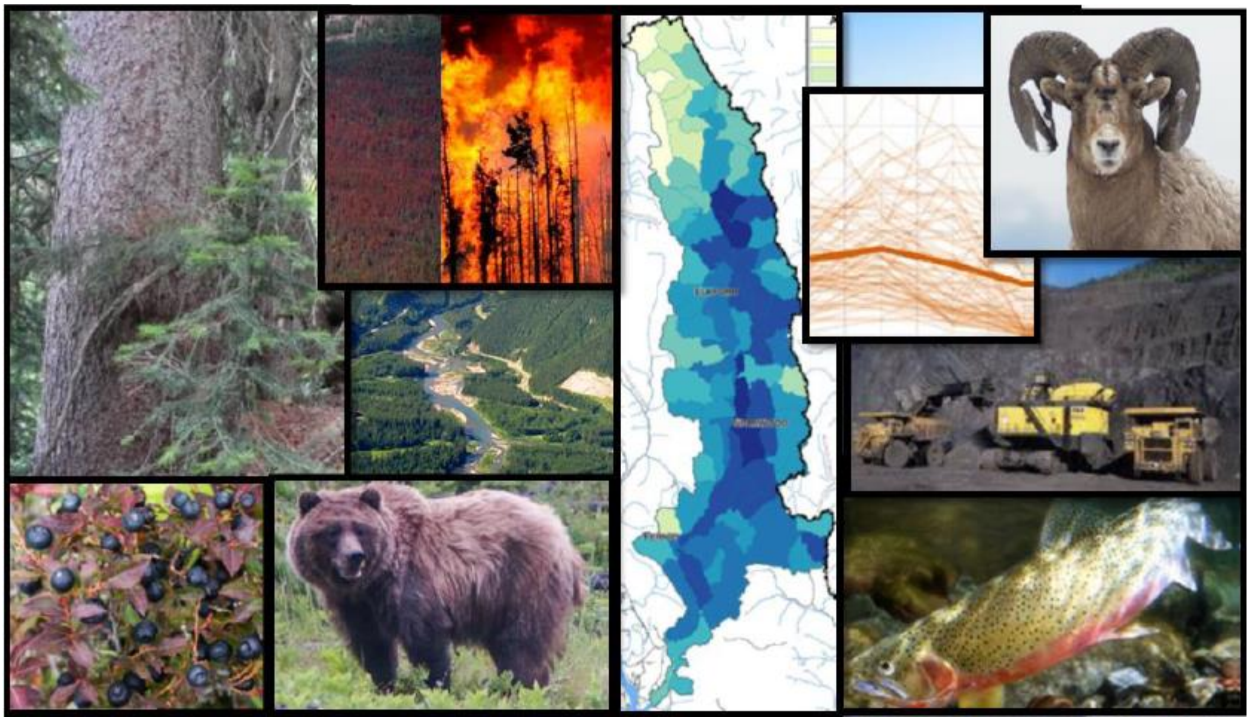
Elk Valley Cumulative Effects Assessment and Management Report



Elk Valley Cumulative Effects Management Framework (EV-CEMF) Working Group

DRAFT December 2018

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Wild at heart.

SPARWOOD

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Executive Summary

Human land use can provide economic and social benefits, but often results in potentially significant environmental, social, and cultural costs. To better understand and manage these benefits and costs, it is essential to assess the effects of land use against defined objectives or targets so that future generations can continue to enjoy cultural, economic, environmental, and social benefits. In practice, effects of land use are usually assessed on a project-by-project basis. However, this approach can underestimate the total impact of all land uses in a region, because many small uses, each affecting only a small fraction of the entire area of interest, can act cumulatively resulting in cumulative environmental impact. For this reason, it is preferable to assess environmental impact by measuring the cumulative effects of all land uses and natural disturbance--past, present, and future. The challenge of an effective cumulative effects assessment is to consider all events--large and small, past, present, and future--and to rigorously compile their effects at various spatial and temporal scales ranging from the individual cutblock, road, and mine site, right up to their combined effects at larger scales like the Elk Valley.

The Ktunaxa Nation Council and other groups in the region advocated for the establishment of a cumulative effects assessment and management process for the Elk Valley. As a result, a Working Group was established in 2012 by Teck Coal Ltd., the Ktunaxa Nation Council, the province of BC, the District of Sparwood (on behalf of municipal government), and the Elk River Alliance (a non-governmental organization), and later expanded to include representatives from additional government ministries, resource companies, and consultant groups. In January 2015, the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) assumed leadership of the group. With input from a broad group of stakeholders, the Working Group established the current Elk Valley Cumulative Effects Management Framework (CEMF) and selected five Valued Components (VCs) to serve as indicators of environmental condition and trends. These five VCs (Old and Mature Forests, Riparian Habitat, Westslope Cutthroat Trout, Grizzly Bear, and Bighorn Sheep) each carry significant social, economic, cultural, or environmental values. Riparian Habitat and Westslope Cutthroat Trout reports have been later integrated to form Aquatic Ecosystems VC. Although a good start, this initial list of VCs is not considered to be comprehensive or represent the full suite of values and range of drivers on the landscape.

The Government of British Columbia has committed to including cumulative effects as a key component of decision-making related to the development of natural resources. This report assesses both natural and human-made land-use changes within the Elk Valley of southeastern British Columbia, from both backward- and forward-looking perspectives. The goal of this report is to provide a framework that can support natural resources management decisions involving the assessment, mitigation, and management of cumulative effects in the Elk Valley.

Currently, 15% of the Elk Valley study area is impacted as a result of human activity including the development of roads, powerlines, cutblocks, mines, and industrial and urban areas.

Cumulatively, these land uses can contribute to an adverse effect on VC performance and have affected indicators used in this analysis. In this assessment, hazard is defined as the likelihood of a risk event for a valued component indicator and is categorized using quantitative benchmarks. In terms of the present-day condition, the key findings from this study are that:

- There is high hazard in terms of the amount of old growth forests in the Elk Valley, particularly in lower elevation portions of the study area
- The valley bottoms and eastern portions of the study area present high hazard for Westslope Cutthroat Trout and riparian areas, with the majority of the Elk Valley falling under moderate hazard
- There is high hazard in terms of highly valued winter range for Bighorn sheep, particularly on the eastern side of the study area
- Grizzly bear habitat suitability is diminished from road development, particularly in the lower elevation portions of the study area
- Road density is the dominant stressor affecting VC performance in the Elk Valley
- Forest harvest and mining are the most prevalent secondary stressors
- Mining has the largest negative effect on VC performance at small spatial scales

The total direct footprint of human activity is expected to increase under all future development scenarios, but does not differ substantially between them, ranging from a low of 27% of the Elk Valley in the Minimum Scenario to a high of 31% under the Maximum Scenario.

Total precipitation is likely to increase in the region over the next 50 years, but less of it is likely to fall as snow. This could affect the predictability of streamflow regimes, with more variation in flows from year to year. Furthermore, average annual air temperature could increase by 4 to 5 ˚C by 2065 under the scenarios used here, with cascading effects on aquatic resources, wildlife, and vegetation.

The combined effects of human land use and climate change are likely to result in further impact to VC performance in the Elk Valley, with the effects of climate change and subsequent changes in natural disturbance like wildfire and insect outbreaks posing the greatest challenge. The analysis also pointed out that Private Managed Forest Lands are likely to experience greater rates and amounts of environmental impact relative to other areas on the landscape. This is largely due to expected levels of timber harvest and road development, which ultimately increases hazard for most VCs used in this assessment.

Mitigation scenarios suggest that deactivating roads, implementing access management, minimizing timber harvest in riparian areas, allowing for recruitment from mature to old growth forest, and minimizing or avoiding development in core sheep winter range habitat are the most important measures for improving VC conditions.

This study provides a foundation from which to work; however, much is still required to ensure the Elk Valley CEMF is successful over the long-term. The CEMF approach should be maintained and adapted, ensuring that data collected for individual projects can be used in a coordinated way to develop policies and support decisions at landscape unit, sub-regional and regional scales.

Long-term strategic planning, with a time horizon beyond the current 50-year (in the future) study, should be conducted at a regional (i.e., Kootenay Boundary Region) level to consider how to best balance improved performance of Valued Components with continued opportunities for resource development.

This report reflects ongoing discourse among the diverse stakeholders regarding land use and management in the Elk Valley. In hindsight, though, it is clear to the Working Group that this cumulative effect assessment could have been improved by completing a range of natural variation scenarios, endorsing a greater range in land use trajectories relating to future development, and by completing a prospective scenario that reflects a full rotation age of forests (~200 years). Additionally, socio-economic indicators were not included in this assessment, and it needs to be recognized that they have a key role in understanding cumulative effects.

Acronyms

AAC	Allowable Annual Cut
ALCES	A Landscape Cumulative Effects Simulator
ABMP	Area Based Management Plan
AR	Annual Range
AW	Assessment Watersheds
BEC	Bio-Geoclimatic Ecosystem Classification
BEO	Biodiversity Emphasis Option
BGC	Biogeoclimatic
BHS	Bighorn Sheep
BRE	Baldy Ridge Extension
CCME	Canadian Council of Ministers of the Environment
CEA	Cumulative Effects Assessment
CEAM	Cumulative Effects Assessment and Management
CEF	Cumulative Effects Framework
CEMF	Cumulative Effects Management Framework
CFLB	Crown Forest Land Base
Ck	Creek
CPX	Cougar Pit Extension
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
ECA	Equivalent Clearcut Area
EF	Endangered Forests
ERA	Elk River Alliance
ESSFdk1	Engelmann Spruce – Subalpine Fir Dry Cool Variant 1
ESSFdk2	Engelmann Spruce – Subalpine Fir Dry Cool Variant 2
ESSFdkp	Engelmann Spruce – Subalpine Fir Dry Cool Parkland
ESSFdkw	Engelmann Spruce – Subalpine Fir Dry Cool Woodland
ESSFwm1	Engelmann Spruce – Subalpine Fir Wet Mild Variant 1
ESSFwmp	Engelmann Spruce – Subalpine Fir Wet Mild Parkland
ESSFwmw	Engelmann Spruce – Subalpine Fir Wet Mild Woodland
EV	Elk Valley
FLNRORD	Forest, Lands, Natural Resources Operations and Rural Development
FRPA	Forest and Range Practices Act
FRO	Fording River Operations
FSC	Forest Stewardship Council
FSI	Fish Sustainability Index
FWA	Freshwater Atlas
GB	Grizzly Bear

GIS	Geographic Information Systems
GOS	General Open Season
H60	elevation of the snowline when the upper 60% of a watershed is covered in snow
HCVF	High Conservation Value Forests
ICHmk4	Interior Cedar Hemlock Moist Cool
IDFdm2	Interior Douglas Fir Dry Mild
IMAun	Interior Mountain-heather Alpine - Undifferentiated
KBLUP-HLPO	Kootenay-Boundary Land Use Plan Higher Level Plan Order
KNC	Ktunaxa Nation Council
LCO	Line Creek Operations
LWD	Large Woody Debris
LU	Landscape Unit
MOTI	Ministry of Transportation and Infrastructure
MSdk	Montane Spruce Dry Cool
MSdw	Montane Spruce Dry Warm
NCC	Non-Commercial Cover
O+M	Old and Mature Forests
OCP	Official Community Plans
OGMA	Old Growth Management Area
PEM	Predictive Ecosystem Mapping
PMU	Population Management Unit
PNOGO	Provincial Non-Spatial Old Growth Order
RB	Rainbow Trout
RCP	Representative Concentration Pathway
RDEK	Regional District of East Kootenay
RoNV	Range of Natural Variation
SARA	Species at Risk Act
SDM	Structured Decision Making
Se	Selenium
SWP	Standard Work Procedure
THLB	Timber Harvest Land Base
UFC	Uplands Function Checklist
UofA	University of Alberta
VC	Valued Component
WCT	Westslope Cutthroat Trout
WG	Working Group
WMU	Wildlife Management Unit
WR	Winter Range
WSG	Workshop Group

Disclaimer

The information contained in this report is presented in good faith. It is by nature a synoptic overview of the key physical, biotic, and anthropogenic dynamics of the Elk Valley region.

The organizations and agencies preparing the data that were entered into Elk Valley ALCES Online simulator are not liable for any implications arising out of the usage of data for any particular purpose.

While caution and effort are practiced for data completeness, those responsible for preparing this report do not accept any responsibility for findings in the document, which are a cumulative effort of primary and secondary research resources. User discretion is recommended for the usage of the data.

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1. Introduction

1.1 Background

Human land use offers economic benefit, providing jobs and revenue, and supports our way of life. However, the benefits of human land use do not come without environmental, social, and cultural cost. Cumulatively, the effects of human land use, natural disturbance, and climate change present a challenge for society. Adapting to and mitigating these effects so that future generations, the environment, and the economy are sustained, forms the basis for cumulative effects management.

Cumulative effects are defined by the BC Government as "changes to environmental, social and economic values caused by the combined effect of past, present and potential future human activities and natural processes" (BC Government, 2016). For some types of human land use actions and disturbances, the effects can be immediate and significant. For others, the effects of each individual action or event may seem negligible, but over time many small events can quickly add up to substantial environmental impacts. It is now recognized that the approval of individual development projects can result in unintended effects that may accumulate on the landscape unless past and future development is also considered (Dube et al., 2013). For example, the construction and planning of forestry and mineral extraction roads is usually done independently of other companies and industrial sectors, and without regard to the total cumulative road density (Schneider et al., 2003). Similarly, when forestry tenures are initially designated the concurrent loss of timber from mineral extraction and other industrial activities are typically not considered, thereby potentially threatening the economic viability of certain forest companies and the ecological integrity of forest health (Schneider et al., 2003).

To fully understand human impact on the environment, one must take a holistic "systems" approach to impact assessment, and consider all anthropogenic effects over appropriate scales of space and time. Cumulative effect assessments (CEAs) are therefore essential, as they are broader in both spatial and temporal scope than conventional project-based impact assessments, and they are focused on total impacts to Valued Components (VC) rather than on an individual project or action (Duinker and Greig, 2005).

One of the biggest challenges concerning cumulative effects, however, is how to properly assess and measure them. Presently in Canada, CEA is typically mandated within environmental assessments at the project level. However, as many experts have noted, CEAs are both conceptually and operationally not well suited for project-based environmental assessments (Gunn and Noble, 2010; Duinker and Greig, 2005). Among many obvious reasons, CEAs are concerned first and foremost with VCs, whereas project-based reviews are usually focused on the project's cumulative contribution to VC stress and not on the total effects of all land uses on the VCs of concern. As Gunn and Noble (2010) have pointed out, "this approach to CEA is fundamentally flawed in that cumulative effects are not about stressors per se, but about the total effects on the receiving environment".

The enduring challenges of project-focused reviews have led some to suggest that CEA is better applied at the regional planning scale through more strategic environmental assessments. Strategic environmental assessments aim to incorporate environmental needs into higher-level decision-making processes, resulting in an earlier onset, holistic picture of cumulative effects (Gunn and Noble, 2010). Conceptually, CEA fits well within strategic environmental planning, although this integration has seldom been implemented successfully – due in large part to the lack of a trickle-down influence on project-based environmental decisions (Gunn and Noble, 2010). Although many challenges exist, addressing cumulative effects from regional or sub-regional lenses at the planning and policy stage by governments remains the most promising mechanism for the practice of CEA (Duinker and Greig, 2005).

1.2 British Columbia's Cumulative Effects Framework

The Government of British Columbia has committed to including cumulative effects as a pivotal component to natural resource decision-making (BC Government, 2016). The Province's Cumulative Effects Framework (CEF) Interim Policy was approved in November 2016 and a guidance on implementation of the CEF Interim Policy was provided to Statutory Decision Makers in February 2017. This framework includes policies and procedures to guide the assessment of cumulative effects, by conveying standards and direction, and providing guidance to manage cumulative effects. The policy is intended for government staff responsible for completing and approving CEF assessments, and for natural resource decision makers.

Opportunities for collaboration and partnership with First Nations are to be explored throughout the CEF assessment process. Specifically, engagement opportunities for both First Nations and other stakeholders shall be provided when defining standard assessment protocols, and when initiating and reviewing regional CEAM reports. The results of the CEAM report should inform future development proposals or strategic government decisions within the Province of British Columbia. It is recommended that future environmental assessments for major projects align with CEF values, indicators, and assessment protocols, to enable comparison and integration of results.

1.3 Creation of the Elk Valley CEMF

The Elk Valley has played a historic role in establishing the railway and coal mining industry in British Columbia (Kinnear, 2012). The production of coal and the arrival of a railway network paved the way for rural communities such as Fernie to flourish. For over a hundred years, the coal mining industry has expanded, despite a decline and stagnation in the 1960s. With a renewed global demand for coal, Japanese steel industries have revitalized the coal mining industry within the region (Bowden, 2012). Today, under Teck Coal Ltd., the Elk Valley continues to produce millions of tonnes of coal for national and international markets on a large-scale at open pit operations (Hume, 2014).

While coal production is the largest industry in the Elk Valley from an economic perspective, the forestry industry has been around for just as long and has a larger anthropogenic footprint on the landscape. The 2017 Allowable Annual Cut (AAC) in the Cranbrook Timber Supply Area, of which the Elk Valley is a part, is ~900,000 cubic meters per year (Penfold and Meyer, 2015). This, combined with harvesting from private lands, makes forestry an important economic and land use driver in the Elk Valley.

In recent decades, tourism has played an increasing role in the Elk Valley. The mountainous landscape that surrounds the region provides an ideal location for the development of winter and summer tourism in western Canada. In 1961, for example, one year before the opening of the ski hill, Fernie made a bid for the 1968 Winter Olympics. Eventually, this laid the foundation for Fernie becoming a site for a world-class ski resort (Hudson, 2004). Today, domestic and international tourism markets continue to play a significant role in fueling economic development for the region.

In addition to strong economic drivers such as mining, forestry and tourism, the Elk Valley supports diverse and rich ecosystems. Although many biota have stable populations with broad distributions, several have experienced significant declines. Some species are considered particularly sensitive to human activities or natural events in the Elk Valley, including Species of Special Concern, such as the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), Grizzly Bear (*Ursus arctos*), and Rocky Mountain Bighorn Sheep (*Ovis canadensis*). Sensitive Old and Mature Forest ecosystems in the Elk Valley also present sustainability challenges to resource managers. The aesthetic beauty of the region and its historic abundance of high-profile wildlife have positioned the Elk Valley as a marquee destination for tourists, anglers, and recreationalists. Collectively, the expanding and intensifying presence from tourism and mining, residential, and forestry development threatens to cumulatively impact VCs.

The management of cumulative effects in the Elk Valley is of increasing concern due to historical, current and proposed stresses that coal mining, forestry operations, residential development, transportation infrastructure, and recreation and tourism will place on the region. Stakeholders, proponents, and government have become increasingly aware of the need for effectively assessing and managing cumulative effects in the Elk Valley. Numerous stakeholder meetings have emphasized that it is imperative to properly assess the cumulative effects of all past, present, and potential future conditions in the Elk Valley, and to effectively mitigate or manage negative environmental outcomes.

In recognition of such broader landscape/land use issues and pressures in the Elk Valley, and in response to the Line Creek Phase ll Project, Teck Coal Ltd. and the Ktunaxa Nation Council (KNC) held a multi-stakeholder workshop in July 2012 to address mounting concerns about cumulative effects in the Elk Valley. The Elk Valley Cumulative Effects Management Framework (CEMF) was subsequently launched, and the Elk Valley CEMF Workshop Group (WSG) was formed from workshop attendees. Teck Coal Ltd. and the KNC led this initiative until January 2015, when leadership was transitioned to the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD).

The WSG helps to legitimize the Elk Valley CEMF as it brings diverse perspectives to the table and aims to achieve consensus-based decisions. Twenty-eight different organizations attended the first workshop, representing members from industry, local municipalities, government, First Nations, environmental NGOs, and private residents.

A smaller Working Group (WG) was formed at the first workshop to ensure that the framework continues to be developed and implemented in an effective and efficient manner. The WG initially consisted of individuals representing Teck Coal Ltd., FLNRORD, the KNC, the District of Sparwood, and the Elk River Alliance (a non-governmental organization). It now includes members from North Coal Ltd, Canadian Forest Products Ltd. (Canfor), NWP Coal Ltd., CanWel Fibre Corp., the Districts of Sparwood and Elkford, Wildsight, the Ministry of Environment and Climate Change, and the Ministry of Transportation and Infrastructure.

The Elk Valley CEMF has been consistent with the provincial CEF process. The goal is to provide an implementable framework that supports decision-making related to assessment, mitigation, and management of cumulative effects in the Elk Valley. The Elk Valley CEMF will serve to inform a larger Cumulative Effects Assessment and Management Framework for the Kootenay-Boundary Region consistent with the provincial CEF.

2. Elk Valley CEMF and Components

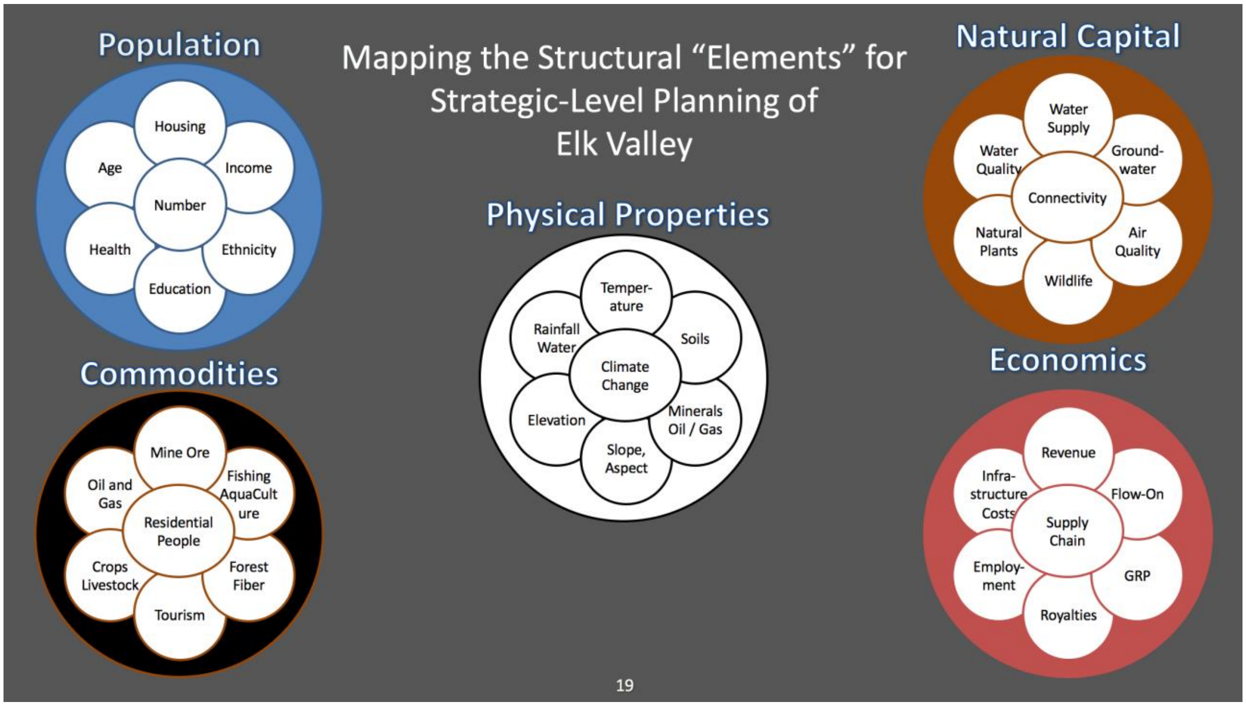
The Elk Valley CEMF was approved by the Workshop Group at the June 2013 workshop. CEMF recognizes that the Elk Valley represents a "system", comprised of a set of interacting elements that relate to key social, economic, and ecological dynamics. These components must be addressed as a "holistic" system, whose elements are identified in Figure 1.

2.1 Framework

The Elk Valley CEMF consists of four stages:

1) **Context**: establishing spatial and temporal boundaries and selecting representative VCs as the focus for the CEA.
2) **Retrospective Assessment**: assessing the historic and current condition of VCs using indicators of population status as applicable or quality and amount of required habitat. Benchmarks that reflect the hazard/risk to each indicator are set and VC conditions are assessed in relation to these.
3) **Prospective Assessment**: simulating future conditions. Alternative scenarios are created to assess how different rates of development may affect the VCs and their indicators into the future. Climate scenarios and mitigation options are identified and integrated with the future development scenarios to shape future conditions.
4) **Management Action and Follow-Up**: develop management recommendations, implementation plans, and monitoring, based on the results of the CEA.

The Elk Valley can be viewed as a system comprised of numerous elements, including its physical properties, its natural capital, the human population, the renewable and non-renewable commodities that are extracted, and the economic properties. Each of these elements can be stratified into sub-elements, which interact within the element sector and between all sectors (Figure 1). A challenge for the Elk Valley stakeholders is recognizing and managing the Elk Valley as a functioning system and that changes to any of its components is likely to have effects on other elements of the system.


Mapping the Structural "Elements" for
Strategic-Level Planning of
Elk Valley

Population
Housing
Age
Income
Number
Health
Ethnicity
Education

Physical Properties
Temper-ature
Rainfall Water
Soils
Climate Change
Elevation
Minerals Oil / Gas
Slope, Aspect

Natural Capital
Water Supply
Water Quality
Ground-water
Connectivity
Natural Plants
Air Quality
Wildlife

Commodities
Mine Ore
Oil and Gas
Fishing AquaCulture
Residential People
Crops Livestock
Forest Fiber
Tourism

Economics
Revenue
Infra-structure Costs
Flow-On
Supply Chain
Employ-ment
GRP
Royalties

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Figure 1. Elements of the Elk Valley, which are stratified into sub-elements that interact within, and between, all sectors. A challenge for the Elk Valley stakeholders is recognizing and managing the Elk Valley as a functioning system and that changes to any of its components is likely to have effects on other elements of the system.

2.1.1 Context

The spatial boundary of the Elk Valley CEMF falls within what is known to the Ktunaxa as qukin ʔamakʔis, or Raven's Land and Ȼaṁna ʔamakʔis, or land of woodtick, extending from the headwaters of the Elk River downstream to Elko, covering an area of approximately 3,568 km^2 (Figure 2). This region is diverse, with an array of different ecosystems. Ktunaxa knowledge holders recognize the importance of plants and vegetation for human use, and as habitat for other living things with qukin ʔamakʔis (Teck Coal, 2015). The ecological, cultural, and societal values associated with the diverse ecosystems in the Elk Valley form the foundation for assessing cumulative effects within this landscape.

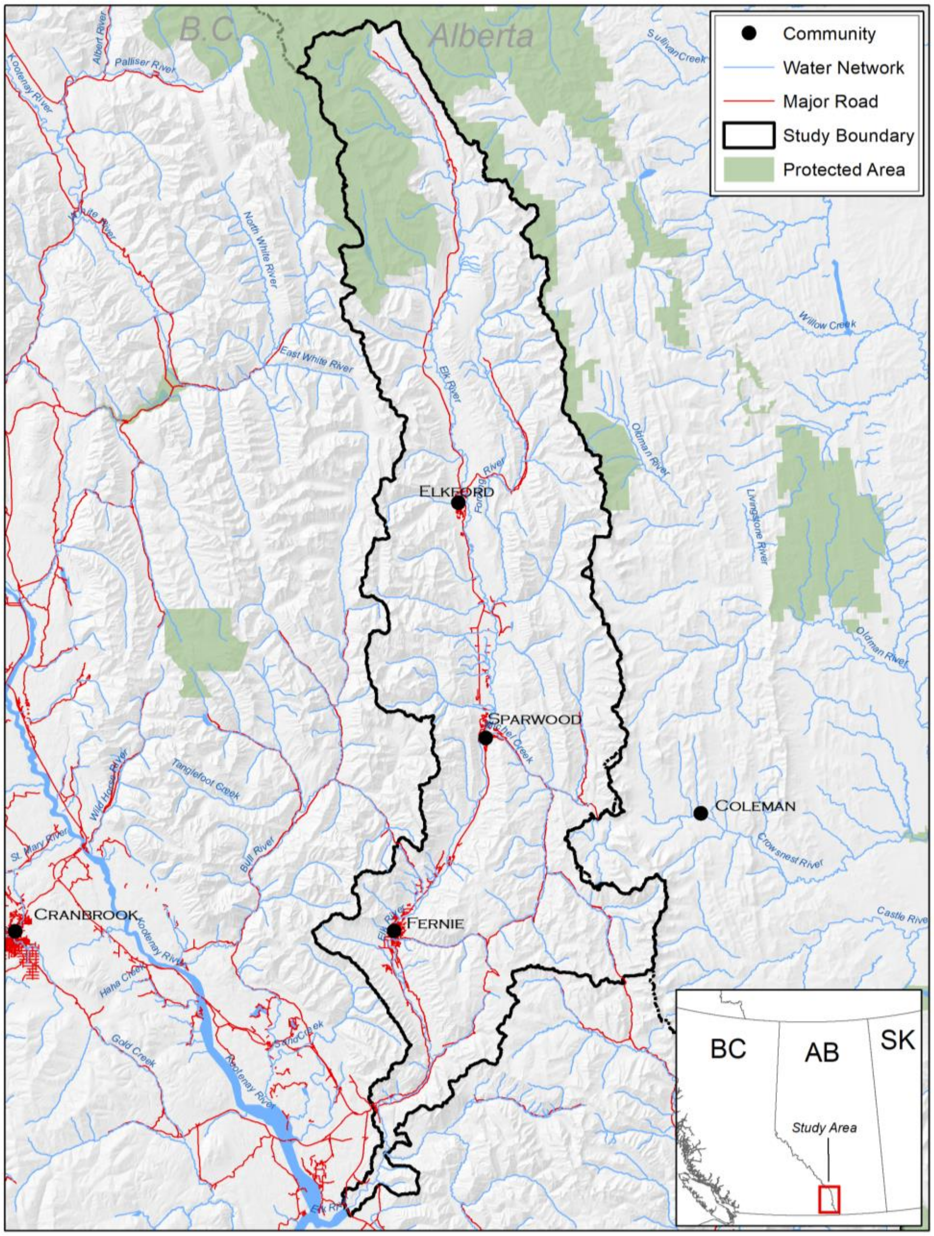

Figure 2. Spatial boundary of the Elk Valley CEMF.

Approximately 13,000 – 11,000 years ago the Elk Valley was fully glaciated (Ferguson and Osborn, 1981; Clague, 1982). A large valley glacier extended from its headwaters near Mount Joffre to below Elko (Osborn and Luckman, 1988). At the end of the Last Glacial Maximum (about 10,000 years ago), the Elk Valley glacier thinned and retreated. As of September 2014, measurements using Landsat imagery (U.S. Geological Survey, 2015) indicate that the Elk Valley glacier has retreated 142 km, and has fragmented, with the Pétain, Castleneau, Elk, and Abruzzi glaciers covering only a combined 7.7 km^2 of watershed. This legacy of glaciation has formed the Elk Valley, creating valleys and lakes, and depositing sediments (Fulton, 1995). This creation of landforms, coupled with disturbance, ultimately dictate how air, water, vegetation, soils, and rock interact to form the diverse ecosystems present in the Elk Valley (Figure 3).

Figure 3. Example of the diversity in elevation and landform, responsible for diversity of ecosystems in the Elk Valley.

Terrestrial ecosystems can be described based on the structure of the ecosystem components and the ecosystem values they provide. British Columbia's Biogeoclimatic Ecosystem Classification (BEC) system is a hierarchical classification system that groups ecologically similar areas and is informative in terms of physically describing ecosystems. The system describes variability at broad regional scales based on climate, forming bio-geoclimatic zones. The Elk Valley is within the Rocky Mountain Region and is generally classified as a Dry Climate sub-region (MacKillop & Ehman, 2016).

Bio-geoclimatic zones are named after one or more dominant species of mature vegetation, often followed by a geographic/climatic modifier. Subzones are then named after the relative precipitation and temperature characteristic of the subzone. Within the Elk Valley, 13 different subzone variants exist (Figure 4), primarily belonging to the Engelmann Spruce – Subalpine Fir (ESSF) or the Montane Spruce (MS) zones with smaller areas of Interior Cedar Hemlock (ICH), Ponderosa Pine (PP), Interior Douglas Fir (IDF) and Interior Mountain Alpine (IMA). These zones represent a wide range of important ecosystems that each contribute to the terrestrial and aquatic biodiversity of the Elk Valley.

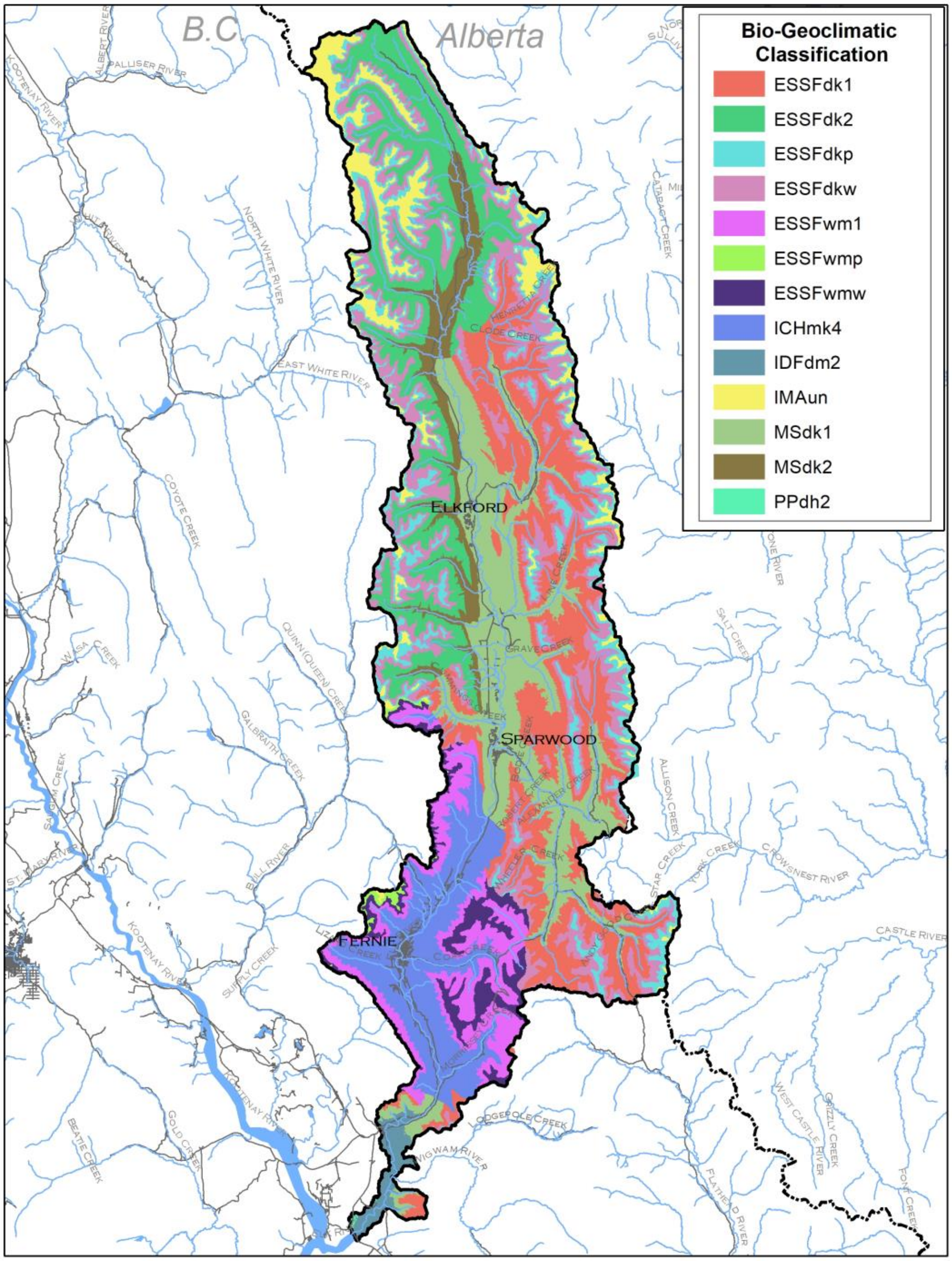

Figure 4. Bio-geoclimatic zone distribution within the Elk Valley.

Over century-scale time periods, streamflow regimes, topography, and land cover determine how sediments and other materials like in-stream wood move throughout streams in the Elk Valley. The Elk River follows an elevation gradient from the headwaters in Elk Lakes Provincial Park through to the mouth at the Kootenay River. This gradient ultimately dictates the structure and function of the aquatic ecosystem (Vannote et al., 1980). Stream channels are continually responding to streamflow and sediment conditions by adjusting their width, depth, speed, slope, roughness, and sediment size (Leopold and Maddock, 1953). This provides a mosaic of habitat types that provide the basis for aquatic ecosystems.

Figure 5. Elk River, demonstrating diverse habitat for aquatic ecosystems (Credit: Elk River Guiding Co.).

Figure 6. Step-pool channel in Alexander Creek (credit: J. Smithson).

The morphology of the Elk River and its tributaries provide diverse habitats for aquatic ecosystems. The Elk River and larger tributaries are characterized by riffle-pool stream channels (Figure 5), where a repeating sequence of riffles (fast flowing and moderately shallow) and pools (slow moving and deep) create a stable and highly functional stream. Through interaction with riparian areas, these types of streams also have a healthy supply of in-stream wood, forming bars and pools while providing food and cover for terrestrial and aquatic organisms.

Upper-elevation tributaries typically transition from step-pool to cascade-pool channel types (Figure 6). In these streams, large boulder substrates and wood create pools and channels remain steep enough that smaller sediments are transported downstream. These types of streams can be ephemeral (flowing only seasonally) or flow year-round with stable groundwater inputs. Although smaller, these tributaries are critical to the maintenance of overall aquatic ecosystem health, providing nutrients and sediment that help sustain larger systems.

The natural setting of the Elk Valley has been shaped over the past several decades by a diverse suite of land uses, occurring within different planning zones (e.g. leases, tenures) in the Elk Valley. These include the land uses of the forestry, mining, residential, livestock grazing, croplands, recreation, and protected area sectors. Collectively, the land uses that occur within these planning zones drive the local and regional economies (Figure 7).

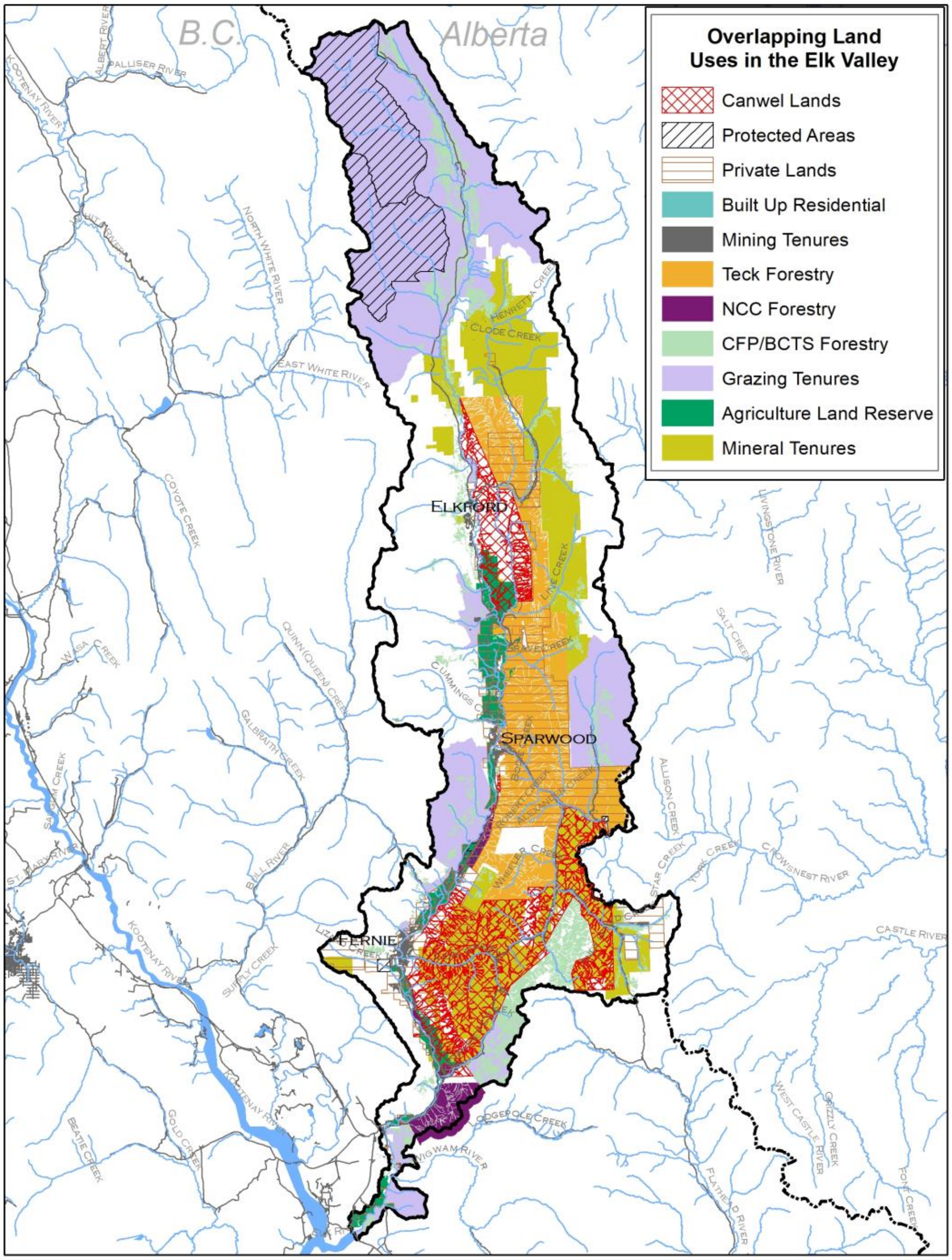

Figure 7. An overlay of the land use zones pertaining to commercial forestry, mining, livestock grazing, crop production, residential, and protected areas, illustrates the overlapping nature of this busy landscape.

As the land use sectors in the Elk Valley continue to grow and expand, there is an increasing probability of conflict for space and resources, and an increasing probability that these combined land uses can degrade key ecosystem properties. Whereas croplands, residential areas, protected areas, and grazing lands are generally persistent in the same geographies, the forest and mining sectors reflect anthropogenic footprints that are intended to be non-permanent and undergo resource extraction and reclamation trajectories. Whereas cutblocks are placed on a post-harvest silvicultural trajectory shortly after a logging event, coal mining footprints can last multiple decades, before being reclaimed, and the end result may be very different from the pre-development ecosystem (particularly in the case of forested ecosystems).

Five VCs were included in the CEMF to evaluate the cumulative effects of human activities and natural disturbance, including climate change, in the Elk Valley. The VCs are Old and Mature Forests, Aquatic Ecosystems (Westslope Cutthroat Trout and Riparian Habitat), Grizzly Bear, and Bighorn Sheep. These are some of the components of the Elk Valley ecosystem, as determined by the Working Group, that convey key social, economic, cultural, or environmental values; however, it is acknowledged that these five VCs are not comprehensive (i.e. representative of the full suite of values potentially impacted by the range of stressors operating in the valley).

Old Growth is provincial core value in the provincial CEF, and this VC is important for biodiversity and the health and condition of other VCs. Old forests harbour very high biodiversity, support vital ecological processes and functions, and provide critical habitats and structural attributes (large veteran trees, snags, large hollow logs, multi-layered canopies, fungi and lichens, etc.) for a wide range of old forest dependent plant and animal species. They are highly-valued within the Ktunaxa culture. They buffer riparian areas and waterbodies and provide economic value for the timber sector and the recreation and tourism industries. Old forests are susceptible to the cumulative anthropogenic impacts caused by harvest, urban development, industrial expansion, and anthropogenic effects of climate change such as wildfire intensity and frequency. Evaluation of mature forests was encompassed in this VC to gain insight into old forest recruitment potential and because they provide some of the same ecological benefits.

Westslope Cutthroat Trout was chosen as a component of the Aquatic Ecosystems VC because of its importance to the Ktunaxa Nation, economic and social importance to residents, as well as visitors of the Elk Valley. The Elk River and its tributaries support Ktunaxa harvest, as well as a world class and economically important recreational fishery. Westslope cutthroat trout are a good indicator of aquatic and watershed health due to its life history characteristics that make it susceptible to development activities. While the largest threat is hybridization with introduced rainbow trout, the species is also susceptible to changes in riparian and instream cover, flow, water quality, and angler access (Muhlfeld et al., 2009, Rubidge, 2003, Allendorf and Leary 1988). Westslope Cutthroat Trout are also thought to be sensitive to selenium, other contaminants, and increasing water temperatures caused by climate change (COSEWIC, 2006), and as such, provide a useful VC to evaluate the effects of climate change on the Elk Valley.

Riparian Habitat, which was chosen as the other component of the Aquatic Ecosystems VC, provides streams with a number of ecological services including moderation of stream temperatures, filtering precipitation runoff, providing organic detritus and inorganic nutrients to support aquatic biological communities, stabilizing streambanks and moderating sediment transport from riparian sources, and providing a source of large woody debris (LWD), particularly important to lower gradient channels for aquatic habitat structural complexity, stability, and water velocity reduction (Gregory 1991, Naiman and Decamps 1997, Naiman et al., 2000, Tschaplinski and Pike, 2010). It is assumed that natural ecological functions of the habitat will be maintained if changes attributable to forest management practices or natural disturbances lie within some defined range of suitability over most of the habitat.

Grizzly Bears are included as a VC due to their high ecological (apex predator), cultural, and harvest value. The cumulative effect of human development is the largest threat to Grizzly Bears in British Columbia (Conservation Data Center, 2012). Cumulative effects include destruction of habitat, loss of connectivity among populations, alteration and alienation of habitats, and increased human access into previously secure areas.

Bighorn Sheep (BHS) are included as a VC due to their high cultural and harvest value as well as their association with a unique habitat (alpine grasslands). The Elk Valley has high value BHS winter range habitat and encompasses the home range of an important population which has no history of wide-spread disease outbreaks that occur in other populations in the region.

2.1.2 Retrospective Assessment

The retrospective assessment evaluated current conditions for all selected VCs, and historical conditions for some of the VCs. Retrospective assessment of VCs allows for an understanding of change through time and attribution of the primary causes of change. Without knowing something about past conditions, it is difficult to understand cumulative loss and the significance of any potential future stress placed on VCs. Comprehensive CEA thus requires some understanding about how VC conditions have changed over time, the range of natural variation (RoNV), and the factors a VC is responsive to in order to project future VC conditions. The retrospective assessment in the Elk Valley CEMF incorporates datasets from 1950 (where possible), 2015 and 2016 in some cases to establish historical and current VC conditions.

Results are reported using hazard maps that reflect the likelihood of a risk event occurring to a valued component. Benchmarks were developed for each indicator that reflects the level of hazard to the valued component.

2.1.3 Prospective Assessment

The prospective assessment was completed to assess how VCs may respond to the cumulative effects of potential future land use and changes in climate (Noble 2014). The intent of the prospective assessment was not one of prediction per se, which is unattainable due to uncertainty and contingency (Peterson et al. 2003). Instead, a scenario analysis was completed to compare the consequences of differing rates, patterns, and types of development and natural disturbance. The analysis provides a mechanism to contrast the benefits and liabilities of land-use options such as management practices and development rates, and to assess the influence of uncertainties such as natural disturbance trajectories in the face of climate change (Thompson et al., 2012, Duinker and Greig 2005).

Projecting and assessing the cumulative effects of multiple drivers over large spatial and temporal scales is aided by computer modelling. Modelling provides a formalized process for integrating information that is required for prospective assessment of cumulative effects. Further, involvement of planning participants in the modelling process can foster a common understanding of cumulative effects, thereby informing objective decision-making. The scenario analysis for the CEMF was completed using ALCES Online (AO) (https://online.alces.ca/), a computer simulation technology designed for comprehensive assessment of the cumulative effects of multiple land uses and natural disturbances to ecosystems (Carlson et al., 2014).

AO's flexible simulation and relative ease at which scenarios were defined, made it possible to explore the outcomes of multiple scenarios to develop an understanding of land-use options and uncertainties that exist. Simulation outcomes in terms of changes in the abundance, location, and age of natural and anthropogenic land cover types were applied to create maps of future landscape composition and indicators of interest. Indicator relationships were implemented using a spatial GIS calculator that allows for simple to complex indicator relationships as represented by mathematical equations, logic statements, dose-response curves, and spatial rules. Indicator outcomes are mapped at the resolution of individual cells or sub-regional scales such as sub-study area watersheds, landscape units, or BGC zones.

This work used AO to develop three future development scenarios and a scenario based on increased natural disturbance and maximum development disturbance:

1) Reference Scenario: This scenario represents a "business as usual" progression in development. Current rates of change in indicators were used to model future conditions.

2) Minimum Scenario: This scenario is meant to present a case where the intensity of human activities in the Elk Valley declines. This scenario takes the reference case and either subtracts from it or substitutes activities which are assumed to be associated with fewer environmental impacts.

3) Maximum Scenario: This scenario is meant to provide decision-makers with an understanding of cumulative effects from the combination of all currently proposed or projected (as of 2015) human activities in the Elk Valley. It should be noted that some of the proposed development under this scenario has already been approved.

4) Higher Natural Disturbance Scenario: This scenario is meant to assess the effects of human activities from the Maximum Scenario in combination with elevated rates of natural disturbance on the landscape as expected with a four degree increase in annual average air temperature. This is similar to climate change projections under RCP 8.5, where there would be no substantial reduction in greenhouse gas emissions. It is meant to provide decision-makers with an understanding of the combined cumulative effects of human activity and maximum development with increased rates of fire and insect outbreak due to climate change.

2.1.4 Management Actions and Follow up

The management action and follow-up stage of the Elk Valley CEMF will involve evaluation of the trade-offs required to reach the desired future development while maintaining the desired condition of each VC. In some cases, it may be determined that offsets or other forms of compensation are necessary. The CEMF results can assist decision-makers in identifying the nature and extent of potential hazard, which can be used to guide the required actions to improve VC condition in the Elk Valley.

Translation of the assessment results into defensible decisions will depend upon:

- How well representative VCs, the drivers that act on them, and the relationships between drivers and VC responses are identified for study;
- How well uncertainty is identified and addressed in the assessment;
- The degree of transparency and accessibility of the decision-making process; and,
- The degree of collaboration and engagement in the decision-making process.

A structured decision-making framework was designed by the province of British Columbia and is presented in Figure 8. This may be the chosen process for translation of CEMF results into decisions. Additionally, the development of detailed implementation plans is crucial and currently in progress by the Working Group.

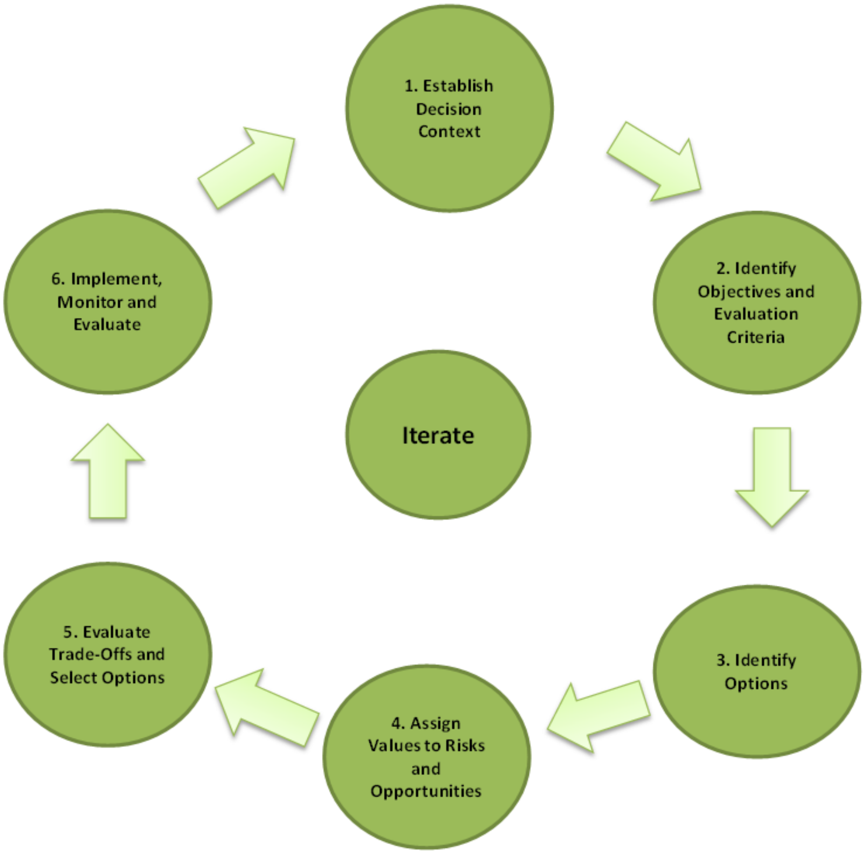

Figure 8. Structured decision-making (SDM) framework promulgated by the province of British Columbia.

Monitoring is an important step in the management action and follow-up stage of the Elk Valley CEMF. Monitoring provides information about how well CEMF VCs are being managed via past regulatory and management decisions. Feedback from monitoring should be timely, accessible, and readily translated into further regulatory or management decisions. Monitoring programs will build on existing regional and site monitoring in the Elk Valley where possible, and the incorporation of community-based monitoring programs will be supported.

2.2 Limitations

As in all such works, the prospective assessment of cumulative effects in the CEMF framework is made challenging by uncertainty and contingency (Peterson et al., 2003). Not only is our understanding of ecosystem response to land use incomplete, but future land use itself is impossible to accurately predict because it is contingent on human behaviour and provincial, national, and even international events. As such, a prospective simulation cannot be considered a prediction, but rather an assessment of the consequences of one of many possible futures, and should act as a tool to identify issues that are most likely to require attention and an approach to compare alternative management strategies.

One of the most important limitations of the prospective assessment, in addition to the narrow list of VCs, was the relatively narrow scope of the scenarios that were assessed. The differences between the scenarios with respect to the rate of future development, the types of management practices, and, perhaps most importantly, the spatial distribution of future development were relatively minor. This is in part due to the spatial scale of the assessment and the fact that there is already substantial land use in the Elk Valley. However, it is also a function of the choice to only include reasonably foreseeable development activities, which can change dramatically in response to resource demand. As a result of the narrow range of scenarios, VC outcomes were relatively similar among the scenarios. Greater learning can be achieved by exploring a wider range of scenarios that, for example, apply alternative zoning strategies to balance development and conservation objectives at the regional scale. As discussed in section 5.2 (Decision Support), a cumulative effects assessment at the scale of the Kootenay Boundary Region would provide the regional perspective that is better suited for: a) exploring a wider range of land use scenarios, including zoning strategies; and b) considering changes relative to natural conditions.

Other key limitations of the present cumulative effects assessment include the following:

- Only five VCs were included in the analysis although it was acknowledged that these were not representative of the full suite of values potentially impacted by the range of stressors acting on them.
- Water quality concerns related to mining are key management issues, and are assessed outside of this framework. It is acknowledged that there is potential for cumulative interactions with other drivers.
- Water supply and water demand were not assessed,
- The modelled relationships between VCs and stressors are uncertain. The relationships should be considered hypotheses that require testing through research and monitoring.

Important examples of uncertainty include: a) the relationship between forest age and grizzly bear foraging habitat at higher elevations; and b) the relationship between road density and westslope cutthroat trout population status.

- Connectivity was not simulated when assessing grizzly bear habitat,
- The temporal scale of the prospective assessment was limited to a 50-year time frame. This limits the applicability of the assessment in providing valuable insight into VCs like old and mature forests over longer time periods.
- Based on climate change projections, forested ecosystems in southeastern BC are expected to change significantly (particularly for drier forest ecosystems; PP, IDF, MS), and it cannot be assumed that ecosystems currently dominated by forest will remain that way in 50-200 years.
- The social implications of trade-offs were not assessed

3. Background on Valued Components

3.1 Old and Mature Forests

Old forests were selected as a Valued Component because of their high ecological, social, economic and cultural value. Mature forests were included in some analyses because of their old forest recruitment value.

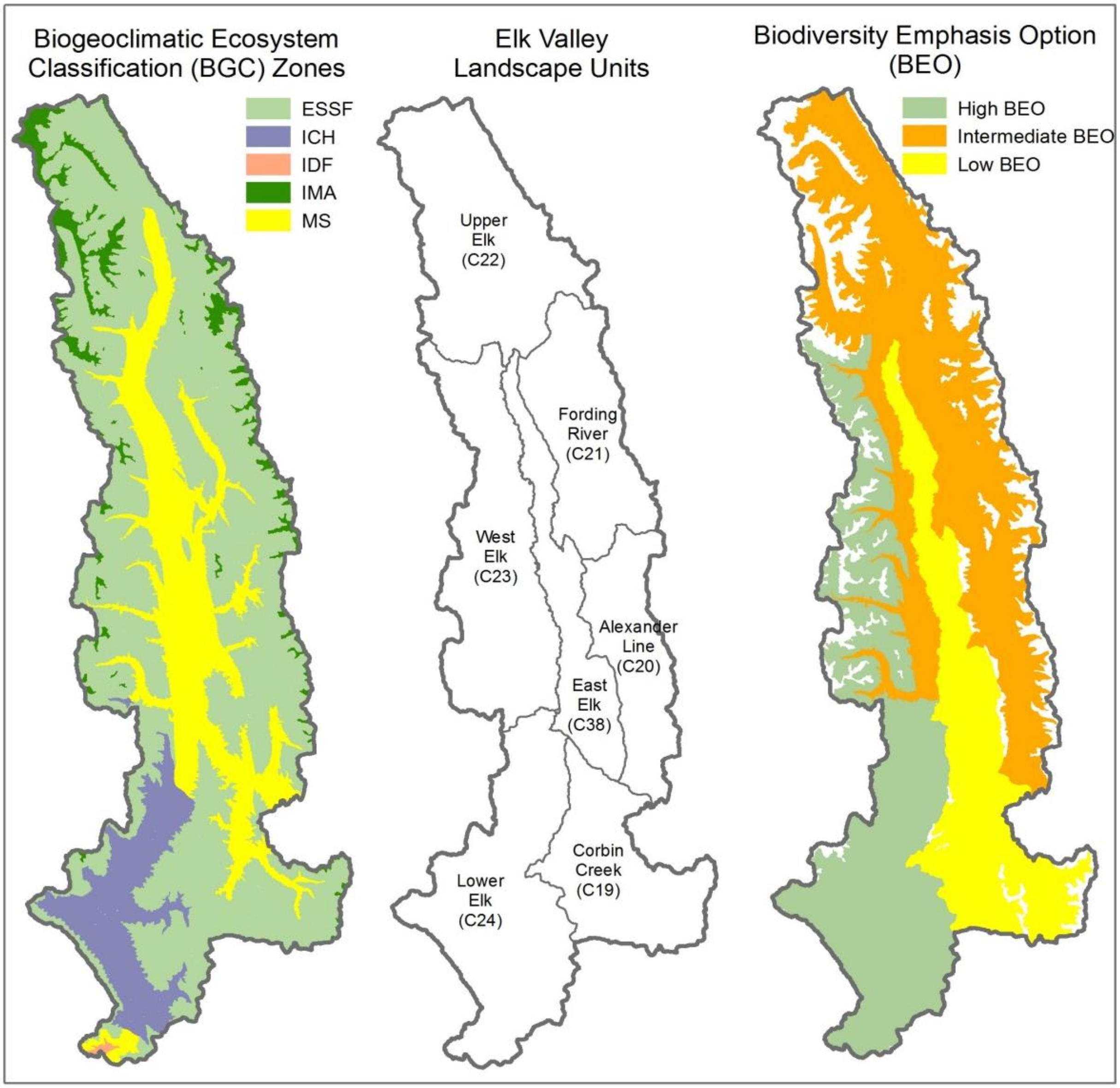

Figure 9. Biogeoclimatic Ecosystem Classification (BGC) zones, Landscape Units (LUs), and Biodiversity Emphasis Options (BEOs).

In the Elk Valley, the Kootenay-Boundary Land Use Plan Higher Level Plan Order (KBHLPO; Forest Practices Board 2005) sets out the specific requirements for the amounts of old and mature forest that must be retained on the crown forest land base (CFLB) by forestry companies. The CFLB includes the part of the crown-owned landscape that is forested and on which forestry may occur. It excludes private land and non-forest land. Required amounts of old and mature forest that must be retained are specified in terms of percentage of old forest and percentage of mature+old forest in a BGC subzone/variant within each Landscape Unit (LU; Figure 9). Landscape units (LUs) are administrative units used for forest management and planning and are usually about 15,000–25,000 ha in size. Within each LU there are usually several BGC subzones/variants, and each BGC subzone/variant by LU combination is assigned a biodiversity emphasis option (BEO) (low, intermediate, or high). The percentage of required old or mature forest varies with this designation and is higher in high BEOs than in lower BEOs. This emphasis option is legally specified in the KBHLPO.

The analysis presented below focuses solely on the BGC subzone/variant. Further description of the assessment methods and full analysis can be found in the Old and Mature Forest Cumulative Effects Assessment Report (Holmes et al., 2018)

Old forest and mature forest z-score values are used to determine hazard for this VC. The z-score is calculated by evaluating the extent to which the observed amount of old forest and mature forest deviates from the average amount expected under the RoNV. Old forests and mature forests are defined by forest type and age (Table 1) and reflect the elapsed time since the last stand-initiating event (either fire, insect outbreak, or logging). The z-scores were then classified into different categories representing different levels of hazard to old forests and mature forests, with lower z-scores reflecting higher deviation from the expected mean under natural conditions:

- very low hazard = z > 0 (greater than what is expected under RoNV)
- low hazard = 0 > z > -1 (one standard deviation less than the mean under RoNV)
- medium hazard = -1 > z > -2 (two standard deviations less than the mean under RoNV)
- high hazard = -2 > z > -3 (three standard deviations less than the mean under RoNV)
- very high hazard = z < -3 (more than three standard deviations less than the mean under RoNV)

Table 1. Old and mature forest age cut-offs (BC Ministry of Forests and BC Environment, 1995).

BGC subzone/variant	Mature Forest (years)	Old Forest (years)
ESSFdk1 ESSFdk2	120	140
ESSFdkw ESSFwm ESSFwmw	120	250
MSdk1 MSdk2 ICHmk4	100	140

3.1 Aquatic Ecosystems

The Aquatic Ecosystem VC consists of a riparian habitat indicator, chosen because of its overall importance to aquatic health, and a Westslope Cutthroat Trout (WCT) indicator, chosen because of its sensitivity to human disturbance.

Figure 10. The Elk River and Westslope Cutthroat Trout (credit: District of Sparwood and Teck).

Although there are many healthy populations of WCT in the East Kootenay, the species was designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) due to concerns regarding introduced species (hybridization and competition), habitat loss and degradation, and increasing exploitation. It is listed as Special Concern in Canada on Schedule 1 of the Species at Risk Act (SARA). In British Columbia, the WCT is ranked S3 (vulnerable) by the Conservation Data Centre and is on the provincial Blue list. The B.C. Conservation Framework ranks the WCT as a priority 2 species.

The overarching management objective for WCT is the “long-term persistence of the species within its native range at abundance levels capable of providing sustainable benefits to society, within the context of broader ecosystem values” (BC Ministry of Environment, 2014).

Hazard to aquatic ecosystems (riparian areas and WCT; Figure 10) was assessed using six land use indicators (Table 2), reported at the scale of Assessment Watersheds (AWs; Figure 11). Indicators were then combined into a single roll-up to assess the overall hazard. Further description on the methodology is available in (Davidson et al., 2018).

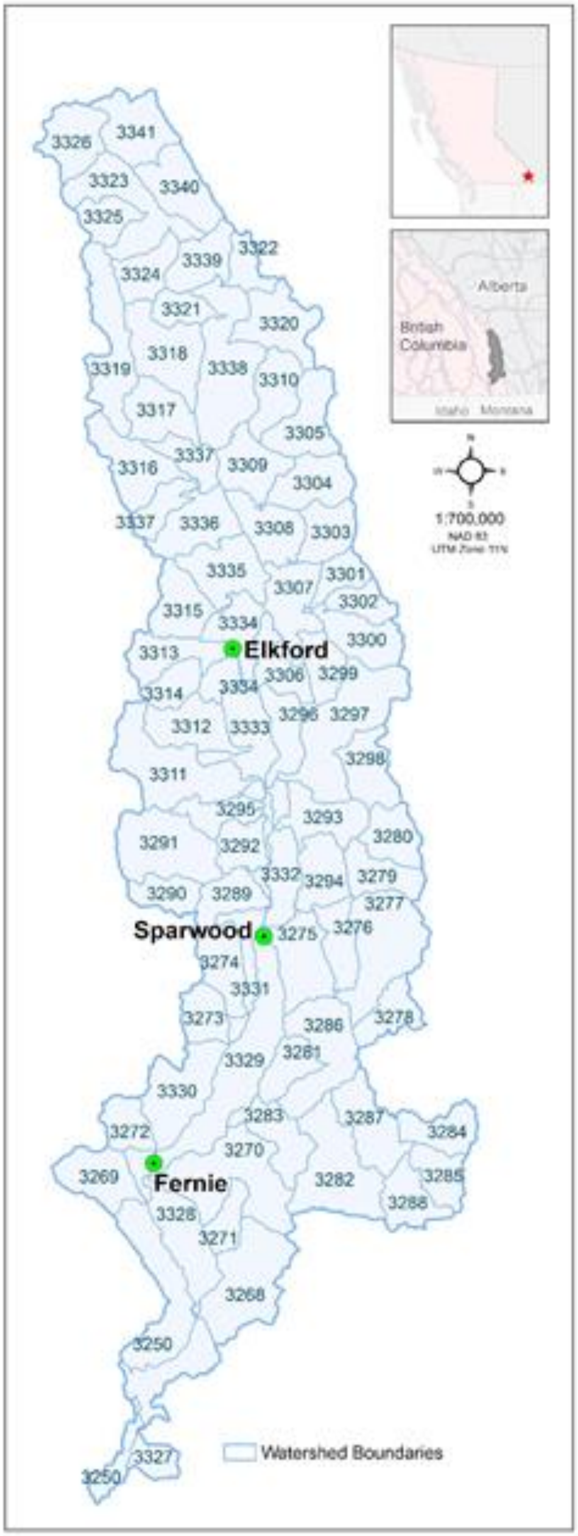

Figure 11. Assessment Watersheds (AWs) across the Elk Valley study area. Overall hazard was assessed as low if the watershed roll-up score was less than 0.4, moderate if the watershed score was between 0.4 and 0.8, and high if the watershed score was greater than 0.8.

Table 2. Aquatic ecosystem indicators and benchmarks.

Indicator	**Benchmark**	**Benchmark source**
Road density within 100 meters of streams (km/km^2)	Low hazard: <0.08 km/km^2 Moderate hazard: 0.08-0.16 km/km^2 High hazard: >0.16 km/km^2	Provincial Aquatic Ecosystem Value Assessment Protocol
Road density on steep slopes (>60%) (km/km^2)	Low hazard: <0.06 km/km^2 Moderate hazard: 0.06-0.12 km/km^2 High hazard: >0.12 km/km^2	Provincial Aquatic Ecosystem Value Assessment Protocol
Stream crossing density (#/km^2)	Low hazard: <0.16/km^2 Moderate hazard: 0.16-0.32 km/km^2 High hazard: >0.32 km/km^2	Provincial Aquatic Ecosystem Value Assessment Protocol
Riparian area disturbance (%)	Low hazard: <10% Medium hazard: 10-20% High hazard: >20%	Provincial Aquatic Ecosystem Value Assessment Protocol
Equivalent Clear-cut Area (%)	Low hazard: <25% Medium hazard: 25-45% High hazard: >45%	Provincial Aquatic Ecosystem Value Assessment Protocol
Hybridization with rainbow trout	Low hazard: 100% pure WCT Medium hazard: 69-99.9% pure WCT High hazard: <95% pure WCT	Management Plan for the Westslope Cutthroat Trout, British Columbia Population (Fisheries and Oceans Canada, 2016)
Stream temperature (°C)	None applied	None applied

3.1 Bighorn Sheep

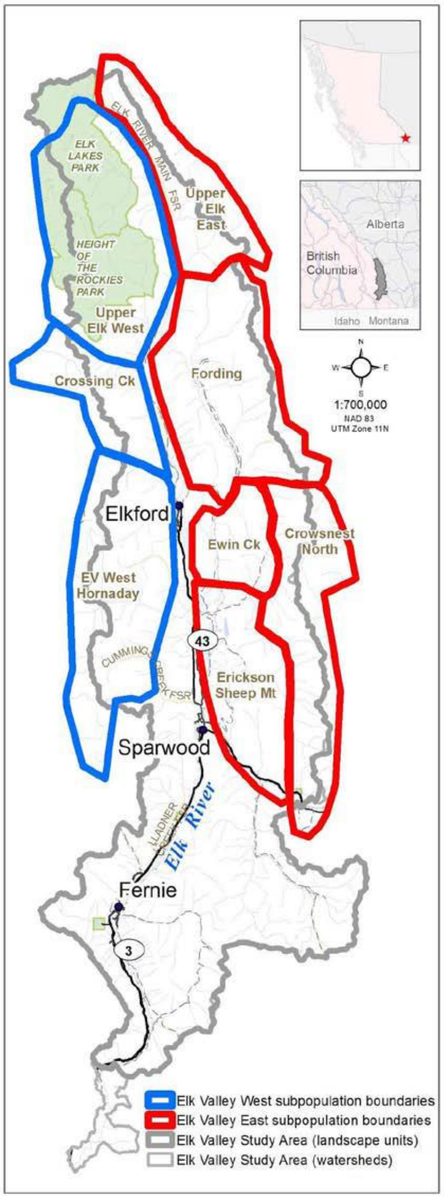

Figure 13. Bighorn sheep ranges.

Bighorn sheep are a valued component of the BC ecosystem because of their high harvest and cultural value and their importance to First Nations. Also, Bighorn Sheep (Figure 12) are blue-listed, which means they are of Special Concern and are particularly sensitive or vulnerable to human activities or natural events. Bighorn Sheep are managed at the population level under the BC Wildlife Act, which addresses hunting regulations and licencing.

Figure 12. Big horn sheep ram in high elevation habitat during the winter (credit: Dean Runzer; Teck).

Management objectives are also set by Population Management Units (PMU) and take the objectives described in the Big Game Harvest Management Procedure into account. The primary management objective in this Procedure is to “maintain post-hunt numbers for each PMU at or near current levels” while the secondary objective is to “maintain desired age structures in the harvest, and/or harvest sex ratios”. It is also important to note that within this Procedure, these objectives “must consider First Nations ability to fulfil their food, social or ceremonial needs”.

The Elk Valley East and West BHS populations are of particular significance because of their unique use of high-elevation winter range and their freedom from widespread respiratory disease. The assessment was restricted to the Elk Valley East and West populations within Wildlife Management Unit 4-23 (Figure 13).

The assessment presented in this report focuses on winter range habitat as opposed to annual range and population indicators are discussed in the BHS narrative (Poole et al. 2018). Winter range habitat ranks from 4 (highly selected) to 0 (not selected), based on use by collared sheep in the 2009-11 telemetry study (Poole et al. 2016).

Ranks were adjusted based on proper functioning condition, and a final winter range product that gives an indication of how suitable the winter range is to support sheep in terms of both quantity and quality of habitat. A hazard score was calculated based on loss of winter range from 1950, using hazard rankings identified by expert opinion from the 5 July 2016 BHS workshop (Figure 14).

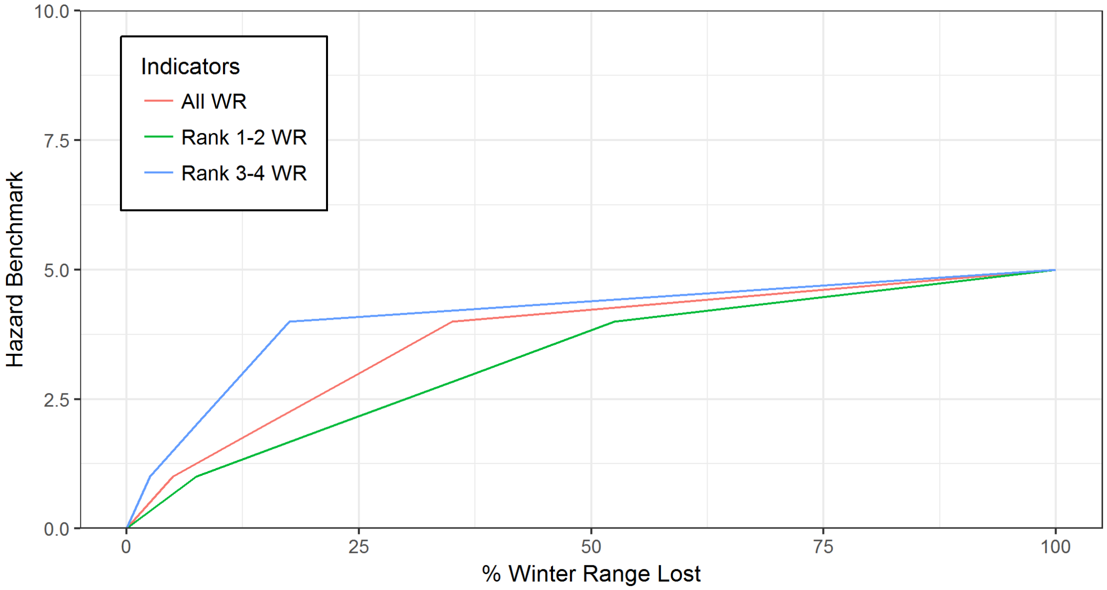

Figure 14. Proposed benchmarks (dose-response curves) for proportion of winter range (WR) lost by BHS subpopulations in the Elk Valley. Benchmarks correspond to 0-1 very low hazard; 1-2 low hazard; 2-3 moderate hazard; 3-4 high hazard; 4-5 very high hazard; and 5 functionally extirpated. Rankings range from Rank 4 – highly selected or highly used – to Rank 1 – low selection or limited use.

Overall hazard was then calculated as a weighted average of the winter and annual ranges, with a higher weight applied to winter range (75%) than annual range (25%) due to the importance of winter range for BHS in the Elk Valley.

3.1 Grizzly Bear

Grizzly bears were chosen as a VC as there is concern over their conservation given that they have high cultural value, harvest value, and contribute to the visual quality on the landscape. They are also a very wide-ranging species, and utilize a variety of habitats; therefore, results of the assessment may help inform many decisions related to the resources in the Elk Valley. Finally, Grizzly Bear (Figure 15) is listed as a Species of Special Concern under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In British Columbia, they are listed as “S3”, or vulnerable species, by the BC Data Conservation Data Centre. Grizzly bear mortality management is guided by the Grizzly Bear Harvest Management Procedure under the Wildlife

Act and the species is currently protected from unrestricted hunting. As well, under the Forest and Range Practices Act (FRPA), wildlife habitat areas and other habitat measures can be established through the land-use plans such as the Kootenay-Boundary Land Use Plan Implementation Strategy. Consideration of First Nations' ability to fulfil their food, social or ceremonial needs, must also be accounted for when considering the Grizzly Bear Harvest Management Procedure.

Figure 15. Grizzly bear in young forest habitat in the Elk Valley (credit: C. Lamb).

The Provincial CEF Grizzly Bear team extensively reviewed existing objectives and proposed the following broad objectives for the cumulative effects assessment procedure of Grizzly Bears:

- At the population scale, manage for viable populations of Grizzly Bear and avoid populations becoming threatened;
- At the landscape scale, maintain the numbers, distribution of Grizzly Bears and their habitats.

Grizzly Bears were assessed at the scale of AWs (Figure 11) using a habitat suitability indicator that integrates habitat availability and road density (to incorporate risk of human-caused mortality). For a full description of the assessment methods please see (Mowat et al. 2018).

Habitat types that were assessed include, avalanche chutes and alpine areas, early seral forests with an open canopy, riparian habitat, berry habitat, and built up areas. The location of huckleberry habitat was informed not only by vegetation data, but also by radio collar data, and as a result, the distribution of huckleberry habitat was restricted. To emulate a similarly restricted buffaloberry habitat, habitat was limited to that which overlapped with forest younger than 20 years or areas with permanent open canopy (e.g., >2200 m). As a result, the location of buffaloberry habitat during simulations shifted in response to forest disturbance and succession.

Habitat suitability was calculated by reducing habitat availability to account for each AW's road density, due to a loose correlation between Grizzly Bear mortality and road density (Boulanger and Stenhouse 2014) and potential avoidance of areas adjacent to roads.

4. Retrospective and Prospective Cumulative Effects Assessment Results and Interpretations

4.1 Land Use and Climate Changes

The basis of the Elk Valley CEMF is an assessment of the condition of the landscape and climate and subsequent VC or indicator response to these changes over time and space.

4.1.1 Land Use

The major land uses in the Elk Valley are coal mining and forestry. Both of these sectors have been active in the Elk Valley since the late 19th Century and substantial footprints existed by 1950, including an extensive road network and numerous mines. In addition to mining, forestry, and agriculture, more recent land uses include recreational developments such as the Fernie ski resort, and exploration for gas. Majority of the Elk Valley's residents, approximately 15,000, live in the communities of Fernie, Sparwood, and Elkford.

Land use and human activity in the Elk Valley has changed substantially since the pre-industrial age. According to Traditional Knowledge, the Ktunaxa people have frequented the Elk Valley for more than 10,000 years, successfully and harmoniously living off the land through hunting, gathering and trapping activities. By the late 1700s the first Europeans arrived in the Elk Valley and the first railway was built through the Crowsnest Pass in the late 1890's (Finch, 2012). Although coal was already known as 'the rock that burns' by the Ktunaxa people for many years, around the 1890s coal was discovered as a mineable resource by William Fernie, and hundreds of skilled miners immigrated from Cape Breton and Europe to the first coal mines at Coal Creek (Finch, 2012). Rapid industrialization of the coal mining industry caused massive change in the Elk Valley. Forest harvest occurred at an immense rate in order to supply timber for construction of the railway, as well as the communities and mines. Roads spread throughout the basin, providing access to previously untracked areas of the valley. Road access through the Crowsnest Pass was established in 1921, which further linked the once-remote Elk Valley to the rest of the country (Finch, 2012).

Historically, natural disturbances such as flooding and fires were common. Large scale seasonal floods were one reason the valley was not frequently used by First Nations (Finch, 2012). Wildfires were very common as well and often threatened communities, such as in 1908 when the town of Fernie was nearly destroyed by wildfire. Recognizing this natural disturbance dynamic, the Bush Fire Act was enacted in 1905, and one of the first fire wardens was appointed in the East Kootenays. Fire suppression activities have continued in the valley since this time.

Coal production stagnated in the 1930s due to the Great Depression and a shift to petroleum as a new energy source. As a result, population growth in the Elk Valley slowed. By the late 1960s, contracts were signed with Asian buyers for metallurgical coal and production in the valley ramped up once more (Finch, 2012). The transition from underground to open pit mining expedited the coal production process and enabled more rapid land use activity and consequently more rapid population growth. Today, many people are drawn to the Elk Valley for work in the coal mining and natural resource sectors.

This intense industrialization and influx of human population within the Elk Valley has changed the landscape and the environment substantially. The cumulative change in landscape between 1950 and 2014 was determined by analysing differences in areal imagery and showed an 856 % increase in total human disturbance (Golder, 2015). It is important to remember that human disturbance has likely increased even further relative to the pre-industrial era, as industrial land use in the Elk Valley was already present prior to 1950.

This section evaluates human land use in the 1950's (historical context), current conditions, and potential future conditions under a range of scenarios. Five anthropogenic footprint indicators representing the major land uses in the Elk Valley were chosen for this analysis, including total footprint, roads, coal mines, built up areas, and cutblocks.

Total Footprint

Total footprint includes all "permanent" anthropogenic disturbance on the landscape. Cutblocks were not included in this definition of footprint. Total footprint is primarily comprised of roads, mines, urban centres, industrial features, recreational features, and electrical transmission lines. A comparison of current and 2065 area values under different potential future scenarios (Table 3) illustrates inter-sectoral land use contributions to the total anthropogenic footprint.

Approximately 146 km^2 (4% of the study area) was comprised of human footprint in the Elk Valley in 1950, with most of this made up of roads. The footprint in the Elk Valley is currently highest around coal mines, specifically near Sparwood and Elkford, and the current basin-wide total human footprint amounts to 7.3% (258.9 km^2) of the study area, which demonstrates a 177% increase over 1950 conditions. Whereas road development has not changed dramatically since 1950, the mining footprint has expanded significantly (Figure 16).

Total footprint is expected to increase under all scenarios, as the rate of construction of new features generally exceeds rates of reclamation. Under the Reference Scenario, footprint area increases by 29%, most notably around coal mines, and occupies ~9% (336 km^2) of the study area by the end of the simulation. Under the Minimum Scenario, total footprint area reaches ~8.7% (311 km^2) by 2065. There are slight reductions in road development under this scenario relative to the Reference Scenario. Under the Maximum Scenario, the total footprint reaches 11% (387.2 km^2) of the study area. This increase relative to the Reference Scenario is primarily attributed to the additional mine expansions, secondarily to an increase in forestry roads and additional municipal/recreational expansion (Figure 16).

Table 3. Current land use footprint in the Elk Valley and cumulative simulated land use footprint in 2065 under the Reference, Minimum, and Maximum scenarios.

Land Use Sector	**Current Area (km^2)**	**Reference 2065 (Area km^2)**	**Minimum 2065 (Area km^2)**	**Maximum 2065 (Area km^2)**
Mining	112.8	148.6	125.6	183.6
Transportation (road/rail)	103.7	114.1	113.4	115.5
Built Up (largely residential and recreational)	7.0	9.8	9.2	11.7
Cropland / Pasture	19.6	19.0	19.2	19.4
Other land use types	15.8	44.5	43.6	57.0
Total Footprint (excluding cutblocks)	**258.9**	**336.0**	**311.0**	**387.2**
Cutblocks	270.6	676.7	640.2	708.4
Total Footprint (including cutblocks)	**529.5**	**1,012.7**	**951.2**	**1,095.6**

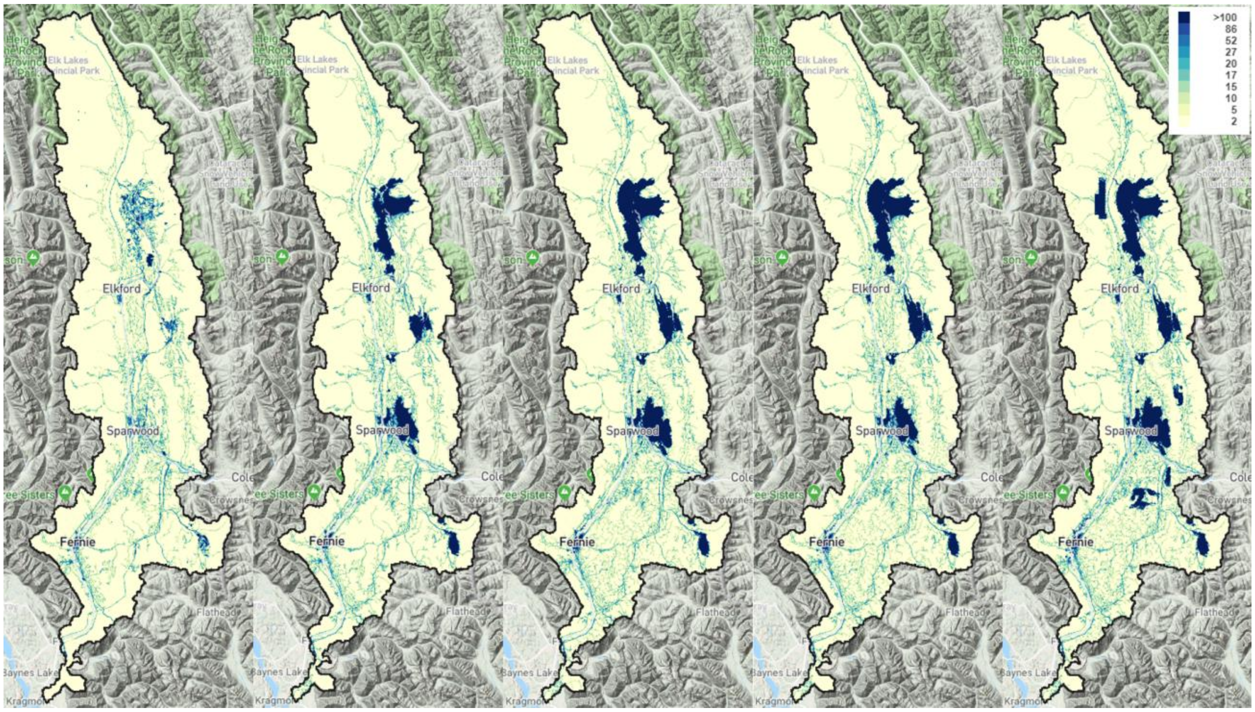

Figure 16. Total human footprint (in percent) in the Elk Valley during 1950, current, and Reference, Minimum, and Maximum scenarios in 2065 (from left to right).

In 1950, roads represented ~1.8% of the study area, with a total linear distance of 3,941 km. In 2015 they represented ~2.6% of the study area, with a total of 5,470 km. By 2065, they are simulated to represent ~2.9%, ~2.4%, and ~3% of the study area under Reference, Minimum, and Maximum scenarios, respectively. These results suggest that road development is already high and well established in the study area. Even marginal changes in timber harvest are not likely to yield substantive difference in road development (Figure 17).

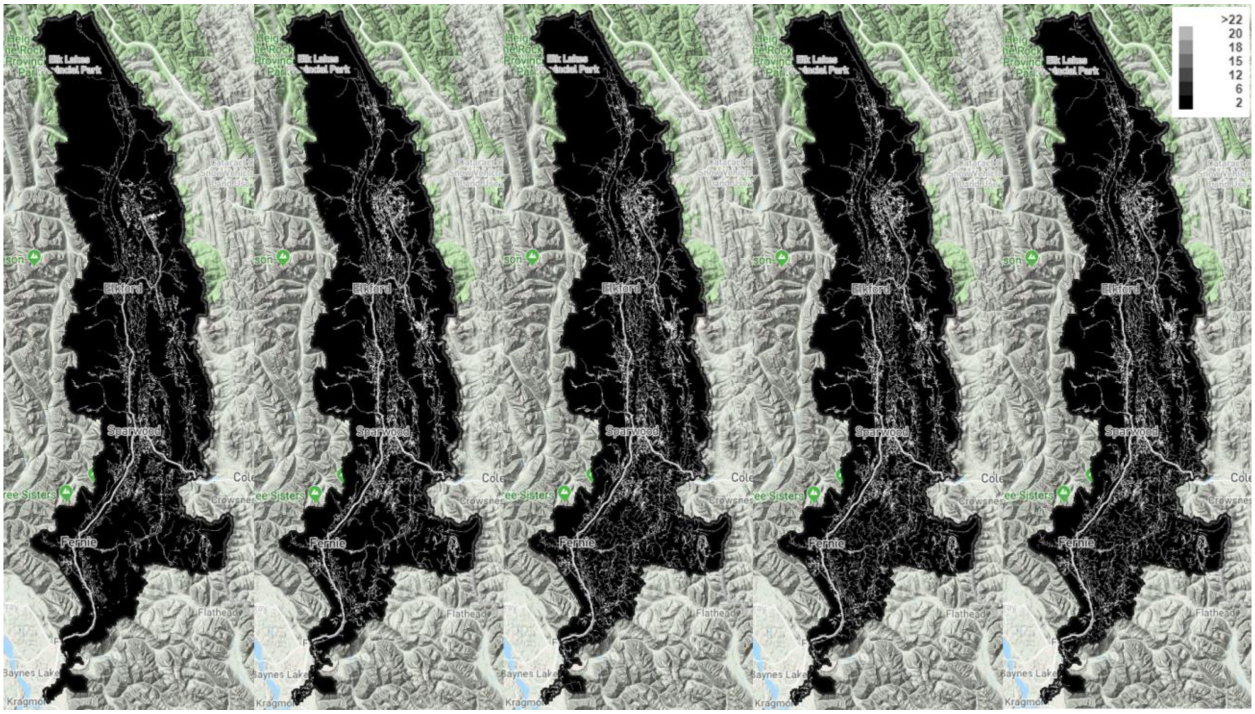

Figure 17. Roads (white network) in the Elk Valley during 1950, current, and Reference, Minimum, and Maximum scenarios in 2065 (from left to right).

Coal Mining

Since 1950, gross coal mine footprint (i.e., including reclaimed footprint) has more than quadrupled from less than 1% (25 km^2) to 4% (143 km^2) of the Elk Valley (Figure 18). Under the Reference Scenario, mine footprint is simulated to reach 209 km^2 and 158km^2, for gross and net footprint respectively (Figure 19). Other development scenarios simulate net mine footprint to reach ~3.7% (134 km^2), and 5.4% (193 km^2) by 2065, under Minimum and Maximum scenarios, respectively (Figure 18). The substantial increase relative to the Reference Scenario is due to all proposed coal mining projects in 2015 being included in the Maximum Scenario.

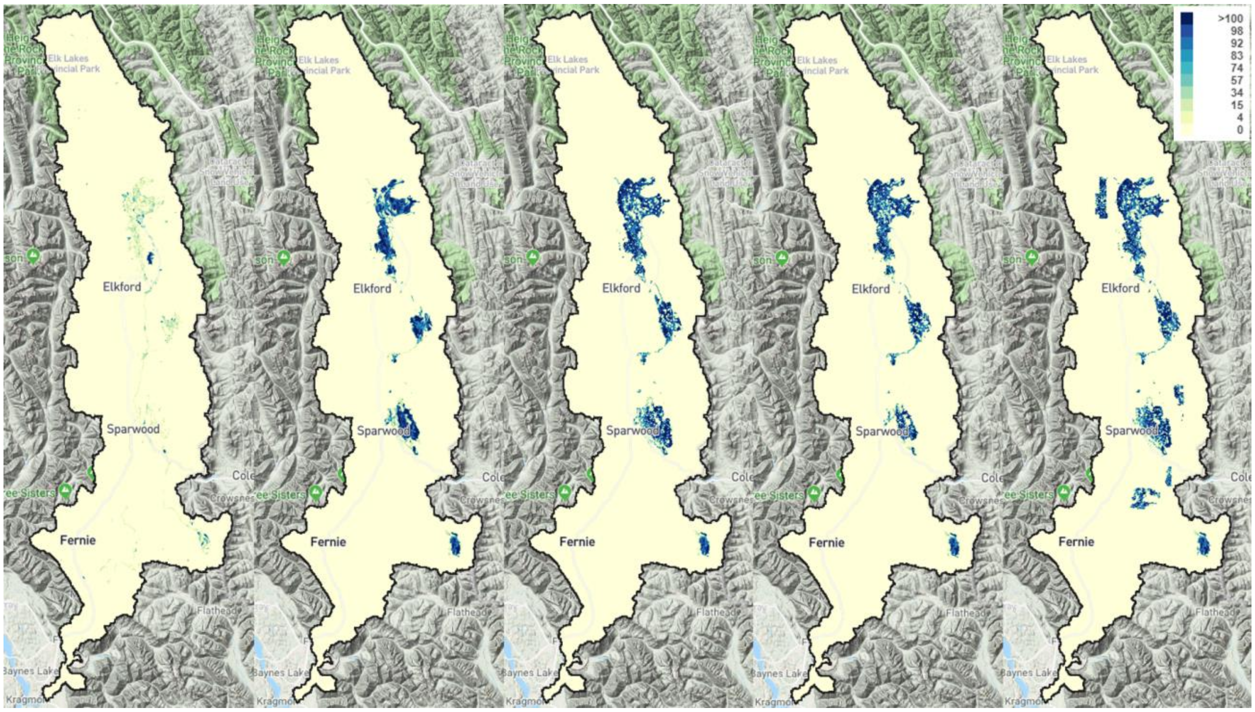

Figure 18. Coal mine area in the Elk Valley during 1950, current, and Reference, Minimum, and Maximum scenarios in (from left to right) 2065.

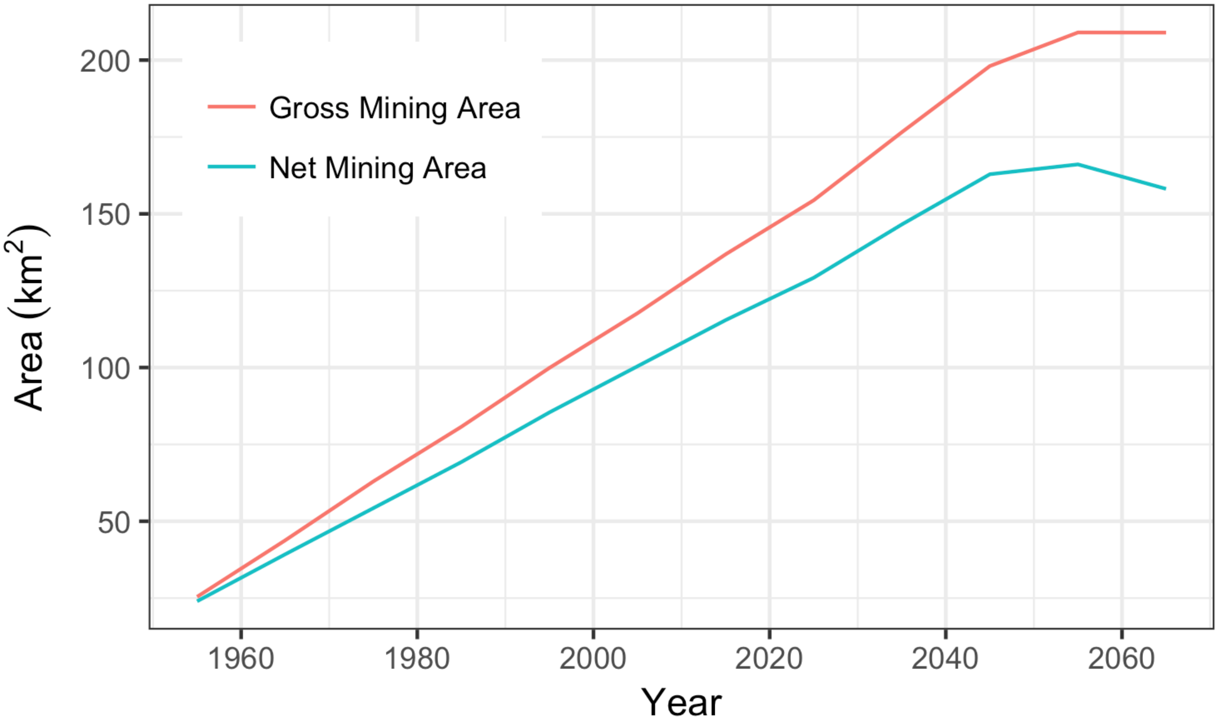

Figure 19. Temporal comparison of net coal mining (taking reclamation into account) and gross coal mining footprint in the Elk Valley. These values represent the Reference Scenario.

Built-up Areas (Residential) and Recreation

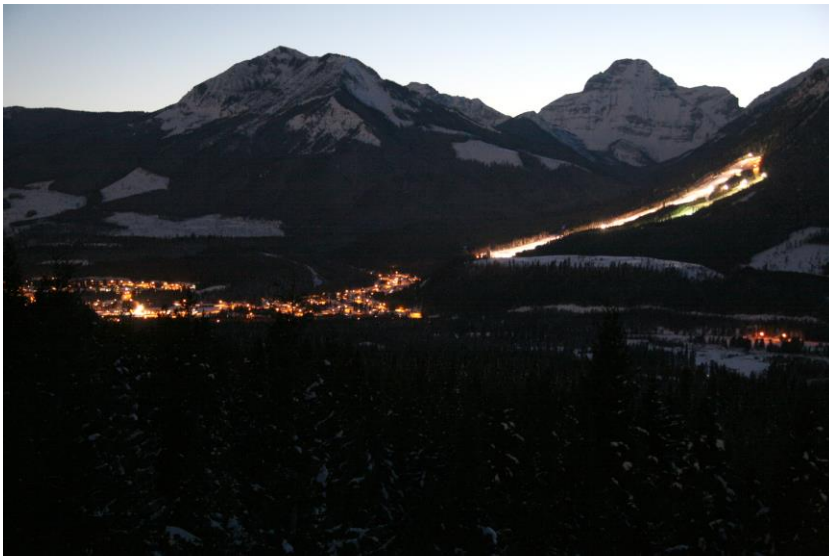

Figure 20. Communities have been expanding incrementally in the Elk Valley (credit: District of Sparwood).

Built-up area is a term used to define a developed area, or any land on which groups of buildings or structures are present. In the study area, built-up area for the most part represents settlements (Figure 20). The built-up area represents ~0.06% (2.4 km^2) of the study area in 1950, increasing to 0.2% (7.7 km^2) by 2015. Simulations suggest total built-up area could reach 9.8 km^2, 9.2 km^2 and 11.7 km^2 by the end of the Reference, Minimum, and Maximum future development scenarios, respectively, (Figure 21). The majority of the growth is expected to occur in and around Fernie, including substantial development in floodplain areas which are vulnerable to floods (Walker et al., 2016).

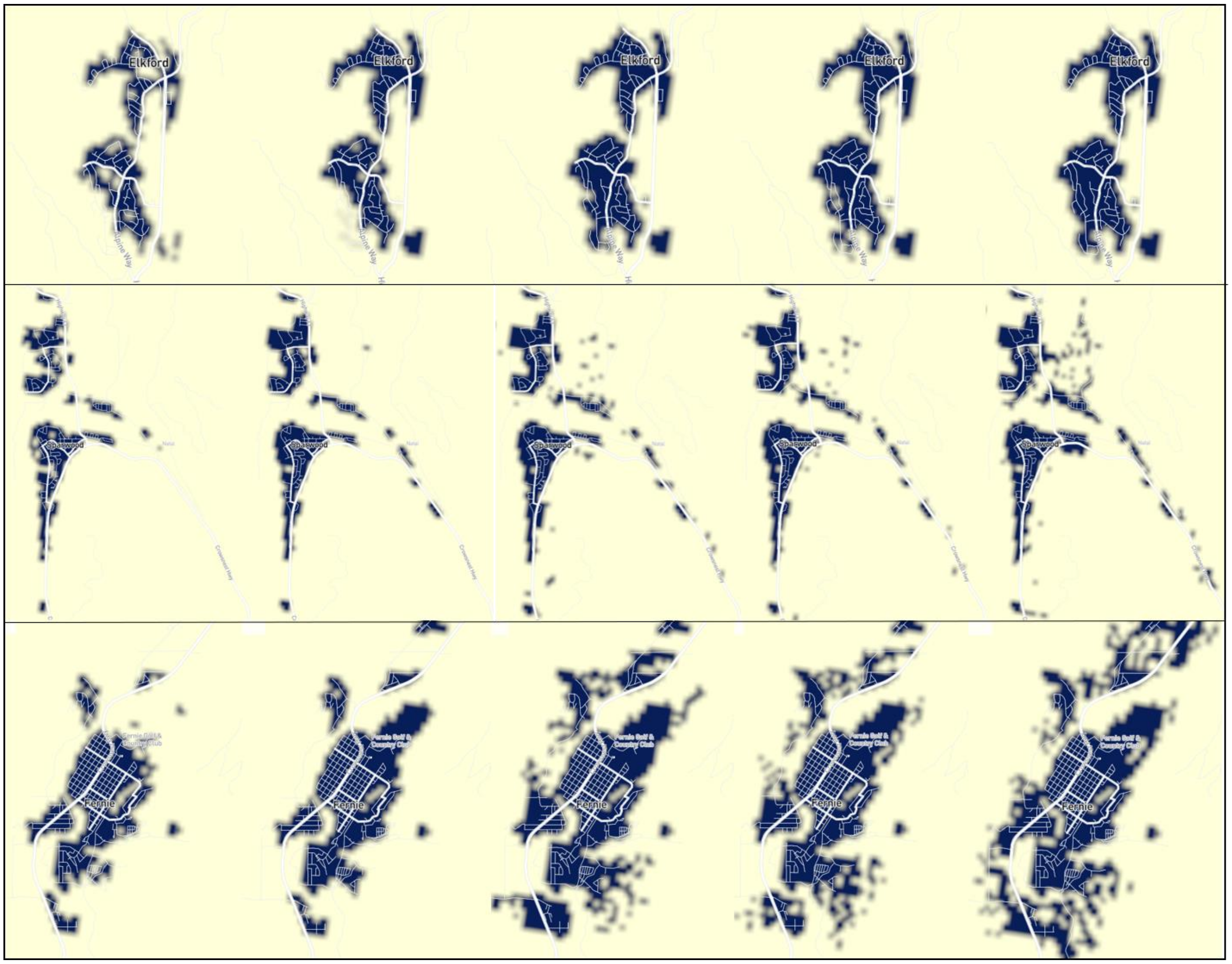

Figure 21. Built-up area (blue) in the Elk Valley communities during 1950, current conditions, reference scenario, minimum scenario, and maximum scenario (from left to right). The top row is Elkford, the middle row is Sparwood, and the bottom row is Fernie.

Cutblocks

Cutblocks are areas on the landscape where harvesting of timber occurs. Approximately 8% of the entire Elk Valley has been harvested in the last 40 years. During the Reference Scenario, the cumulative gross area harvested doubled from 10% to 20% of the Elk Valley (Figure 22 and Figure 23). However, this does not account for forest recovery that occurs in the years following timber harvest. Cutblocks less than 30 years of age currently cover 8% of the Elk Valley (Figure 22). By 2065, cutblocks younger than 30 years of age increase to 10%, in large part to due intensive timber harvest on private managed forest in the Reference Scenario, but decline thereafter to account for 6% of the Elk Valley by the end of the simulation. The portion of the study area with the most intensive simulated future timber harvest is the private land southeast of Fernie. Timber harvest is also likely to increase in the northern portion of the study area relative to current conditions. Under all scenarios, timber harvest is simulated to occur primarily in lower elevation portions of the Elk Valley (Figure 22).

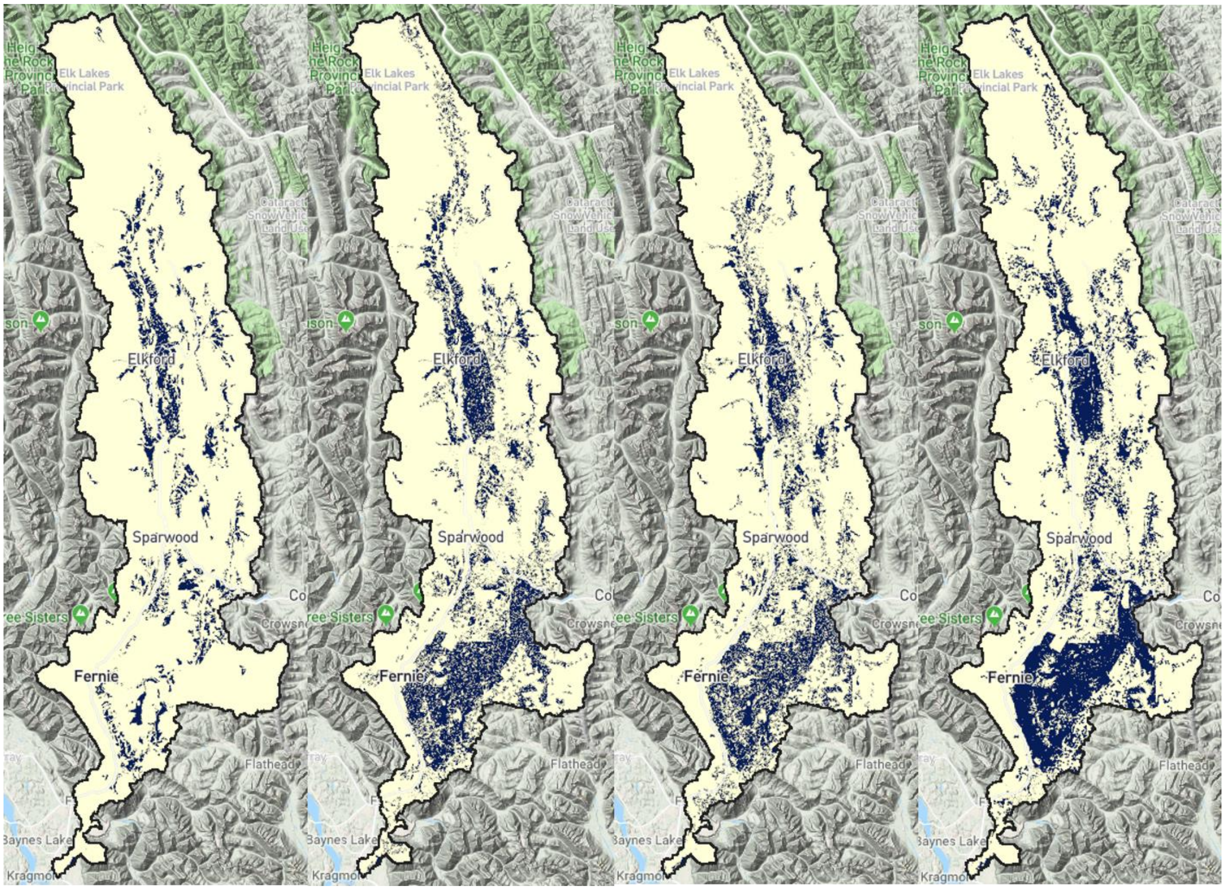

Figure 22. Cutblocks in the Elk Valley under current conditions, Reference Scenario, Minimum Scenario, and Maximum Scenario in 2065 (from left to right), where a value greater than 0 (blue) represents an area of harvest. Note this does not imply this whole area is harvested at one time; it shows the cumulative area that could be harvested under these scenarios.

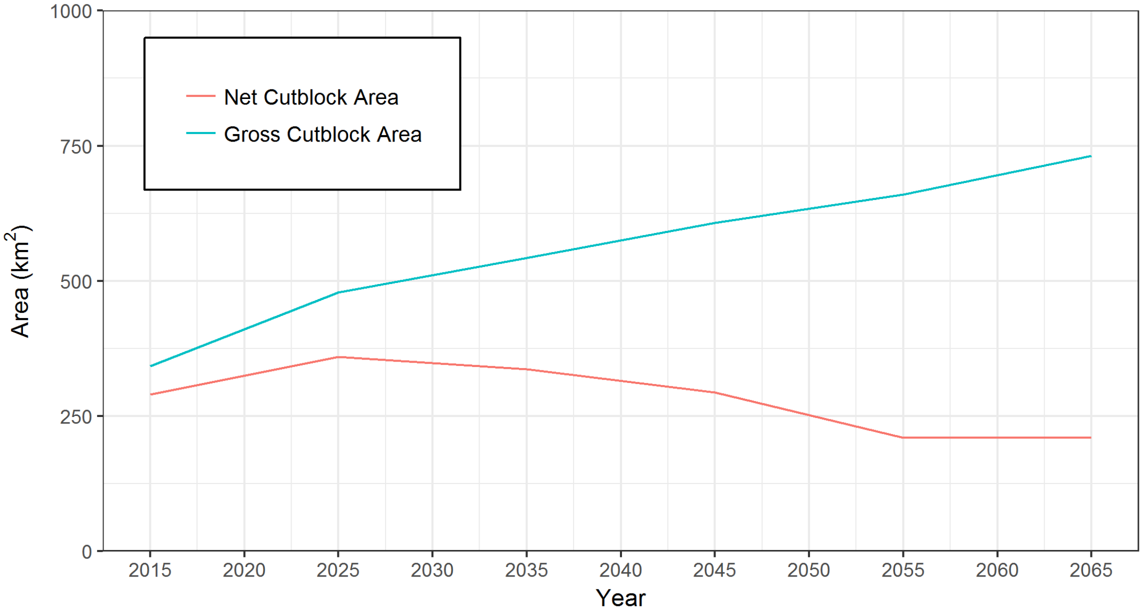

Figure 23. Temporal comparison of net and gross cutblock footprint in the Elk Valley. The values presented reflect the Reference Scenario.

4.1.2 Climate Change

Just as the landscape has changed over the past few decades in the Elk Valley, changes in climate have occurred as well, and are expected to continue. Climate change poses an increasing threat to the sustainability of freshwater resources, aquatic, and terrestrial ecosystems in North America. Increases in greenhouse gas emissions have resulted in a wide range of effects, posing substantial challenges for resource management related to aquatic and terrestrial ecosystems (IPCC, 2014; Jiménez Cisneros et al., 2014). The western alpine regions of North America, particularly the northern Rocky Mountains, are critical freshwater resources, where studies have already shown earlier snowmelt and probable snowmelt declines within these regions (Burn, 1994; MacDonald et al., 2011; MacDonald et al., 2014; Mote et al., 2005; Meritt et al., 2006; Stewart et al., 2005).

Many studies have shown changes in water temperature and flow regime that are likely to occur due to climate change which will affect biotic interactions (Pederson, et al., 2010; Wenger et al., 2011). Expected changes in species life-cycles and the spatial distribution of habitats with respect to changing flow regimes have been reported (Schindler, 1997; Wenger et al., 2011). For example, a study by Wenger et al. (2011) found that high winter flows predicted moderate to high population declines in fall-spawning trout species, such as Bull trout. However, in spring-spawning species such as the native Westslope Cutthroat Trout, high winter flows led to only modest negative responses, while non-native rainbow trout species showed a positive response in population (Wenger et al., 2011). Although this study found that biotic interactions play a role in the habitat distribution of various trout species, they also determined that alteration of stream temperature and flow regimes plays a more dominant role, as corroborated by other studies (Muhlfeld et al., 2014, Muhlfeld et al., 2017). The Elk Valley has experienced high variation in streamflow over the past several decades and has encountered dry years like the summer of 2015 when fishing closures occurred on tributaries to the Elk River due to high water temperature conditions. It is likely that these conditions will prevail, or intensify, in the future and pose a substantial threat to freshwater ecosystems.

A warming climate will also have adverse impacts on terrestrial ecosystems. In mountain environments, a variety of habitats support high levels of biodiversity at a regional scale due to altitudinal gradient in plant communities, topography and aspect (Price and Neville, 2003). The Montane Cordillera region within British Columbia offers a forest biomass that could mitigate the increasing concentrations of atmospheric CO_2 (Mansuy et al., 2017; Nitschke and Innes, 2008; Price and Neville, 2003). However, the continued large extent of forest harvest within the province poses a great concern when there is increasing forest disturbance due to wildfires and insect outbreaks. Gillett et al. (2004) and Flannigan et al. (2009) reported increasing areal extent of wildfires in Canada, and similar trends occur in western US (Westerling et al., 2006). The recent mountain pine beetle outbreak in British Columbia and Alberta was unprecedented in its severity and extent, and climate change has greatly contributed to its spread (Caroll et al., 2003; Cooke and Carroll, 2017; Kurz et al., 2008). Spittlehouse (2004) also outlined other potential negative effects of climate change of warmer annual and summer conditions in British Columbia, many of which have reported reduced forest growth rates, increased competition from vegetation, insects, and diseases, as well as changes in wildlife habitat suitability (Dale et al., 2001; Gillett et al., 2004; Price and Neville, 2003; Thom et al., 2016, Wood and Van Sickle, 1991; Xu et al., 2017). Therefore, adaptation and mitigation measures are needed for present and future management strategies that protect biodiversity in terrestrial ecosystems within the Elk Valley. Indicators used in this analysis include precipitation as snow, average annual precipitation, and air temperature given that these indicators represent the fundamental effects of future climate change.

Precipitation as Snow

Precipitation as snow is an important indicator of water availability in nival systems such as the Elk Valley, and central to sustaining numerous ecosystem functions. The 2015 average annual precipitation as snow was approximately 368 mm, and is expected to increase under the RCP 4.5 Scenario, to an average of 400 mm/yr. Total precipitation as snow reaches an average of 337 mm for the study area by year 2065 under RCP 8.5 due to higher air temperatures (Figure 24). This represents a substantial decrease relative to present and reflects the effect of higher air temperatures (Figure 26). These results are similar to other studies (Knowles et al., 2006; MacDonald et al., 2012) and suggest water supply and the stability of current streamflow regimes are likely to change in the future.

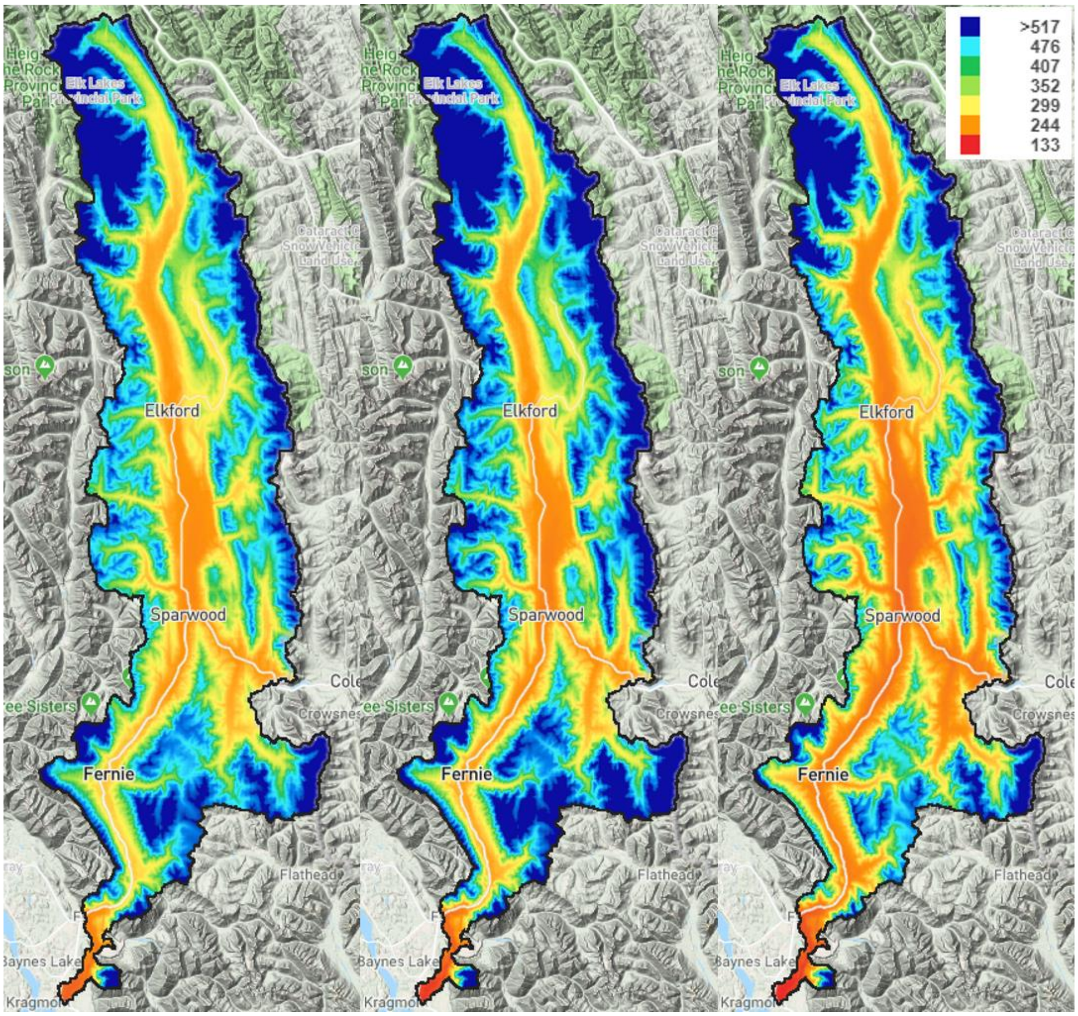

Figure 24. Precipitation as snow (mm/yr) in the Elk Valley during current conditions, RCP 4.5, and RCP 8.5 (from left to right).

Precipitation

Average annual precipitation was approximately 746 mm in 2015, increasing to 1,005 mm by 2065 under the RCP 4.5 Scenario and to 1,089 mm by 2065 under the RCP 8.5 Scenario (Figure 25). Although average annual precipitation is expected to increase under these future scenarios, it is important to remember that the seasonal distribution of precipitation and the intensity of precipitation events are likely to dramatically shift. There may be more precipitation at an annual scale relative to today over long time periods, but the inter-annual seasonal variation in timing of precipitation is likely to become more dramatic. As such, an elevated annual amount of precipitation does not necessarily mean that there will be higher levels of water flow throughout the year. Warmer weather could result in higher amounts of water loss, and lower recharge of soils and groundwater throughout the year.

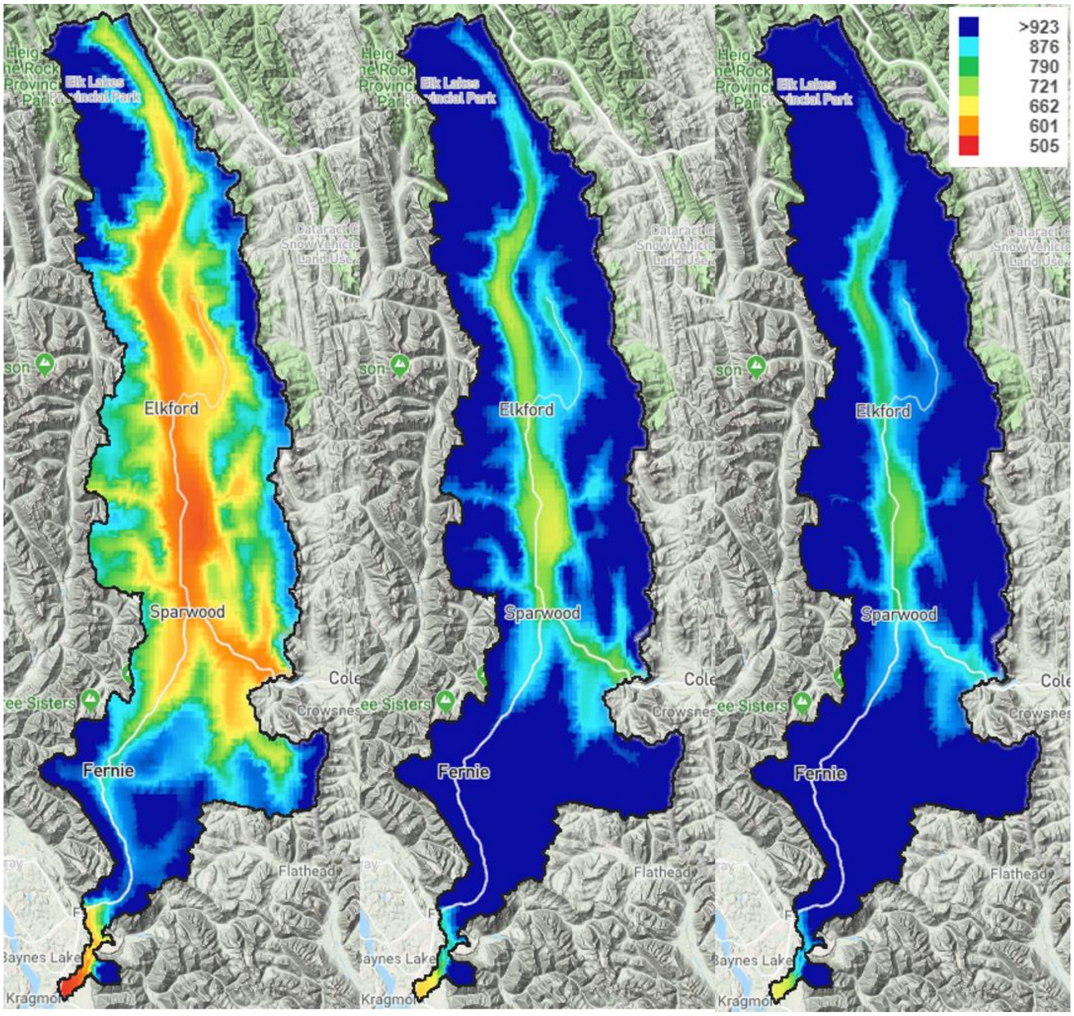

Figure 25. Average annual precipitation (mm/yr) in the Elk Valley during current conditions, RCP4.5, and RCP8.5 (from left to right).

Air Temperature

Average annual air temperature is currently approximately 0.9 ˚C and this could increase to 5 ˚C and 6 ˚C under RCP 4.5 and 8.5, respectively, by 2065 under future climate change (Figure 26).

This has important implications for ecosystem function, human lifestyles and land use. Higher air temperatures can have numerous cascading effects on water resources, wildlife, and vegetation. Higher air temperatures will lead to elevated potential evapotranspiration and hence reduce the effect of higher precipitation on streamflow.

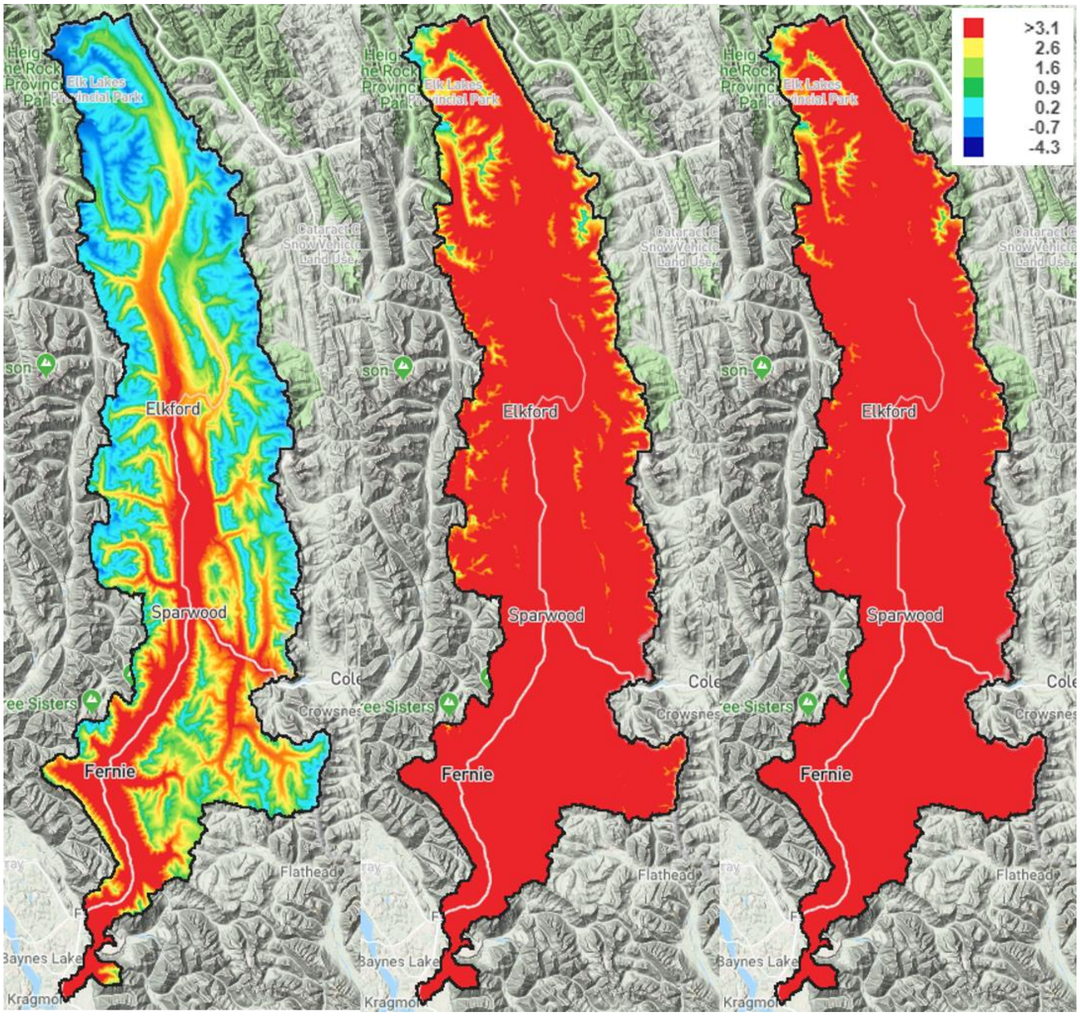

Figure 26. Average annual air temperature (°C) in the Elk Valley during current conditions, RCP4.5, and RCP8.5 (from left to right).

Natural Disturbance Regimes

Since the ablation of glacial ice sheets ~ 12 000 years ago, the Elk Valley has experienced recurrent natural disturbance events that vary in spatial and temporal scale. Examples of natural disturbance include wildfire, insect outbreaks (Figure 27), floods, droughts, avalanches, and landslides, as well as periods of major climatic shifts. During recent decades, fires have been successfully suppressed in the Elk Valley and commercial forestry has emerged as the primary disturbance regime responsible for spatial variation in forest age structure.

Figure 27. Wildfires and insect outbreaks are ecological events that create diversity in forest ages and forest structure. The shifting forest age class structure created by disturbance is a key factor that determines the abundance and distribution of many plant and wildlife communities.

4.2 Historic and Current Conditions

4.2.1 Combined Valued Component Analysis

An analysis was completed to evaluate the cumulative response of all VC indicators. This analysis scaled all indicators from zero to one, where zero was no hazard and one was high hazard. The scaled indicators were then used to calculate an average by AW. BHS indicators were factored into the average only where BHS ranges occurred. The combined indicator is presented in Figure 28, demonstrating that the highest hazard for all VCs is currently located in AWs where mining has occurred and along the valley bottoms. These areas currently experience the highest amounts of land use in the study area. This map supports decision makers to prioritize management/mitigation actions by showing the worst of the worst AWs. Also, it may point to AWs where to minimize/avoid further development.

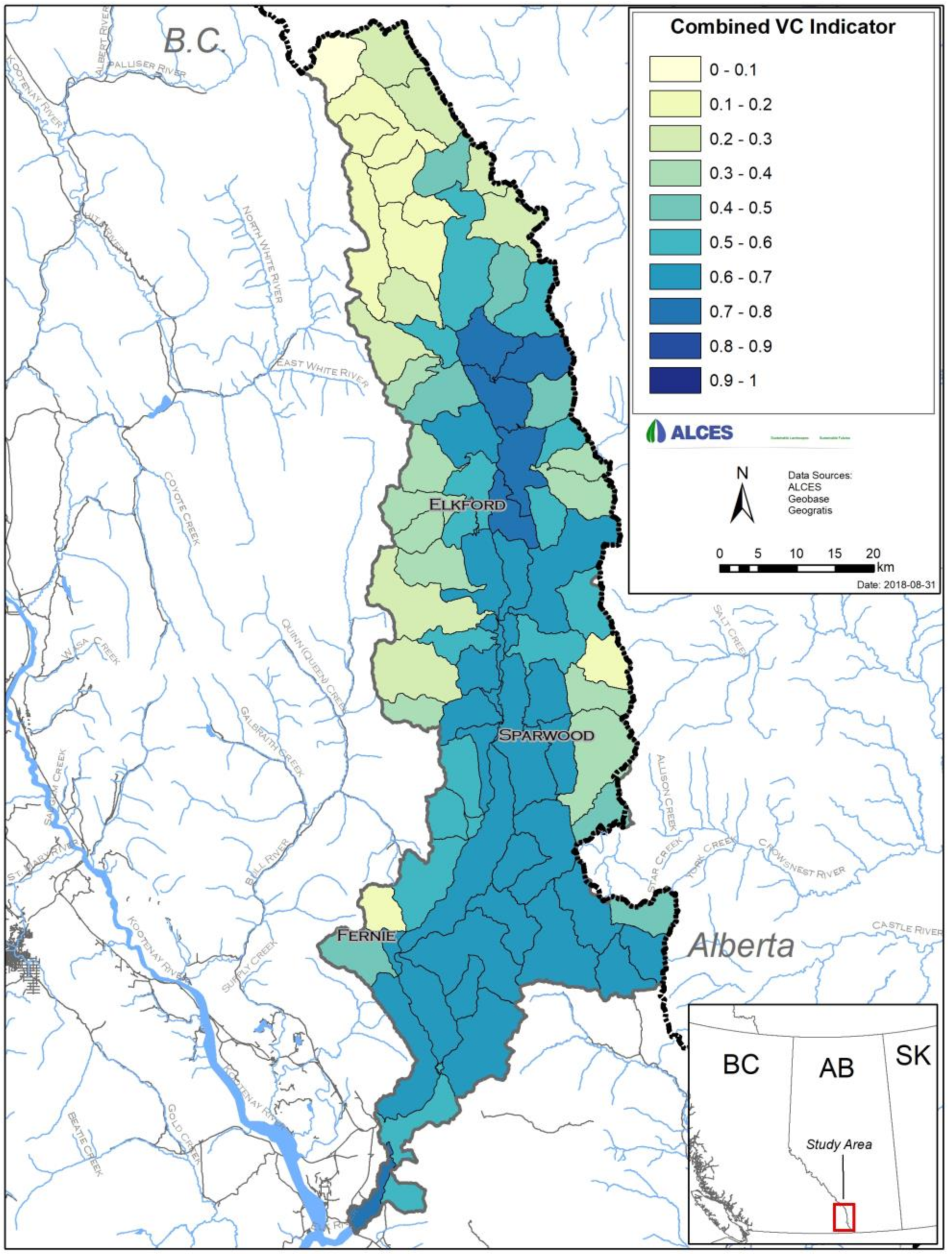

Figure 28. A combined indicator of all VCs for 78 AWs in the Elk Valley. No thresholds of hazard are available for this combined indicator.

Not all land use was distributed equally throughout the Elk Valley, nor did each land use have the same effect on VC performance. An analysis of the correlation between combined indicator performance and land use demonstrated that overall, road development had the greatest effect on VCs at the scale of the Elk Valley (Figure 29). Timber harvest and mining had a similar effect, with built-up areas having the lowest relative effect on indicator performance (Figure 29).

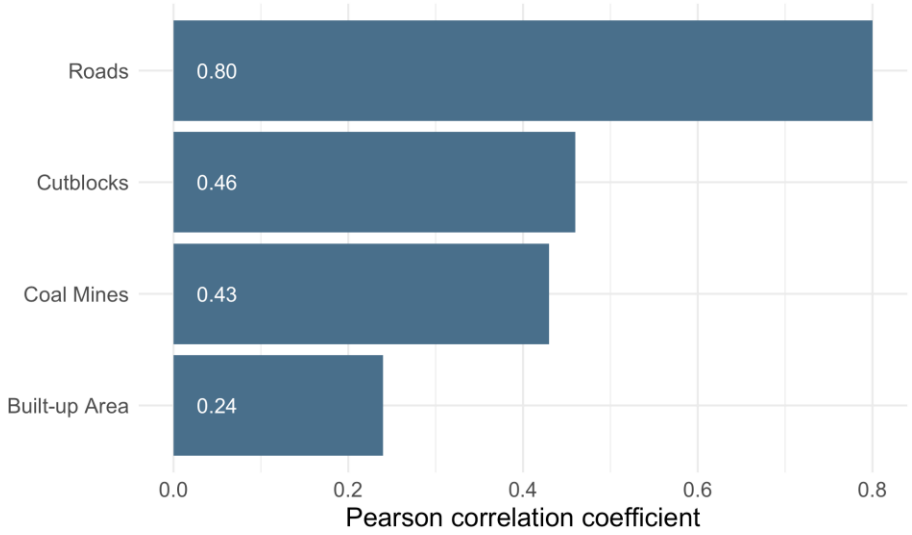

Figure 29. Pearson correlation coefficients between land use variables and combined VC indicator performance. Higher correlations infer a greater effect on indicator performance.

These results suggest that of all land use, activities that are dispersed widely throughout the Elk Valley have the greatest potential to affect multiple VCs. These results are intuitive; however, quantitative analysis can be used to support decision making in terms of developing priorities for implementing management actions. In this case, results indicate that management strategies aimed at reducing the influence of road development on VC performance should receive the most attention and would have the greatest effect on all VCs.

4.2.2 Old and Mature Forests

The Old and Mature forest VC was assessed using z-score and whether legal targets were met (Holmes et al., 2018). The analysis comparing the percentage of old forest to Kootenay Boundary Higher Level Plan Order (KBLPHO) targets showed that 41% (12 of 29) BGC/LUs (> 10 ha) did not have enough old forest present within them to meet legal targets for old forest. This lack of old forest mostly occurs in the mid-valley and the wet ESSF units. Six of eight MS units, one of two ICH units, three of six ESSFwm units, but only 4 out of 15 ESSFdk units lacked enough old forest on the CFLB to meet KBHLPO objectives. In addition, analyses using mapped Old Growth Management Areas (OGMAs) showed that deficits in OGMAs compared to legal targets were still present in the same number of BGC/LU units (12 of 29). However, half of the OGMA deficits were very small (< 0.5% of the target) and in the LUs in which they occurred, there were generally surpluses in other BGC units in the same LU which made up the deficit amount over the total LU (Holmes et al., 2018).

In terms of z-score, lower values indicate higher deviations from the amount expected under the Range of Natural Variation (RoNV). Z-scores currently range from -3 (high hazard) to +1 (very low hazard), depending on the location in the Elk Valley. The majority (60% of units assessed) of the Old forests fall under high to very high hazard, suggesting that expected targets based on the RoNV are not being met (Figure 30). Old forest in the ESSFwm1 and ESSFwmw subzone/variants in Landscape Unit (LU) C23 are rated very low hazard whereas the

ESSFdk2 in LU C21, and ESSFdkw and MSdk in LU C38 fall under very high hazard. In contrast, the combined analysis of Old and Mature forests, representing hazard to mature forest and recruitment potential, showed varying hazard ratings that were generally lower than old forest hazard (with 21% in high to very high hazard). The concentration of timber harvest at lower elevation within the CFLB has resulted in younger forest and, therefore, lower z-scores and a medium to high hazard to biodiversity. Conversely, BGC subzones/variants that are located at higher elevations currently have higher z-scores and lower hazard to biodiversity (Figure 30).

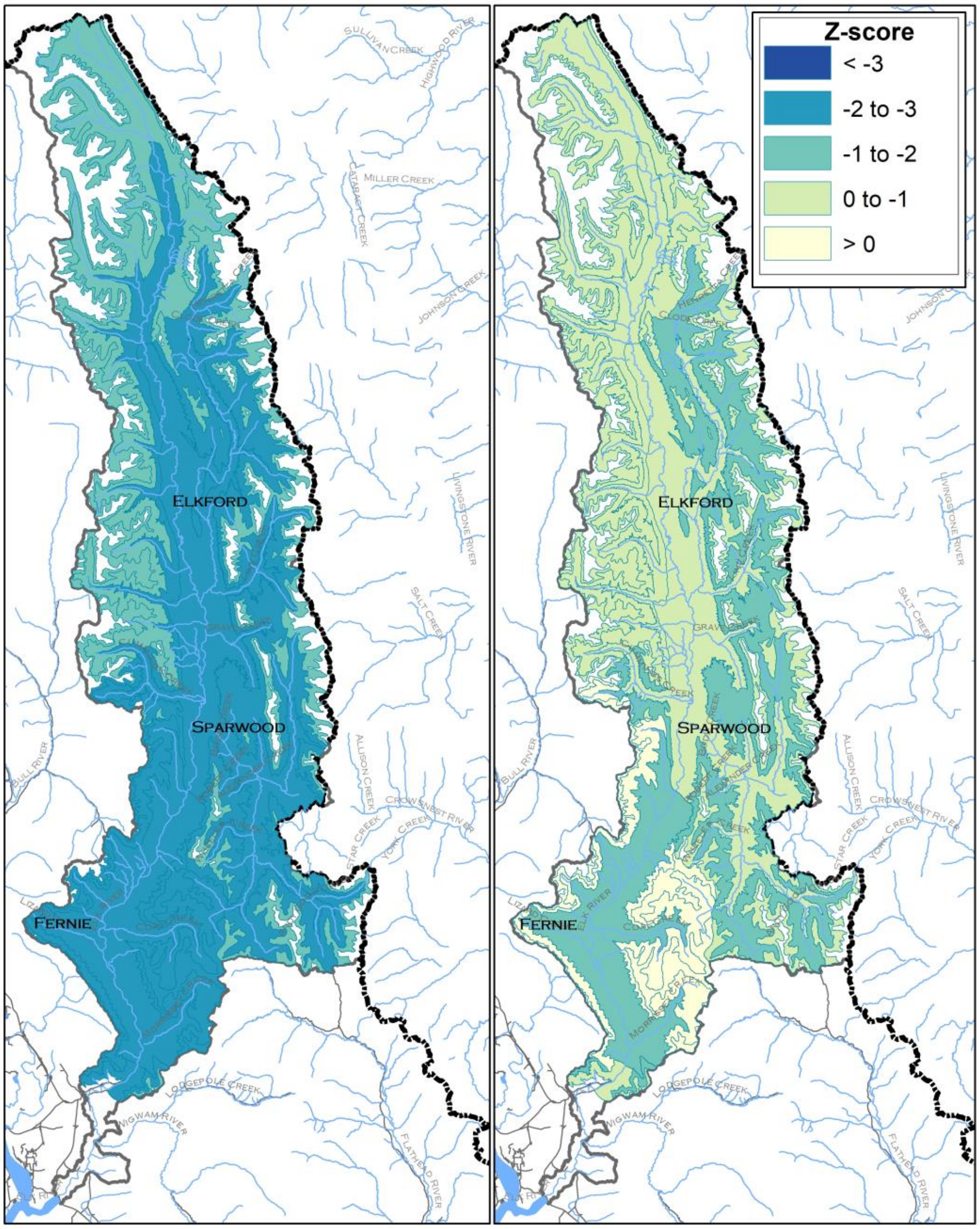

Figure 30. Z-score values for Old growth (left) and Mature forests (right) by BGC subzone/variant across the Elk Valley.

4.2.3 Aquatic Ecosystems

Aquatic ecosystems were assessed using a range of indicators, representing a range of hazard types (Figure 31) for riparian habitat and WCT. The full details of the aquatic ecosystem analysis can be found in Davidson et al., 2018. Across the entire study area, 82% of the AWs were categorized as high hazard for riparian disturbance, 85% had high stream crossing hazard, 91% had high hazard for road density near streams, 38% had high hazard for road density on steep slopes, and 14% had high Equivalent Clearcut Area (ECA) (Figure 31). These impacts to aquatic ecosystems are greatest in the central and southern portion of the study area where road density, timber harvest, and other forms of development are highest (Figure 32).

In addition to land use indicators, estimates of the average warmest month stream temperature were made currently well within the suitable range for WCT, with an average of 6.2 °C across all streams. High hazard of hybridization is currently limited to three AWs that are located near sources of Rainbow Trout.

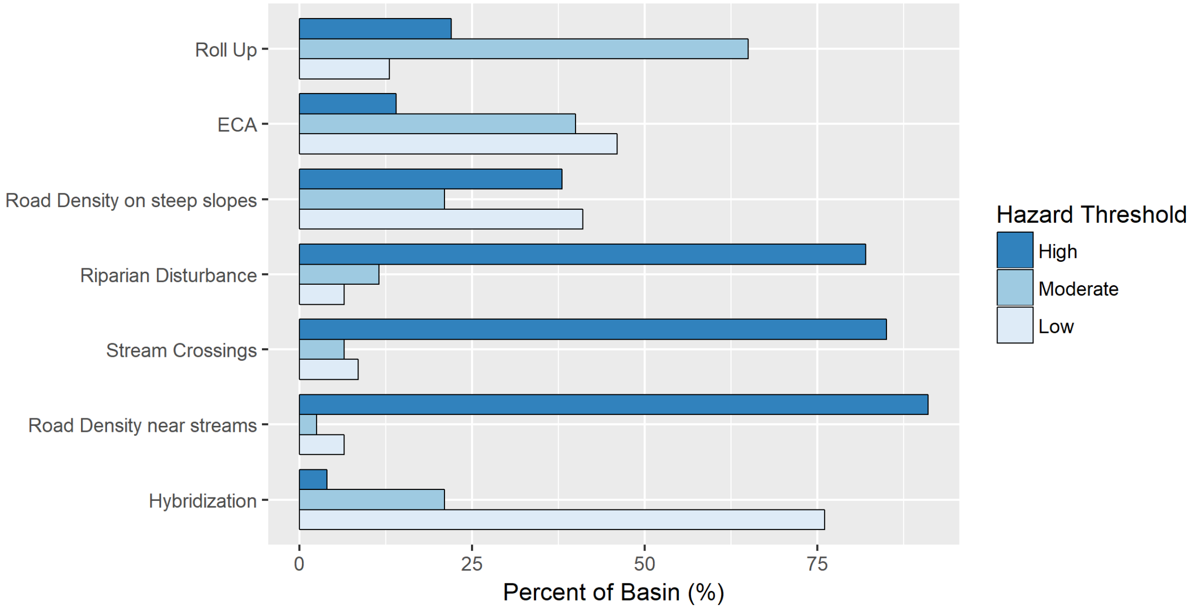

Figure 31. Percent of study area by hazard level for individual indicators contributing to the hazard roll-up as well as hybridization.

Based on the indicator roll-up, the majority (65%) of AWs are assessed as being at moderate hazard, while 13% are at low hazard and 22% are at high hazard (Figure 32). Mining disturbance resulted in the highest hazard to aquatic ecosystems at the scale of the AW, evidenced by Lake Mountain and Clode creeks having the highest hazard values. Stream crossings and road density near streams contributed the greatest hazard to aquatic systems at the scale of the Elk Valley, with the clear majority of the study area categorized as high hazard. The influence of roads (e.g., stream crossings and road density) on aquatic roll-up hazard is reflected by the elevated hazard in the southern and central portion of the study area where road density is greatest. In contrast, low hazard AWs areas are almost exclusively located in the protected northern portion of the study area.

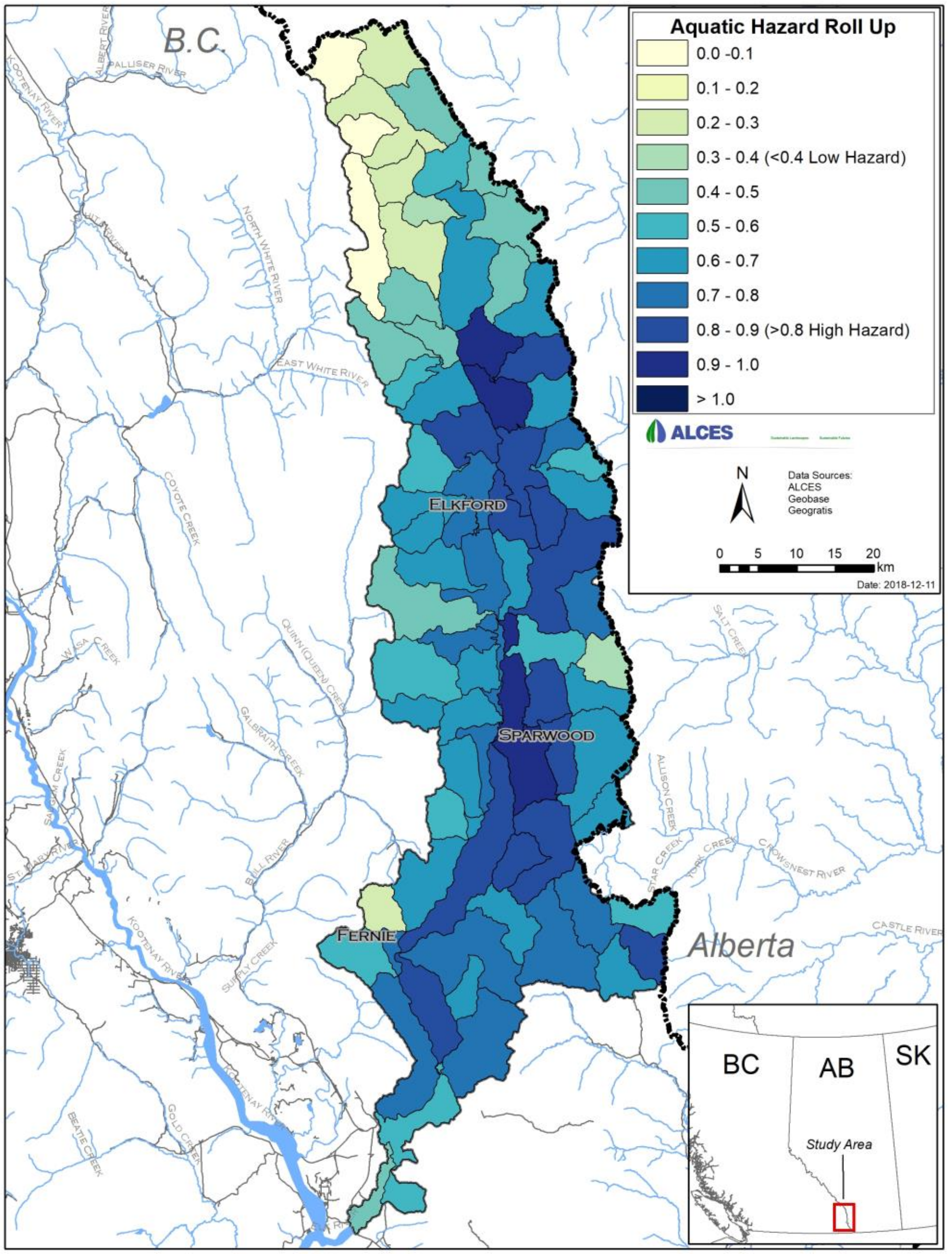

Figure 32. A roll-up of 5 pressure indicators of aquatic ecosystems hazard for 78 AWs in the Elk Valley. The roll-up classified a low rating where the normalized score fell below 0.4 and a high rating where the normalized score goes above 0.8.

4.2.4 Bighorn Sheep

The current area of ranked winter range habitat (Figure 33 and Figure 34) was summarized by subpopulation and compared with historic conditions from 1950. The full details of the bighorn sheep analysis can be found in Poole et al. 2018. The Fording subpopulation exhibits the highest winter range hazard, followed by Ewin Creek, Elk Valley West Hornaday, and Erickson Sheep Mt. The greatest decline in winter range habitat relative to 1950 occurred in the Elk Valley East populations and was associated with coal development between the early 1980s and 2000s as well as habitat degradation. Mining activities within the Fording subpopulation range resulted in removal of high-value native annual and winter ranges on Eagle Mountain, with no sheep observed after 1987 and the first use of the Greenhills area by sheep detected in 1986 (D. Martin and D. Ryder, FLNRORD, pers. comm.). These habitats were replaced in some cases by reclaimed mine areas, some of which were used by wintering sheep in some years. Removal of Eagle Mountain during the 1980s likely had the greatest impact on sheep winter range within the study area; more limited changes have occurred in recent years. Also contributing to the loss of habitat is overgrazing by domestic livestock and by other ungulates.

Rank 3 and 2 habitats are the most prevalent types within both winter and annual ranges, and have remained stable or exhibited minor growth relative to 1950. Rank 1 habitat is also stable (Figure 33 and Figure 34). Rank 4 (i.e., high quality) habitat has declined substantially, with the change focused on the Erickson, Ewin, and Fording sub-populations (Figure 33 and Figure 34). Percent loss of Rank 4 habitats for Erickson-Sheep Mt. (-8.5%), Ewin Ck. (-41%) and Fording (-36%) subpopulations was tempered by increases in area of Rank 3 habitat due to mine reclamation, resulting in percent change in combined Rank 3 and 4 habitat of +24%, -12% and -19%, respectively. These declines in Ranks 3 and 4 winter range habitats relative to historic conditions place the Ewin Ck. subpopulation at moderate hazard, and the Fording subpopulation at very high hazard (Figure 33 and Figure 34). Little to no change in habitat occurred in the Elk Valley West population, primarily because of a lack of resource development.

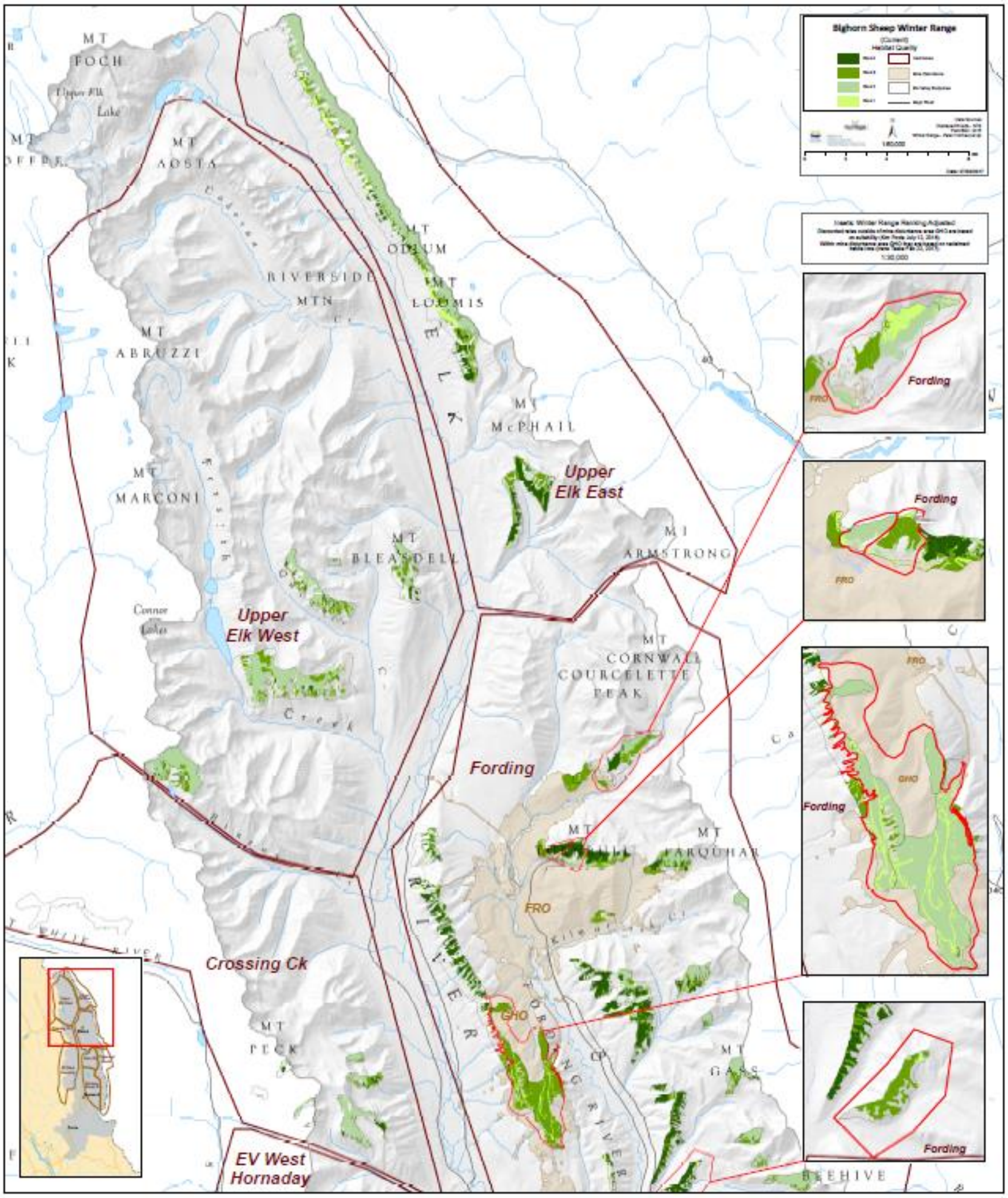

Figure 33. Bighorn Sheep winter range in the northern Elk Valley ranked by habitat quality based on Predictive Ecosystem Mapping (PEM) site series data (2015). The insets show applied winter range condition qualifier discounts.

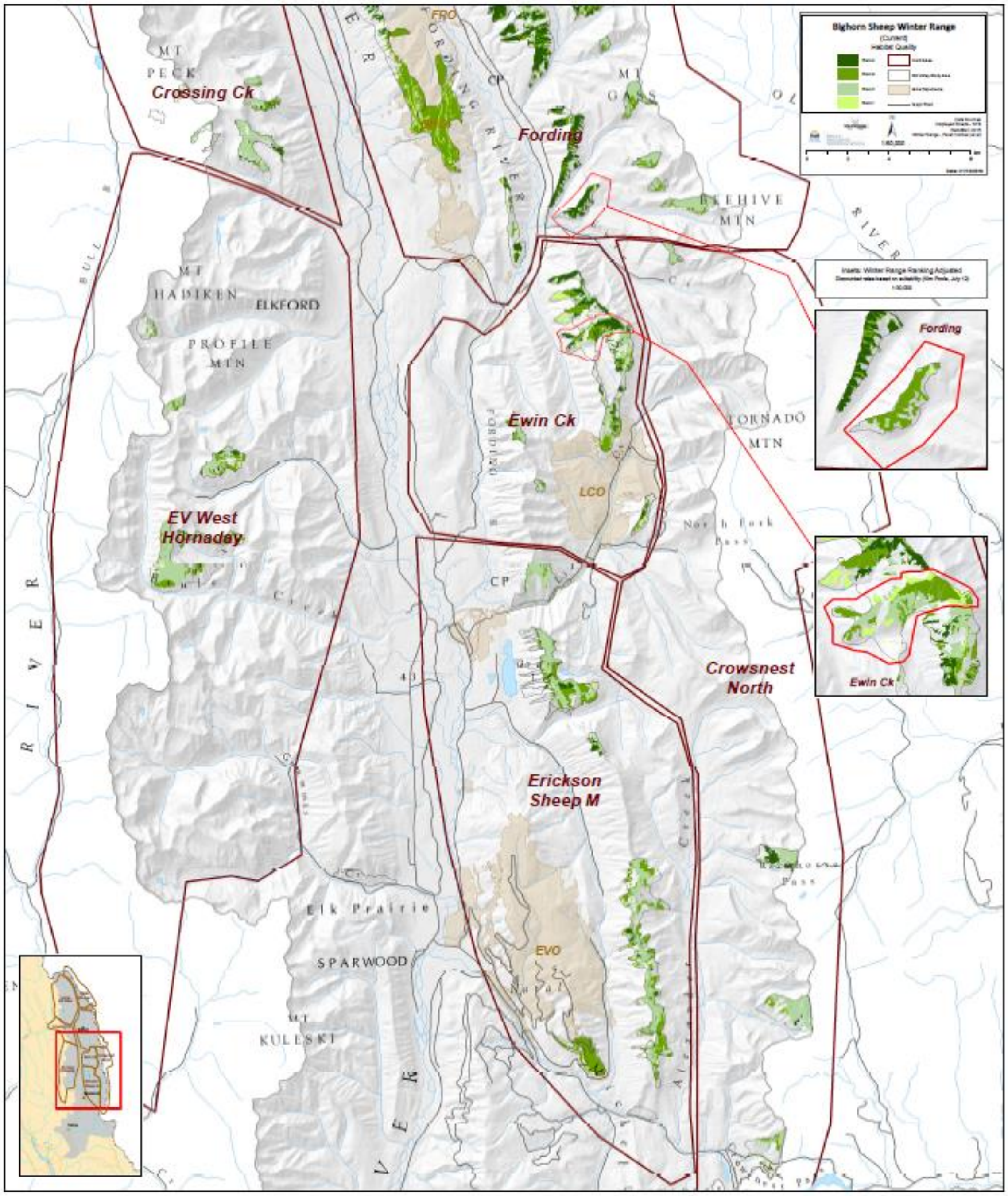

Figure 34. Bighorn Sheep winter range in the southern Elk Valley ranked by habitat quality based on Predictive Ecosystem Mapping (PEM) site series data (2015). The insets show applied winter range condition qualifier discounts.

4.2.5 Grizzly Bear

Three measures of Grizzly bear habitat were assessed: habitat availability, which reflects habitat value (0 to 1) without taking into consideration the impact of roads and built-up areas; habitat suitability, which combines habitat availability with the impact of roads and built-up areas; and a hazard index which is calculated as the inverse of the suitability. The full details of the Grizzly bear analysis can be found in Mowat et al., 2018. Habitat availability varies substantially across the study area, ranging from 0 to 1 with an average value of 0.31 (Figure 35). The dominant driver of high-quality habitat is young forest with open canopy that supports berries. Alpine, avalanche, and riparian areas have a smaller influence due to their limited distribution. Habitat suitability is substantially lower than habitat availability due to the effect of roads (Figure 35).

The impact of roads is greatest where high road density is combined with high habitat availability, as is the case in the central portion of the study area. Road density is substantially lower in the protected northern portion of the study area and other mountainous AWs along the study area's perimeter. Habitat suitability reaches its maximum and hazard reaches its minimum in AWs with low road density and substantial open canopy forest (e.g., Lower Alexander Creek, Dry Creek) or high-quality alpine habitat (e.g., Fairy Creek); the maximum habitat suitability value for an assessment watershed is 1.

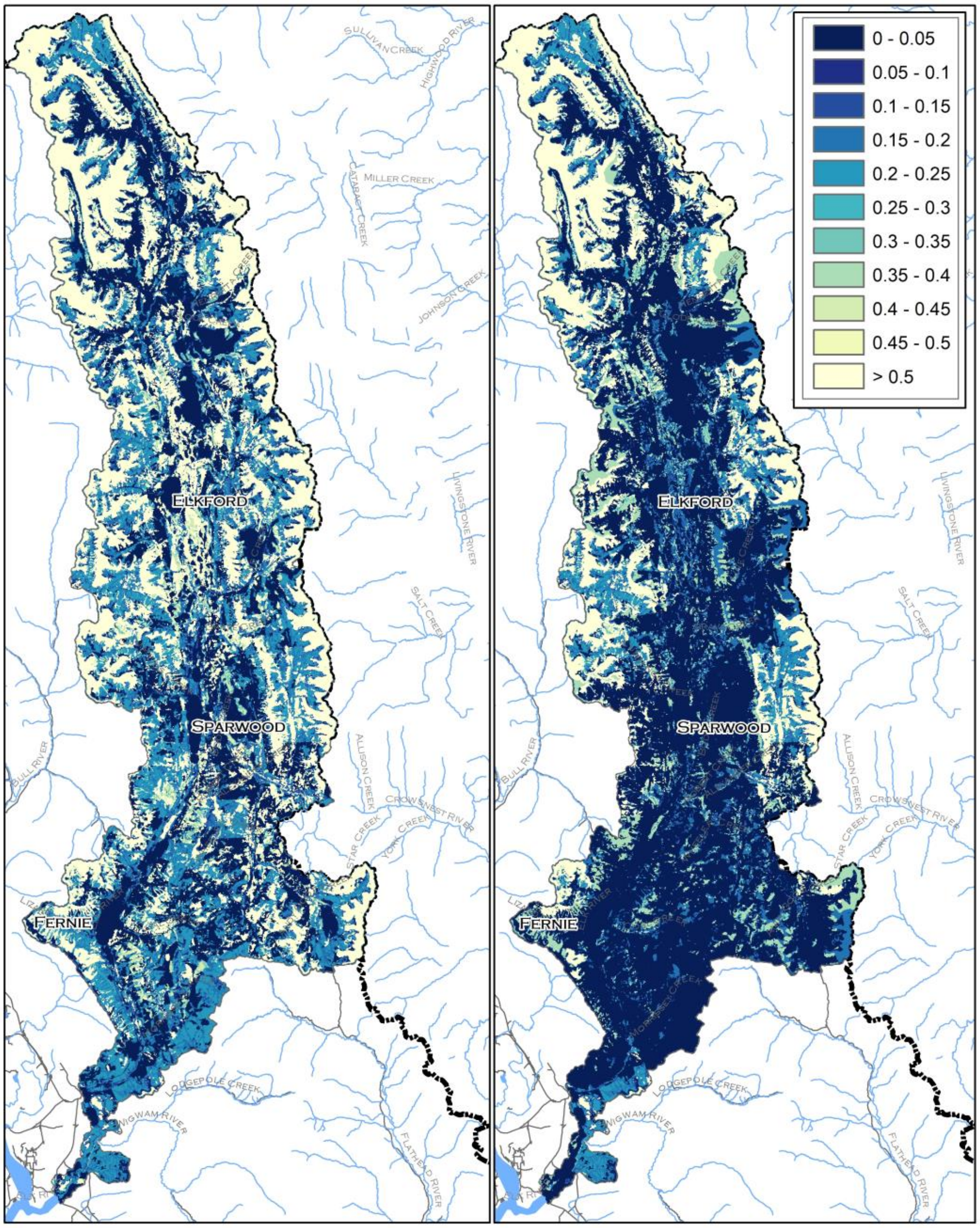

Figure 35. Grizzly Bear habitat availability (left) and suitability (right) in 2015. Higher values (lighter colours) indicate higher availability or suitability.

The high density of roads, combined with the patchy distribution of high-quality habitat, results in high hazard across most of the central and southern portion of the study area (Figure 36). High hazard is consistent with the provincial Grizzly Bear assessment which identifies southern (C19, C24) and central (C20, C21, C38) landscape units as exceeding 5 out of 6 benchmarks that are intended to identify where cumulative effects may be acting on Grizzly Bears. The provincial analysis is also consistent with the pattern of lower Grizzly Bear hazard in the northern portion of the study area where road density is lowest.

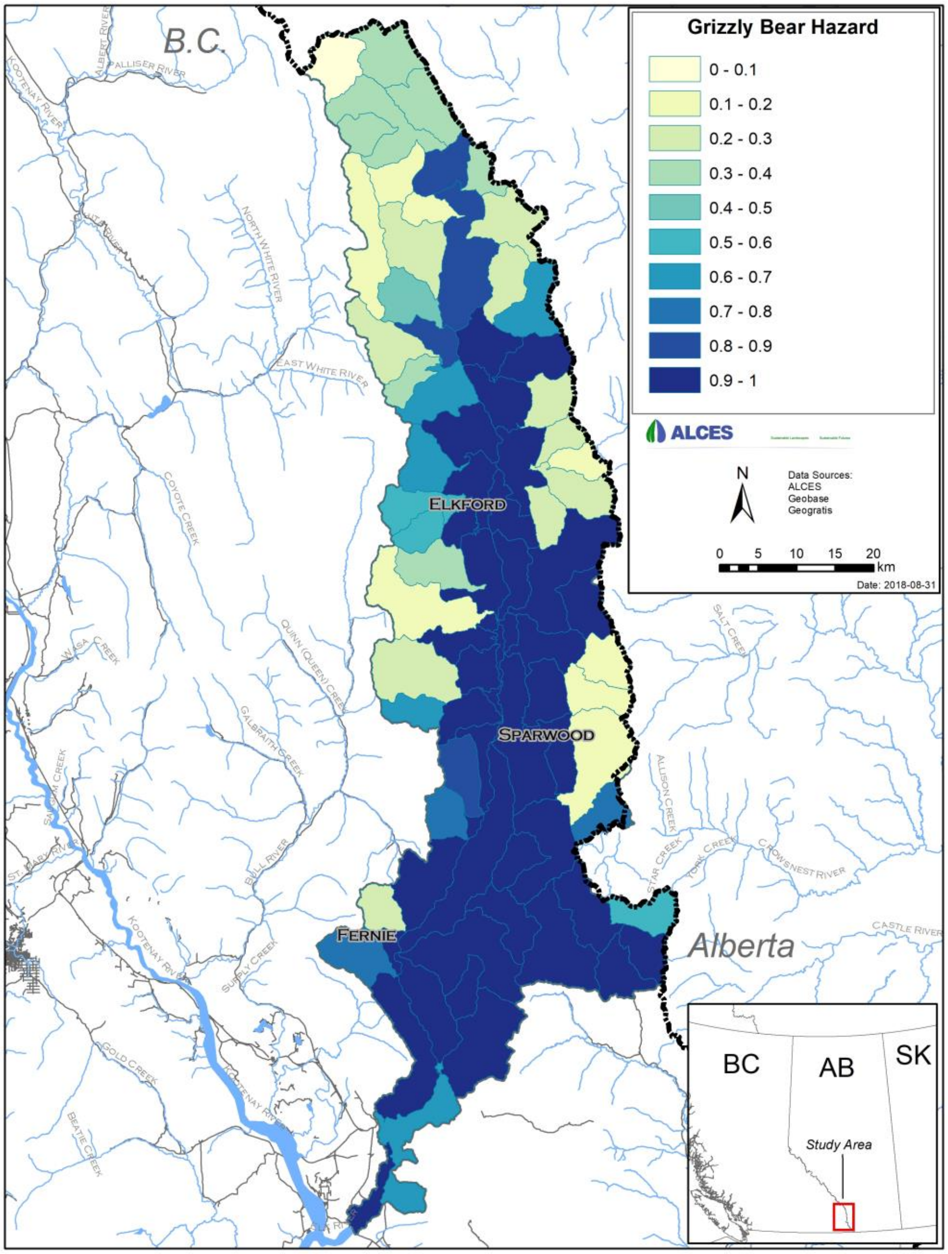

Figure 36. Grizzly Bear hazard in 2015. Higher values (darker colours) indicate higher hazard.

4.3 Potential Future Conditions

4.3.1 Combined Valued Component Analysis

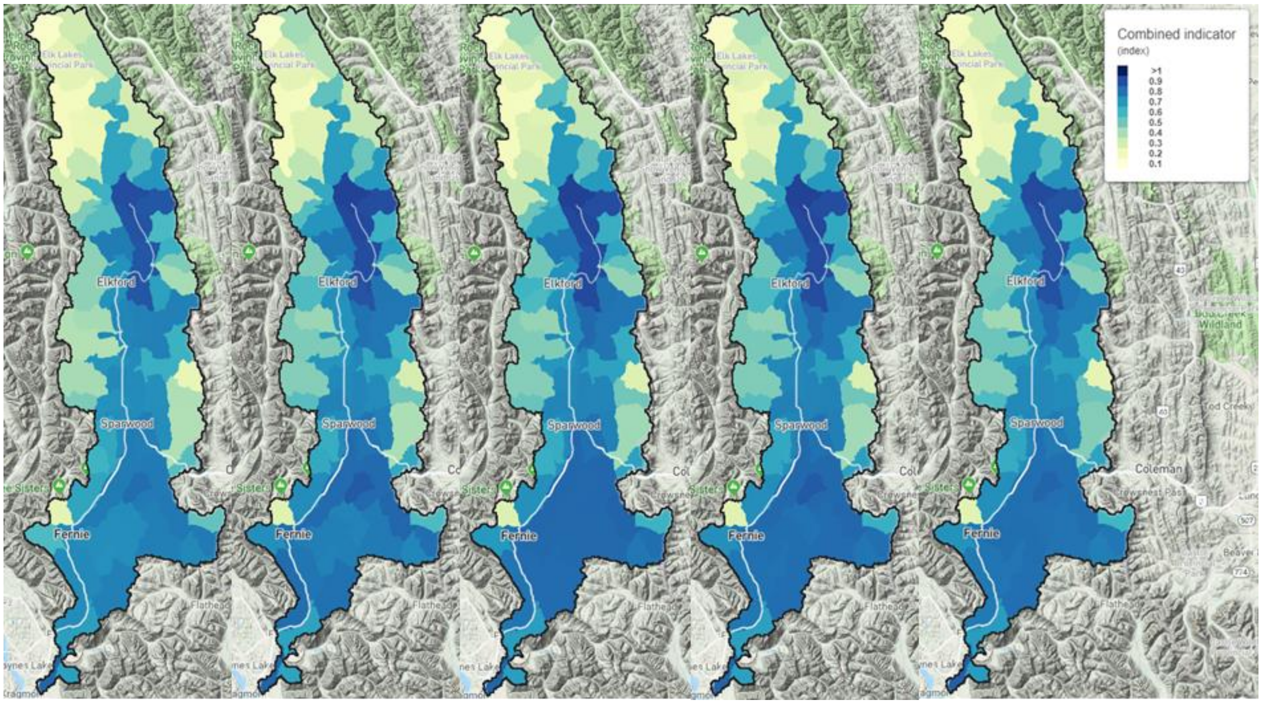

Figure 37. Combined VC indicators hazard in 2015 and in 2065 under the Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios (from left to right).

Similar to the current condition, it was determined that the highest combined hazard at the scale of the AW is likely to continue to be from mining disturbance north east of Elkford. At the scale of the Elk Valley, however, the highest disturbance is expected to occur along the valley bottom and on private managed forest land (Figure 37). At the end of the reference simulation, 52 (67%) of AWs measured above 0.5 for hazard for the combined VC indicator, while 26 AWs were below 0.5, with only one of these below 0.1 (Figure 37). Number of AWs measuring above 0.5 at the end of the Minimum, Maximum, and Higher Natural Disturbance scenarios were 50, 53, and 53, respectively (Figure 37). No hazard thresholds are available for this indicator. Interestingly, unlike individual VC analysis, the Higher Natural Disturbance Scenario did not stand out as having the largest overall effect. This is due to the conflicting effects of individual indicators on VC performance, where young forest was included as a positive factor for grizzly bear, but as a negative factor for old forest. Therefore, the combined analysis helps to highlight the effect of land use, and in general, land use was viewed as having a negative influence on VC condition.

4.3.2 Old and Mature Forests

Average z-scores for old forests and mature forests increased (closer to the range of natural variability) during all decades of the simulation under the Reference, Minimum, and Maximum future development scenarios (Figure 38). This increase in z-score was due to an increase in overall forest age outside of the THLB, including maturation of forests that were affected by the large fires that occurred in the 1930's. The Higher Natural Disturbance Scenario resulted in continued low z-scores or higher hazard (Figure 38). At the scale of the Elk Valley, it can be concluded that in the presence of continued low natural disturbance rates related to fire suppression, the expected timber harvest rate is unlikely to cause a significant decline in Mature and Old forest over time. However, a return to pre-suppression natural disturbance rates combined with timber harvest would cause a decline in Mature forest, resulting in moderate hazard at the end of the simulation. In addition, it is important to note that the 50-year simulation period is relatively short when assessing Old and Mature forest response given the length of time required to recruit into these age classes. The resilience of Old and Mature forest to the land use scenarios is in part due to a legacy effect of past fires on forest age, whereby, continued aging of those areas can offset the loss of mature and old forest from timber harvest.

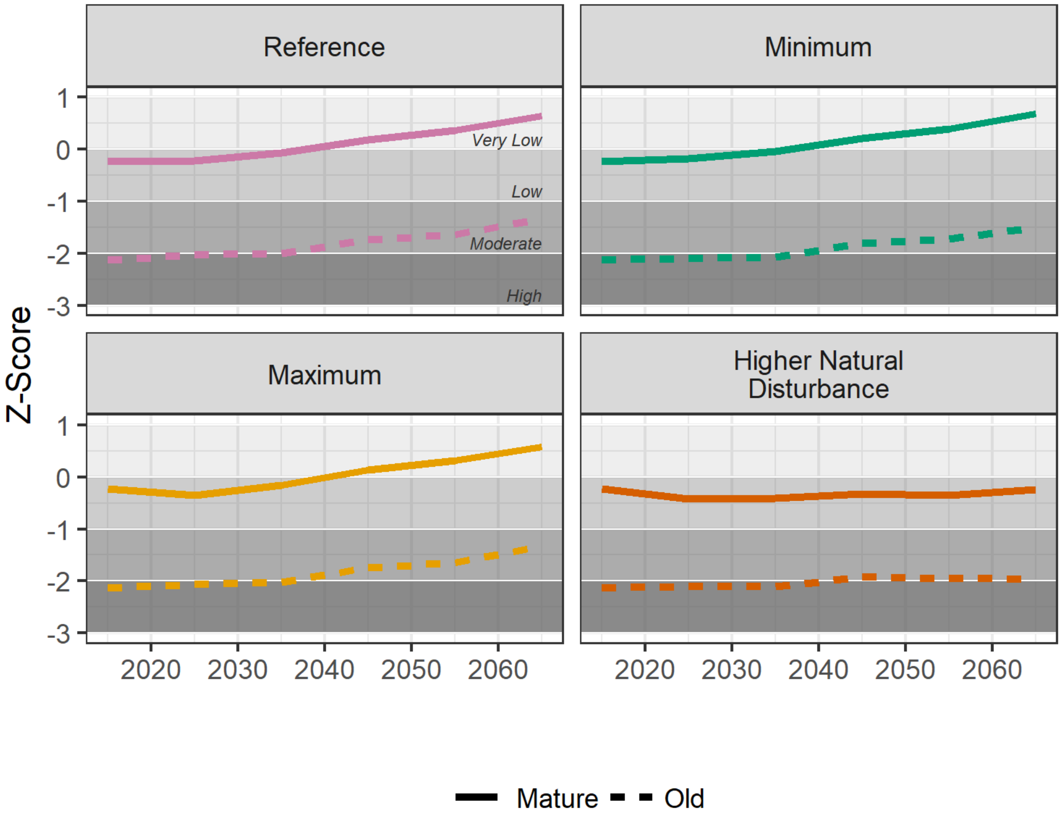

Figure 38. Simulated temporal trend in mature forest (solid) and old forest (dashed) hazard averaged over the study area under the Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios.

When assessed at the scale of the BGC subzone/variant, it is evident that some zones may be more sensitive to natural disturbance than others, particularly at higher elevation like ESSFdk1 and ESSFdk2. Furthermore, mature forest hazard at the scale of private lands is drastically higher relative to hazard on public lands. This result emphasizes the importance of effective forestry management on private lands (Figure 39).

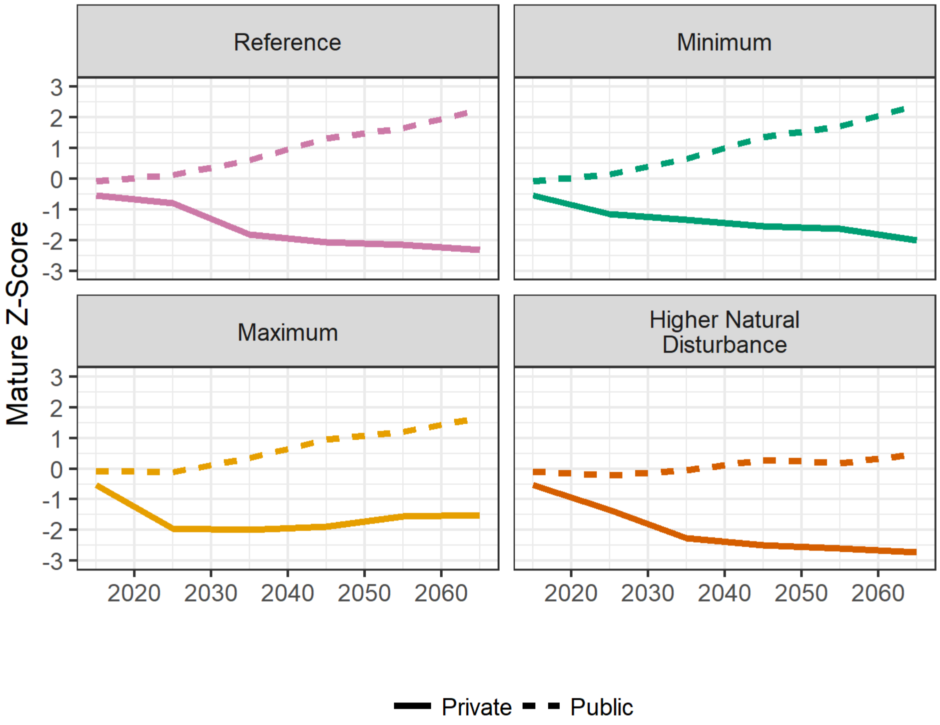

Figure 39. Mature forest hazard on private lands compared to crown (public) lands under Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios over the 50-year simulation timeframe.

In summary, the amount of old forest and to a lesser extent mature forest in the Elk Valley are well below historic amounts. Although younger stands are present that have the potential to recruit into the mature age class and increase the mature patch size within 50 years, this potential depends on the rate of wildfire and insect pest outbreaks. Old forest will still be deficient after 50 years due to the length of time it takes to recruit stands into this age class.

Mitigation scenarios were also evaluated, using the Higher Natural Disturbance Scenario as the base case. The description of mitigation scenarios can be found in the methods document (FLNRORD, 2018). The application of Moderate and Intensive mitigation scenarios resulted in a slightly lower hazard for both Old forests and for Mature forests in all BGC units assessed. Largest effects were seen for both Old and Mature in the ICHmk4 and ESSFwm1 BGC units.

Although higher rates of natural disturbance had a larger effect on Old and Mature forests, mitigation was shown to reduce hazard ratings and potentially decrease risk to biodiversity.

Scenario analysis also enables an evaluation of the effectiveness of mitigation strategies spatially, where differences in Old forest z-score performance between no mitigation and implementing intensive mitigation can be evaluated. Results of this analysis suggest the greatest effect of mitigation could be achieved on private managed forest lands in the lower Elk Valley and the eastern portion of the Elk Valley (Figure 40).

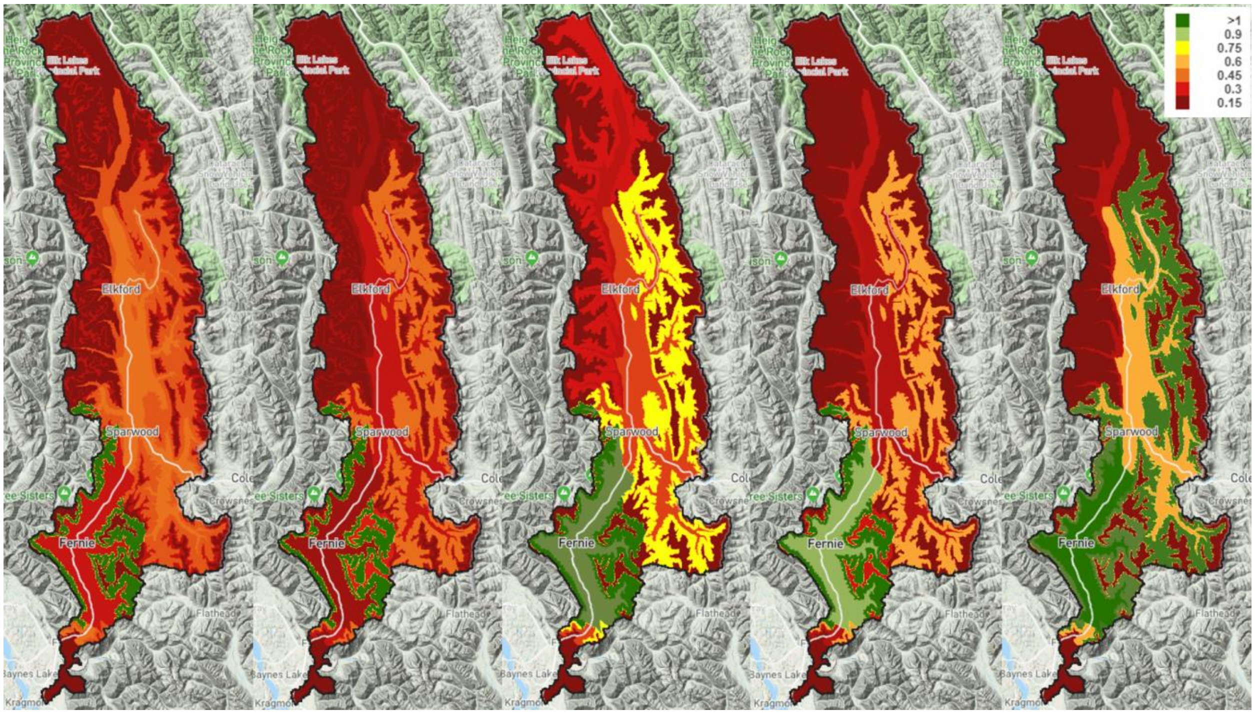

Figure 40. Effect of mitigation on old forest hazard at the scale of BGC zones for each future decade (2025, 2035, 2045, 2055, 2065), as assessed by a mitigation effectiveness index. Higher values (green) indicate greater improvement.

4.3.3 Aquatic Ecosystems

Aquatic hazard was relatively stable in the prospective analysis (Figure 41). The Higher Natural Disturbance Scenario resulted in the highest level of hazard by the end of the 50-year simulation. In terms of anthropogenic disturbance, roads remained the dominant Elk Valley-scale stressor due to the high hazard created by road and crossing densities. This is important given that studies have shown significant negative effects of road densities on WCT abundance, particularly roads near streams (Valdal and Quinn, 2011).

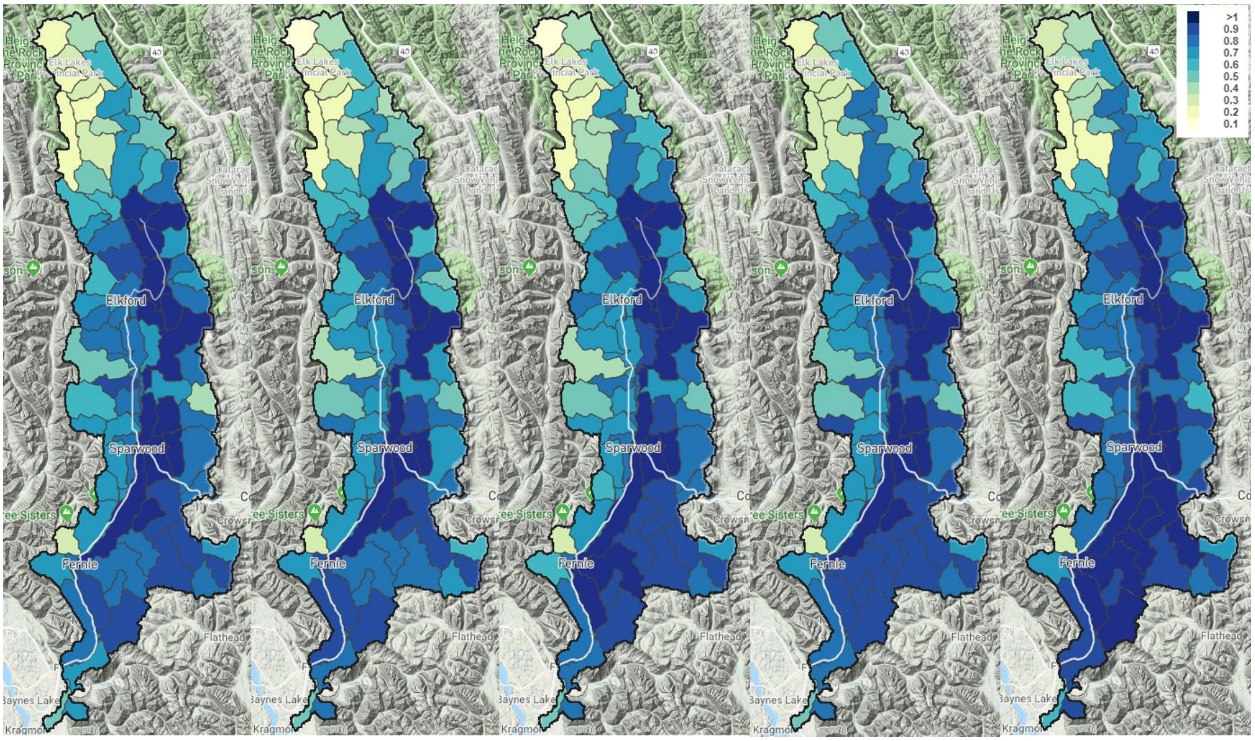

Figure 41. Roll up hazard today (left) and after five decades under the Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios (from left to right). Hazard is calculated as a roll-up of 5 indicators for 78 AWs in the Elk Valley. The roll-up classified a low rating where the score fell below 0.4 and a high rating where the score fell above 0.8.

The actual and simulated road network expansion was focused in the valley bottom and south and east of Fernie (Figure 42) and caused elevated hazard to aquatic ecosystems in associated AWs (Figure 41). Individual AWs located on private managed forest lands are likely to experience the greatest increases in road development. For example, Coal Creek, Marten Creek, and Matheson Creek were simulated to have 65%, 46%, and 36% more roads in the Reference Scenario, respectively. This is contrasted by the study area-wide average of a 10% increase.

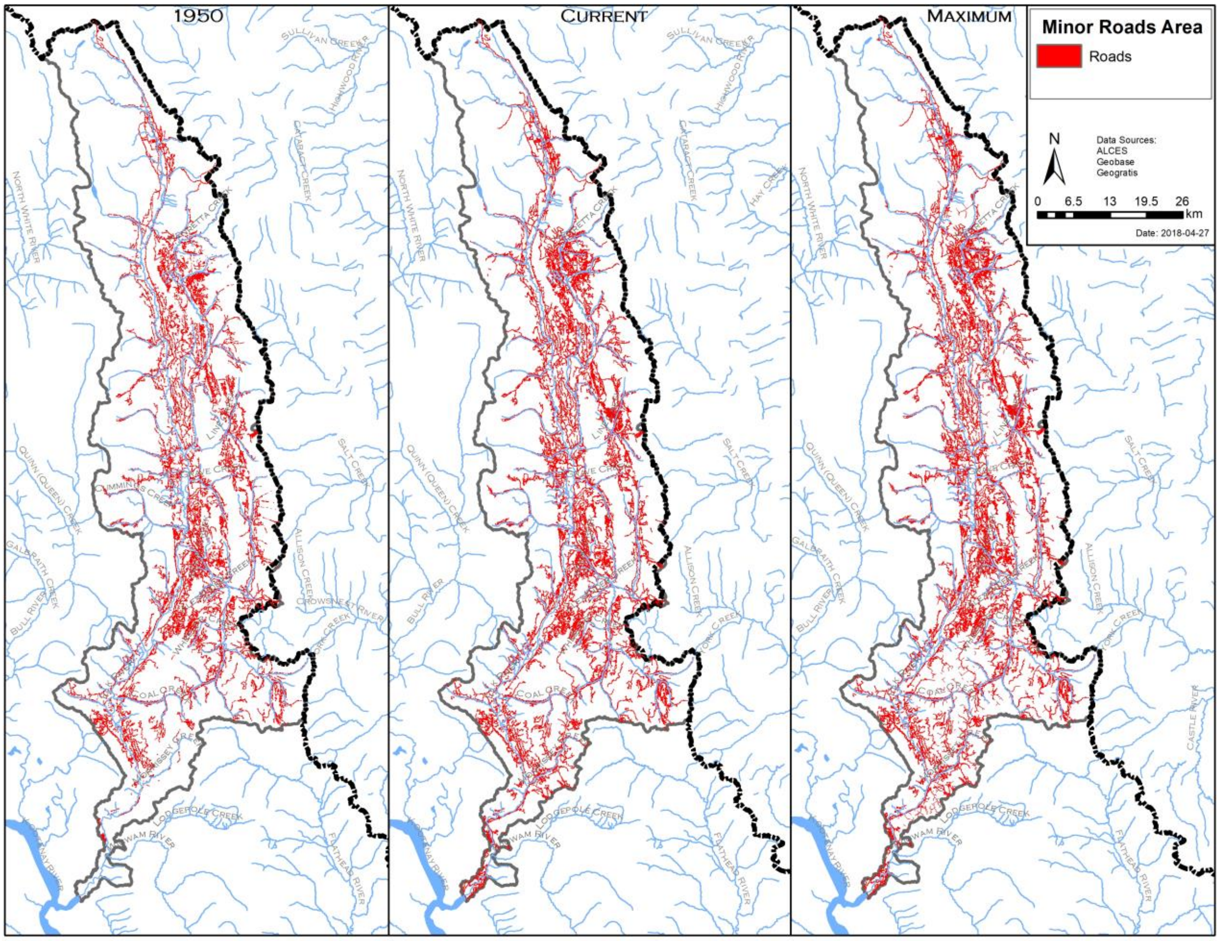

Figure 42. Road development in the Elk Valley in 1950 (left), 2015 (middle), and 2065 under the Maximum Scenario (right).

The mitigation scenarios that were simulated aimed to reduce stream crossings and road densities across the study area, and implemented measures to reduce ECA in sensitive watersheds, without changing allowable annual cut. The mitigation scenarios were compared to the Higher Natural Disturbance Scenario given that this scenario had the largest effect on individual aquatic indicators. Implementing the road reduction strategies across the entire study area is likely unrealistic given that the majority of roads are located close to streams. Over 2,000 km of roads are located within 100 m of streams; this would need to be reduced to ~500 km and 200 km under moderate and intensive mitigation strategies, respectively. Therefore, targeting watersheds that are higher priority in terms of their aquatic values is integral to the implementation of mitigation actions as part of managing cumulative effects of land use on aquatic ecosystems.

Mitigation strategies were evaluated in terms of their effectiveness, where differences in aquatic hazard between no mitigation and intensive mitigation scenarios within each sub-basin were calculated. Mitigation effectiveness was highest in the southern and east-central portions of the Elk Valley (Figure 43). This highlights areas where mitigation may be most effective and where future work could be targeted.

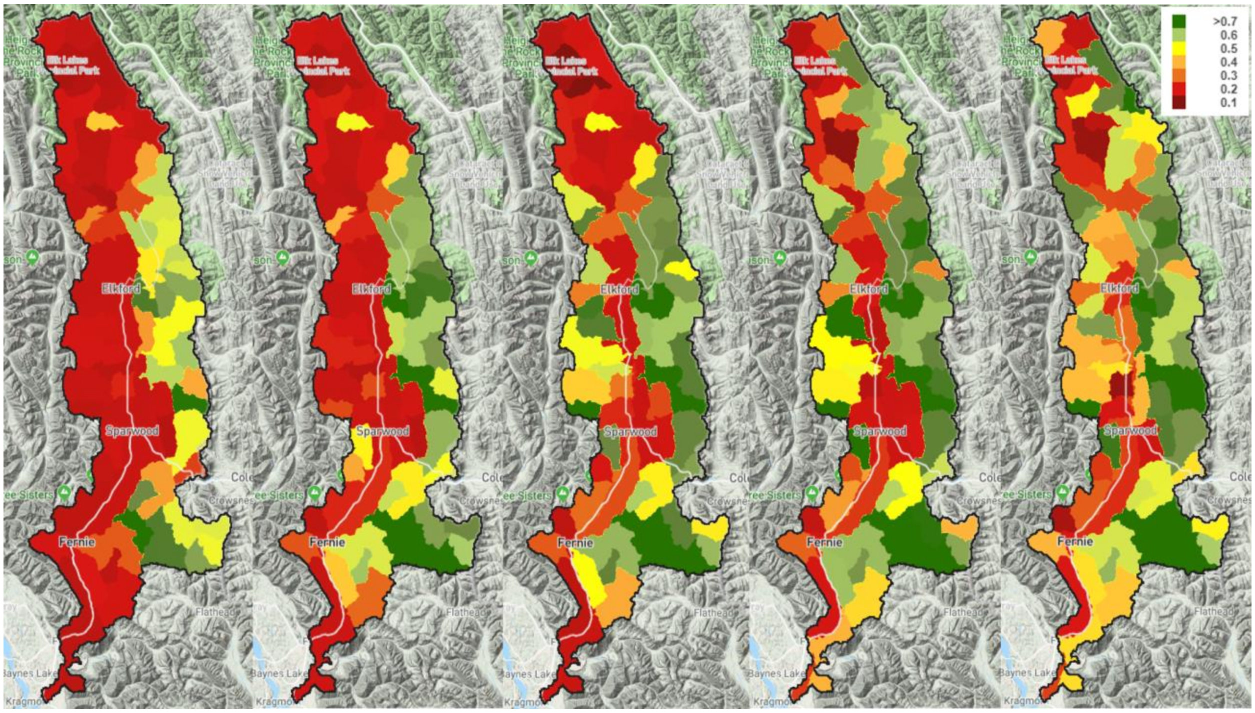

Figure 43. Mitigation effect on the roll-up score for 2025, 2035, 2045, 2055, and 2065 (from left to right). Mitigation effectiveness index ranges from 0 (red) to 1 (green), with a higher value indicating greater indicator improvement.

4.3.4 Bighorn Sheep

There was limited additional disturbance of BHS habitat during the prospective development scenarios (2%) and thus, BHS hazard did not change. However, future mining development incorporated in the scenarios was limited to the reasonably foreseeable expansions over the next three decades. This does not account for all potential development in the Elk Valley, as demonstrated by the limited extent of foreseeable mine expansion relative to mineral tenures (Figure 44). Future work should evaluate where plausible coal development could occur and implications to BHS hazard.

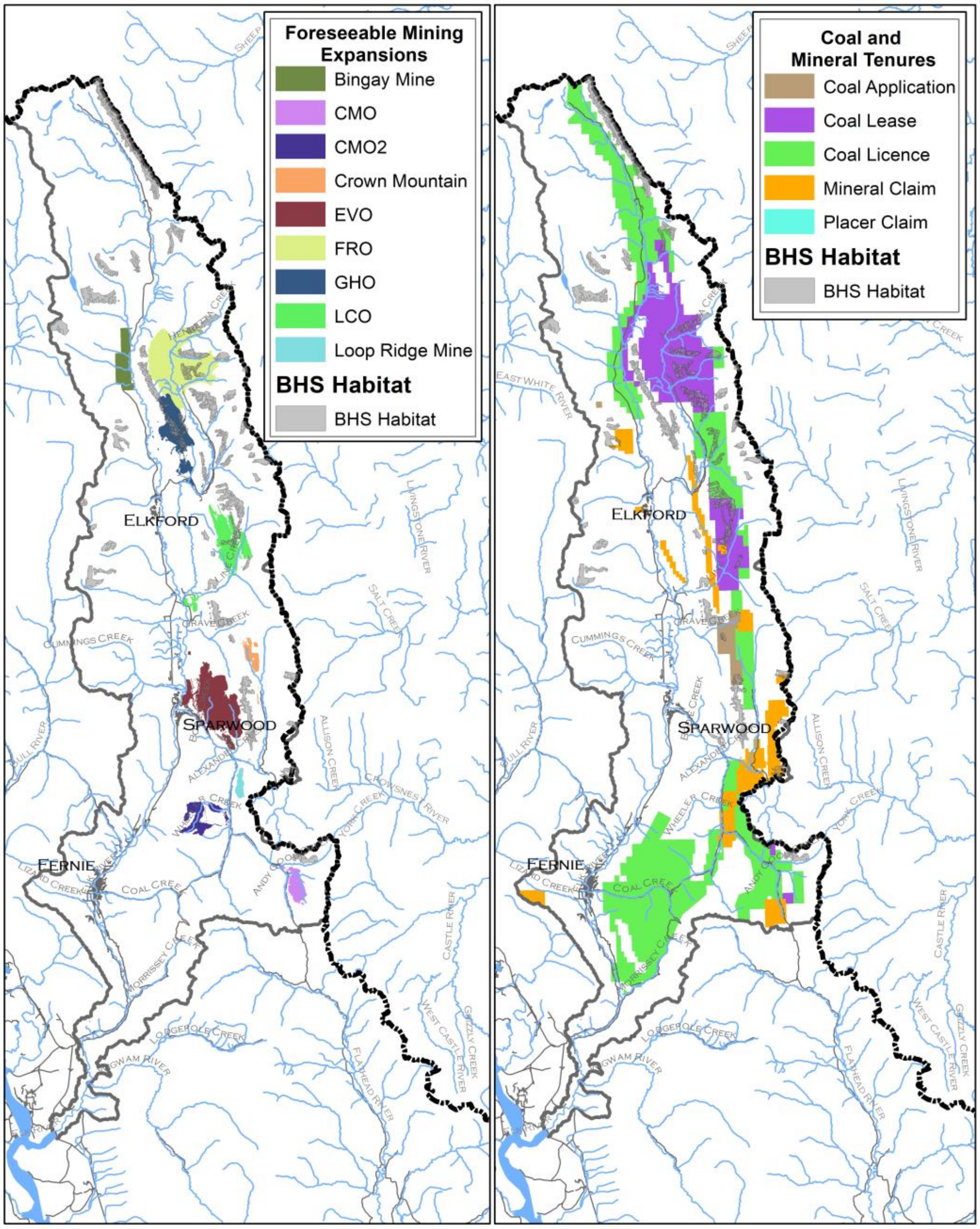

Figure 44. Foreseeable mining expansion polygons (left) and mineral tenure polygons (right).

4.3.5 Grizzly Bear

Grizzly bear hazard increased during the second and third decades of the future development scenarios (Figure 45Figure 1). This decline can be attributed to the aging of young forest, and a decline in open canopy forest capable of supporting desirable food like berries.

More influential than development rate, was the natural disturbance rate, having a positive effect on habitat suitability due to greater amounts of open canopy forest (Figure 46). The positive influence of natural disturbance on habitat suggests that prescribed burning is a mitigation strategy worthy of consideration.

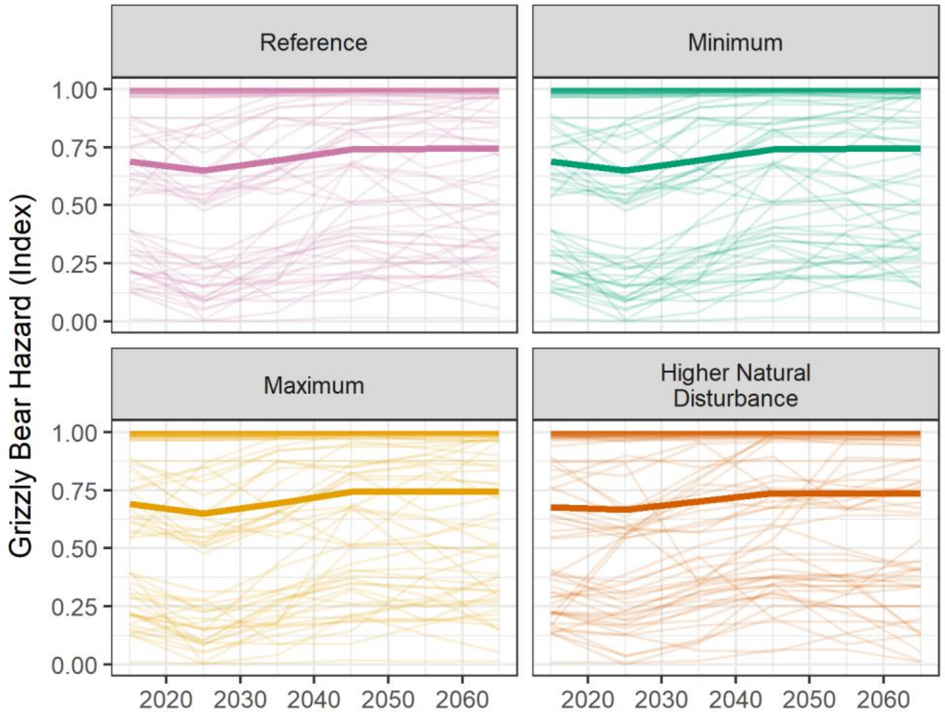

Figure 45. Response of Grizzly Bear hazard to Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios.

Of note, the simulated decline in open canopy forest in areas without high levels of harvest, especially forests at higher elevation, may be exaggerated. Open canopy forest in these areas may persist in the absence of disturbance events due to marginal conditions (climate, soils) for forest growth. To capture this dynamic, simulations assumed that forests higher than 2,200 meters or within the subalpine remained open canopy (and therefore high habitat value) regardless of their age. However, high elevation and subalpine areas only account for a small portion of the forest that is currently classified as young (i.e., does not have a history of recent disturbance). As such, the analysis may still exaggerate decline in open canopy forest during the simulation. Questions that warrant future investigation are: whether young forests are as abundant as the forest age data suggest; and whether time since disturbance is an adequate predictor of canopy closure, especially at higher elevation.

Due to the strong adverse effect of roads on habitat suitability, a road closure strategy was explored as a mitigation action. Invoking road closures for a subset of assessment watersheds is a more practical option for balancing Grizzly Bear conservation with development, compared to a study-area wide road closure program.

Furthermore, rather than simulate a single mitigation scenario that closed a subset of the study area's roads, an analysis was completed to assess the implication of a range of road closure levels to Grizzly Bear hazard. The analysis was completed by incrementally removing the effect of roads one assessment watershed at a time, starting with those watersheds that exhibit the highest hazard. As roads were closed across more and more of the study area's watersheds, incrementally more of the Grizzly Bear hazard was eliminated (Figure 47). This analysis demonstrates that closing 25% of the roads in the study area could remove approximately 40% of the hazard to grizzly bears.

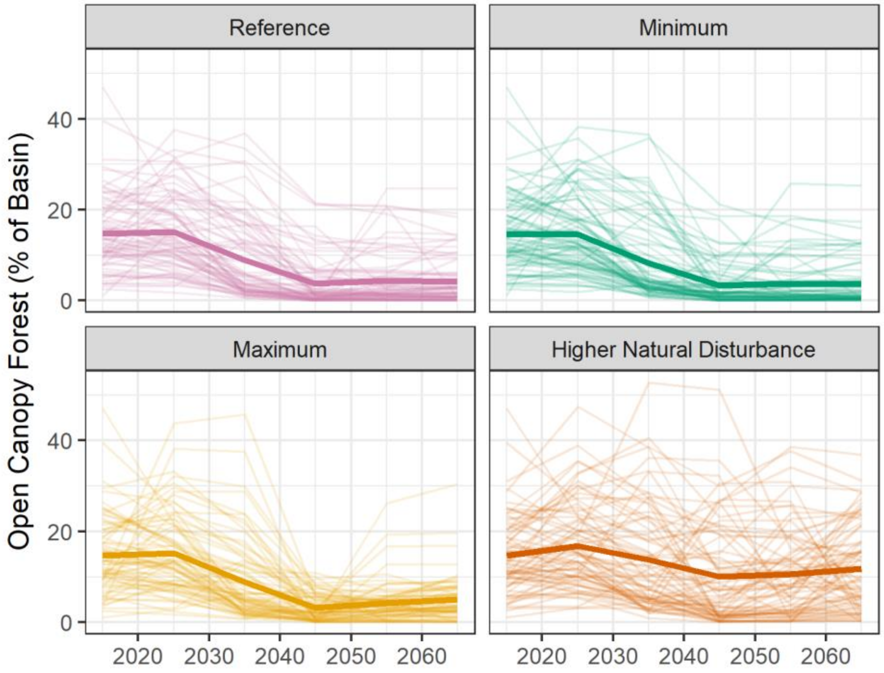

Figure 46. Response of open canopy forest to the Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios. Open canopy forest is defined as forest 20 years or younger.

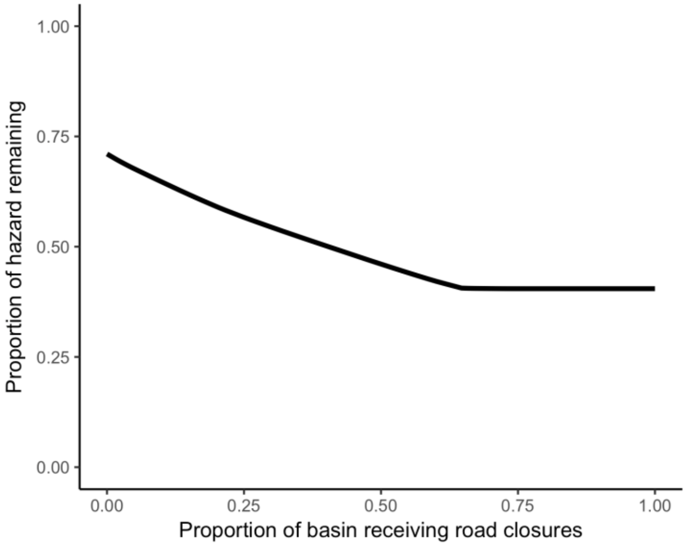

Figure 47. Proportion of hazard remaining as a function of road deactivation or closure.

The mapped Grizzly Bear mitigation effectiveness provides insight into which AWs should be prioritized for road closure (Figure 48). The high effectiveness in the central and southern portions of the study area indicates high potential to improve habitat through road closures. However, the decline in effectiveness in these watersheds at the end of the simulation indicates that road closures may be insufficient as a mitigation strategy unless combined with strategies to maintain or increase the availability of open canopy forest habitat through time. Essentially, there is much that can currently be done to reduce hazard to Grizzly Bears; however, if development practices don't substantially change going forward, hazard will still increase.

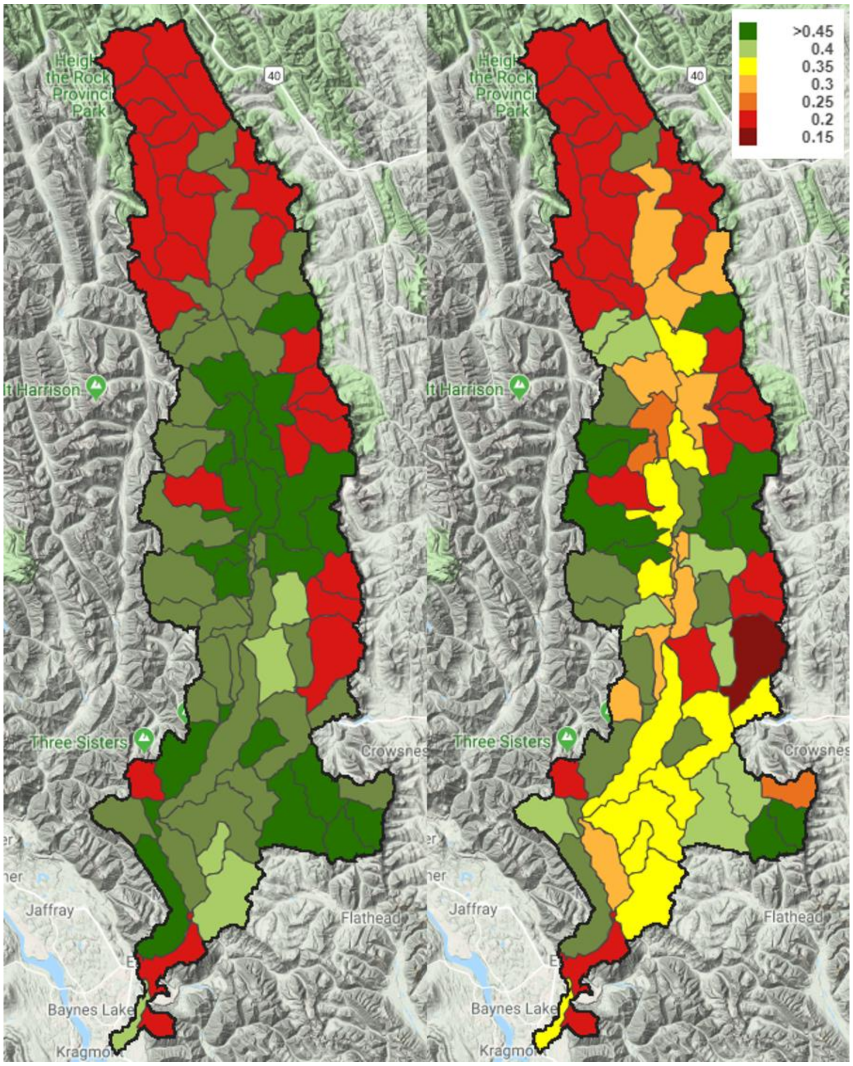

Figure 48. Reduction in hazard achieved through road closure from today (left) and in five decades (right) under the Reference Scenario. The Reference Scenario was used given that future road development does not differ dramatically between scenarios.

5. Cumulative Effects Management Process

5.1 Management Responses

Strategic management responses include measures to define or establish strategic direction for the management of land and/or resources, typically led or coordinated by government. This can include new objectives for Valued Components, new legislation, and/or regulations. Strategic planning is focused at both the provincial and regional levels. At the provincial level, Value Summary reports (e.g., Grizzly Bear) establish indicators and benchmarks, and identify areas of concern.

Operational management responses include consideration of site- or project-level guidance or implementation of measures to mitigate the effects of projects or activities and monitor the effectiveness of mitigation, typically undertaken by proponents. Operational planning assesses the compatibility of project proposals or outcomes with management practice guidelines (as identified in sub-regional assessment) and resource management zone objectives (as identified in regional assessment). Operational planning has the most direct influence on activities occurring on the contemporary landscape. It is therefore essential that operational planning reflect the direction of strategic and tactical decisions to avoid undesirable cumulative effect outcomes through time. This requires that operational management responses be proactive, so that project decisions are responding to what 'could be' as opposed to only 'what is' or 'has happened'. This proactive perspective can be provided by operational decision making that is designed to mitigate modelled future impacts, despite the associated uncertainty. Doing so can reduce the risk of undesirable outcomes, and monitoring can reduce uncertainty in decision making through time.

Tactical management responses include processes to improve consistency and/or coordination in applying current policy direction or to seek further information, that may be undertaken by government, proponents, stakeholders and/or First Nations. This can include assessment, monitoring, evaluation, research, coordination, collaboration, guidelines, management plans, etc. Tactical planning acts as a bridge between strategic and operational-planning, with a focus on coordination of management activities at the sub-regional scale. Our key recommendation for tactical decision-making is that monitoring plans be developed to ensure that data collected by proponents and government agencies are coordinated in such a manner to allow application of the data to assess performance of Valued Components not only at local scales but also at sub-regional and regional scales. Important considerations during the development of such monitoring plans are that a consistent set of indicators be measured that link to Valued Components, and that sufficient sampling intensity be conducted at sub-regional and regional scales to achieve the statistical power required to detect change.

5.1.1 Strategic Management Responses

Overall, common themes for strategic management responses across VCs used in this assessment are primarily focused on establishing new regulation related to private lands, the development of access management areas, and setting population and habitat objectives.

In relation to old and mature forest, policy makers in British Columbia should consider adjusting the Private Managed Forest Land Regulations to require retention of old forest. There may also be incentives that could be offered to private landowners to retain existing forest on their land. For example, tax or Carbon credits could be allocated. In addition to old growth retention, regulation that aligns Private Managed Forest Land Regulation and the Forest and Range Practices Act with respect to riparian reserves and management areas is required. Currently, there is a large divergence in how riparian areas are regulated on private lands vs. public lands, leading to a high potential to adversely affect riparian and aquatic values.

The fact that private lands present substantial threat to VCs evaluated here is in part due to the relatively high proportion of private land holdings in the Elk Valley. Therefore, it is also important to consider Crown lands for the potential to implement strategic management strategies, particularly given that legislative changes are likely to be more easily implemented on public land. A potential strategic management strategy on Crown land is developing OGMA replacement guidelines and policy that address wildfire, forest health, and impact from industries other than forestry, as well as forestry-related effects. In addition, a subset of high value OGMAs could be legally spatialized and, where necessary, actively managed to maintain old growth forest values (e.g., protection from wildfire and insects, fuel reduction). Finally, cumulative effects should be considered when establishing annual allowable cuts, and when determining harvestable surplus for wildlife.

Like old forests, strategic management strategies can be implemented to minimize the effects of forestry, mining, climate change, and other pressures on aquatic ecosystems and wildlife. Disturbance from road development was identified as having high potential for affecting aquatic ecosystem function as well as grizzly bear habitat. Therefore, strategic management could look at setting thresholds for road density and implementing access management. The Wildlife Act provides a mechanism for the Ministry of Environment to place restrictions on road use for the purpose of hunting or fishing (section 108), or on road use that may impact fish and/or wildlife habitat and ecosystems (section 109). Another effective means of implementing strategic management related to roads would be to include road deactivation in the Appraisal system for forestry-related activities. This would provide incentive for forestry companies to deactivate roads, ultimately having a positive effect on VC indicator performance.

Although land use is viewed as a primary stressor, other strategies can be implemented that do not directly relate to land use. Strategic management should also aim to establish clear/quantitative objectives as they relate to fish and wildlife populations and their habitats. This is relevant for WCT, Grizzly bear, and Bighorn sheep. There are currently no population objectives for these species, which makes evaluating their status relatively difficult.

5.1.2 Operational Management Responses

Operational management responses that should be applied throughout the Elk Valley include certain forestry and silvicultural practices, avoiding new road development if possible, and deactivating existing ones, and encouraging industry and landowners to apply best management practices.

Operational strategies surrounding road construction and old road deactivation is an important management response for all VCs in the Elk Valley. Road deactivation or access management would help reduce Grizzly bear hazard, improve the quality of Bighorn sheep habitat, improve old growth values, and could decrease hazard to aquatic systems. Levels of deactivation can range from cross ditching to minimize hydrologic effects to complete road deactivation in highly sensitive areas. The Watershed Restoration Program, established under Forest Renewal BC, provides an example of large-scale deactivation of forestry roads in the province (Underhill 2002). The removal of forestry roads, primarily in coastal British Columbia, was undertaken to restore and protect fisheries and aquatic resources. Roads constructed prior to the Forest Practices Code's regulations to protect streams were of concern due to aquatic impacts including blocking fish passage, excessive sediment delivery to streams, slope failures and erosion, and disturbance of riparian zones. Removal of a portion of the historical road network to achieve compatibility with today's progressive forest management regulations is analogous to what is needed in the Elk Valley. In the case of the Elk Valley, deactivation of a portion of the historical road network could achieve road densities that are now understood to be compatible with riparian habitat, WCT, and Grizzly bear.

Forestry and silvicultural practices can play a relatively large role in promoting a resilient forest land base and maintaining biodiversity to support multiple ecosystem needs. Within this context, landscape level fuel breaks could be applied to help protect old growth stands from wildfire. Furthermore, thinning from below or fungal inoculation could be used as strategies to encourage old growth values. Prescribed burns could be applied in specific areas for setting back forest ingrowth to Bighorn sheep winter range or for encouraging berry growth for Grizzly bear habitat. The forestry practices of replacing hanging culverts and minimizing riparian disturbance could help improve aquatic ecosystems, while selective cutting and harvesting below the H60 line could help control runoff and peak flows.

A final recommended operational management response involves encouraging land owners and industry to apply best management practices on their private land. Such best practices include retention of existing forest, and habitat enhancement activities for Bighorn sheep winter range such as invasive plant management, improvements to forest and range conditions, fencing off over-utilized habitat to allow for recovery, and setting back forest ingrowth. Other best practices include attractant management in the front country to reduce human-bear encounters, reclamation with native forbs of high values, and applying a "banking approach" to habitat restoration programs to encourage participation. Industry should also continue their efforts in monitoring and controlling water quality on and off their private sites.

5.1.3 Tactical Management Responses

Tactical management responses that should be applied to the Elk Valley generally surround the two basic concepts of improving our understanding of the landscape and coordinating with other groups to better manage the landscape.

Tactical responses to improve our understanding of the Elk Valley can include conducting research to better understand the general relationship between stressors and VC responses. The effectiveness of existing OGMAs should be evaluated, and old forest retention and mature forest recruitment opportunities should be identified. Research should focus on identifying wildlife migration routes, and updating population estimates and habitat mapping and condition every three to four years.

An inventory of stream crossings should be maintained by the province to inform maintenance and rehabilitation efforts. More generally, assessment watersheds identified as having excessive roads, stream crossings, riparian disturbance or ECA should be prioritized for field verification to investigate areas most likely to have dysfunctional riparian systems. Proposed mitigation is ideally left until field assessment confirms the presence of impact and what type of mitigation is appropriate. However, it may be necessary to provide initial recommendations for mitigation and management until field verification is possible. Initial recommendations made prior to field verification may vary significantly from halting all development in instances of high hazard to allowing limited development where the perceived hazard will not be exacerbated.

Research should focus on advancing our understanding of the relationships between stressors and WCT response. A fish sustainability index should be developed with WCT experts to create a series of dose-response curves that relate WCT response to stressors. The index would provide a hypothesis that should be tested through management experiments that assess WCT response to different levels of stressors such as road density, harvest, mining development, and access management.

Certain tactical management responses often require some level of coordination between groups. In terms of access to data and information, government, proponents, and data users should coordinate to ensure datasets are up to date and easily accessible. Efforts should also be made to ensure all hazard/risk mapping and e-Guidance is available through Front Counter BC. Finally, a coordinated effort should be made to ensure the results of the Elk Valley Cumulative Effects Assessment are considered in the Integrated Silvicultural Strategy (ISS) project for the Rocky Mountain District that is currently ongoing. Access management coordination between companies and sectors should ensure shared access and maintenance of resource roads; this could reduce the need for an increased road network and would help ensure all existing roads are managed properly in terms of their influence on VC condition. NGOs should coordinate with the public to ensure riparian stewardship and attractant management programs (Bear Smart program) are implemented and successful in communities of the Elk Valley. Finally, a coordinated approach to managing timber harvest and fire to preserve existing high value old forest and foraging habitat should be made.

5.2 Decision Support

5.2.1 Considering Cumulative Effects in Natural Resource Decision Making

The Elk Valley CEMF is designed to integrate cumulative effects considerations into existing natural resource decision-making processes. In so doing, the framework can improve the capacity to address current hazard and avoid unintended consequences, identify the trade-offs associated with different decisions about land use and mitigation, and lead to land-use strategies that support economic, social, and environmental values. A development project does not occur in isolation, but rather in combination with other past, present, and potential future developments, natural disturbances and climate change. Decision making that focuses only on individual activities while insufficiently accounting for cumulative effects is likely to result in unintended and often undesirable outcomes that are difficult to reverse. On their own, small decisions are unable to address regional objectives, and as a result the future condition arises by default as opposed to by design (Odum 1982). Planning for desired economic, social, and environmental outcomes requires a more integrated approach to decision making to deliver the comprehensive and proactive perspective needed to address cumulative effects.

There is generally a strong element of uncertainty at play when managing landscapes and land use at strategic scales. That uncertainty can be viewed within the Elk Valley itself when one examines its history. Unpredictable changes in commodity prices, emergence of technology and risk capital, regional natural disturbance events, shifting climate, and political administrations have combined in space and time to shape the valley into its current configuration. Uncertainty will remain a hall-mark within the Elk Valley for decades and centuries to come; however, by adopting the principles of strategic planning, and placing its practices within a context of a cumulative effects framework, the citizens, governments, and industry of this region can greatly reduce the magnitude and frequency of undesired results, and more actively engineer a collection of land uses that optimize performance across a broad suite of social, economic, and environmental performance indicators.

5.2.1.2 Direction from Environmental Assessment Office (EAO):

To assist in the evaluation of cumulative effects for environmental assessments in the Elk Valley, the Environmental Assessment Office (EAO) will use the Elk Valley Cumulative Effects Management Framework (EV CEMF) as an additional tool. For relevant project receptor Valued Components (VCs), cumulative effects predictor models developed by the EV CEMF will be used to inform assessments. The proponent will be directed to present and discuss the results of the EV CEMF modelling for each applicable VC. This will be in addition to the project-specific cumulative effects assessments the proponent will complete for each project VC. Cumulative effects of a project on water quality will be considered separately within the framework of the Elk Valley Water Quality Plan.

Where appropriate and practical, and in consultation with the EV CEMF Working Group when feasible, the EAO will incorporate Management Responses in legally binding conditions intended to mitigate the effects of a project.

5.2.2 First Nations engagement

Many of the resource development issues faced by First Nations are much larger than any single project undertaking – they concern such matters as whether resource development is appropriate in a region given traditional land uses and values, the legacy effects of previous developments, and how cumulative effects to traditional lands and resources due to future developments will be managed. In the northeast region of British Columbia, for example, the West Moberly First Nations and Halfway River First Nation have expressed concerns about the "death of a thousand cuts…because oil and gas has their mandate, and their planning process, forestry has their mandate and planning process [and there's] nobody managing the impacts of those interactions on Treaty Rights" (Booth and Skelton 2011). The persistent challenge, both in British Columbia and across Canada, is that instead of helping to proactively shape resource development and region-wide resource sector planning processes, the history of First Nations engagement in project-driven environmental assessment processes has been reactive to resource development proposals. The Elk Valley CEMF, and the provincial CEF, present an important opportunity for departure from this practice to get involved with shaping resource development and land use.

Cumulative effects frameworks provide opportunities for First Nations engagement in land use and resource development that reach far beyond the Crown's legal duty to consult. Such frameworks provide a means for government to honour the United Nations' Declaration on the Rights of Indigenous Peoples, by providing a venue whereby First Nations can work alongside industry, government and municipalities to determine priorities and strategies for the development or use of traditional lands, territories and other resources (UNDRIP, Article 32). At the sub-regional scale, the Elk Valley CEMF provides an opportunity for the Ktunaxa Nation Council to engage in planning appropriate land use and mitigation before individual resource projects are on the table. It provides a strategic opportunity for the Ktunaxa Nation to use the assessment to monitor the condition of values important to them, and for the Province to help support obligations for considering cumulative impacts on First Nations interests and Aboriginal and treaty rights.

The Elk Valley CEMF was developed based on a modest set of Valued Components, with the intent to advance a framework that was both timely and practical. Moving forward, as the framework is reassessed and updated, it will be important to expand the scope of VCs (acknowledging the Ktunaxa Nation perspective on “All Living Things”) to capture a broader range of traditional values and land uses, and to consider how planning and development trajectories either facilitate or constrain First Nations’ ability to use traditional land and practice treaty rights. Further, the Elk Valley CEMF captures only part of the traditional territory of the Ktunaxa, which is the entire lands of the Kootenay in southeast British Columbia and extending into the United States. A much larger, regional CEMF for the Kootenay Boundary region would better serve to capture a more comprehensive range of First Nations’ traditional use and values, and the implications of a wider range of scenarios (e.g. land uses, zoning) on those uses and values.

5.2.3 Linkages with Other Processes

There are several ongoing processes and initiatives in the Elk Valley in addition to the CEMF. Perhaps the most significant is the Area Based Management Plan (ABMP), also referred to as the Elk Valley Water Quality Plan (the Plan). This is a plan that was implemented in 2014 with the objectives of protecting aquatic ecosystem health, managing bioaccumulation of constituents released by mining, protecting human health, and protecting groundwater. The Plan was developed exclusively by Teck Coal Ltd (2014), with input from the Ktunaxa Nation, the public, government, experts, and other stakeholders. The focus of the Plan was to identify and implement strategies for addressing elevated selenium and nitrate concentrations within the Elk Valley, with additional consideration given to other metals and calcite. The Plan has important implications for the Elk Valley CEMF in that it directly influences the Westslope Cutthroat Trout VC. The Plan required that Teck engage with other operators, who opted not to be involved in plan development. Therefore, it does not include other mining operators in the Valley. However, it does set water quality targets which all industrial operations in the Elk Valley must adhere to.

In addition to initiatives led by large industry, the Elk Valley is home to one of the most established watershed stewardship groups in the province. The Elk River Alliance (ERA) is a community-based organization with a mandate of connecting people to the Elk River and ensures this water body is drinkable, fishable, and swimmable for future generations. The ERA is an active participant in the Elk Valley CEMF Working Group and leads several stewardship activities in the Valley. Recent work on the Elk Valley Flood Strategy ties in with the CEMF in that land use and climate change can play a role in influencing streamflow regimes and ultimately affecting residents.

Other processes such as Timber Supply Review, the provincial Flood and Wildfire Recovery Programs, and Land Stewardship Planning can all benefit from information obtained through the Elk Valley CEMF. Although clear linkages need to be established, it is important that the CEMF process, as it evolves in the future, remains aware of and responsive to all other societal, industrial, or governmental initiatives. Its recommendations are unlikely to be fully implemented without the ongoing endorsement of the varied stakeholder sectors that comprise the Elk Valley.

5.2.4 Guidelines and Other Tools

Principles for cumulative effects management identified by the Canadian Council of Ministers of the Environment (CCME) provide high-level guidelines for considering cumulative effects in natural resource decision-making (CCME, 2014). The principles are listed in Table 4, along with types of tools or approaches for implementing the principles and examples from the BC Cumulative Effects Framework.

Examples of tools that exist within the BC Cumulative Effects Framework address the full range of CCME’s cumulative effects management principles. The effectiveness of these tools will be maximized if they are implemented in a horizontally and vertically integrated manner. Horizontal integration refers to the need for consistent policies across sectors and across those government agencies and departments responsible for land uses or VCs of concern. For example, coordinated planning of road development across natural resource sectors is needed to achieve an efficient road network that abides by regional road density targets. Targets must be known and agreed upon across those government agencies responsible for managing the land uses and resource sectors of concern – for example, forest access roads and mining access roads. The CEF seeks to address horizontal integration in part through boards and committees that involve all sectors in the process of providing executive direction at the provincial level and management direction at the regional level. Horizontal integration is also facilitated through cumulative effects assessment and management reports which deliver strategic assessments of current and future condition of multiple values in response to all sectors that are active in a region. Properly executed, horizontal integration of sector footprints can help enable the development of best management practices that minimize the adverse elements of anthropogenic features, while optimizing the extraction of resources.

Table 4. Principles, tools and some examples for cumulative effects management.

Principles	Tools	Provincial and Elk Valley Examples
Knowledge-based	On-going monitoring at regional and local scales Research to understand mitigation effectiveness and enhance understanding between land use and VC response	Grizzly Bear population monitoring (e.g., Mowat and Lamb 2016)
Outcomes and environmental objectives based	Establishing objectives, indicators and targets based on monitoring, First Nations engagement, and better-practice management standards	Grizzly Bear assessment protocol (e.g., objective = sustainable Grizzly Bear population; indicator = core security areas; target = 60% coverage of landscape units)
Future-focused	Scenario analysis to explore a wider range of 'what if' choices	Prospective assessment
Place-based	Regional or watershed-based planning	Elk Valley Cumulative Effects Framework
Collaborative	Collaborative decision-making processes engaging First Nations, industry, governments and the public	Elk Valley CEMF Working Group
Adaptive	Setting thresholds Linking monitoring to decision making Management experiments	Adjustment of harvest allocation based on overall human caused mortality and population monitoring
Comprehensive	Planning across resource and land use sectors	Elk Valley Cumulative Effects Framework

Vertical integration refers to the coordinated planning of land use across multiple scales and levels of government decision making. Coordinated assessment of cumulative effects across multiple temporal and spatial scales has the potential to harness the strategic benefit of planning at provincial and regional scales, the tactical benefit of coordinating land use at sub-regional scales, and the operational benefit of implementing management practices at local scales. To realize this benefit, analyses and planning at larger scales should inform planning at smaller scales. If not, tactical and operational decision-making becomes detached from the strategic perspective needed to support provincial and/or regional objectives. To realize the full potential of the cumulative effects framework, regional CEAM reports are needed to complement and inform sub-regional CEAM reports (e.g., Elk Valley CEMF). Further, sub-regional CEAM reports should aim to inform the terms of reference developed for project-specific environmental assessment and monitoring. This may involve, for example, identifying specific indicators that must be assessed, or by focusing project reviews and monitoring programs in certain sub-regions or higher hazard areas. The scope of the Elk Valley CEMF is well suited to inform coordinated planning of management practices in support of established objectives. However, a regional cumulative effects assessment is required to inform strategic allocation decisions, i.e., what land uses can occur where, and explicit links between regional frameworks and project-specific regulatory reviews and approvals.

The range of development scenarios assessed for the Elk Valley (reference, minimum, maximum) address uncertainty in the future rate of development within the context of existing zoning (e.g., protected areas and mine claims). As well, mitigation scenarios assessed for the Elk Valley rely on changes to management practices (e.g., road reclamation, harvest practices) as opposed to more fundamental changes to how the landscape is allocated to land use. An implication is that differences in indicator performance among the scenarios were relatively minor. Missing from the prospective assessment were hypothetical long-term scenarios that are intended to support strategic zoning decisions (e.g., allocation decisions, setting of land-use objectives). Exploration of a more diverse set of hypothetical scenarios is outside of the scope of the current Elk Valley CEMF prospective assessment which was guided by existing policies, plans and programs that dictate how the basin is zoned for land use. However, hypothetical scenarios should be included in a prospective assessment completed at the regional scale where zoning decisions are made. Such an assessment, for example completed for the Kootenay Boundary Region, could assess a wider range of scenarios to explore what zoning decisions are best-suited to balance the region’s economic, social, and environmental objectives. Another important benefit of a regional prospective assessment is that it would capture the dynamics of indicators that operate at large spatial scales. Examples include forest age, which is affected by large historical and potential future disturbance events, and connectivity among Grizzly Bear home ranges, each of which can cover hundreds of square kilometers.

In addition to assessing a broader range of scenarios and a larger more comprehensive suite of VCs representative of the potential range of impacts, the regional cumulative effects assessment would benefit from a longer historical perspective. Specifically, the cumulative effects assessment should assess range of natural variability (RoNV) for the Valued Components. For the Elk Valley cumulative effects assessment, historical condition was estimated by reconstructing the 1950 landscape, and focused primarily on the present (2015) landscape. Although such an analysis provides insight into landscape change that has occurred in recent decades, it is compromised in terms of its ability to provide a baseline of natural condition. Industrial development occurring prior to and during the first half of the 20th Century had created a substantial footprint by 1950, including an extensive road network, altered forest demography, and multiple small-scale mines. To estimate the natural condition prior to such development, stochastic natural disturbance regimes (fire and insects) can be applied to the pre-industrial landscape to simulate natural landscape dynamics and calculate the response of VCs. This method can be applied to characterize natural variability by completing multiple simulations of stochastic natural landscape dynamics, and calculating summary metrics (e.g., mean and confidence intervals) for the VCs. An estimate of RoNV provides a mechanism to assess the risk associated with current and potential future conditions, using the principle that increased divergence from natural condition is associated with increased risk. Application of the approach to estimate RoNV in British Columbia could be informed by characterizations of natural disturbance regimes that are presented in the Biodiversity Guidebook.

In addition to the strategic perspectives, another important advantage of completing a regional cumulative effects assessment prior to sub-regional assessments is associated efficiencies. Completing detailed cumulative effects assessments at the scale of the Elk Valley across the province is a daunting task. Completing cumulative effects assessments for larger spatial units such as regions is much more feasible due to the smaller number of assessments that are required. Although sub-regional assessment is still valuable to inform tactical decisions, the scope of such assessments would be narrowed substantially by comprehensive regional assessments that identify priority issues worthy of more detailed analysis. Further efficiencies can be achieved through a coordinated approach to completion of regional assessments across British Columbia. Historical and prospective simulations across large jurisdictions should be conducted at sufficiently detailed spatial resolution. The simulations can then be applied to explore the response of VCs across a spectrum of spatial scales ranging from provincial to regional to sub-regional to local. Not only is this approach dramatically more efficient, it also has the advantages of providing a multi-scale perspective and ensuring that spatially extensive processes such as natural disturbance and grizzly bear habitat are simulated at suitable scales. It is recommended that a coordinated approach be adopted for historical and prospective assessment of cumulative effects across British Columbia.

Vertical integration of planning not only requires that information be transferred from regional to local planning scales, but also that outcomes of actions implemented at local scales (e.g. project-specific monitoring and evaluation) inform planning at regional scales. If project mitigation actions are not working as expected such that unacceptable outcomes are observed, land-use strategies identified by higher level plans need to be modified. Further, monitoring programs implemented at local scales, when informed by broader regional frameworks and initiatives, must collectively be able to inform changes or adaptations in regional scale strategies of initiatives. This flow of information back up to higher levels of planning requires coordinated monitoring across projects and insertion of outcomes into the planning process. Coordination of monitoring will be supported by requiring that a common set of indicators be monitored using consistent approaches as part of the environmental assessment, permitting, and authorization process. This coordination would substantially increase the feasibility of scaling-up project level monitoring to assess regional change over time. Key components of vertically integrated cumulative effects assessment across strategic, tactical, and operational decision-making levels (Figure 49) are described in section 5.1.

Currently, the Working Group is developing a detailed implementation plan for identified management responses, and the Province is in the process of developing operational guidelines to integrate cumulative effects consideration in natural resource decision-making.

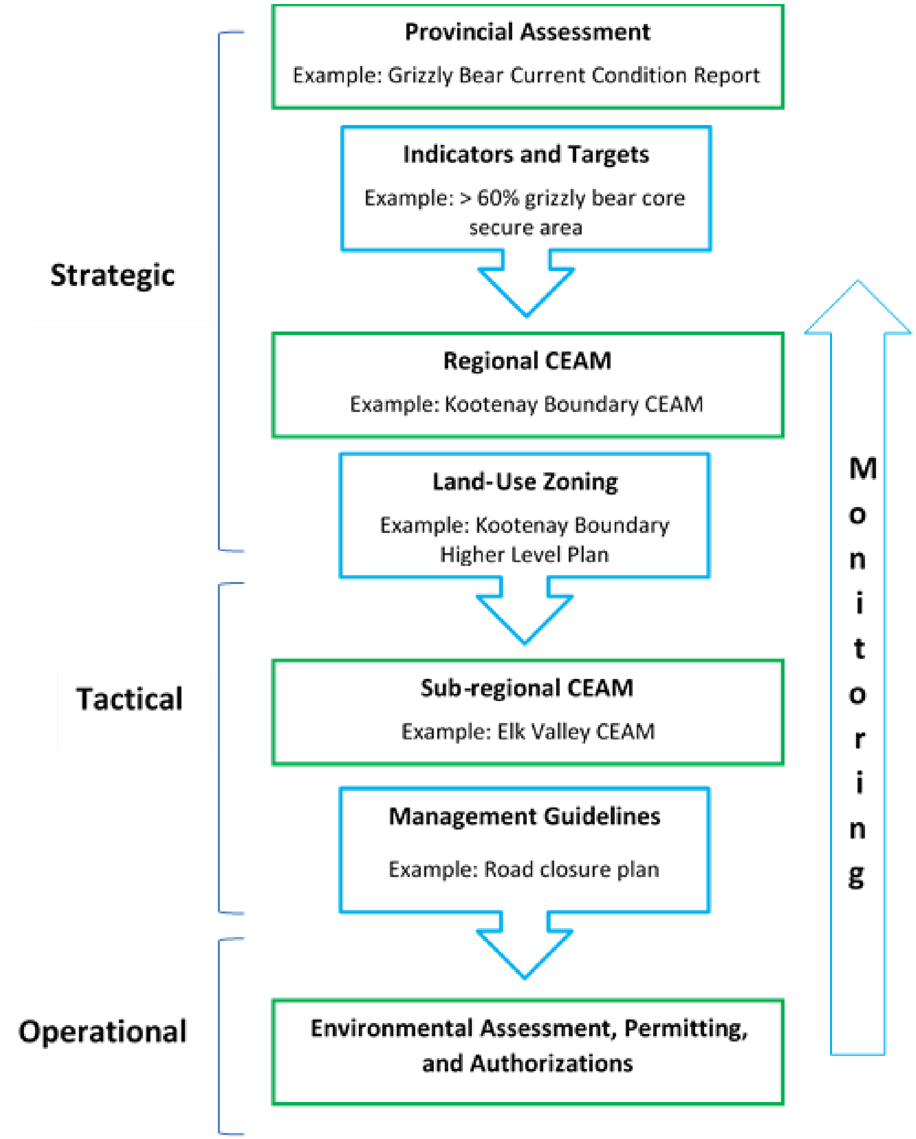

Figure 49. Vertically integrated cumulative effects assessment. Provincial and regional assessment provides strategic guidance to sub-regional planning which in turn provides tactical guidance to operational decisions. Cumulative effects assessments at each scale are identified by green boxes. Examples of management decisions at each scale that provide guidance to lower level cumulative effect assessments are identified by blue downward arrows. Coordinated monitoring provides a flow of information from project outcomes back to higher level planning levels, as illustrated by the upward arrow.

5.3 Reassessment and Updating

The resources (budget, labor, societal input) required to conduct integrated resource management are significant and can readily exhaust available fiscal and non-fiscal resources. While it might be ideal for monitoring, re-assessments, and prospective scenarios to occur at short temporal intervals and high resolution, prudent decisions are required to build assessment systems that maximize knowledge and best inform managers within known constraints.

Whereas all regional and sub-regional assessments are unique, there are several descriptions of landscapes that can help guide discussions of how frequently to reassess systems and invest resources. In general, the spectrum of infrequent to frequent re-assessments can be informed by the following gradients:

- constant versus highly dynamic natural landscapes
- constant versus highly dynamic anthropogenic landscapes
- simple versus complex systems
- low profile versus high profile VCs
- late stage versus early stage of land use trajectory
- small to large investment capital required for assessments

It follows, therefore, that landscape/land use systems that are, in aggregate, highly dynamic in both natural disturbances and land uses, are complex, have numerous VCs, are investment rich, and early in development trajectory will require greater attention and re-assessment than ones that are changing slowly, are relatively simple, contain low profile species, and are nearing maturity in land use trajectory.

The Elk Valley is a dynamic place, with rapidly expanding land use associated with development and recreation. Although the frequency of re-assessment has not been determined, it has been identified that there is a need for a long-term management plan with a set of clear objectives. These objectives should:

- Consider and plan for long-term sustainability of cumulative effects assessment
- Set out clear accountability for the maintenance and management of cumulative effects assessment
- Seek to establish specific processes for ensuring the CEMF meets broad, as well as focused, objectives
- Take into consideration critical assessment needs to support robust decision making (i.e. social indicators)
- Integrate CEMF into developmental decision making
- Integrate into other decision-making processes (i.e. BC Environmental Assessment Office)
- Provide a clear mechanism for legislative change
- Develop a plan for re-assessment at approximately 5-year increments to ensure adaptive management strategies can be effectively implemented

6.0 Conclusions

The Elk Valley has been and continues to be shaped by hundreds of existing and new small changes (e.g. roads, cutblocks, mine sites, industrial, residential, and natural disturbance). Individually, these changes can, and generally do, have profound effects on selected ecological dynamics at their immediate scale. However, when an individual development is expressed as a fraction of the total Elk Valley watershed, the effects will inevitably be numerically diluted. The challenge of an effective cumulative effects assessment is to keep track of all of the innumerable small changes (past, present, and future), and to rigorously compile these effects at numerous spatial scales ranging from the individual cutblock, road, and mine site, right up to their combined effects at the larger spatial scale. Another notable challenge is to develop feasible mitigation options across a range of VCs, some of which have conflicting requirements. This work aimed to meet the objectives of cumulative effects assessment, guided by a diverse Working Group. Overall, the Elk Valley CEMF has resulted in meaningful outputs that provide decision makers with guidance at multiple levels. Further work on implementing the framework and refining the analysis is required; however, substantial gains have been made in terms of our understanding of cumulative effects in the Elk Valley.

The Elk Valley's long history of land use, primarily forestry and coal mining, has created footprints that present hazards to Valued Components, especially in unprotected and lower elevation portions of the watershed. Of principal concern is the extensive road network and its effects on riparian areas, westslope cutthroat trout, and Grizzly bear. Highest hazard values across all VCs are related to mining activity, even though road development results in the most hazard overall at the scale of the Elk Valley. An implication of the high hazard caused by the current road network is that VCs remained relatively stable during the prospective assessment. Exploration of mitigation strategies indicated that substantial reduction in road density in terms of deactivation or closure is likely needed to improve VC performance. As such, the highest priority management action to address cumulative effects in the Elk Valley is likely a coordinated approach to reduce road density and/or access in areas with high habitat potential for VCs such as riparian habitat, westslope cutthroat trout, and Grizzly bear.

Although road development was shown to play the largest role at the scale of the landscape, disturbances affecting bighorn sheep and old forest were more related to either mining, habitat degradation, or changes in forest age class. Mining and sheep habitat dynamics are likely to be best managed at more local scales through the implementation of best management practices. Likewise, maintaining resilience and promoting the establishment of old forest will rely on best management practices coupled with research and inventory. The potential for new legislation on Private Managed Forest Lands is also promising but is likely to be a longer-term strategy for addressing the effects of land use on VC performance.

Although important learnings concerning cumulative effects within the Elk valley were gained, the most substantive gains made throughout this project were associated with a better understanding of how to conduct a cumulative effect assessment, rather than understanding the effects themselves. Challenges with data management, assessment scale, scenario development, and level of detail comprise a few of the important learnings that came from this work. It was found that consistent data collection and storage across all VCs was important in terms of transparency and feasibility of the assessment. The scale of assessment unit is incredibly important, as large-scale dynamics are often different from very local scales in terms of their influence on VC performance. Cumulative effects assessment is inherently high-level; however, still requires a certain level of rigour when evaluating indicator performance. The Working Group found that it’s often difficult to determine the right level of effort relative to the overall goals of the cumulative effects assessment. The scenarios assessed through this work did not diverge substantially given that they were based on reasonably foreseeable future scenarios. Testing a wider range of future scenarios would have potentially led to a broader understanding of the possible range of future outcomes and management strategies required to address them. These learnings will continue to be a work in progress as the Elk Valley CEMF evolves.

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8. Glossary

Anthropogenic:

Relating to the influence of human beings on nature.

Bio-geoclimatic ecosystem classification:

Method to classify and manage sites on an ecosystem—specific basis. Classifies a large geographic area into characteristic zones of vegetation, soils, and topography.

Crown land:

Land that is owned by the provincial government. This type of land is available to the public for many different purposes – from industry to recreation and research.

Cumulative Effects:

Changes to environmental, social, and economic values caused by the combined effect of past, present and potential future human activities and natural processes.

Edge effects:

The processes that occur at the edges of an area which result in a detectable difference in the structure, composition, and/or function of a system's biodiversity.

Elk River Alliance:

A community-based water group that aims to connect people to the Elk River, ensuring it is drinkable, fishable and swimmable for future generations.

Environmental Stochasticity:

Unpredictable spatiotemporal fluctuation in environmental conditions.

Equivalent Clearcut Area:

The area of forest that has been clearcut, with a reduction factor to account for the hydrologic recovery due to forest regeneration.

Hybridization:

The act or process of mating organisms of different varieties or species to create a hybrid.

Land Use:

The management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as arable fields, pastures, and managed woods.

Linear Disturbances:

All human caused disturbances of a linear nature, including but not limited to, roads, trails, transmission lines, railways, etc…

Nival:

Relating to or characteristic of a region of perpetual snow.

Old and Mature Forests:

Defined in the Elk Valley CEMF by specific age cutoffs for specific BEC zones. See narrative report for details.

Old and Mature Z-score:

A statistical metric indicating how many standard deviations an element is from the mean. Within the Elk Valley CEMF this metric is calculated by evaluating the extent to which the observed amount of Old and Mature forest deviates from the amount one would expect in a natural system, under a natural range of variation.

Open canopy forest:

Forests or woodlands in which the individual tree crowns do not overlap to form a continuous canopy layer but are more widely spaced, leaving open sunlit areas within the woodland.

Peak flow index:

The risk of a change in peak flows for an entire watershed.

Predictive Ecosystem Mapping:

A new and evolving inventory approach designed to use available spatial data and knowledge of ecological-landscape relationships to automate the computer generation of ecosystem maps.

Range of natural variation:

Refers to the spectrum of ecosystem states and processes encountered over a long enough time period to capture the natural stochasticity of the system.

Resilience:

The capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.

Riparian Areas:

The interface between land and a river or stream.

Strategic Environmental Assessment:

A systematic decision support process, aiming to ensure that environmental and possibly other sustainability aspects are considered effectively in policy, plan and program making.

Structured Decision Making:

An approach to identifying alternatives, evaluating tradeoffs, and making decisions in complicated situations.

Valued Component (VC):

An element of the environment that has scientific, economic, social or cultural significance.

9. Supporting Materials

9.1 Valued Components Technical Reports

The following technical reports are available up on request for further details:

1) Bighorn Sheep Cumulative Effects Assessment Report
2) Aquatic Ecosystems Cumulative Effects Assessment Report
3) Grizzly Bear Cumulative Effects Assessment Report
4) Old and Mature Forest Cumulative Effects Assessment Report