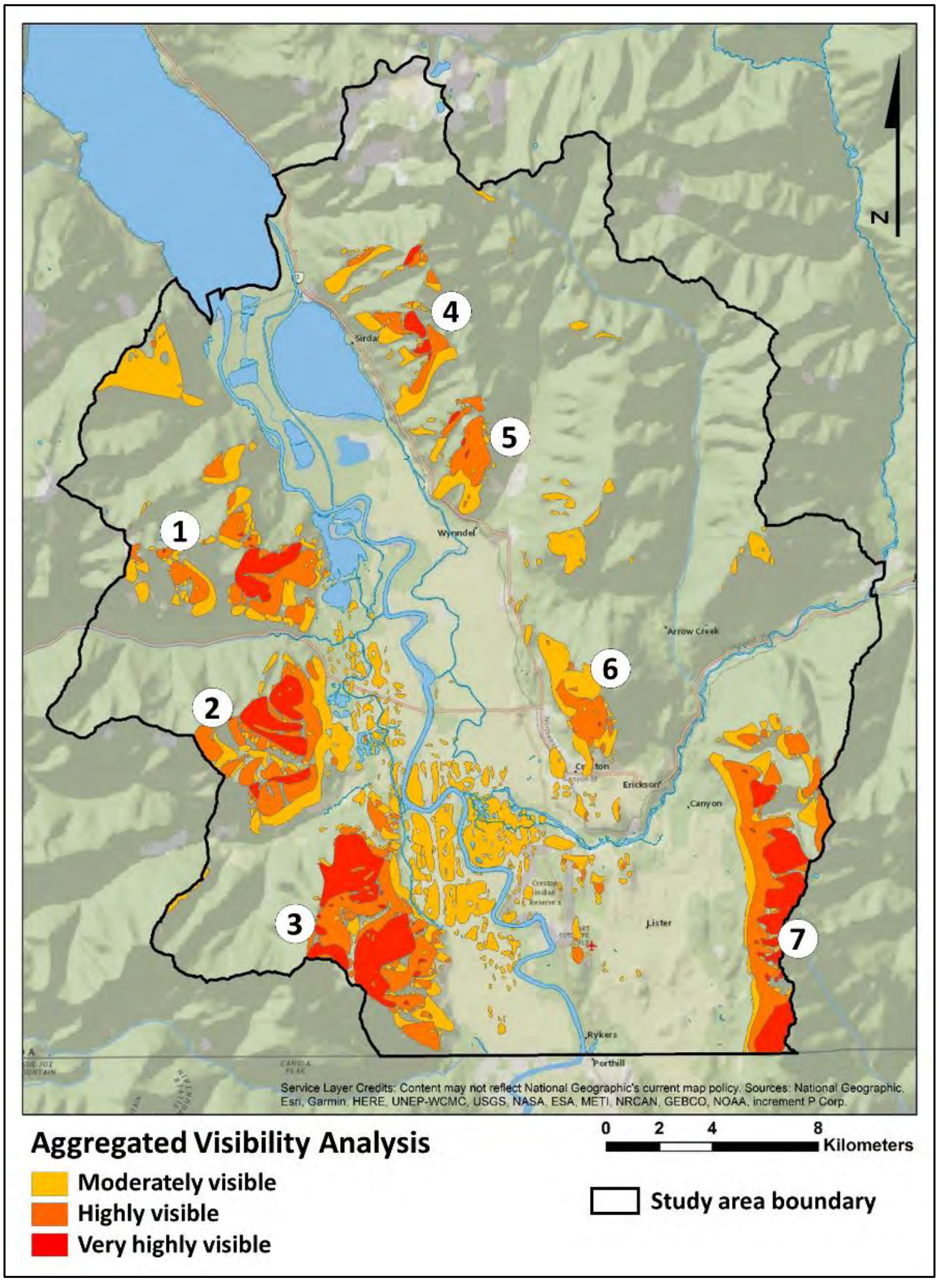


Figure 53:
High visibility areas in the Creston Valley

Using a combination of different possible viewpoints, the aggregated visibility layer highlights the parts of the study area that are most visible overall.

The highest values are found in the small but steep watersheds that directly overlook the Creston Valley on its western flank, notably

1) Mount Midgeley
2) David/Maclellan/Moores creeks;
3) Betts/Simmons creeks.

Other notable landmarks in the study area include

4) Duck Lake face;
5) Ridges overlooking Wynndel;
6) Goat Mountain;
7) The Skimmerhorn cliff faces.

Of note, features beyond the study area boundary are not considered, but may also be highly visible from within the study area. The flanks of the Kootenay Lake valley and some high peaks are notable examples.

5. Discussion and Conclusion

The preparation of the Creston Valley Green Map involved the inventory, examination and assessment of a considerable number of geospatial datasets which have a bearing on our understanding of the Creston Valley's social and ecological fabric.

Results compiled according to the project's six themes provide detailed insights into the factors that may justify enhanced conservation efforts in one part or another of the study area.

Our **Rarity** analysis suggests that the most extensive rare habitats in the Creston Valley are associated with low altitude riparian areas, most notably around Duck Lake, Corn Creek and the Goat River. Most of these areas are currently unprotected and could benefit greatly from increased conservation efforts. Ridgetop ecosystems were also identified as being rare, though with lower rarity values. Because the study area is centered on the Creston Valley and limited to the moist visible parts of the valley's watershed, it is not surprising that the alpine ecosystems of the Wooden Shoe Lake area boast high levels of rarity. These areas are currently included in caribou winter habitat and are currently protected from harvest. The protections afforded by this designation would be worth preserving in the future. Finally, some isolated mid-slope forest stands can also be considered rare. The density of these stands is higher in the western half of the study area.

According to the gap analysis, there are certain types of forest for which there a few examples in existing conservation areas. **Under-represented** habitats tend to be situated at mid-slope and are concentrated in the *Dry Interior Cedar Hemlock* units (ICHdm and ICHdw) of BC's Biogeoclimatic map system. The northern flank of the Corn Creek watershed shows a high occurrence of under-represented forest types. The western flank of the Arrow Creek watershed also boasts several areas of forest types that are not adequately represented in existing conservation areas.

The two previous themes were analysed based on a strictly quantitative approach (i.e. comparing area size ratios). Though *rarity* and *under-representatio*n are classic metrics in conservation planning, there may be very little intrinsic value associated with some of the map features that are identified as rare or under-represented. Moreover, it is important to consider the quality and nature of the input data. Biogeoclimatic Ecosystem Classification (BEC) is a coarse mapping tool that is also constantly evolving in its scope and level of precision with every new version that is released. The latest version of the BEC dataset was released in August 2018. Results of the analysis would likely be slightly different with this latest version of the dataset. Similarly, the Vegetation Resources Inventory (VRI) must be appreciated for what it is: primarily a forest harvesting planning tool focussed on the attribute of merchantable wood. Information made available from the VRI can be considered thin from the point of view of ecological sciences. In addition, the accuracy of VRI data is often questioned in scientific circles. None the less, it is a finely detailed dataset that allows users to extract insightful patterns at the scale of the local landscape, which is what was made it most useful for this analysis.

High-ranking **Wildlife** habitat in the study area is found extensively in the valley bottom. According to the aggregation of our data sources, the most extensive high-value areas for wildlife are located in the low-lying areas (mostly wetlands) along the Kootenay River. The Creston Wetlands Management Area protects less than half of these habitats. The majority of the remaining high-ranking wildlife habitats fall under the management of the Lower Kootenay Band. Alpine ecosystems within the study area offer caribou winter habitats. These enjoy a high level of legislated protection. Finally, steep low-altitude slopes offer valuable habitats for the valley's ungulate populations, very few of which are currently protected.

As a general observation, the **Aggregated Forest and Floral Attributes** analysis reveals concentrations of high-value areas in the Arrow Creek watershed. Regulations linked to caribou winter ranges are successful at protecting the old forests of the upper reaches of the watershed, but the lower, more productive reaches of the watershed remain unprotected. The west-facing slopes overlooking Duck Lake are the next most extensive high-value forest and flora area. The tentative Old-Growth Management Areas (OGMA) may help preserve some of the valley's valuable old growth stands. Riparian sites in the valley-bottom offer strings of small high value polygons very near human populations. Targeted conservation measures could prove interesting to engage the public and capture some of the valley's best examples of productive forest ecosystems. The lower reaches of the Goat River stand out as a remarkable area of interest in this regard.

In our analysis of **Conservation in relation to the Human Footprint**, the results highlight areas where ecological services (e.g. water quality) justify conservation measures as a tool for better land use management. The presence of community watersheds has an important influence on this output. The upper Arrow/Duck Creek watersheds are by far the largest areas highlighted by this analysis. Of note, the output map reveals an area of interesting potential located immediately to the east of the intersection of Highway 3 and 3A (Alice Siding).

When considering **Conservation in relation to Geotechnical and Wildfire Risks**, large, high-ranking areas are found in the more intact portions of the valley's floodplains. An area of particularly high value is found on the lands of the Lower Kootenay band. The fast-flowing waters of the Goat River also justify appropriate risk management of its lower reaches. The steep talus slopes of the Skimmerhorn area are also delineated. The analysis suggests that some of the steeper streambeds of the higher-elevation forested areas offer possibilities for conservation. It also takes into account priority areas for treatment against wildfire.

The Creston Valley Green Map project aims to provide mapping products for public outreach. The overall results of the *Natural Value* analysis are given in figure 54, where the top 3 (out of 7) classes are displayed as *hotspots* in shades of green. For the purpose of creating a single, all-encompassing map, a graphic overlay of the *natural* and *social* output results was also designed (figure 55). In this map, hashed red polygons indicate areas where social factors are important. This map is intended as a 'big picture' snapshot of the overall hotspots of potential for conservation in the Creston Valley, along with the social factors that may constrain conservation efforts.

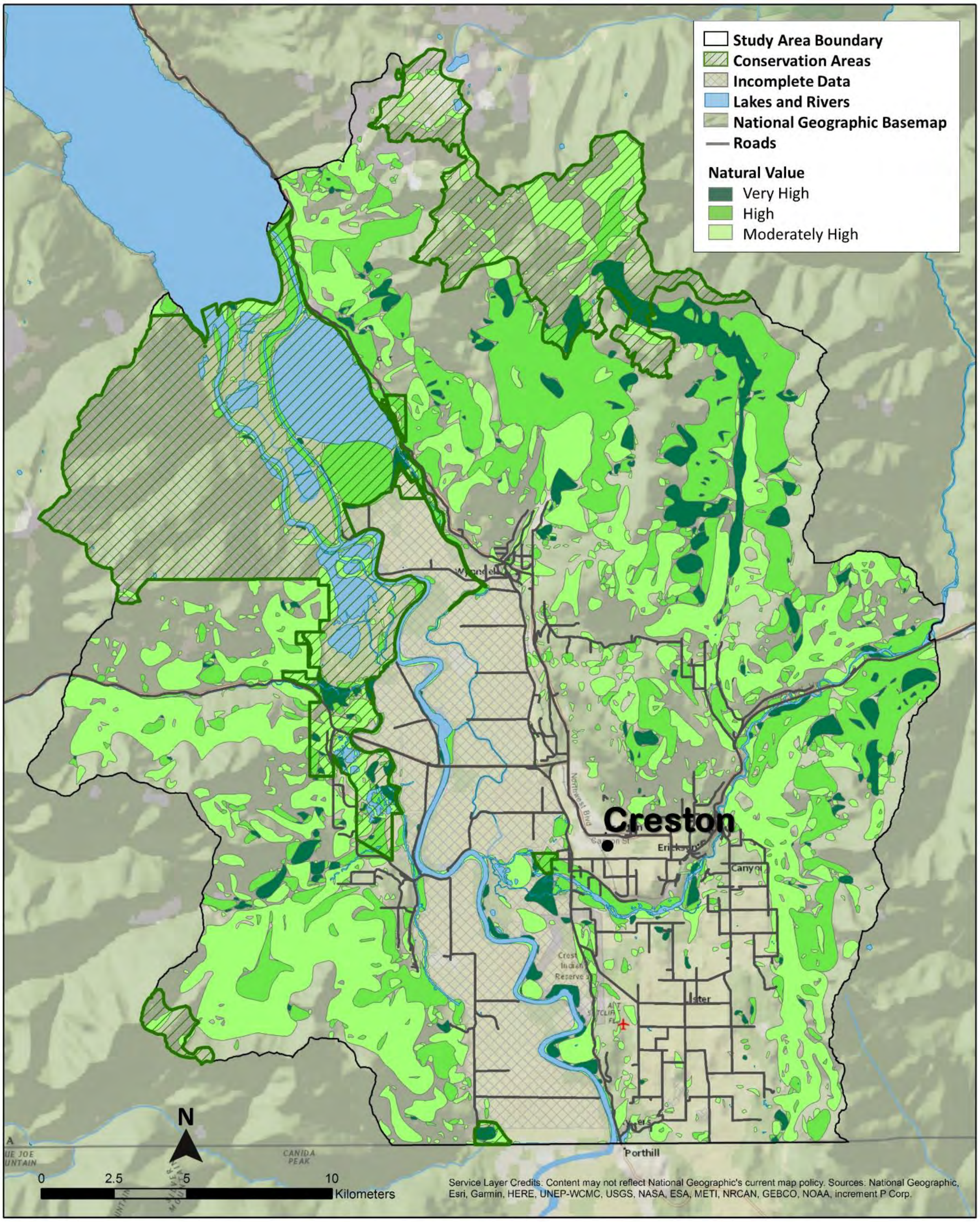


Figure 54: Hotspots of high natural value and potential for conservation in the Creston

Valley

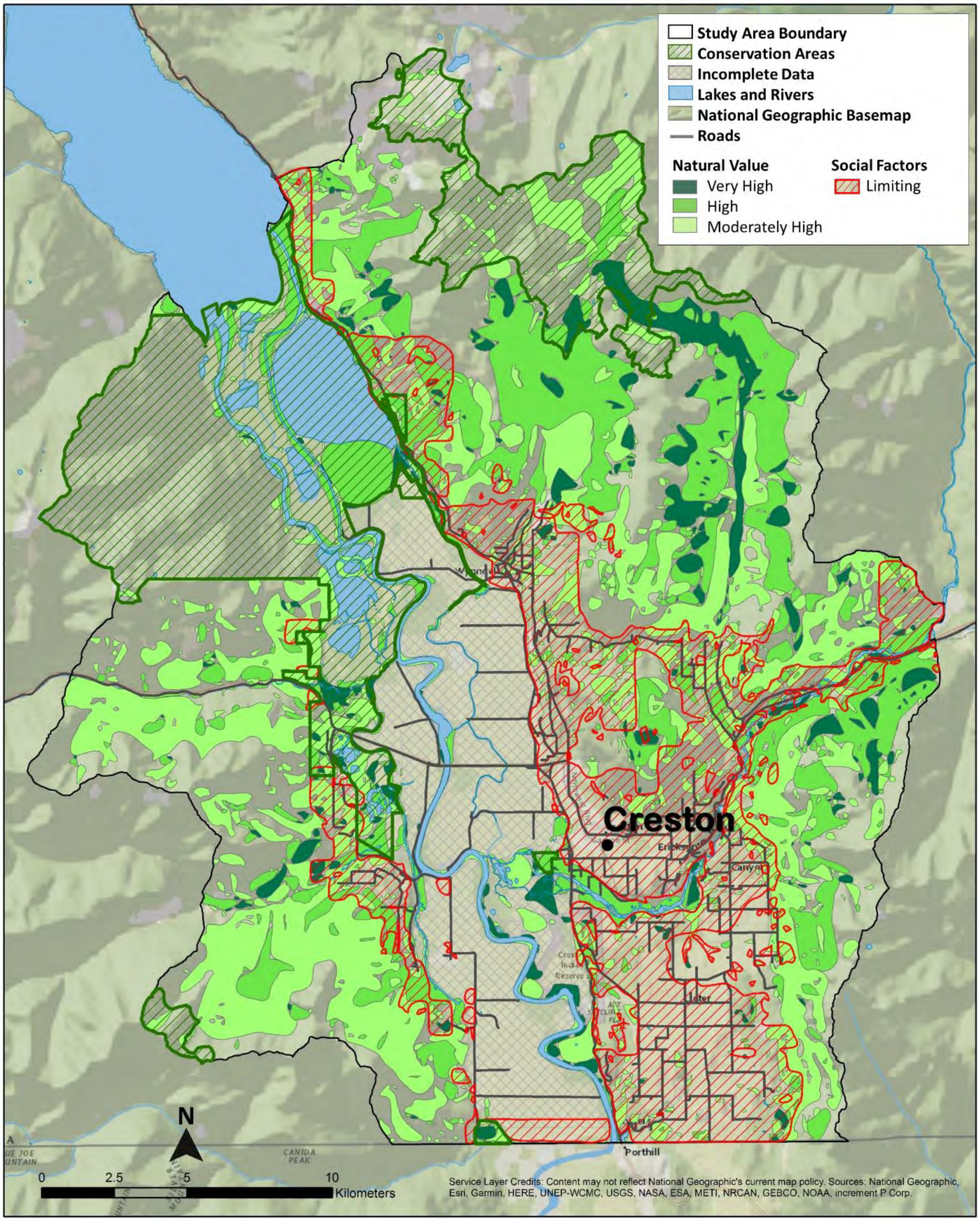


Figure 55: Hotspots of high natural value and areas of social limitations with regards to the potential for conservation in the Creston Valley

A general examination of the information shown in figures 54 and 55 reveals some of the following key points:

- The largest areas of high natural value in the study area are found in the upper reaches of the Arrow Creek and Duck Creek watershed;
- The northwest-facing slopes of Mount Thompson boast a high concentration of high-quality habitats;
- The northern flanks of the Corn Creek watershed have areas of high natural value;
- Riparian areas account for most of the valley bottom's high-ranking natural hotspots; these are concentrated along the lower reaches of the Goat River and Summit Creek as well as on the east bank of the Kootenay River, on Lower Kootenay band lands;
- Large areas of very high social constraints are centered on the urban centres of Creston and Wynndel;
- Areas of high social constraints affect the Lister Plateau, the upper sections of the Goat River, the area of West Creston and most of the lower, west-facing slopes between Creston and Kuskonook;
- Goat Mountain forms an isolated 'island' surrounded by areas of high human footprint.

Of note, there are significant data gaps that must be considered in the interpretation of the figure 53 map. For instance, we were unable to obtain the Vegetation Resources Inventory (VRI) dataset for the Darkwoods property. In addition, several datasets exclude the agricultural lands of the valley bottom. Accordingly, there is a general under-estimation of the value of the lands within these extents. And while the problem may be of lesser concern for the Darkwoods property (because it is already protected), it is of real concern for the valley-bottom ecosystems, where so much of the landscape has been converted in such a deep way, and where habitats of high richness would be expected to occur.

Among the points listed above, the Goat Mountain 'island' provides a good example of ecosystem fragmentation, which is becoming a problem of growing concern in the field of landscape ecology. The Creston Valley is located at the crossroads of significant, known wildlife and climate connectivity corridors. Being able to model finely-detailed linkages based on the project's analysis outputs is one of the most powerful possible applications of GIS as part of the Creston Valley Green Map project. By including expert knowledge and by modelling internal and cross-valley connectivity, the project helps to map the most promising linkages to reconnect important habitats within and around the study area.

Focussing on the top classes of the *connectivity potential*, we were able to delineate potential ecological corridors in the Creston Valley:

- A major corridor running south-to-north through the study area
- A major corridor crossing the northern half of the study area (Duck Lake – Upper Arrow)
- A double corridor crossing the southern half of the study area (Corn Creek - Skimmerhorn)
- A narrow corridor across the central part of the study area (Summit – Goat)

- South-to-north connectivity across the Goat River (Thompson – Upper Arrow)

As a final complement to the natural, social and connectivity models developed above, the project's steering committee was interested in harnessing the power of GIS to model the level of *visibility* of different parts of the Creston Valley landscape.

Using a combination of viewpoint sources, the aggregated visibility layer highlights the parts of the study area that most visible overall. The highest values are found in the small but steep watersheds that directly overlook the Creston Valley on its western flank. The steep cliffs of the Skimmerhorn area are another landmark feature of the valley. Finally, the ridges overlooking Wynndel and Duck Lake also constitute an important visible feature in the northern part of the study area.

The Creston Valley Green Map project is intended as a platform to spark and inform further conversations with local stakeholders, knowledge-holders and decision-makers. This report provides the background and results of a first iteration of the analysis. As mentioned above, the analysis suffers from some of the datasets being incomplete. Moreover, it is difficult to assess the overall quality of the input data, as very little ground validation has been attempted. The added information and perspectives obtained from ground-truthing and outreach efforts will help define future iterations of this map and help shape a clearer vision for proactive evidence-based conservation in the Creston Valley.

6. Preliminary Recommendations and Future Work

The following are early recommendations for future work following the completion of Phase 1 of the Creston valley Green Map project:

- Spot-check field validations to document and assess the quality of the analysis results.
- Consultations with biologist and ecologists to evaluate the need for process review or further analysis.
- Solicitation and integration of added local and traditional ecological knowledge.
- Presentations of results to stakeholder and decision-makers.
- Identification of promising sites for the implementation of field-based conservation efforts.

7. Team

The Creston Valley Green Map Project analysis was performed by Yann Troutet, coop student at the Selkirk Geospatial Research Centre (SGRC), under the guidance of the SGRC Coordinator and a steering committee comprised of a wildlife biologist, a forest ecologist, and a forester.

Wildsight (Creston Valley Branch) Steering Committee

Brian Churchill
Creston Valley Branch President

Brian grew up in Cranbrook and was thrilled in 2011 to return to the Kootenays and call Creston home. He has a MSc in Forestry Wildlife and had a career as a Wildlife Biologist for BC Government in Fort St. John followed by 15 years of consulting as an ungulate habitat specialist. Brian "enjoyed" a prominent role in NE Coal and later led northern Land use plans with the government especially the creation of the special Muskwa-Kechika Management Area including Dune Za Keyih, Northern Rocky Mountains, Redfern Keily, Kakwa and Graham Laurier Provincial Parks. Brian served as Coordinator for the M-K board, Director for Y2Y and expert witness for BC Nature in the Northern Gateway Pipeline hearings. Enjoying the outdoors since a first experience as a child at West Creston fostered his passion for the environment, birds, river travel, fishing and hunting. He has been involved in conservation biology and wildlife research projects including swans, mountain goats, caribou, moose, elk, deer and grizzly bear.

Brian's NEB résumé:
https://apps.neb-one.gc.ca/REGDOCS/File/Download/867049

Jim Smith
Regional Director Creston Valley Branch

Born and raised in rural west central Minnesota, Jim graduated from the University of Minnesota School of Forestry in 1969, married Sandy and headed west. Over the following 30 years, he worked various industry and government positions from Prince George and Burns Lake, to Creston and Vernon and back to Creston again. Throughout most of this experience, Jim was fortunate to work with people who "saw the forest through the trees." In the late 1990's he was drawn to the new vision of community forestry and finished his forestry career working with wonderful people in Creston, Harrop Proctor and the Slocan Valley. Jim says, "The whole 40 years has been risky, meaningful and fun. I wouldn't change it…."

Keeping All The Parts: The Story Of Jim Smith's Work in The Creston Community Forest:
https://wildsight.ca/blog/2018/01/12/keeping-all-the-parts-the-story-of-jim-smiths-work-in-the-creston-community-forest/

Gitte Grover
Creston Valley Branch Vice President

I was born in Marburg, Germany and immigrated to Canada after I obtained my Ph.D. in biology from the Justus-Liebig-Universitaet in Giessen. Previously, I worked for 21 years as a researcher with a forestry company (Alberta-Pacific) in Northern Alberta. I liaised with various universities and other research organizations to study the impact of forestry on biodiversity and ecosystem health, and we developed new paradigms such as ecosystem management modeled after natural disturbance. The research evolved into implementation of innovative forest management systems that included partial harvest with white spruce understory protection, structure retention, and single pass harvesting. I held the position of adjunct professor with the University of Alberta for over 10 years and was active in the academic community through guest lectures, graduate student supervision, field tours and many presentations at conferences and workshops. I was part of a group of forest managers that founded the Mixedwood Management Association to pool resources for research and development of boreal forest mixedwood systems, and I chaired this Association for many years. I am passionate about protecting the environment and Wildsight gives me the opportunity to contribute.

Selkirk Geospatial Research Centre

Ian Parfitt
SGRC Coordinator

Ian began his work with Selkirk College as a GIS Instructor in the IEP program in 2002. His background is in conservation geographic information science (GIS) including work for the Long Beach Model Forest on Vancouver Island and for the Fish and Wildlife Compensation Program in Nelson as GIS Coordinator. Ian brings an expertise in GIS analysis, data management and cartography as well as an extensive local and regional network of GIS and natural resource professionals to the SGRC team. As coordinator of the SGRC Ian has been crucial in the development of the centre's research infrastructure and capacity, as well as the curriculum for Selkirk College's Advanced Diploma in GIS.

Yann Troutet
SGRC Coop Student

Born in Saskatchewan and raised in Québec, Yann has a keen interest in landscapes and how we share them with living and non-living things. With a background in Environmental Science (U of Ottawa/Tasmania/Laval), Yann pursued graduate studies in Remote Sensing (U de Sherbrooke), mapping land cover in Auyuittuq National Park. From 2004 to 2016, he worked for Parks Canada as a Warden, Park Scientist, Ecologist and Acting Manager. Yann spends much of his spare time advocating for the creation of new protected areas, and promoting their use for self-propelled adventures. His dream for future work is to help create new protected areas and to help these places live up to their wide-ranging promises.

Appendix 1 - Data Sources

Biogeoclimatic Ecosystem Classification (BEC)

The Creston Valley Green Map Project used BEC Version 10, released in 2017. As of October 2018, this is not the current version of BEC. Both the current and previous datasets can be accessed via DataBC's online catalogue.

BEC version (version 10) used for the Green Map project:
https://catalogue.data.gov.bc.ca/dataset/old-versions-of-biogeoclimatic-maps
https://www.for.gov.bc.ca/ftp/HRE/external/!publish/becmaps/GISdata/PreviousVersions/

Current version (version 11), released in August 2018):
https://catalogue.data.gov.bc.ca/dataset/biogeoclimatic-ecosystem-classification-bec-map

Predictive Ecosystem Mapping (PEM)

Data download:
http://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/

PEM Project Report (2002):
http://a100.gov.bc.ca/appsdata/acat/documents/r1528/pem_4020_pro_1096482575216_3bdbb3d990af46a99c54d1748e646dc2.pdf

Project report (2013):
http://a100.gov.bc.ca/appsdata/acat/documents/r41058/pem_5677_pro_1389726494895_9717533180.pdf

Vegetation Resources Inventory (VRI) – 2017 version

Data download:
https://pub.data.gov.bc.ca/datasets/6ba30649-14cd-44ad-a11f-794feed39f40/

Data dictionary:
https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/stewardship/forest-analysis-inventory/data-management/standards/vegcomp_poly_rank1_data_dictionary_draft40.pdf

Forest Cover and Loss

https://earthenginepartners.appspot.com/science-2013-global-forest

Conservation Areas

Non-governmental organisations (NGO) conservation areas:
https://catalogue.data.gov.bc.ca/dataset/ngo-conservation-areas-fee-simple

Conservation lands:
https://catalogue.data.gov.bc.ca/dataset/conservation-lands

Approved Ungulate Winter Ranges:
https://catalogue.data.gov.bc.ca/dataset/ungulate-winter-range-approved

Land Capability Analysis

Digitized map:
http://sis.agr.gc.ca/cansis/publications/maps/cli/250k/cap/cli_250k_cap_west_kootenay.jpg

Available as a .kmz:
sis.agr.gc.ca/siscan/publications/maps/cli/250k/cap/index.kml

Digital Elevation Model

Canadian Digital Elevation Model portal:
https://open.canada.ca/data/en/dataset/7f245e4d-76c2-4caa-951a-45d1d2051333

Data download for sheet 82f:
http://ftp.geogratis.gc.ca/pub/nrcan_rncan/elevation/cdem_mnec/082/

Species and ecosystems at risk

B.C. Conservation Data Centre data request:
https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/request-cdc-data

Whitebark Pine Habitat suitability

Selkirk Geospatial Research Centre internal dataset:
M:\sgrc\Projects\WhiteBarkPine\

Old Growth Management Areas- Non legal

https://catalogue.data.gov.bc.ca/dataset/old-growth-management-areas-non-legal-all

Digital Road Atlas

https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads

Watersheds

BC Freshwater Atlas watersheds:
https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-watersheds
Community Watersheds:
https://catalogue.data.gov.bc.ca/dataset/community-watersheds-restricted-access

Water Licenses

https://catalogue.data.gov.bc.ca/dataset/licensed-springs
https://catalogue.data.gov.bc.ca/dataset/drinking-water-sources-surface-water-pods
https://catalogue.data.gov.bc.ca/dataset/bc-points-of-diversion-with-water-licence-information

Parcel Fabric

https://catalogue.data.gov.bc.ca/dataset/parcelmap-bc-parcel-fabric

Flooding and erosion

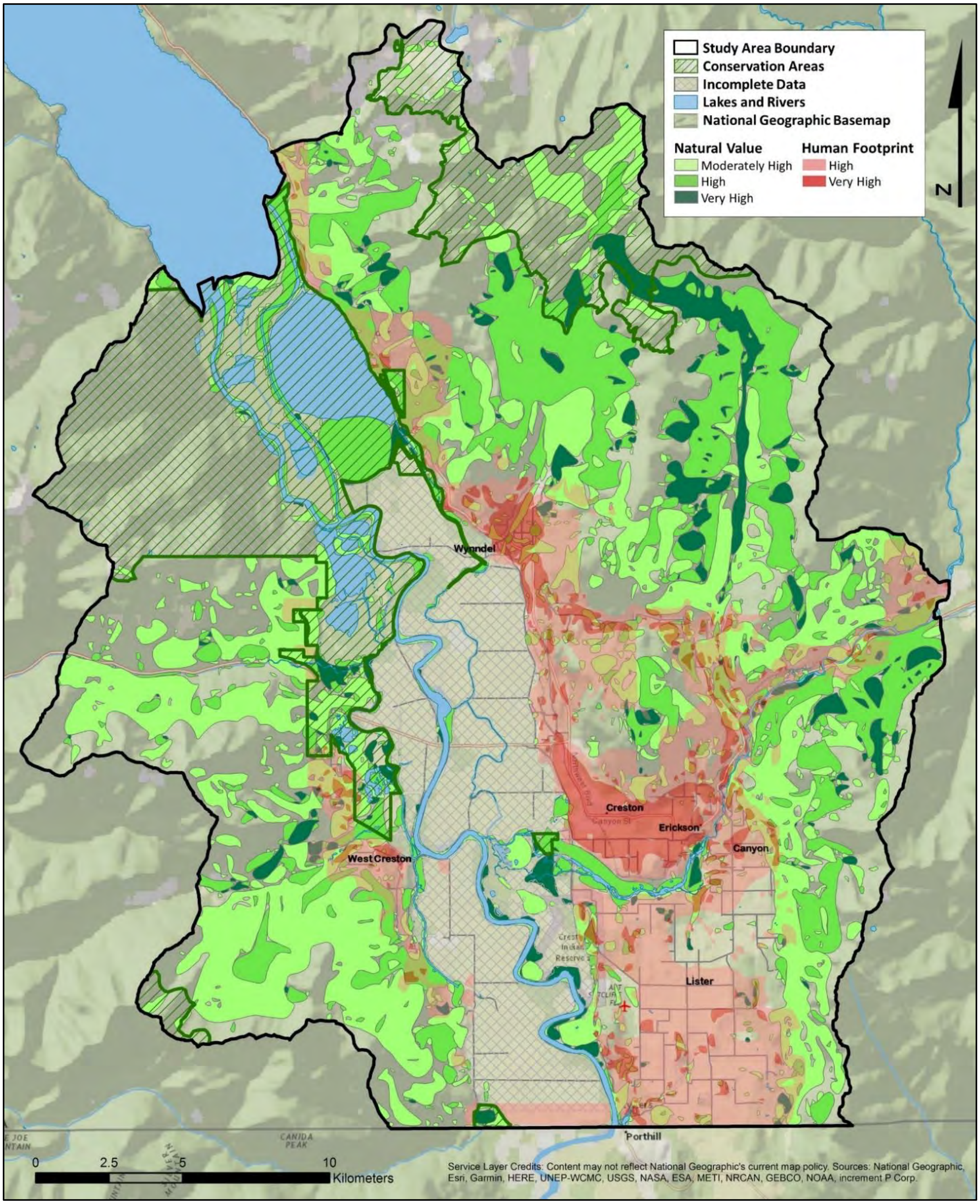
https://catalogue.data.gov.bc.ca/dataset/mapped-floodplains-in-bc-historical
https://maps.rdck.bc.ca/HTML5Viewer/ (NonStandard Flooding and Erosional Areas Layer)

Wildfire Fuel Treatment Priorities

Selkirk Geospatial Research Centre internal dataset
M:\sgrc\Projects\WUI

Appendix 2 – Alternate 'Green Map'

Below is an alternate display option for the 'Human Footprint' in the overall Green Map.



Appendix 3
Creston Valley Green Map Project
Iceberg of information

The diagrams below provide *infographic* renderings of the information contained in Table 3 of this report. The diagrams are copied from the Powerpoint presentation of the Green Map Project.

Themes and Data Layers
Risk Factors
• Wildfire fuel treatment priorities
• Erosion and flooding risks
• Terrain instability
• Surface material modifying processes
Human Footprint
• Roads density
• Building density
• Community watersheds
• Water licenses
• Private property ownership type
Wildlife Values
• Ungulate Winter Ranges
• Blue-listed animal species
• Red-listed animal species
• 'Cost of travel' to nearest water source
Conservation Gap Analysis
• BEC unit under-representation in provincial conservation areas
• BEC unit under-representation in local conservation areas
• Leading Tree species under-representation in local conservation areas
Habitat Rarity
• BEC unit site series province-wide rarity
• PEM site series local rarity
• VRI Tree species local rarity
Forest and Flora Attributes
• Forest cover
• Logging (1966 -2016)
• Forest stands of interest
• Whitebark pine habitat
• Blue- and Red-listed plants
• Blue- and Red-listed ecosystems
• Site Index
• Projected Forest Age
• Old-Growth Management Areas

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