Old and Mature Forest
Cumulative Effects Assessment Report

Elk Valley
Kootenay-Boundary Region

Old and Mature Forest Expert Team

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Version 9

July 2018

EXECUTIVE SUMMARY

Old forests were selected as a Valued Component because of their high ecological, social, economic and cultural values and mature forests were included in some analyses because of their potential old forest recruitment value. The age at which old and mature stands develop depends on forest and ecosystem type, but this study follows definitions in the Kootenay Boundary Higher Level Plan Order (KBHLPO); the age of old forest is considered to be >250 years in ecosystems with infrequent stand-initiating events and >140 years in ecosystems with frequent stand-initiating events. Mature forest is considered to be > 120 years or > 100 years, respectively. Stand-initiating events are disturbances like severe wildfire that kill nearly all trees and re-set the age of the stand to zero.

Four indicators were selected to assess the conditions of old and mature forest in the Elk Valley:

1) Amount (ha), relative to legal targets and ecological benchmarks;
2) Interior patch size (the area of the patch (ha) minus a 100 m buffer adjacent to any anthropogenic disturbance);
3) Ecosystem representation (amount of old relative to wet, mesic, and dry ecosystems); and
4) Distribution with respect to land tenure.

Assessments were conducted for both old forest and mature forest, and for the entire forested landbase (private and crown; FLB) and crown forest landbase (CFLB) only. Two main spatial scales were examined; 1) Biogeoclimatic (BGC) subzones/variants within Landscape Units (LU), and 2) BGC subzones/variants. There are five forested BGC subzones in the Elk Valley: the Interior Cedar Hemlock (ICHmk4), the Montane Spruce dry cool and dry warm (MSdk and MSdw), and the Englemann-Spruce Sub-alpine Fir dry cool and warm moist (ESSFdk and ESSFwm). The Biogeoclimatic Ecosystem Classification (BEC) Version 11 was used for the analysis, and forest cover data were current to May 2016.

For the retrospective analysis, the first two indicators (amount and patch size) were compared to the mean of the Range of Natural Variability (RoNV), as defined in the Biodiversity Guidebook (BGB), with adjustments by the Expert Team. Area of mature and old forests, across the landbase and represented in Old Growth and Mature Management Areas (OGMAs and MMAs), was also compared to legal requirements for forest licensees as set out in the KBHLPO.

A prospective analysis was conducted to determine the impact of four different scenarios on the first two indicators, comparing to both ecological benchmark and the legal targets, over a 50-year time horizon using the ALCES Online model.

The assessment showed that there is considerably less old forest now in the Elk Valley than would be expected under historical natural disturbance regimes. Twenty of the 33 BGC/LU assessment units (61%) in the forested landbase were assessed as very high or high hazard for old forest. Based on the expected range of natural variability, these low amounts of old forest

would have occurred less than 2.5% of the time historically. Although these assessments units are small, this pattern was similar when examined at the larger spatial scale of BGC units, with the ICHmk4 around Fernie showing the largest deficit of old forest and the highest hazard.

Although old forests have declined, mature forests are relatively abundant and the hazard level was substantially lower for the amount of mature forest at both spatial scales, with only 12% of the BGC/LU units and none of the BGC units still ranking high or very high hazard for assessments of mature forests.

Further, there was not enough existing old forest on crown land to meet KBHLPO objectives in 45% of the BGC/LU units, and the legal objectives were only met by OGMAs in 62% of the BGC/LUs, although, in half the unit's surpluses in adjacent BGC units within an LU achieved objectives over the LU. Deficits in old forest were predominantly in the ICH, MS and wet ESSF units. Examination of OGMA deficits suggests they were due to two factors: 1) this project used a different BEC version and CFLB definition than was used when the OGMAs were established, and 2) the OGMAs adopted by the primary forest licensee in the Southern Rocky Mountain Management portion of the study area were established by Ministry of Sustainable Resource Management staff in 2003, and were set by BGC zone in the ESSF rather than subzone/variant. The current lack of old forest across the landbase in the MS and ICH is due to a combination of very large and severe fires that occurred in 1919 and in the 1930's, forest clearing for urban/rural development and agriculture that began with European settlement, and timber harvesting that has been ongoing since the early 1900s.

Current patch size distributions of interior old and mature forest were heavily skewed towards patches less than 40 ha, with the largest proportion of the patches being in the 1-5 ha class. The percentage of patches in this category was considerably higher than those expected under historic disturbance regimes for almost all BGC/LU units. This pattern was consistent across Natural Disturbance Types (groups of BGC units) and on private and crown land, suggesting high levels of fragmentation of existing old and mature forest in the Elk Valley.

Representation of ecosystem types within OGMAs, however, was sufficient. The percentage of dry forest within OGMAs was similar to the percentage of dry ecosystems on the landbase, although there was higher representation of intermediate (mesic) and wet ecosystems in OGMAs than for these ecosystems on the forest landbase.

The prospective modelling assessed shifts in hazard for the amount of old forest and mature forests (calculated as mature+old) on the forested landbase (crown and private) and for patch size distribution. Benchmarks were based on the Range of Natural Variability, as described in the BGB and with input from the Expert Team, for both indicators. Four scenarios are included: reference (similar to current levels of economic development), minimum (reduced development), maximum (increased development), and higher natural disturbance (projected higher incidence of fire and insect outbreak).

Modelled future amounts of old forest suggest a slight reduction in hazard across the full study area under the reference scenario, minimum and maximum development scenario, but hazard remains high for the higher natural disturbance scenario. The simulated old forest hazard remains outside RoNV as the majority of forest stands will not age enough to be considered old forest in the next 50 years. The results for mature forest hazard differ substantially. The analysis suggested a decline in hazard for the amount of mature forest in the Elk Valley over the 50 years. The improved hazard ratings are much greater for the three scenarios based on the reference, minimum, and maximum levels of economic development, shifting from an average of moderate to high in the current time period to low or very low at the end of the simulation period (2065) in BGC zones across the study area. The decline is due to forests reaching mature age classes following the 1930s fires, and especially the aging of the forest outside of the Timber Harvesting Landbase (THLB). This suggests there are good recruitment opportunities from younger stands into the mature age classes but not into the old. These results indicate the importance of maintaining existing old forest and mature forest that is nearing the age criteria for old in order to ensure old forests remain on the landscape into the future.

The hazard in the higher natural disturbance scenario did not decline as much as in the other three scenarios, especially in the ICH and MS. This implies that, at the scale of the Elk Valley, rates of human land use have a comparatively small effect on mature+old forest hazard relative to the influence of fire and insect outbreaks. At the end of the simulation period, hazard for mature forest remains moderate in the MS and ICH.

Due to forest regeneration following the fires in the 1930s, the ESSFdkw, ESSFdk2, ESSFdk1, and MSdk2 were predicted to have relatively large increases in old forest patch size under the Reference, Minimum, and Maximum scenarios, but decrease under the Higher Natural Disturbance Scenario. The average mature+old patch size increased substantially in the reference (25x) and minimum growth (16x) scenarios and to a lesser extent in the maximum growth scenario (7x) by the end of the simulation timeframe, but the higher natural disturbance scenario showed no notable increase in patch size. Increases in patch size in the reference scenario were especially notable in the steep terrain of the western portion of the lower Elk Valley. It is unlikely that hazard associated with patch size for old forests would decline and concerns around patch size expressed in the retrospective analysis are likely to continue or increase over the next 50 years.

Given the large area covered by private managed forest lands in the Elk Valley, trends on these lands were examined separately. The contrast between the changes in hazard for the amount of mature+old forest on private versus crown lands was stark. On crown forest land the hazard went from high to low, while on private managed forest land it went from high to very high. Hazard ratings of very high have a probability of occurring $< 0.5\%$ of the time under the natural disturbance regime. By the end of the simulation, there were virtually no patches of mature+old forest > 9 ha on private managed forest lands. These changes were due to high harvest levels, not high rates of natural disturbance. These results demonstrate that retention of old and mature forests on private lands should be a management priority if cumulative effects are to be effectively managed in the Elk Valley.

In summary, the amount of old forest and to a lesser extent mature forest in the Elk Valley are well below historic amounts, and what exists is highly fragmented in small patches, particularly at the lower elevations. 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 is unlikely to be realized with higher rates of wildfire and insect pest outbreaks, a potential outcome of climate change. Old forest will still be deficient after 50 years due to the length of time it takes to recruit stands into this age class. This has significant implications for species that require old and interior forest habitat and associated structure (e.g., interior northern goshawk, flammulated owl, Western Screech-Owl, American marten).

OGMA deployment will need to change when old and mature objectives are updated to new BEC (e.g., V11). This offers an opportunity to re-examine the representation of OGMAs with respect to vulnerability to natural disturbance. Given the higher predicted incidence of insect pests and wildfire with climate change (i.e., the higher disturbance scenario), a strategy of distributing OGMAs amongst leading tree species groups in order to ‘spread the risk’ could be prudent, as would relocating OGMAs in areas with lower risk of high severity fire and actively managing the forest matrix around existing OGMAs and old forest patches to improve their resilience to fire. Given that forests are dynamic, and fires and insect infestations are expected to increase with climate change, a dynamic strategy of recruitment should also be considered, with mature and old stands of various ages being identified for retention, management, and recruitment. Overall, management for resilience is key, through the above suggestions and through silvicultural practices where applicable (e.g., thinning from below, ecosystem restoration) and perhaps also through implementation of landscape level fire breaks around key areas.

Finally, given the high proportion of private managed forest lands in the Elk Valley, it is unlikely that any strategy directed solely at crown lands will be effective at mitigating the high hazards for old and mature forest in this watershed. The results of this study suggest policy makers will need to seriously consider the current and future impacts of not having any old and/or mature retention requirements on managed forest private land.

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List of Acronyms and abbreviations

- ALCES – A Landscape Cumulative Effects Simulation
- BC – British Columbia
- BGC- Biogeoclimatic
- BEC - Biogeoclimatic Ecosystem Classification
- BEO - Biodiversity Emphasis Options
- BGB - Biodiversity Guidebook
- CANFOR - Canadian Forest Products Ltd
- CEA - Cumulative Effects Assessment
- CEMF - Cumulative Effects Management Framework (Elk Valley)
- CFLB - Crown Forest Land Base
- ECA – Equivalent Clearcut Area
- ESSF - Engelmann Spruce-Subalpine Fir
- FLB - Forested Land Base
- FLNRO – Forests, Lands and Natural Resource Operations
- GIS – Geographic Information System
- ICH - Interior Cedar-Hemlock
- KBLUP - Kootenay-Boundary Land Use Plan
- KBLUP-HLPO - Kootenay-Boundary Land Use Plan Higher Level Plan Order
- KBLUP-IS - Kootenay-Boundary Land Use Plan Implementation Strategy
- KNC - Ktunaxa Nation Council
- LU - Landscape Unit
- MMA – Mature Management Area
- MRVA - Multiple Resource Value Assessment
- MS - Mountain Spruce
- NGOs - Non-Governmental organizations
- NDT - Natural Disturbance Type
- OGMA - Old Growth Management Areas
- PEM - Predictive Ecosystem Map
- RoNV - Range of Natural Variability (also called Historic Variability)
- RSA - Regional Study Area
- TEM – Terrestrial Ecosystem Map
- VCs - Valued Components
- VRI - Vegetation Resources Inventory

DOCUMENT PURPOSE

The purpose of this document is to outline the rationale, methods, and results of the Cumulative Effects Assessment (CEA) of old and mature forests in the Elk Valley, which comprises part of the broader Elk Valley Cumulative Effects Management Framework (CEMF). The various sections provide details about the existing policy framework, indicators, associated benchmarks, hazard ratings, and description/interpretation of the results. A range of management responses are discussed, including mitigation measures for old and mature forests in the Elk Valley.

The cumulative effects assessment methods were developed by a Working Group and an Expert Team comprised of BC government, First Nations, industry partners, environmental non-governmental organizations (NGOs), municipalities, and consultants. The Old and Mature Forest Expert Team refined these procedures during regular meetings. Further review was completed by the Elk Valley CEMF Working Group and a broader stakeholders' Group (a.k.a. Workshop Group).

1.0 INTRODUCTION

1.1 ELK VALLEY CUMULATIVE EFFECTS MANAGEMENT FRAMEWORK

The Elk Valley is located in the southeast corner of the Kootenay-Boundary region of British Columbia. The study area for the Elk Valley CEMF extends from Mount Fox in the north to Lake Koocanusa in the south, and encompasses the Elk River watershed, with the exception of the Wigwam River tributary (Figure 1). The Elk Valley is an area rich in biodiversity, culture and economic wealth. Coal mining and forestry are the biggest industries in the region, with tourism playing a smaller but growing role. Furthermore, the Ktunaxa Nation has a deep, long-standing connection to this valley in terms of cultural and spiritual values and resource uses.

Cumulative Effects: *"changes to environmental, social and economic values caused by the combined effects of past, present and potential future activities and natural processes".*

The management of cumulative effects in the Elk Valley has been of increasing concern due to current and proposed resource development, including open pit coal operations, timber harvesting occurring on public and private lands, increasing recreational pressures and municipal development, all of which are contributing to stresses on the watershed. There has been growing awareness of the need for a broadly accepted, credible, and workable approach to the management of cumulative effects in the Elk Valley, and provincially.

Developing a cumulative effects management framework is a condition in Teck Coal's Line Creek Operations Phase II EA certificate. In recognition of this, Teck Coal Ltd. and the Ktunaxa Nation Council (KNC) worked together to hold a multi-stakeholder workshop in July 2012. The Cumulative Effects Management Framework was launched during this initial workshop. Teck

Coal Ltd. and KNC led this initiative until January 2015, when leadership was transitioned to the Ministry of Forests, Lands and Natural Resource Operations. A Working Group comprising 11 organizations (Appendix 8) oversees the CEMF business. Annual workshops have been held for a broader stakeholder group.

The purpose of CEMF is to develop a practical approach to assess historic, current and potential future conditions of selected Valued Components (VCs) and to provide a practical, workable framework that supports decisions related to the assessment, mitigation and management of cumulative effects in the Elk Valley. The goal is to inform and support natural resource decisions at all levels.

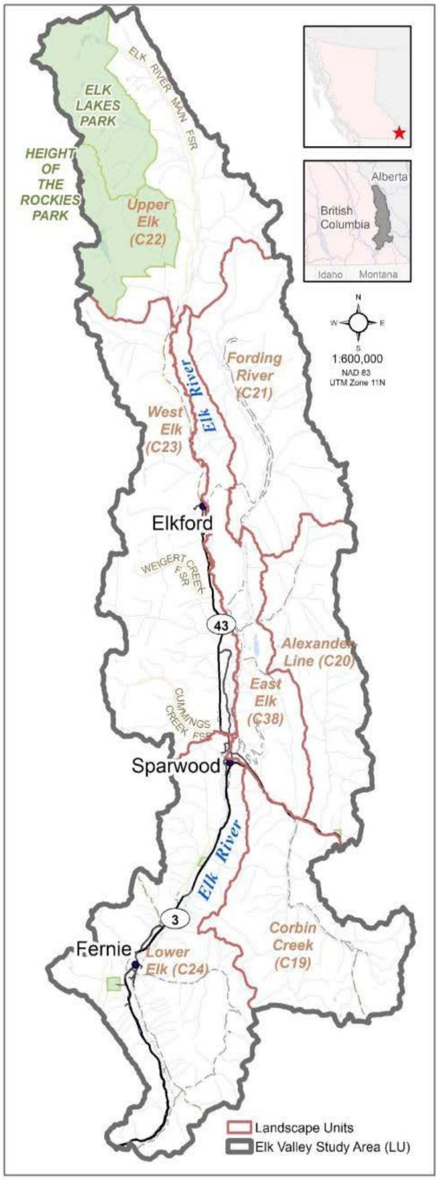

Figure 1. Elk Valley CEMF old and mature forest study area.

The Elk Valley CEMF is being implemented in four stages:

1. Context: includes establishing spatial and temporal boundaries and selecting valued components as the focus for the cumulative effects assessment. The temporal coverage spans from 1950 to 2065.
2. Retrospective Assessment: includes assessing the historic and current condition of each VC using indicators of population status and/or quality and amount of required habitat. Additionally, benchmarks that reflect the hazard/risk to each indicator were set and VC conditions assessed in relation to these.
3. Prospective Assessment: involves forecasting potential future conditions. Alternative scenarios were created to assess how different rates of development may affect the valued components and their indicators into the future. In addition, two climate change scenarios, a higher natural disturbance (fire and insect), and three mitigation scenarios have been identified and integrated with future development scenarios to simulate potential future conditions.
4. Management Action and Follow-up: includes management recommendations and monitoring based on the results of the cumulative effects assessment.

The first three stages have been completed and stage 4 remains ongoing.

1.2 WHY OLD AND MATURE FOREST?

Old forests were selected as a valued component primarily because of their relative rarity in the Elk Valley, the time they take to develop, and the habitat they provide for many species. Generally, old forests are characterized by features such as large, tall trees (both live and dead), large and hollow logs, multiple-layered canopies with gaps, and, in moister ecosystems, a high abundance of lichens, mosses, and shade-tolerant plants (Sillett, et al., 2000). Ecologically they can be defined as forests in which gap processes predominate (Wells, et al., 1998). The age at which old-growth develops is highly variable, and depends on the forest and ecosystem types in which the stand is growing. In British Columbia minimum ages are considered to be between 200-250 years in ecosystems with infrequent disturbance and 140-150 years in ecosystems with more frequent disturbance (Wells, et al., 1998; BC Ministry of Forests and BC Environment, 1995).

Mature forests are younger in age and at an earlier stage of stand development. They are important because they transition into old forests if left undisturbed and thus serve as recruitment stands in areas where there is not enough old forest to meet objectives. Mature forests typically have moderately large trees, but form a more even canopy with fewer canopy gaps, dead trees and logs than are typically present in an old forest. The understory in mature forests is also less well developed, with fewer layers and lower species diversity. As with old forests, the age and structure of mature seral forest varies significantly by forest type, species composition, and ecosystem characteristics. In southern BC, the minimum age of mature forests is generally 100 or 120 years, depending on species and site conditions (BC Ministry of Forests and BC Environment, 1995).

Over 400 species of vascular and non-vascular plants and animals in British Columbia rely on old-growth forests for at least part of their life cycle (Bunnell, 1999). Although no similar data exist specifically for the Elk Valley, the variety of ecosystems that are present (from wet cedar-hemlock forest, to dry, open Douglas-fir forests and high-elevation spruce-subalpine fir forests) suggest that species richness would also be relatively high.

Ecology aside, old forests also provide tremendous social, economic and cultural values to the people of British Columbia. The presence of old forests in an area can enhance recreation and tourism, and First Nations consider old trees highly important, both spiritually and for ongoing traditional resource use. Old-growth forests can also provide high value wood for the forest industry.

The importance of old and mature forests in British Columbia is reflected in the legislation, regulations and policies that have been implemented by the province. However, old-growth forests are impacted by multiple resource development activities and natural disturbance events, making them subject to cumulative effects. Old Growth is also a provincial core value in the BC Cumulative Effects Framework. Mature forest represents important old forest recruitment habitat and it was therefore considered with old forest in some analyses.

1.3 Legal and Management Context

1.3.1 Management Definition of Old and Mature Forests

In BC, old and mature forests are most often defined for management purposes by their age class in the Vegetation Resource Inventory (VRI). The specific age class at which a stand is considered old or mature is dependent on a combination of the ecosystem classification and natural disturbance type of a stand.

Biogeoclimatic Ecosystem Classification (BEC) system

The Biogeoclimatic Ecosystem Classification (BEC) system of British Columbia groups ecologically similar sites based on climate, soils, vegetation and topography. Ecosystems are classified at different scales, ranging from broad Biogeoclimatic (BGC) zones, to large subzones, and smaller, geographically restricted variants. BGC zones are large areas with a broadly homogenous macroclimate. They have one or more typical, major climax tree species and are usually named after the dominant climax tree species. For example, interior forests dominated by western red cedar and western hemlock are classified as the Interior Cedar-Hemlock Zone (ICH). There are three principal forested BGC zones (Figure 2) within the Elk Valley.

Detailed information about the BEC system can be found at BECWEB: https://www.for.gov.bc.ca/hre/becweb/

- Engelmann Spruce-Subalpine Fir (ESSF)
- Mountain Spruce (MS)
- Interior Cedar-Hemlock (ICH)

A map of all BGC zones in the Elk Valley and a detailed description of each can be found in Appendix I.

Subzones reflect variations of precipitation and temperature that occur within the broad climatic zones and are named with letter codes for these variations. For example, the ICHmk stands for the moist cool subzone of the Interior Cedar-Hemlock Zone. Similar subzones have similar plant associations.

Variants are generally implemented to differentiate between slightly drier, wetter, snowier, warmer, or colder areas within a subzone. These climatic differences result in corresponding differences in vegetation, soil, and ecosystem productivity, although the changes in the vegetation are not sufficient to define a new plant association or subzone. Variants are given numeric codes that have historically reflected their relative position from south to north within the subzone. The BEC system can be further refined down to site series, site variations, and others. Those classifications were not used in this assessment, although groups of similar site series were used to assess ecosystem representation of old and mature forests in this study.

There are 13 different BGC subzone/variants in the Elk Valley, with the majority of the basin comprised of the ESSFdk1, ESSdk2, ESSFdkw, and MSdk1. The MSdk2 and ICHmk4 are also present (Appendix 1, Figure A.1.1 and 2).

Natural disturbance types

Five different natural disturbance types (NDTs) are recognized in BC, each characterizing different natural disturbance regimes. The NDTs describe the relative frequency with which stand-initiating events (i.e., events which induce secondary succession) or stand-maintaining events (which maintain succession) occur. Each NDT is associated with different stand-replacing disturbance intervals, which leads to differing expected seral stage distributions. Although the expected seral stage distributions vary over time and space, it is possible to calculate an estimated seral stage distribution for a given landscape (using the mean disturbance interval in the negative exponential equation in the Biodiversity Guidebook (BC Ministry of Forests and BC Environment, 1995). For example, a landscape with an average disturbance return interval of 100 years would have 25% of the forest >140 years old, while a landscape with a longer return interval of 250 years would have 57% of the forest >140 years old. The NDTs are used to set landscape level biodiversity objectives throughout the province.

It is worth noting that, since the Biodiversity Guidebook was developed in 1995, new research into fire regimes has revealed the presence of 'mixed-severity fire regimes' in many ecosystems (Marcoux, et al., 2013).

Definitions of Natural Disturbance Types

NDT1 – Ecosystems with rare stand-initiating events
NDT2 – Ecosystems with infrequent stand-initiating events
NDT3 – Ecosystems with frequent stand-initiating events
NDT4 – Ecosystems with frequent stand-maintaining events
NDT5 – Alpine Tundra (Interior Mountain-Heather Alpine) and Subalpine Parkland ecosystems

Each BGC subzone/variant in the province is assigned an NDT. The only ecosystems in the Elk Valley that are assigned to NDT2 are the wetter ESSF units (e.g., the ESSFwmw and ESSFwm1), while all others are described as NDT3 (e.g., ESSFdk1, ESSFdk2, ESSFdkw, MSdk1, MSdk2, ICHmk4). Two subgroups of NDT3 are defined for patch size analyses; NDT3 with Douglas-fir throughout, which includes the lower elevation MS and ICH, and NDT3 with Douglas-fir restricted or absent, which includes the ESSF units. NDT classifications describe the dominant landscape-level patterns, but even within NDT2 and NDT3, areas of mixed severity fire (including some low-severity, stand-maintaining disturbances) would be expected. Historically, these would have likely existed at Grave Prairie and on the south-west slopes of Fording Mountain, although this is not officially mapped. High-elevation ecosystems (alpine and parkland) are NDT5 and are not included in biodiversity objectives for old and mature forests.

There is no NDT1 in the Elk Valley. NDT4 (IDFdm2) only exists in a tiny area at the southern end of the study area and was not incorporated into the analysis.

In the Elk Valley, as in the remainder of the Kootenay-Boundary Region, the age of old and mature forests is defined in the Kootenay Boundary Higher Level Plan Order (KBHLPO (Forest Practices Board, 2002)). Although there is a provision in the KBHLPO for stands of other ages to be considered mature or old if they have sufficient biological value, age-based definitions were used in this project and are most commonly applied across the Kootenay-Boundary Region (Table 1).

Table 1 Definition of Mature and Old forests by NDT Type and BGC Zone (KBHLPO (Forest Practices Board, 2002)).

NDT Type	BGC Zone	Mature (yrs)	Old (yrs)
NDT2	ICH	>100	>250
	ESSF	>120	>250
NDT3	ICH	>100	>140
	ESSF	>120	>140
	MS	>100	>140
NDT4	ICH	>100	>250
	IDF	>100	>250

1.3.2 Policy and Legal Context

The only legal requirements for old and mature forests in BC apply to forest licensees operating on crown land with a Forest Stewardship Plan. There are no legal requirements around old and mature forests for forest companies or private landowners operating on private land, or for other activities such as mining, recreation, or urban and rural development.

In the Elk Valley, the Kootenay-Boundary Land Use Plan Higher Level Plan Order (including Variance 7, 2005) sets out the specific requirements for the amounts of old and mature forest that must be retained on crown forest land (referred to as the CFLB) by forestry companies (Forest Practices Board, 2002). The CFLB includes the part of the crown-owned landscape that is forested and on which forestry may occur. It excludes private land, parks, and non-forest land. Amounts are specified in terms of percentages of old and mature+old forest of the CFLB in a BGC subzone/variant within each landscape unit. Landscape units (LUs) are administrative units used for forest management and planning and are usually about 15,000–25,000 ha in size. There are 7 LUs within the Elk Valley (Figure 2). 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; see Box 1). This emphasis option is legally specified in the KBHLPO. The percentage of old or mature forest required varies with this designation and is higher in high BEO LUs than in lower BEO LUs. The biodiversity emphasis options are shown for the Elk Valley in Figure 2.

Box 1: There are three options for emphasizing biodiversity at the landscape level. Each option is designed to retain a different level of natural biodiversity and a different risk of losing elements of natural biodiversity:

- The low biodiversity emphasis option may be appropriate for areas where other social and economic demands, such as timber supply, are the primary management objectives. This option will provide habitat for a wide range of native species, but the pattern of natural biodiversity will be significantly altered, and the risk to habitat suitability, capability and effectiveness will be high.
- The intermediate biodiversity emphasis option is a trade-off between biodiversity conservation and timber production. Compared to the lower biodiversity emphasis option, this will enable more natural levels of biodiversity and a reduced risk of eliminating native species from the area.
- The high biodiversity emphasis option gives a higher priority to biodiversity conservation and would have the greatest impact on timber harvest, but a lower risk to extirpation of species.

(BC Ministry of Forests and BC Environment, 1995)

The specific percentages of old and mature+old forest that must be present in each BGC/LU combination at any given point in time are shown in Table 2 (summarized by BGC zone, but applied at the subzone/variant level). It is important to note that, as per provincial policy defined in the Landscape Unit Planning Guide (BC Ministry of Forests and BC Environment, 1995), the KBHLPO objectives permit a 2/3 drawdown of the targets in low biodiversity emphasis option areas for old forest only. This means that only 1/3 of the full old forest target in these Landscape Units needs to be met at the current time – the full target must be met over 3 rotations (240 years). Originally, provincial policy required a recruitment strategy to be in place for how that will be achieved, but the requirement for a recruitment strategy was deferred by government and has not yet been reinstated. The 2/3 old forest drawdown was established for areas where full implementation of biodiversity objectives would have adverse effects on timber supply. However, the full target for mature+old forest must still be met at the current time.

By way of example, in a low BEO landscape unit in the ICHmk4 (which is classified as NDT3), there is a legal requirement for 14% of the Crown Forest Landbase to be retained in mature+old forest (forest > 100 years), and 4.5% to be retained in old forest (> 140 yrs., Table 1, Table 2). The old forest amount is intended to be part of the mature+old target, such that 9.5% of the CFLB must be mature forest and 4.5% of the CFLB is intended to be old forest to meet the combined 14% mature+old target.

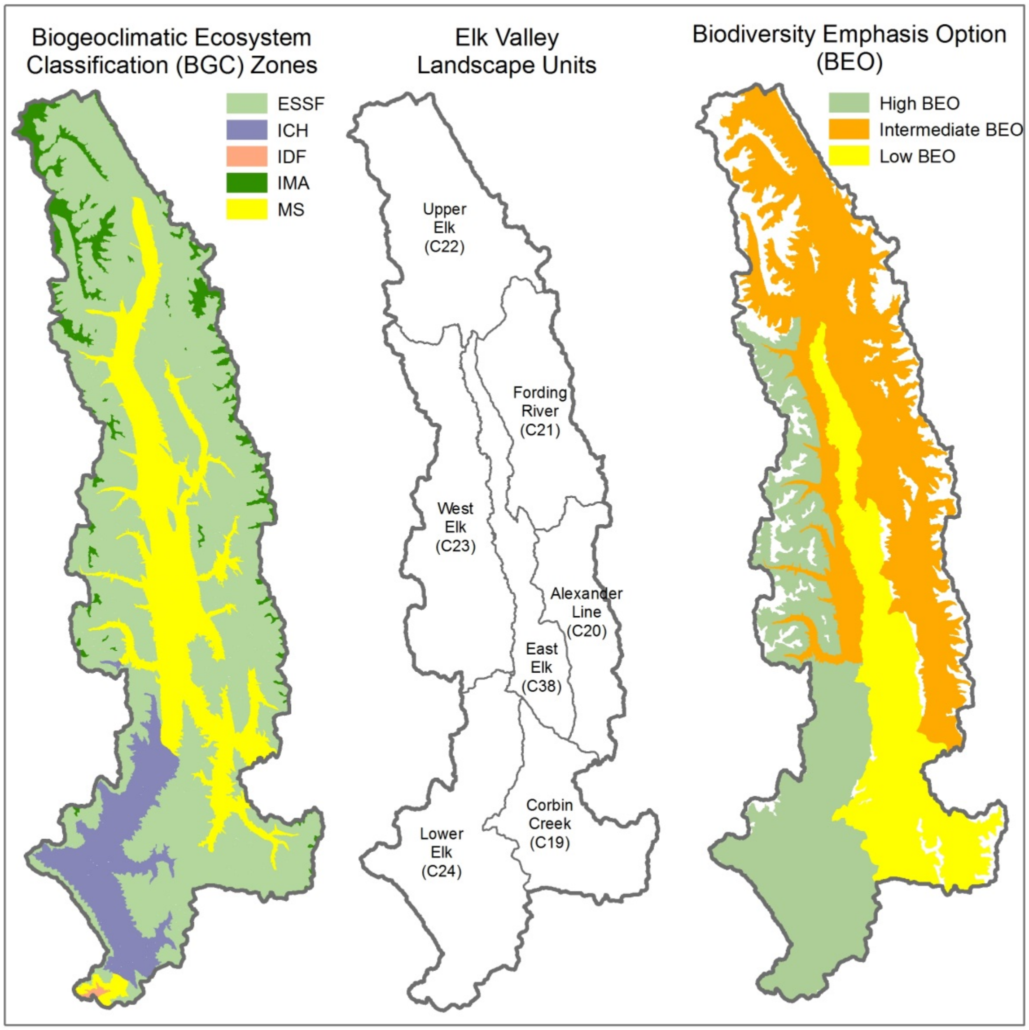

Figure 2 Biogeoclimatic Zones (left), Landscape Units (centre) and resultant Biodiversity Emphasis Options by BGC zone (right) for the Elk Valley.

Table 2 Legal objectives for mature+old forest and old forest applicable to the Elk Valley, by NDT, BGC Zone, and BEO, as established by the Kootenay Boundary Land Use Plan – Higher Level Plan Order. *

NDT Type	BGC Zone	**Mature + Old (%)**			**Old (%)**		
		Low BEO	Inter-mediate BEO	High BEO	Low BEO (full target)	Inter-mediate BEO	High BEO
2	ICH	15	31	46	3 (9)	9	13
	ESSF	14	28	42	3 (9)	9	13
3	MS	14	26	39	4.5 (14)	14	21
	ESSF	14	23	34	4.5 (14)	14	21
	ICH	14	23	34	4.5 (14)	14	21

***footnote a: The minimum requirement for the old seral stage is included in mature+old target (Biodiversity Guidebook)**

Spatial vs Non-spatial OGMAs and MMAs

The targets specified in KBHLPO are not spatially explicit; that is, they do not identify specific stands that must not be logged. However, in order to manage more easily for the old and mature targets, specific stands were identified that best met the criteria for old and mature forests. These areas are avoided for cutblock and road placement by forest licensees and are referred to as **Old Growth Management Areas (OGMAs)** and **Mature Management Areas (MMAs).**

OGMAs and MMAs are intended to include forest stands that meet the age criteria as set out in Table 1. However, in landscape units where there are not enough old (or mature) stands to meet the targets, younger stands are included. This is the case in the Upper Elk Valley, where a very severe fire burned extensive areas of forest in the 1930s, particularly in the MSdk. For this BGC/LU, mature stands were designated as OGMAs, with the intention that these will age over time into old forest. These were identified in areas most likely to have the highest biodiversity value, such as riparian areas, or in forested areas between OGMAs, to provide connectivity for wildlife.

While it is the intention that OGMAs and MMAs will be maintained and not logged, it should be noted that many of these were identified through a GIS process, and may not represent the best old and mature stands. Since they are not legally spatial, OGMAs and MMAs can be harvested if they are replaced with another OGMA or MMA of equal or greater value in the same Landscape unit and BGC variant, so long as the targets continue to be maintained. This may be done for example if an OGMA is attacked by bark beetles or burned by wildfire and no longer provides old forest value. In other cases, an OGMA may be moved if an alternate stand of old forest with ‘equal or better’ old-growth characteristics is identified on the ground. Some licensees (e.g., Canfor) have developed procedures and forms to document the old-growth characteristics of previous and newly designated OGMAs to demonstrate that OGMAs are only moved if equal or better stands are located.

2.0 METHODS

2.1 ASSESSMENT UNITS AND REPORTING UNITS

The assessment was calculated at different scales depending on the indicator:

1) Regional Study Area (RSA), which is defined by the majority of Elk River watershed;
2) Landscape Units (LUs). There are seven LUs in the study area (C19, C20, C21, C22, C23, C24, C38).
3) Biogeoclimatic zones, subzones/variants and Natural Disturbance Types.

Results were typically reported as old forest and mature+old forest. While old forest is the main value of interest, mature forest can provide recruitment into old forest in the future. Values for mature forest were calculated using data for mature+old. As per the Biodiversity Guidebook, the minimum requirement for the old seral stage must be met in order to achieve targets for mature+old; where old targets are not met, the risk to mature+old is a better reflection of the hazards and targets for mature only. For this reason, reporting on old and mature+old data are presented separately.

2.2 DATA SOURCES AND DATASETS

Several data sources were used to define stand age, each with different degrees of accuracy. The best available data for stand age is the provincial Vegetation Resource Inventory (VRI). VRI is available for the Crown forest landbase, and on private forest managed land within the Elk Valley (provided by Canwel). The crown VRI layer, available from the BC Geographic Warehouse, was accessed in June 2017. The crown VRI attribute PROJ_AGE is based on a one-time interpretation of aerial photography and is updated regularly to represent the estimated age of a stand as time progresses. The 2017 version when accessed had been updated to 2016.

Where VRI was not available (e.g., for non-managed forest private lands), structural stage was determined using satellite image interpretation conducted for Teck Resources as part of the Predictive Ecosystem Mapping (PEM) process (Ketcheson, 2015) (Ehman, et al., 2017). These data provide an approximation of age, and are not field validated; they are considered to be less accurate than the estimates from VRI.

The VRI stand age value was used for all analyses that only covered areas within the CFLB.

For analysis covering the entire land base, the VRI stand age was converted to structural stage so that a consistent layer was available for the entire study area. Mark McGirr (Provincial Cumulative Effects Team) provided the seral stage values derived from VRI and based on the Biodiversity Guidebook. This layer was combined with the structural stage values for the remainder of the landbase to create a complete structural stage layer for the Elk Valley. The resulting layer was used to identify old and mature forests as those stands assigned a structural stage of 6 (mature) or 7 (old).

For analysis using OGMAs, the provincial OGMA dataset was used. Draft OGMAs were posted to this dataset for Rocky Mountain District in 2007 and no updates have been made since that time to account for changes due to new BEC mapping, changes in the CFLB, or OGMA replacements due to harvesting, road building, or natural disturbance in original OGMAs. The largest forest licensee in the Elk Valley, Canfor, manages their own OGMAs and MMAs in-house but their layer was not available for the retrospective analysis; if included, the results may differ. When the OGMA layer was included in the analysis, it was included for reporting purposes only, and not used to define the old growth areas on the ground.

The landscape units (LU) were accessed from the BC Geographic Warehouse in June 2017.

BGC units were based on a BEC layer that was created from the current, but not yet published, PEM. The resulting BEC will be very close to BEC version 11, which is due for official release in 2018.

The BEO was based on the line work identified on the BEO map published with KBHLPO targets. BEO line work is being updated and will be published with BEC version 11, although no changes are anticipated in the Elk Valley.

The NDT category came from the unpublished BEC version 11.

The Crown forest landbase layer was defined using the layer created for and used in the previous Cranbrook Timber Supply Area (TSA) Timber Supply Review (TSR III, 2005), as this was the available layer at the time the analysis was initiated. The forest landbase was derived from the PEM as all site series that start with ‘1’, indicating a forested ecosystem.

2.3 INDICATORS AND BENCHMARKS

Valued components (VC) can be measured and assessed directly or indirectly. Where measures of a VC are not quantitative or where data are not available, indicators and benchmarks can be used to assess and evaluate the status and threats for a VC.

> ***Indicators*** *are the metrics used to measure and report on the condition and trend of a valued component.*
>
> ***Benchmarks*** *are points along the continuum of a measured indicator that reflect the level of risk or hazard to a valued component.*

The following section describes the indicators used for the cumulative effects assessment of old and mature forest and the associated benchmarks/thresholds. Each of these indicators will be assessed and summarized by the relevant assessment units. The indicators are described with the following structure:

- Scientific Context – description of the scientific basis for the selection of the indicator;
- Management Context – what type of management decisions will be supported with this indicator;
- Indicator Overview – description of the indicator,

including units;

- Benchmarks – ecological thresholds identified to report the level of hazard/risk. Here we define:
  Risk = **Likelihood** of a risk event (aka **Hazard**) x **Consequence** for goals, objectives or VCs.
  Since we were not able to calculate the consequence portion of the risk equation for lack of supporting data, we have assessed and mapped hazard, not risk.

2.3.1 AMOUNT OF OLD AND MATURE FOREST

Scientific Context
This indicator is a measure of the total amount of old and mature forests on the landscape within different forest types. It is a direct indicator of the abundance of mature and old forests expressed as the percentage of old and mature+old forest within the Crown Forest Landbase for each Landscape Unit (LU), summarized by BEC unit (BGC zone or subzone/variant). The scientific foundation is further provided below under the sub-title 'benchmarks'.

Management Context
Measures of the amount of old and mature forest provide an indication of whether objectives are being met under the KBHLPO requirements. This is the only indicator that has legal objectives for retention of old and mature forest, although these only apply to forest licensees on crown land. In areas where objectives are not being met, or are flagged as being close to the required targets, increased attention and monitoring are required, and management decisions must be made related to old forest retention and recruitment. The degree of deviation from the expected mean under the Range of Natural Variability (RoNV), which is an ecological indicator, will also inform decisions, but is not a legal objective.

Indicator Overview
Two analyses were completed related to the amount of old and mature+old forests:

1. Current amount (%) of old and mature+old forest in comparison to the Kootenay Boundary Higher Level Plan Order (KBHLPO) legal targets and Biodiversity Guidebook (BGB) non-legal targets – CFLB only
2. Current amount (%) of old and mature forest as compared to the expected mean amount under the Range of Natural Variability (RoNV) – all forested land (private and crown)

Benchmarks
Each indicator had a separate benchmark.

1. Amount of old and mature forest on the CFLB in comparison to the Kootenay Boundary Higher Level Plan Order objectives (Forest Practices Board, 2002) and Biodiversity Guidebook (BGB) targets.

These comparisons were assessed at the scale of BGC subzone/variant by LU, as per the specifications of the KBHLPO. The percentage of the CFLB in OGMA/MMA was also compared to the KBHLPO objectives.

Note that the only difference between the current KBHLPO objective and the BGB targets is that the KBHLPO objectives for old forest are ⅓ of the BGB targets in low biodiversity emphasis BGC unit/LUs. This affects only 7 of the 33 BGC unit/LUs in the Elk Valley, since all other units are intermediate or high BEO.

Caveats and Data Limitations

- The most up-to-date OGMA/MMA spatial layers from licensees were not used because they were unavailable at the time of the assessment. Thus, any OGMAs/MMAs that were identified by licensees in order to replace OGMAs or portions of OGMAs that were harvested were not reflected in the input data. Thus, OGMA/MMA percentages in the results are known to be inaccurate, which adds to the level of uncertainty around old forest availability, patch size and quality.
- The OGMA/MMA's were created using a different BEC version (BEC Version 5/6) and a different CFLB layer than the ones being used to evaluate them in this analysis. Thus, deficits may occur that do not reflect changes due to logging or road building, but simply changes in the BEC Version or CFLB. Examples of this occurred with the creation of the ESSFdk1 and dk2, which were mapped as distinct units in BEC version 6, but were combined as one (ESSFdk) when the OGMA layer was defined in 2006.
- Values for mature forest were calculated using data for mature+old. As per the Biodiversity Guidebook, the minimum requirement for the old seral stage must be met in order to achieve targets for mature+old; where old targets are not met, the risk to mature+old is a better reflection of the hazards and targets for mature only.

2. Difference between the current amount of old and mature+old forest and the expected mean of the Range of Natural Variability (RoNV).

The Range of Natural Variability (RoNV) reflects the amount of old and mature forest that existed historically in the Elk Valley under natural disturbance regimes, before the influence of European settlers (circa 1850). The natural disturbance approach to forest management assumes that species are adapted to the natural disturbance regimes where they live, and that the more closely forest management can emulate the ecological patterns and processes produced by natural or historic disturbance regimes, the greater extent to which biodiversity will be maintained (Swanson, et al., 1994; Landres, et al., 1999; Keane, et al., 2009). By comparing the current amount of old and mature forests to the amount that existed historically, a degree of risk or hazard can be inferred. It is important to note that burning by First Nations is considered part of the natural or historic disturbance regime.

The assessment method and benchmark to measure changes in the amount of old and mature forests based on RoNV were adapted from the Provincial Forest Biodiversity Draft Assessment Protocol (Lewis, 2016). Deriving the mean expected amount of old forest was done by estimating stand-replacing disturbance return intervals and creating a normal distribution around the mean to reflect variability in stand-replacing disturbance return intervals through time. Estimates of disturbance return intervals for each BGC variant/subzone were made by the Old and Mature Team, each with an upper, middle, and lower value, based on expert opinion and a recent literature review on fire regimes in the East Kootenay (Appendix 2, Canfor 2017). In addition, the estimates for NDT2 and 3 in the BGB were also used (Appendix 2). A combined “z-score”, which weighted each of the upper, middle, lower, and BGB estimates equally, was calculated to measure the deviation of current old and mature forests from the historic mean, which measures how many standard deviations the observed value is below or above the expected value. For example, a z-score of -1 is one standard deviation below the expected value, whereas a z-score of +1 is one standard deviation above the expected value. The benchmarks for the deviation of old and mature forest from the expected mean are presented below.

- very low hazard = $z > 0$ (expected to occur 50% of the time historically)
- low hazard = $0 > z > -1$ (expected to occur 34% of the time historically)
- moderate hazard = $-1 > z > -2$ (expected to occur 13.5% of the time historically)
- high hazard= $-2 > z > -3$ (expected to occur 2% of the time historically)
- very high hazard = $z < -3$ (expected to occur 0.5% of the time historically)

The deviation from expected and associated hazard for old and mature+old forest is reported for each BGC/LU unit in the study area and then by BGC subzone/variant across the full study area.

Caveats and Data Limitations

- The range of natural variability was based on the assumption of a stand-replacing fire regime (one dominated by severe fires in which nearly all of the trees are killed). Stand-maintaining (low severity) or mixed-severity fire regimes (fire regimes in which a mix of severities exist) were not considered. However, recent scientific studies suggest that mixed-severity fire regimes are more common in mountainous ecosystems than previously thought (e.g., Hessburg, et al., 2007; Marcoux, et al., 2013). In mixed-severity fire regimes, recurring low and moderate severity fires create and maintain open, multi-aged stands with a diversity of structural features (Perry, et al., 2011). Evidence that these stands existed in the Elk Valley is found on the south-west facing slopes of Fording Mountain, for example.

- The RoNV approach is meant to be applied over large spatial scales. However, many of the analysis units in this study (BGC/LU) are small (< 5000 ha) and a normal distribution of the amount of mature and old forest would not be expected to occur in these areas, particularly where fire sizes are larger relative to the analysis unit size (e.g., as in NDT3). The smaller the analysis unit, the greater the variability in the amount of old forest that would be expected at any given point in time.

- The estimates of fire return intervals, although informed by recent scientific information, may not be correct for all BGC units.

2.3.2 INTERIOR PATCH SIZE DISTRIBUTION

Scientific Context

The size of a patch can influence the species that inhabit it. Larger patches provide more habitat for species adversely affected by edge effects, which are changes in the ecological conditions and processes at forest edges. Where forest abuts openings such as roads, recent clearcuts or agricultural fields, changes in microclimate due to increases in light, temperature, and wind speed and decreases in relative humidity and soil moisture lead to changes in the plant community, which in turn influence the animal community (see Kremsater & Bunnell, 1999). Changes in rates of processes, such as predation, nest parasitism, competition and tree mortality also occur along edges, influencing biotic communities.

The degree to which edge effects impact a forest patch depends on the nature of the edge (i.e., whether it is a permanent edge, such as between a woodlot surrounded by agricultural fields, or a transitional edge, such as an old growth patch surrounded by younger stands which grow through time). Roads produce different edge effects than edges between forests and openings, due to the human traffic on roads which can transport invasive plant seeds, disturb sensitive species and cause mortality for some species.

Although the total number of species is often higher at forest edges than in the interior, some species are forest interior specialists and are not found near forest edges or breed more successfully in large patches of forest away from edges. For example, the probability the northern goshawk (*Accipiter gentilis*) will continue breeding in a forest patch following timber harvest adjacent to that patch is directly related to the size of the patch, with patches less than 25 ha ceasing to be used and those over 80 ha having the highest probability of continued use (Stuart-Smith, et al., 2012).

Generally, most edge effects are considered to extend an estimated 50-200 m into a forest from an edge (Kremsater & Bunnell, 1999; Huggard & Kremsater, 2010). Some effects penetrate further than this, such as those from roads, which can deter grizzly bears, some songbirds, and other vertebrate species from using areas 150 to almost 1,000 m away from forest edges

(Kremsater & Bunnell, 1999). Edge effects also depend on other factors, such as traffic rates, seasonal usage patterns, and land cover type that were not assessed in this study. To account for edge effects that might alter or reduce the functionality of mature and old growth forest, a distance of 100 m was used in this study between mature and old forest patches and any anthropogenic disturbance.

Management Context
The results of the analysis of interior patch sizes will inform decision makers on one aspect of the quality of old and mature forest patches and whether management approvals will result in unacceptable impacts on this value.

Indicator Overview
The total amount (hectares, %) of old and mature+old interior forest patch sizes by LU/NDT in the FLB and the CFLB.

Patches of interior old and mature forest were defined by adding a 100 m buffer to the merged disturbance layer (produced for the CEMF process) then subtracting that from the total size of the original old or mature patch. See Appendix 3 for detailed information on the disturbance layer and patch calculations. Patches were not split by BGC zone and assigned to a subzone based on the majority of the patch. Patch distribution within the CFLB was presented for old and mature+old patches.

Benchmarks

The results of the patch size analysis were compared to the recommended distribution for patch size for cut and leave areas set by the Biodiversity Guidebook for the CFLB (Table 3). Although this distribution pertains to patch size, and not interior patch size, no distribution for interior patch size was found.

Caveats and Data Limitations

- Due to the paucity of data on the size distribution of historic fires, the patch size targets from the BGB were used as benchmarks. Note that the size distribution for NDT3 does not include patches greater than 1000 ha, which were known to occur historically (and currently).
- The patch size targets are for patch size, and not interior patch size. Comparing these to interior patch size, which is smaller, biases our comparisons in the direction of smaller patches.
- The 100 m edge buffer used for this analysis may not reflect the greater sensitivity and avoidance of edges reported for some wildlife species in the Elk Valley, such as grizzly bear.
- The model does not factor in the reduced longevity and reduced quality of small forest patches due to their increased susceptibility to windthrow, blowdown, snowpress, etc.

Table 3. Recommended patch size targets for cut and leave areas by NDT as per the Biodiversity Guidebook.

NDT	Patch Size	Recommended % forest area within an LU
NDT2 (ESSFwm1, wmw)	<40	30-40
	40-80	30-40
	80-250	20-40
NDT3 – Fd throughout (MSdw, MSdk, ICHmk4)	<40	20-30
	40-80	25-40
	80-250	30-50
NDT3 – Fd restricted or absent (ESSFdk1, dk2,dkw)	<40	10-20
	40-250	10-20
	250-1000	60-80

2.3.3 Ecosystem Distribution

Scientific Context

Ensuring that a variety of distinct ecosystem types are represented in a relatively unmanaged state is an important contribution to sustaining species, particularly the majority of species for which knowledge is absent or sparse (Dunsworth & Bunnell, 2009; Higgins, et al., 2004; Margules & Usher, 1981; Pressey, 2004, Scott, et al., 2001). To assess whether OGMAs are capturing a range of ecosystems, the distribution of dry, intermediate and wet ecosystem types in OGMAs was compared to the distribution of these ecosystems across the broader Elk Valley landbase.

Management Context

This indicator provides managers with information on ecosystem representation in existing OGMAs and future direction for re-deployment of OGMAs to meet new BEC systems or selection of additional OGMAs if required. In the absence of better information, it is thought that a balanced representation of OGMAs across dry, intermediate and wet ecosystems reduces risk for biodiversity.

Indicator Overview

This indicator describes the amount of dry, intermediate and wet forested ecosystems in OGMAs by BEC unit as compared to the distribution of these ecosystems across the landbase. To define ecosystems, site series were grouped across generalized soil moisture regimes, with xeric and subxeric site series combined for the Dry Forest group, submesic and mesic site series for the Intermediate Forest group, and subhygric through subhydric site series for the Wet Forest group.

Grouping only occurred within the same biogeoclimatic subzone/variant. The site series in each grouping are listed in Appendix 4.

Benchmarks

In the absence of better information, this indicator was compared to the distribution of ecosystems on the forested landbase (FLB), and on the FLB/BGC.

2.3.4 DISTRIBUTION WITH RESPECT TO LAND TENURE

Scientific Context

Distribution with respect to land tenure provides an indication of the distribution of old and mature forests amongst the different land tenures and management zones existing in the Elk Valley.

Management Context

This indicator provides information about what management areas and land use designations to focus management efforts on when assessing old and mature forest retention and recruitment.

Indicator Overview

The amount of old and mature forest (hectares, %) in various tenures and management zones:

1) Crown land, 2) forest tenure, 3) private land, 4) private managed forest lands, 5) conservation lands, 6) protected areas, 7) mine tenure, 8) mining license/lease, 9) secondary/overlapping tenures, 10) agriculture tenures, and 11) recreation tenures.

Benchmarks

No benchmarks were created for this indicator, but patterns were examined for comparison to the distribution with the tenure distribution on the forest landbase.

Caveats and Data Limitations

- Many of the tenures are overlapping

2.4 PROSPECTIVE ASSESSMENT

In a prospective assessment, models are developed based on the retrospective assessment and information gained from new data or lessons learned elsewhere.[1] The models are used to predict how indicators may respond to future conditions and changes in the landscape. These changes will be due to a combination of natural and human-induced phenomena.

ALCES (A Landscape Cumulative Effects Simulator) technology was used to model potential

[1] From Presentation by Dr. Bram Noble at Workshop 2, November 2012

future conditions based on alternative future scenarios.

The following are the principles that were used in the development of the prospective assessment:

1. The assessment must support the goals of the BC Cumulative Effects Framework and the Elk Valley CEMF.
2. The assessment must inform decisions regarding the management of cumulative effects in the Elk Valley within the context of applicable policies, plans and programs (e.g., the Area Based Management Plan).
3. The assessment must be capable of distinguishing among alternative scenarios.
4. The assessment must be conducted at the Elk Valley watershed scale and apply to a time period applicable to both certain and reasonably foreseeable actions.[2]

The outcome of the prospective assessment will allow us to assess how old and mature forest and its indicators may respond to alternative future development, different mitigation options and climate change.

2.4.1 FUTURE DEVELOPMENT SCENARIOS

Current practice in prospective assessment places particular emphasis on the development of **alternative future scenarios**. Modelling of the different future scenarios will illustrate the response of indicators to variations in rates, spatial configurations, density or pattern of development and disturbance over the next 50 years.

Four alternative future scenarios were defined. The following are the principles used in the development of the alternative future scenarios:

1. There must be a "reference scenario" against which other scenarios can be compared.
2. The scenarios must address First Nations rights and interests.
3. Each scenario must include interactions (either positive or negative) between human activities and VC.
4. The scenarios must be distinct enough that decision-makers can clearly discern differences among the scenarios in terms of effects on values.
5. The number of scenarios must be manageable and feasible.
6. There must be sufficient information to support analysis of each scenario, and the information must be of acceptable quality.
7. The scenarios must not be in conflict with policies or legislation. However, results may suggest new policy directions or set new objectives.
8. The scenarios must be amenable to comparisons of before and after mitigation.

[2] Reasonably foreseeable actions are those that are expected to proceed (e.g., a proponent has publicly disclosed its intention) and may also include hypothetical actions that are of potential concern for cumulative effects should they proceed. A major criterion is whether future actions are likely to affect the same VC.

The following are the 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.

It should be noted that all future scenarios incorporate climate change through higher rates of fire. The reference, minimum, and maximum scenarios were assumed to have an average annual fire rate of 0.085% annually based on Boulanger et al. (Pers. Comm.). The Elk Valley is in the Southern Cordillera fire regime zone, where it is projected that there would be an annual area burned of 0.074% during the 2011 to 2040 period under RCP 4.5 and 0.085% under RCP 8.5 (Boulanger Pers. Comm.). The historical annual area burned for the Elk Valley of 0.077% falls between these two values. Therefore, a single value of 0.085% was used for the future development scenarios. It should be noted that Boulanger (Pers. Comm.) also suggests fire occurrence could decrease in the Southern Cordillera fire regime zone in the future. Pest outbreaks were assumed to remain similar to historical, which may not be realistic under future climate change.

The Higher Natural Disturbance Scenario assumed fire size would double by 2065 to 19,076 ha burned (Haughian, et al., 2012). This is the expected average fire size by 2080, where it is assumed there would be a 4 ºC increase in air temperature in the southern interior of British Columbia (Nitschke & Innes, 2008). It should be noted that this assumption is based on a regionally specific study but represents a potential scenario and our analysis suggests this areal extent of fire would be more similar to fire sizes that were observed in the Elk Valley during the 1930s, where area burned exceeded 30,000 ha. This increase in area disturbed by fire is about 2,000% higher than the area burned by fires in the past several decades. The higher natural disturbance scenario also assumed that mature forest in pine and spruce leading stands would be 100% affected by mountain pine beetle (disturbed in third decade) and spruce bark beetle (disturbed in first decade), respectively. This would reset the age of those stands to zero.

Details and assumptions on the scenarios are provided in a separate document on the EV-CEMF Modelling Assumptions.

To summarize the old and mature+old forest VC for the prospective assessment, the old and mature+old forest z-score metric was displayed as a regional average by BGC subzone/variant. Old and mature forests are defined by forest age and reflect the elapsed time since the last stand-initiating event (either fire, insect outbreak or logging). Forest age was derived from VRI data, and where absent, a combination of data sources was used consisting primarily of the structural stages modelled using satellite imagery (Ketcheson, 2015; Ehman, et al., 2017) that were converted to ages based on BEC, disturbance history including pest outbreaks, fire and forest cutblocks, and an additional NASA satellite interpretation. For remaining gaps, interpolation for forest age was done by converting the study area and surrounding area to a raster (25 m resolution) and using known ages adjacent to the raster cells to assign forest age. This resulted in the entire study area having an assigned forest age.

In all assessment scenarios the model assumed no harvest of forests less than 60 years old or within riparian reserve zones. This assumption does not always hold in reality with increased insect outbreaks. Planned harvest was spatially simulated until 2020, after which the 2017 Annual Allowable Cut (AAC) was applied to the CFLB in a random distribution with clustering. Preferential harvest of burnt and pest-infected forests (salvage logging) was included as a base assumption of the model. Wildfires and pest outbreaks were simulated in a random distribution with clustering across the entire landscape. The model assumed no burning of forests less than or equal to 10 years of age. For private managed forest land, the estimates of area harvested each year for the first decade provided by Jemi in 2015 were applied. The company is now owned by Canwel and these projections most likely differ.

The minimum growth scenario assumed a decrease in harvest levels by 10% relative to the reference scenario, as well as fewer approved coal mine expansions and no expected growth for the Districts of Sparwood and Elkford.

The maximum growth scenario assumed an increase in harvest levels by 20% relative to reference, as well as all coal mine expansions and growth of the Districts of Sparwood and Elkford to 100% of municipal projections using the Official Community Plans (OCP) polygons (as compared to 50% for the reference scenario).

Several model runs were completed for each scenario and a representative run chosen to represent the results. In the future, Monte Carlo simulations could be run.

3.0 RESULTS FOR THE RETROSPECTIVE ASSESSMENT – HISTORIC AND CURRENT CONDITIONS

3.1 AMOUNT OF OLD AND MATURE FOREST

3.1.1 COMPARISON OF OLD AND MATURE TO KBHLPO OBJECTIVES AND BGB TARGETS

On crown forested land, the percentage of old forest within each BGC/LU unit varied from 0–71.2% with an average of 24.1%, and the percentage of mature ranged from 0–90.4%, with an average of 11.2% (Table 4).

The aspatial analysis comparing the percentage of old forest to KBLPHO targets showed that 13 of 29 BGC/LUs (> 10 ha) did not have enough old forest present within them to meet KBHLPO legal targets for old forest (two-third drawdown in C19 and C38, Table 4). This number increased by one to 13 of 29 units when the full targets (BGB) were used for comparison (the difference was the MSdk in C38). In the six BGC/LUs with mature+old targets, half of them did not have enough mature+old forest combined to meet the targets, demonstrating there was not enough mature forest in these units to meet legal targets either.

Lack of available old forests in the aspatial analysis ranges from 6 to 100% of KBHLPO objectives, and predominantly occurs in the mid-valley and the wet ESSF units. Six of 8 MS units, 1 of 2 ICH units, 3 of 6 ESSFwm units, but only 5 out of 15 ESSFdk units lacked enough old forest on the CFLB to meet KBHLPO objectives. When percentages are calculated as hectares of CFLB, they equate to very large areas – e.g., 1675 ha in the ICHmk4, 296 ha in the ESSFwm1, 72 ha in the ESSFdk1, and 155 ha in the MSdw in C24 (the LU with the largest deficits). The other units showed surpluses ranging from 15 to 1040% (Table 4), equating to up to 1690 ha (ESSFdkw in C23).

The results of the spatial analysis using mapped OGMAs showed that deficits in OGMAs compared to legal targets were still present in the same number of BGC/LU units (13/29). 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. In the remaining BGC/LU units with deficits, deficits ranged from 1.9% to 15.7%, which translates into areas as low as 14 ha (MSdk in C38, where there is little CFLB) to as high as 203 ha (ESSFdk2 in C23 where OGMAs cover ~2% less area than the target, but the CFLB area is large).

Interestingly, the deficits in OGMAs were not always in the same units that did not have old forest available as identified in the aspatial analysis. For example, although the ESSFdkw in C20 has 40.6% old forest, well above the target of 14%, the OGMA percentage was 13.8%, resulting in a small deficit (Table 4). In other units, such as the MSdk in C22, there was only 4.5% old forest, less than the target of 14.0, but the OGMA percentage was 14.1%.

Mapped OGMAs are often comprised of a combination of old forest and younger stands, which explains the discrepancy between the spatial and aspatial analysis. Where a BGC/LU unit does not have enough old forest to meet KBHLPO objectives (in the aspatial analysis) but is meeting legal targets through OGMAs, it is clear that younger age classes were included within the OGMAs. For example, Table 4 shows that in the MSdw in C20, there was only 7.8% old forest; 6.2 less than the legal objective of 14.0. However, there was 30.2 % in mature forests, which was used to create more OGMAs so that they totalled 14.2% to potentially meet the intent of the KBHLPO objective in future years with old forest recruitment. In some units, there isn't enough old forest available on the landscape to meet targets, and the old that is available is not necessarily retained in OGMAs.

In general, the largest deficits are seen in the lower Elk Valley around Fernie (C24), while the largest surpluses are found in the Upper Elk Valley near the parks. The lack of old forest in the MS and ICH is due to a combination of the very large and severe wildfires that occurred in the Elk Valley in 1919 and in the 1930s (Figure 3), the clearing for urban and rural development and agriculture that occurred early in the century, and timber harvesting ongoing since the 1900s.

The KBHLPO objectives that were not met with OGMAs illustrate two things. First is the fact that this analysis used a different BEC version than the one in place when the OGMAs were established. For example, in C21 there are no OGMAs at all in the ESSFdk2, but a surplus in the ESSFdk1. When the OGMAs were established in 2006, the ESSFdk1 and dk2 variants were combined as the ESSFdk for OGMA allocation. This resulted in OGMAs being distributed without respect to the boundaries of these two new variants. Similarly, there is a deficit in the MSdk in C23, but a surplus in the MSdw (mapped as MSdk2 and MSdk1 in BEC version 6 from 2006). Second is the fact that Canfor, the dominant forest licensee in the area, adopted the OGMAs identified by the FLNRORD biologists for the Southern Rocky Mountain Management Area, which includes the Upper Elk Valley. These OGMAs were placed in the best ESSF old growth stands without regard to variant. This, combined with the change in BEC system from 2006 to now, has led to results as in C23, where there is a deficit in the ESSFdk1 and dk2, but a large surplus in the ESSFdkw.

The results above show that there will need to be changes in the OGMA deployment in order to be compliant with BEC version 11. There are opportunities to adjust OGMA boundaries in BGC/LU units where there is more old forest than required to meet the targets, either to meet legal targets or to improve the old-forest content of the suite of OGMAs in BGC/LU units. Younger forests will have to be "recruited" through inclusion in OGMAs where the amount of old forest is below the targets.

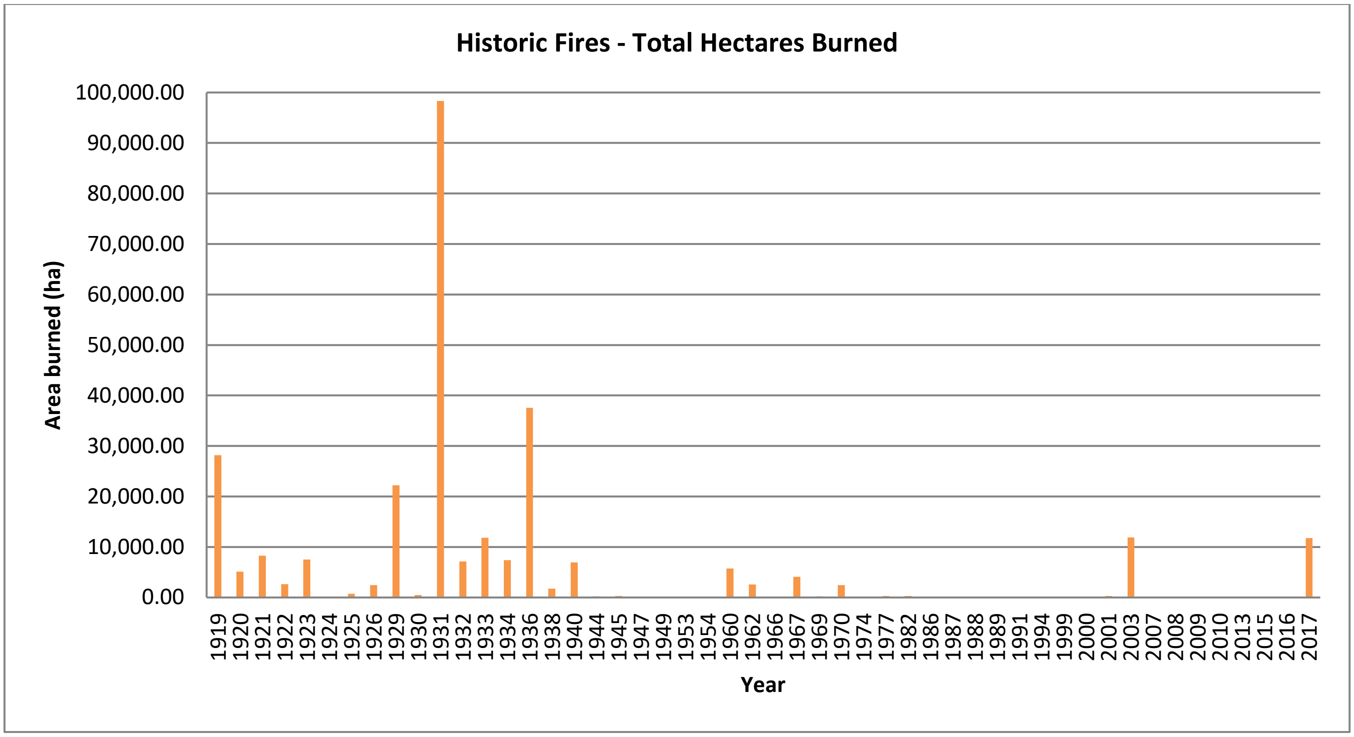

Figure 3 The area burned by fire, by year, in the Elk Valley between 1919 and 2017.

Table 4. Comparison of Non-legal Spatial OGMAs and MMA+OGMAs and Aspatial Old and Mature Analyses to the KBHLPO objectives (as a percent of the CFLB). **Targets not reported (n/a) for units with <10ha, and total old forest minus KBLUP target not calculated for BGC units with <10 ha.**

LU	NDT	BE0	BGC Unit	Total Area in CFLB (ha)	Non-legal Spatial OGMAs (%) (Red indicates a deficit) Percent of CFLB in		KBHLPO Targets		Mature in CFLB		Old in CFLB		Total Old - KBHLPO Target (ha)	Percent Deviation of old from KBHLPO target (%)
					OGMA	MMA+ OGMA	Old (Full)	Mature+ Old	Area (ha)	Percent	Area (ha)	Percent		
C19	NDT 2	low	ESSFwm 1	0	-	-	n/a	n/a	-	-	-	-	n/a	n/a
			ESSFwm w	7.2	-	-	n/a	n/a	6.5	90.4	0	0	n/a	n/a
	NDT 3	low	ESSFdk1	2,381	4.6	-	4.7 (14)	n/a	117.1	4.9	479.5	20.1	367 (146)	328 (44)
			ESSFdk w	452	4.7	-	4.7 (14)	n/a	16.2	3.6	193.5	42.8	172 (130)	811 (206)
			MSdw	351	6.4	-	4.7 (14)	n/a	9.3	2.6	5.3	1.5	-11 (-44)	-68 (-89)
C20	NDT 3	int	ESSFdk1	5,830	14.3	-	14	n/a	529.1	9.1	1,273	21.8	457	56
			ESSFdk w	1,190	13.8	-	14	n/a	58.1	4.9	483.1	40.6	317	190
			MSdw	1,914	14.2	-	14	n/a	578.0	30.2	148.3	7.8	-119	-44
C21	NDT 3	int	ESSFdk1	8,109	15.2	-	14	n/a	782.3	9.6	1,074	13.2	-61	-6
			ESSFdk2	772	0	-	14	n/a	3.6	0.5	0	0	-108	-100
			ESSFdk w	1,794	15.6	-	14	n/a	153.9	8.6	714.7	39.8	464	184
			MSdw	803	13.9	-	14	n/a	211.6	26.3	188.2	23.4	76	67
C22	NDT 3	int	ESSFdk2	15,732	13.9	23.9*	14	23	387.0*	2.5	2,530	16.1	328	15
			ESSFdk w	1,812	15		14	23	57.0	3.1	712.6	39.3	459	181

			MSdk	4,752	14.1	25.7*	14	26	156.3*	3.3	214.8	4.5	- 450	-67
C23	NDT 2	high	ESSFwm 1	535	24.8	-	13	n/a	111.8	20.9	285.4	53.4	216	311
			ESSFwm w	179	31.8	-	21	n/a	41.1	23	73.6	41	36	95
	NDT 3	high	ESSFdk1	887	7.6	35.0*	21	34	0	0	119.6	13.5	-67	-36
			ESSFdk2	10,677	19.1		21	34	1586.5	14.9	3,282	30.7	1040	46
			ESSFdk w	2,955	29.4		14	34	205.0	6.9	2,104	71.2	1690	409
		int	ICHmk4	175	61.8	-	14	n/a	3.7	2.1	105.1	60	81	329
			MSdk	7,183	11.5	-	14	n/a	1451.1	20.2	764.5	10.6	-241	-24
			MSdw	4,340	15.5	-	14	n/a	490.7	11.3	511.4	11.8	-96	-16
C24	NDT 2	high	ESSFwm 1	3,428	13.1	-	13	n/a	1006.1	29.4	149.9	4.4	-296	-66
			ESSFwm w	267	5.3	-	21	n/a	157.9	59.0	37	13.8	-19	-34
	NDT 3	high	ESSFdk1	736	20.7	-	21	n/a	40.3	5.5	82.1	11.1	-72	-47
			ESSFdk w	101	28.9	-	21	n/a	15.4	15.3	62.4	61.9	41	195
			ICHmk4	9,395	20.6	-	21	n/a	1865.4	19.9	297.7	3.2	-1675	-85
			MSdw	1,292	21.2	-	19	n/a	287.0	22.2	90.7	7	-155	-63
C38	NDT 3	low	ESSFdk1	3.6	0	-	4.7 (14)	n/a	0	0	2	56.1	n/a	n/a
			ESSFdk2	0	0	-	n/a	n/a	0	0	0	0	n/a	n/a
			MSdk	289	0	-	4.7 (14)	n/a	0	0	29	10	15 (-11)	113 (-29)
			MSdw	726	6.6	-	4.7 (14)	n/a	25.6	3.5	124.5	17.1	90 (23)	264 (22)

- MMAs not calculated in this analysis, so results taken from Canfor 2017 analysis.

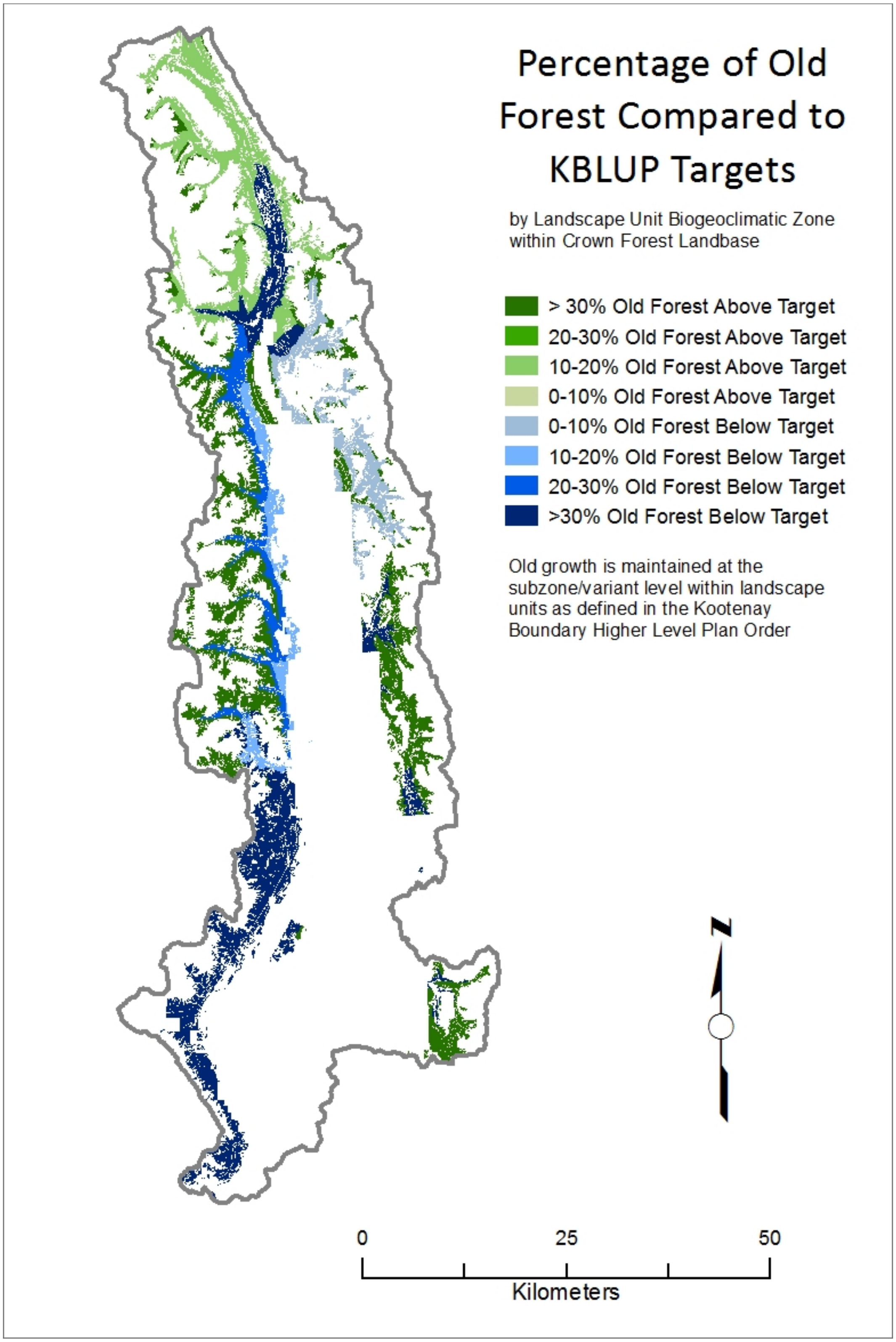

Figure 4 Spatial distribution of the deviation of the percent of old forest from the KBHLPO targets in the Elk Valley.

3.1.2 Range of Natural Variability Assessment

On crown forest and private land combined (the Forest Landbase, FLB), the percentage of old forest within each BGC/LU unit varied from 0-39.2% with an average of 11.1% (lower than on crown forest alone), and the percentage of mature ranged from 0.4-60.9%, with an average of 23.3% (higher than on crown forest alone; Table 5).

When the amount of old forest on the FLB, in each BGC unit within each LU, was compared to the mean expected under RoNV, 20 of the 33 (60%) units were rated high or very high hazard, and nearly all units (30/33, 91%) were rated at medium or higher hazard for old forest (Table 5). The three units that rated low or very low were all in C23 and each has less than 1000 ha in total forested area, suggesting this result may be a scale issue.

This analysis was also conducted at the larger scale of BGC unit without being divided by LU for reasons discussed below. When this was done, the hazard assessment showed similar results, with six of the units showing high hazard and the other two with moderate hazard (Table 6). The ICHmk4 showed a significantly lower z-score (-2.9) than the other units rated high (mean of -2.1 for all units), suggesting that the risk is highest in this BGC variant.

When mature forests were added to the analysis, the hazard level dropped at both scales. Almost half of the BEC unit/LUs (47%) were assessed as being low or very low hazard for mature+old, 30% were moderate, and 21% were high or very high hazard (Table 5). Only one unit was rated Very High hazard (ESSFdk in C21), and it was less than 1000 ha in total, suggesting as above this extreme rating could probably be a scale issue. At the larger scale of BGC unit only, hazard with mature fell to very low for 4 units, low for 3 units, and medium for 1 unit (Table 6). These apparent declines in hazard are only because there is sufficient mature forest in most units to compensate for the lack of old forest. This means that there are potentially many opportunities for recruitment of old forest over time, but it does not reduce the current high hazard and risk to biodiversity loss associated with old forest deficits that exists in several areas of the Elk Valley. Spatially, the greatest hazard exists along the mainstem of the Elk river, where the amount of old and mature forest is greater than 3 standard deviations below the expected mean using RoNV (Figure 7, Figure 8).

In interpreting the results above, it should be noted that a RoNV analysis is intended to be interpreted at large spatial and temporal scales. The FLB in the BGC unit/LU sizes in this study range from 197 ha to 25,874 ha, with an average of 5592 ha (Table 5). Yet, the majority of fires recorded in the Elk Valley from 1919 to 1986 were over 5,000 ha, with the largest over 37,000 ha (Figure 3). These fires would have usually crossed multiple BGC subzones/variants, with their effects on seral stage distribution and patch size distributed across the landscape. Although this size distribution most likely does not represent the full range of natural or historic variation because a) this time period was already impacted by the cessation of First Nations burning and the early settlement fires set to clear the land for mining, and, b) it is also missing the many small fires that would very likely have occurred and simply not been recorded because they extinguished naturally. However, it does show that very large fires occur in the Elk Valley. Thus, at any given point in time an average or smaller BGC unit could have been almost all recently burned forest, or all old forest if fires had not occurred for some time. Essentially, the smaller the size of the analysis unit relative to the size of the fires, the higher the variability of old forest that would be expected.

Table 5. The area, RoNV z-score, and hazard rating for old and mature+old forest within each BGC/LU unit on the Forested Landbase in the Elk Valley.

LU/BGC	Total Ha in FLB	Mature ha in FLB	Old ha in FLB	Old z-score*	Old Forest Hazard	Mature+Old z-score*	Mature+Old Forest Hazard**
C19	**29615**	**6,714**	**1,909.4**				
ESSFdk1	14370	2,048	1350	-2.35	High	-1.69	Medium
ESSFdkw	4492	1755	294	-2.57	High	0.00	V.Low
ESSFwm1	1694	718	12	-2.28	High	-0.37	Low
ESSFwmw	1409	858	36	-2.12	High	1.16	V.Low
MSdw	7650	1193	202	-2.45	High	-2.06	High
C20	**18756**	**2763**	**2877**				
ESSFdk1	10560	1269	1916	-1.68	Medium	-1.19	Medium
ESSFdkw	3998	843	741	-1.65	Medium	-0.46	Low
MSdw	4198	651	220	-2.23	High	-1.86	Medium
C21	**21685**	**4682**	**2117**				
ESSFdk1	12731	1886	1277	-2.31	High	-1.60	Medium
ESSFdk2	781	3	5	-3.03	V.High	-3.43	V.High
ESSFdkw	4916	1652	409	-2.44	High	-0.28	Low
MSdw	3260	1141	425	-1.58	Medium	0.32	V.Low
C22	**31090**	**2592**	**4195**				
ESSFdk2	21313	1253	3021	-1.99	Medium	-1.97	Medium
ESSFdkw	4232	1083	948	-1.35	Medium	0.18	V.Low
MSdk	5545	256	227	-2.33	High	-2.82	Medium
C23	**39584**	**8361**	**6364**				
ESSFdk1	1698	152	139	-2.45	High	-2.19	Medium
ESSFdk2	14891	2305	3534	-1.25	Medium	-0.49	Low
ESSFdkw	6023	2180	1,092	-1.68	Medium	0.67	V.Low
ESSFwm1	660	104	259	0.94	V.Low	0.53	V.Low
ESSFwmw	315	83	120	0.85	V.Low	1.24	V.Low
ICHmk4	197	8	64	-0.57	Low	-0.70	Low
MSdk	8378	1882	699	-1.97	Medium	-1.06	Medium
MSdw	7422	1647	457	-2.15	High	-1.25	Medium
C24	**53954**	**13699**	**1128**				
ESSFdk1	2687	235	296	-2.23	High	-1.99	Medium
ESSFdkw	396	121	25	-2.59	High	-0.67	Low
ESSFwm1	15628	4521	166	-2.24	High	-1.35	Medium
ESSFwmw	4578	2150	31	-2.28	High	-0.03	Low
ICHmk4	25874	6308	581	-2.90	High	-1.46	Medium

MSdw	4330	365	29	-2.61	High	-2.79	High
C38	**20790**	**6268**	**2255**				
ESSFdk1	4648	1142	951	-1.50	Medium	-0.04	Low
ESSFdk2	302	35	11	-2.79	High	-2.32	Medium
ESSFdkw	516	255	0.0	-3.08	V.High	0.28	V.Low
MSdk	557	39	47	-1.96	Medium	-2.28	High

*Hazard rating: *z* > 0 = very low; 0 > *z* > -1 = low; -1 > *z* > -2 = medium; -2 > *z* > -3 = high; *z* < -3 = very high

** Based on combining all available old and mature forests, even where old forests do not meet the minimum targets.

Table 6. The area, RoNV z-scores, and hazard rating for old and mature+old forests by Biogeoclimatic (BGC) unit on the Forested Land Base (FLB) in Elk Valley.

BGC Unit	Total Area in FLB (ha)	Mature Forest Area in FLB (ha)	Old Forest Area in FLB (ha)	Old z-score*	Old Hazard	Old & Mature z-score*	Mature Forest Hazard**
ESSFdk1	46,693.6	6729.7	2929.6	-2.10	High	-0.99	Low
ESSFdk2	37,286.8	3596.0	6571.41	-1.72	Medium	-0.98	Low
ESSFdkw	24,570.2	7888.71	3507.9	-1.98	Medium	0.49	V. Low
ESSFwm1	17,981.9	5342.8	437.2	-2.13	High	0.65	V. Low
ESSFwmw	6,302.4	3091.2	187.9	-2.08	High	2.00	V. Low
ICHmk4	26,070.7	6315.7	645.3	-2.89	High	-1.02	Medium
MSdk	14,479.4	2177.6	973.1	-2.11	High	-0.85	Low
MSdw	41,627.5	9794.1	2577.4	-2.15	High	-0.19	Low

* Hazard rating: *z* > 0 = very low; 0 > *z* > -1 = low; -1 > *z* > -2 = medium; -2 > *z* > -3 = high; *z* < -3 = very high

** Based on combining all available old and mature forests, even where old forests do not meet the minimum targets.

Old growth in the ESSFwm1.

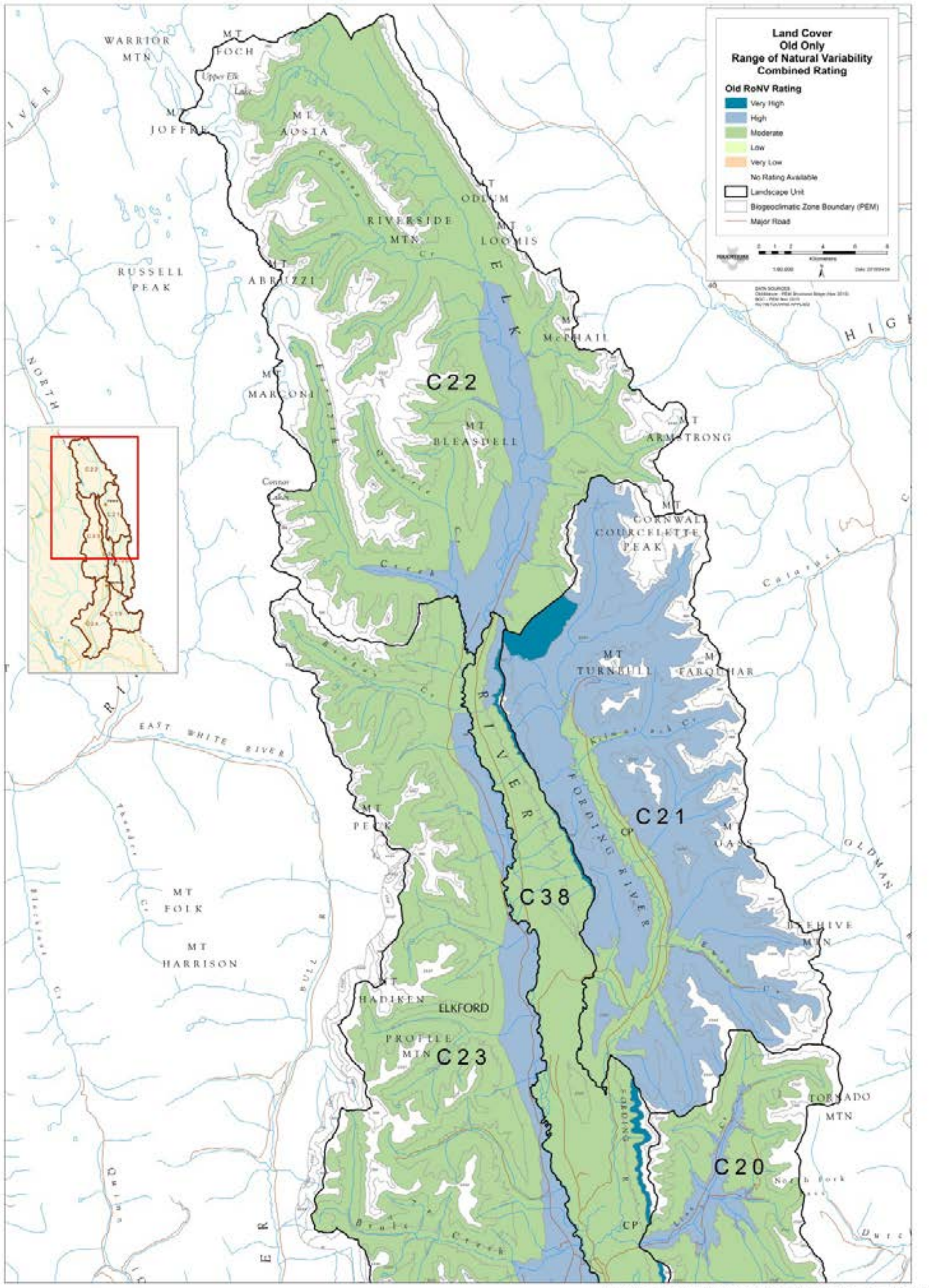

Figure 5 The spatial distribution by Landscape Unit of the deviation of current amounts of old forest on the Forested Landbase from expected mean amounts under Range of Natural Variability (RoNV) estimates, North Elk Valley. Hazard rating: $z > 0$ = very low; $0 > z > -1$ = low; $-1 > z > -2$ = medium; $-2 > z > -3$ = high; $z < -3$ = very high.

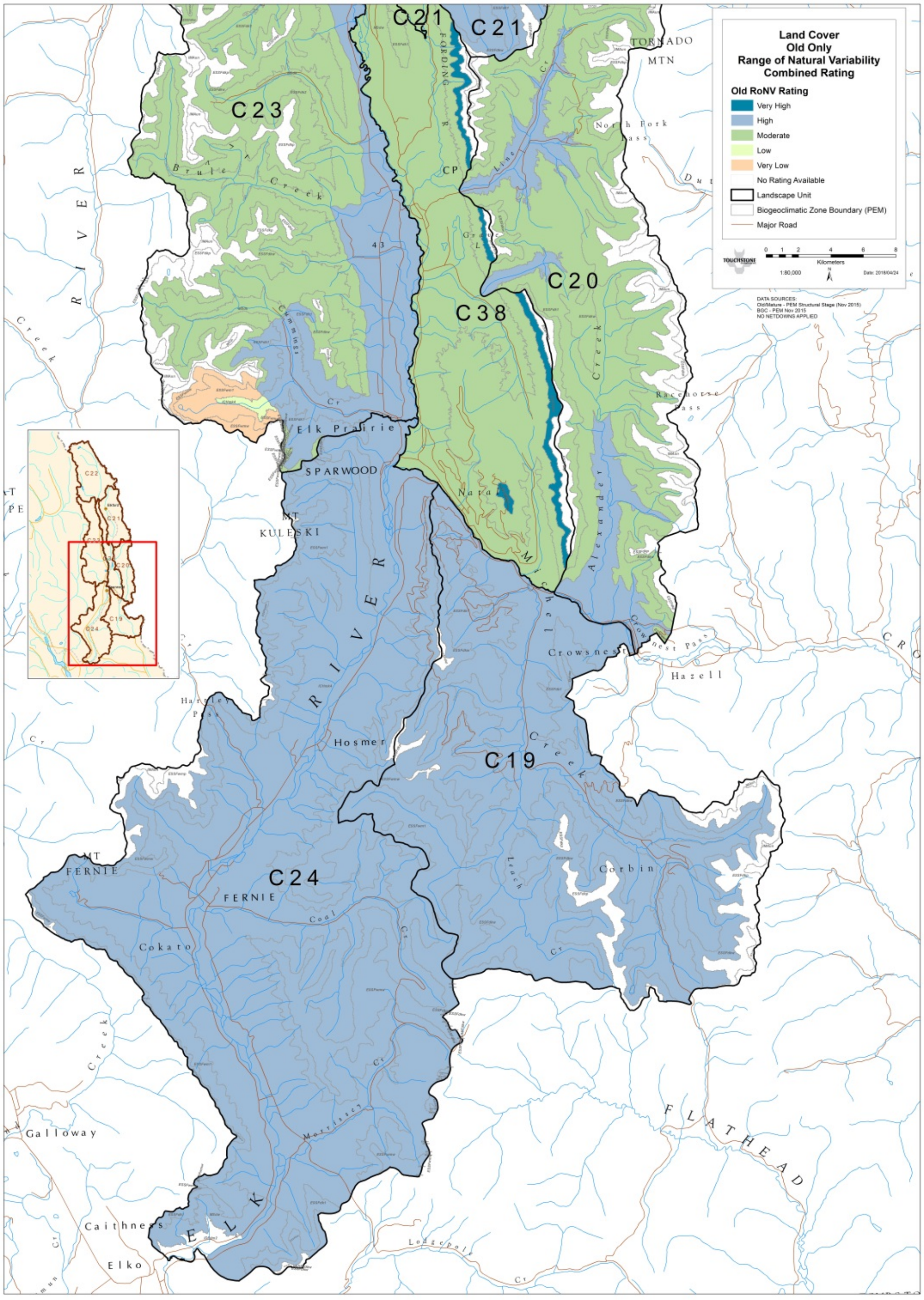

Figure 6 The spatial distribution by Landscape Unit of the deviation of current amounts of old forest on the Forested Landbase from expected mean amounts under Range of Natural Variability (RoNV) estimates, South Elk Valley. Hazard rating: $z > 0$ = very low; $0 > z > -1$ = low; $-1 > z > -2$ = medium; $-2 > z > -3$ = high; $z < -3$ = very high.

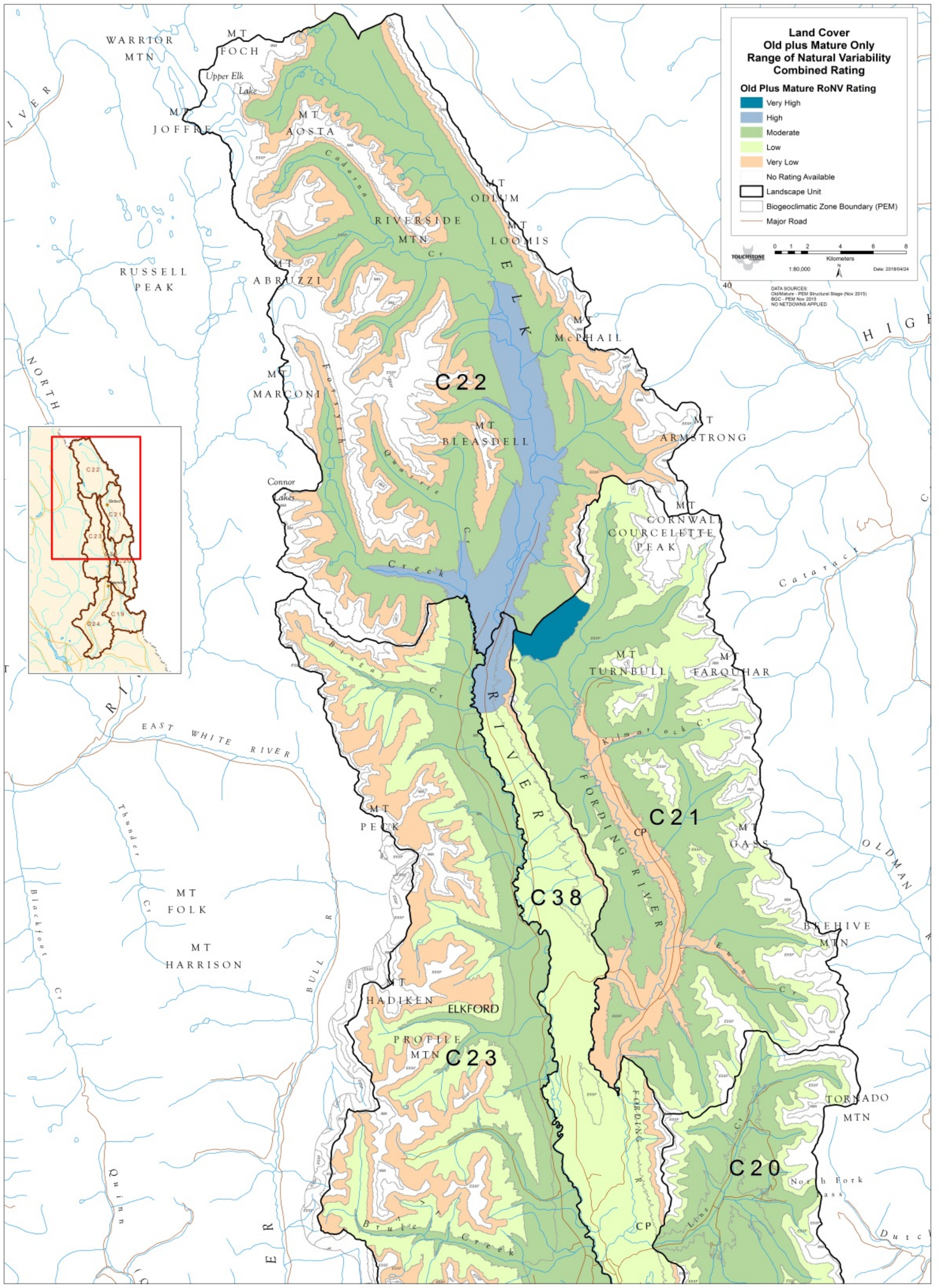

Figure 7 Mature forest hazard: the deviation of current mature+old combined forest from the mean amount expected under Range of Natural Variability (RoNV), North Elk Valley. Hazard rating: $z > 0$ = very low; $0 > z > -1$ = low; $-1 > z > -2$ = medium; $-2 > z > -3$ = high; $z < -3$ = very high

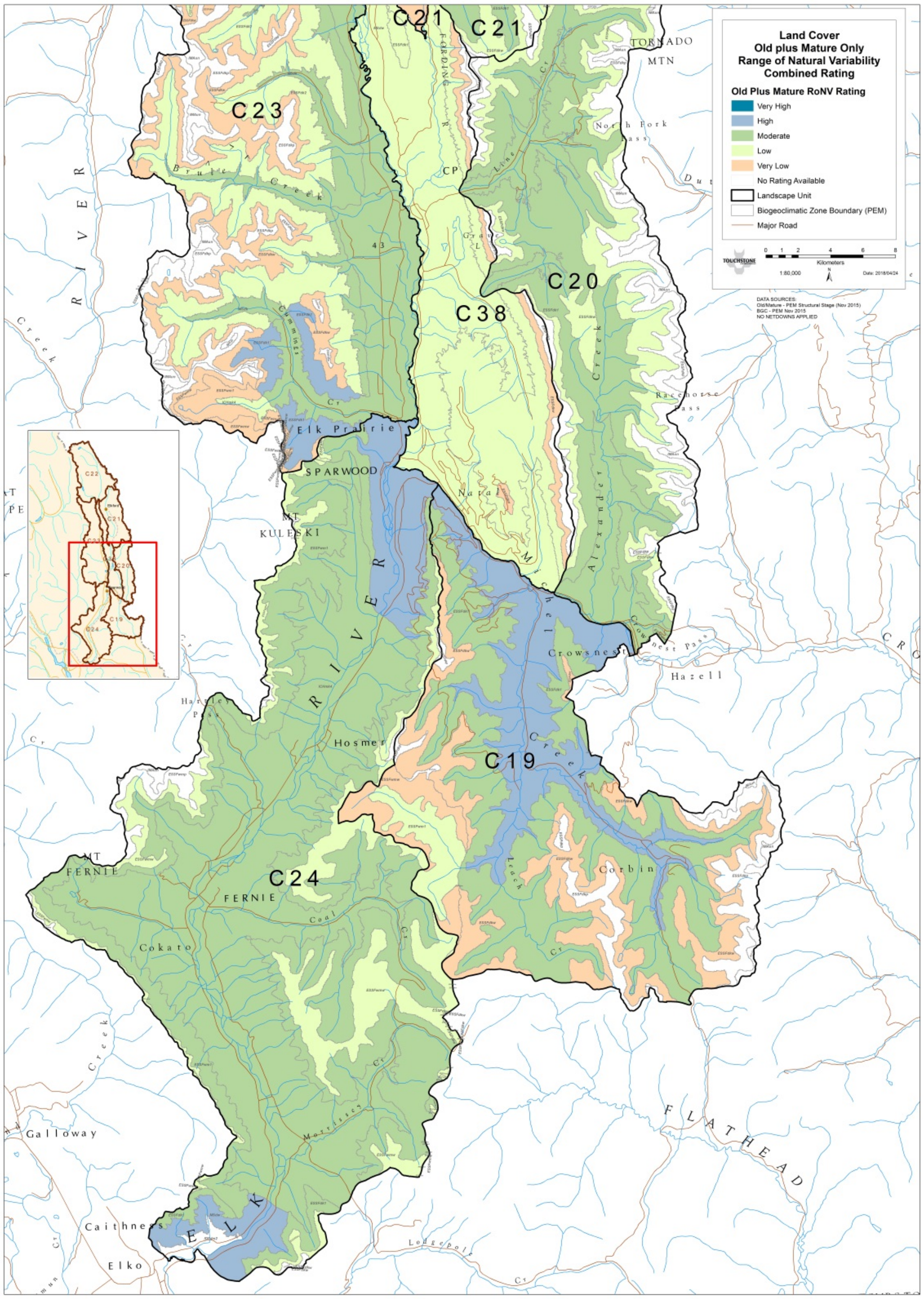

Figure 8 Mature forest hazard: the deviation of current mature+old combined forest from the expected amount under Range of Natural Variability (RoNV), South Elk Valley. Hazard rating: *z* >0 = very low; 0 > *z* > -1 = low; -1 > *z* > -2 = medium; -2 > *z* > -3 = high; *z* < -3 = very high

3.2 INTERIOR PATCH SIZE DISTRIBUTION

Overall, the patch size distributions of interior old and mature forest were heavily skewed towards patches < 40 ha in area, with the current percentage of patches in this category considerably higher than the percentages expected under the Range of Natural Variability for almost all BGC/LU units (Table 7, Table 8). Although it must be kept in mind that the results are conservative because the tables are comparing interior patch size (100 m buffer) to patch size, this pattern was consistent across NDT types (including subgroups of NDT3 with Fd throughout and Fd restricted), for old and mature and old forest patches combined on the FLB (private plus crown), and for old forest patches separately on the CFLB (Table 9). The pattern was not as strong for old and mature patches combined on the CFLB however (Table 10).

For NDT3 with Fd restricted (the dry ESSF BGC units), there was a high percentage of patches in the 40-250 size class relative to the target range, but a very low percentage in the 250-1000 ha size class. The exception to this pattern was found in C22, which is related to the presence of large patches of old forest in Elk Lakes Park and large OGMAs in that landscape unit (Figure 9, Figure 10).

The pattern was different for NDTs with smaller historical fires; patch size distributions for NDT2 (wet ESSF BGC units) and NDT3 with Douglas-fir throughout (MS and ICH BGC units) tended to be low compared to target ranges for the 40-80 and 80-250 size classes, although there were exceptions to this pattern in some units.

Examining the spatial distribution of patch sizes helps determine where to focus efforts to increase patch size. For example, the old and mature that exists in C38 is primarily in patches 20 ha or less (Figure 9, Figure 10). Efforts on CFLB should focus on creating larger patch sizes through OGMA and MMAs, while conservation on private land easements can help contribute to larger patches on the FLB. Figure 11 and Appendix 5 show the distribution of patch sizes by BGC unit and demonstrate that the MSdw, MSdk and ICHmk4 are particularly lacking larger patch sizes compared to other BGC variants.

In all BGCs, there is an overabundance of very small patches (1-5 ha; Table 7; Figure 11) and such small patches are considered to have minimal functionality from an interior forest perspective. Small patches lack functionality and longevity (because of their greater susceptibility to windthrow, blowdown, snowpress, etc.). Recruitment of larger patches with greater ecological function and longevity is a clear priority in all units.

Table 7. Comparison of the current percent of *interior old forest patches* in the FLB with the recommended target ranges for patch size in the Biodiversity Guidebook (BGB), by LU and NDT. + indicates above range, - indicates below range, ✓ indicates within range.

LU	NDT	Total Area Interior O FLB (ha)	Interior Patches < 40 ha			Interior Patches 40-80 ha			Interior Patches 80-250ha			Interior Patches 40-250ha			Interior Patches 250-1000 ha		
			% Old	BGB Range	In Range?	% Old	BGB Range	In Range?	% Old	BGB Range	In Range?	% Old	BGB Range	In Range?	% Old	BGB Range	In Range?
C19	NDT2	0.25	100	30-40	+	0	30-40	-	0	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-Non-Fd*	904.7	50	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	14	10-20	✓	37	60-80	-
C20	NDT3 – Non-Fd	1147.3	55	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	49	10-20	+	0	60-80	-
	NDT3 Fd	3.7	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C21	NDT3-non-Fd*	865.1	66	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	35	10-20	+	0	60-80	-
C22	NDT3-non-Fd	3715.4	29	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	29	10-20	+	42	60-80	-
	NDT3-Fd	129.9	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C23	NDT2	342.9	57	30-40	+	43	30-40	+	10	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-non-Fd	4555.5	51	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	42	10-20	+	6	60-80	-
	NDT3-Fd	534.3	80	30-40	+	20	30-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C24	NDT2	144.9	100	30-40	+	0	30-40	-	0	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-non-Fd	167.5	71	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	29	10-20	+	0	60-80	-
	NDT3-Fd	112.2	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C38	NDT3-Fd**	49.7	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A

* C19, C21 were 90% or above ESSFdk, dk1 and/or dkw variants (calculated by CFLB), so they were compared to the NDT3 Douglas-fir absent or restricted target ranges.
** C38, >95% was NDT3 with Fd so it was classified as such.

Table 8. Comparison of the current percent o*f interior mature and old combined forest patches* in the FLB with the recommended target ranges for patch size in the Biodiversity Guidebook (BGB), by LU and NDT. + indicates above range, - indicates below range, ✓ indicates within range.

LU	NDT	Total Area Interior O+M FLB (ha)	Interior Patches < 40 ha			Interior Patches 40-80 ha			Interior Patches 80-250ha			Interior Patches 40-250ha			Interior Patches 250-1000 ha		
			% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range?
C19	NDT2	158.6	100	30-40	+	0	30-40	-	0	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-Non-Fd*	944.4	40	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	41	10-20	+	37	60-80	-
C20	NDT3 – Non-Fd	2204.5	55	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	32	10-20	+	12	60-80	-
	NDT3 Fd	32.5	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C21	NDT3-non-Fd*	2680.5	53	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	47	10-20	+	0	60-80	-
C22	NDT3-non-Fd	5539.4	46	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	16	10-20	✓	38	60-80	+
	NDT3-Fd	278.8	74	20-30	+	26	25-40	✓	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C23	NDT2	517.8	47	30-40	+	43	30-40	+	10	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-non-Fd	8506.9	41	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	55	10-20	+	4	60-80	+
	NDT3-Fd	845.5	35	30-40	✓	6	30-40	-	0	30-50	-	N/A	N/A	N/A	59	N/A	N/A
C24	NDT2	2688.1	33	30-40	+	13	30-40	-	11	20-40	-	N/A	N/A	N/A	42	N/A	N/A
	NDT3-non-Fd	153.9	100	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	0	10-20	-	0	60-80	-
	NDT3-Fd	950.4	70	20-30	+	18	25-40	-	12	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C38	NDT3-Fd**	165.2	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A

* C19, C21 were 90% or above ESSFdk, dk1 and/or dkw variants (calculated by CFLB), so they were compared to the NDT3 Douglas-fir absent or restricted target ranges.
** C38, >95% was NDT3 with Fd so it was classified as such.

Table 9. Comparison of the observed proportion of *interior old forest patches in the CFLB* with recommended target ranges in the Biodiversity Guidebook (BGB), by LU and NDT. + indicates above range, - indicates below range, ✓ indicates within range.

LU	NDT	Total Area Interior Old CFLB (ha)	Interior Patches < 40 ha			Interior Patches 40-80 ha			Interior Patches 80-250ha			Interior Patches 40-250ha			Interior Patches 250-1000 ha		
			% Old	BGB Range	In Range?	% Old	BGB Range	In Range?	% Old	BGB Range	In Range?	% Old	BGB Range	In Range?	% Old	BGB Range	In Range?
C19	NDT2	0															
	NDT3*	223.7	74	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	26	10-20	+	0	60-80	-
C20	NDT3 - NonFd	700.4	49	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	51.1	10-20	+	0	60-80	-
	NDT3 Fd	2.1	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C21	NDT3-nonFd*	619.5	62	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	38	10-20	+	0	N/A	N/A
C22	NDT3-nonFd	2548.7	20	10-20	✓	N/A	N/A	N/A	N/A	N/A	N/A	34.0	10-20	+	45.7	N/A	N/A
	NDT3-Fd	124.6	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C23	NDT2	193.7	48	30-40	+	52	30-40	+	0	20-40	-	N/A	N/A	N/A	0	N/A	N/A
	NDT3-nonFd	3420.6	46	10-20	+	47.6	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	6.6	60-80	-
	NDT3-Fd	449.3	77	30-40	+	23.4	30-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C24	NDT2	70.6	100	30-40	+	0	30-40	-	0	20-40	-	N/A	N/A	N/A	0	N/A	N/A
	NDT3-nonFd	93.1	47	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	52.7	10-20	+	0	60-80	-
	NDT3-Fd	83.1	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	0	N/A	N/A
C38	NDT3-Fd**	37.7	94	20-30	+	4	25-40	-	0	30-50	-	N/A	N/A	N/A	0	N/A	N/A

* C19, C21 were 90% or above ESSFdk, dk1 and/or dkw variants (calculated by CFLB), so they were compared to the NDT3 Douglas-fir absent or restricted target ranges.
** C38, >95% was NDT3 with Fd so it was classified as such.

Table 10. Comparison of the current observed proportion of interior *mature+old patches in the CFLB* with recommended targets in the Biodiversity Guidebook (BGB), by LU and NDT 2 and 3. There are no BGB targets for patches >250 ha. + indicates above range, - indicates below range, ✓ indicates within range.

LU	NDT	Total Area Interior O+M CFLB (ha)	Interior Patches < 40 ha			Interior Patches 40-80 ha			Interior Patches 80-250ha			Interior Patches 40-250ha			Interior Patches 250-1000 ha		
			% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range?	% M+O	BGB Range	In Range ?	% Old	BGB Range	Within Range?
C19	NDT2	6.5	0	30-40	-	0	25-40	-	100	20-40	+	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3*	369.7	48	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	52	10-20	+	0	60-80	-
C20	NDT3 - NonFd	881.3	45	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	53	10-20	+	0	60-80	-
	NDT3 Fd	22.4	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C21	NDT3-nonFd*	1056.8	39	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	61	10-20	+	0	60-80	-
C22	NDT3-nonFd	2613.9	22	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	22	10-20	+	56	60-80	-
	NDT3-Fd	191.0	77	20-30	+	23	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C23	NDT2	294.1	37	30-40	✓	46	30-40	+	17	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-nonFd	4604.8	30	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	65	10-20	+	5	60-80	-
	NDT3-Fd	1441.0	30	30-40	✓	8	30-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C24	NDT2	1260.8	17	30-40	-	12	30-40	-	14	20-40	-	N/A	N/A	N/A	N/A	N/A	N/A
	NDT3-nonFd	42.6	100	10-20	+	N/A	N/A	N/A	N/A	N/A	N/A	0	10-20	-	0	60-80	-
	NDT3-Fd	440.6	64	20-30	+	12	25-40	-	24	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A
C38	NDT3-Fd**	76.9	100	20-30	+	0	25-40	-	0	30-50	-	N/A	N/A	N/A	N/A	N/A	N/A

* C19, C21 were 90% or above ESSFdk, dk1 and/or dkw variants (calculated by CFLB), so they were compared to the NDT3 Douglas-fir absent or restricted target ranges.
** C38, >95% was NDT3 with Fd so it was classified as such

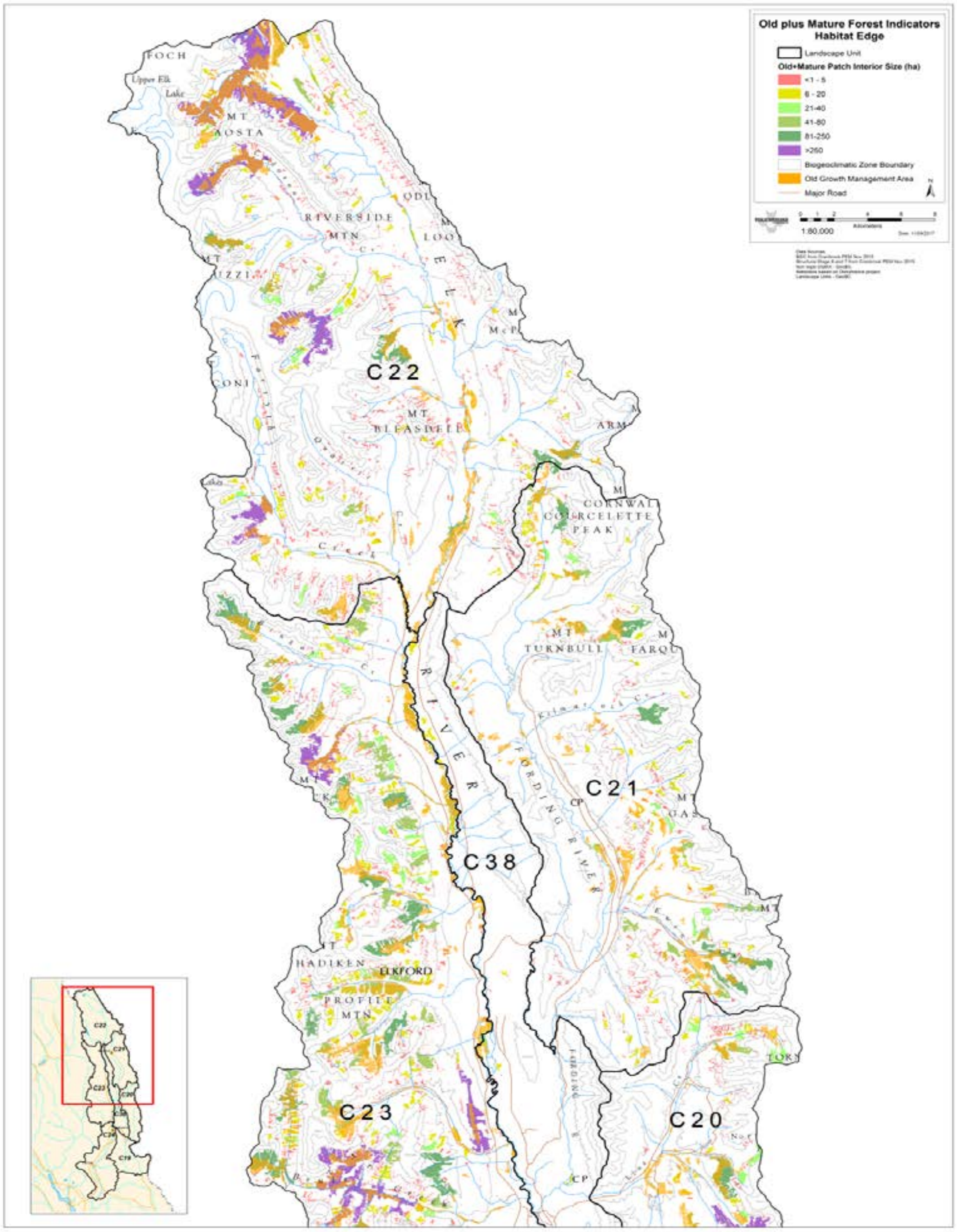

Figure 9. Size and distribution of interior patches of mature and old forests combined in the North Elk Valley.

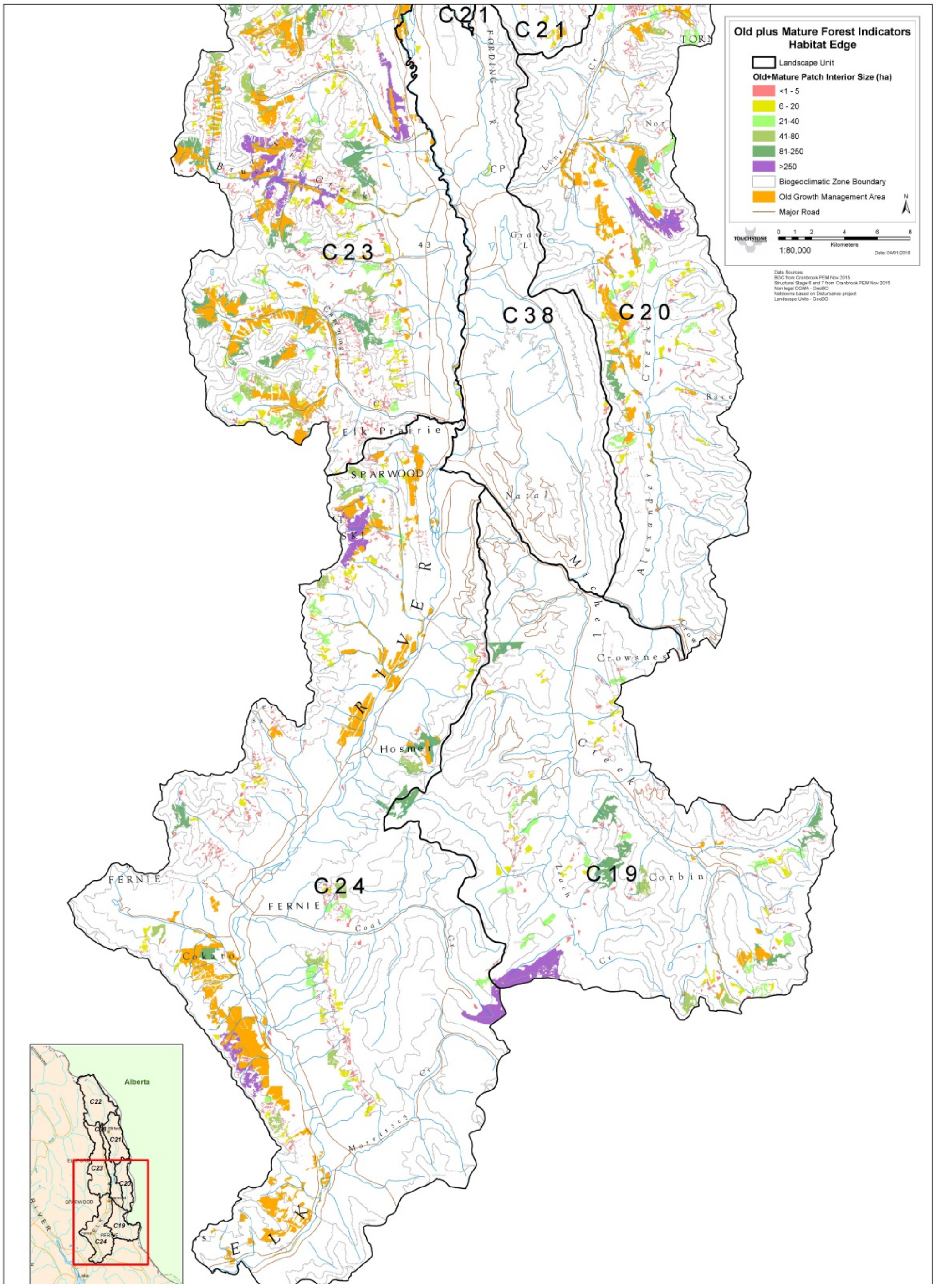

Figure 10. Size and distribution of interior patches of mature and old forests combined in the South Elk Valley.

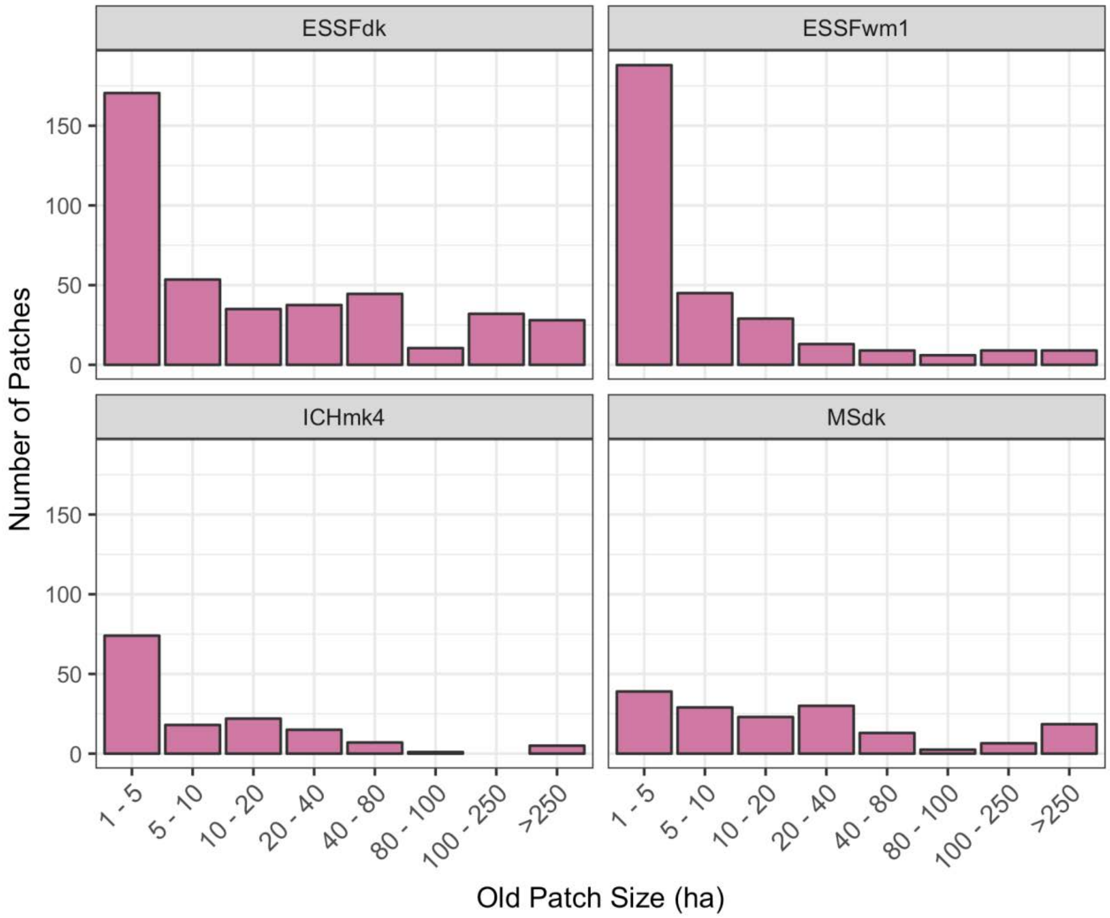

Figure 11 Patch size frequency of old forest (ha) for the ESSFdk, ESSFwm1, ECHmk4 and MSdk.

3.3 ECOSYSTEM DISTRIBUTION

Across the full Elk Valley study area, approximately half of the area is comprised of ecosystems (site series) with intermediate moisture (49.6%), with the remainder comprised of dry ecosystems (13.8%), wet ecosystems (8%) and non-forest ecosystems, such as wetlands, talus, rock, avalanche, etc. (28%). Overall the representation of dry forest within OGMAs was very close to the percentage of dry forest on the landbase (11.9% vs 13.8%), but there was higher representation of intermediate and wet ecosystems in OGMAs than overall (61.6% vs 49.6% for intermediate and 15.1% vs 8% for wet). OGMA percentages cannot fairly be compared to the percentage of 'other' ecosystems because even if an OGMA includes non-forested areas within its boundaries, the legal targets only allow for areas of crown forest to contribute to the targets (Table 11, Figure 12, Figure 13).

The pattern across the study area was not the same for each of the BGC variants/subzones, particularly for dry ecosystems. Some BGC units, such as the ESSFdk1 and dkw, had higher representation of dry ecosystems in OGMAs than in the landbase, while others, like the ESSFwmw and the ICHmk4, had lower representation. Intermediate ecosystems had higher representation in OGMAs than in the BGC overall in every BGC unit except in the MSdk. Wet ecosystems also tended to have higher representation in OGMAs, except in the ESSFwm1 and ESSFwmw.

Typically, ecosystem representation is intended to include ecosystems in similar proportions to the landbase. This ensures habitat is conserved for species associated with conditions in each type. In some cases, it may be advantageous to place OGMAs in areas that are less common on the landbase, as a means of providing habitat to specialized species. For example, wet ecosystems often provide important moose winter range and riparian habitats that are critical for fish and other aquatic species. Similarly, dry ecosystems are associated with several rare plants, and, particularly in older seral stages, provide critical winter range for mule deer and sheep. Although most abundant on the landbase, intermediate forests receive the highest pressure from human development, so establishment of OGMAs in these ecosystems is important to protect many wide-ranging old-forest associated species, such as interior northern goshawks.

Table 11. Distribution of dry, intermediate, wet forest and other ecosystems in BGC subzones/variants and their representation in OGMAs.

BGC Variant/ Subzone	Dry Ecosystems		Intermediate Ecosystems		Wet Ecosystems		Other Ecosystems*	
	% in OGMA	% Total	% in OGMA	% Total	% in OGMA	% Total	% in OGMA	% Total
ESSFdk1	10.1	5.4	66.2	59.7	17.2	10.1	6.6	24.8
ESSFdk2	11.1	12.2	70.6	58.8	15.5	10.8	2.8	18.1
ESSFdkw	28.0	19.4	39.1	25.4	3.9	0.7	29.0	54.5
ESSFwm1	18.2	17.9	76.0	62.7	3.7	4.0	2.1	15.4
ESSFwmw	8.8	24.3	64.4	34.9	1.6	2.2	25.1	38.7
ICHmk4	13.0	27.6	62.5	42.3	12.2	9.5	12.2	20.6
MSdk	2.4	3.7	48.9	62.3	29.7	11.8	19.0	22.1
MSdw	4.5	10.0	58.7	52.9	17.4	11.2	19.4	25.9
Overall	**11.9**	**13.8**	**61.6**	**49.6**	**15.1**	**8.0**	**11.4**	**28.7**

* Areas of non-forest within OGMA boundaries are not counted towards the old forest objectives set in the KBHLPO; only areas of CFLB within OGMAs are counted towards targets.

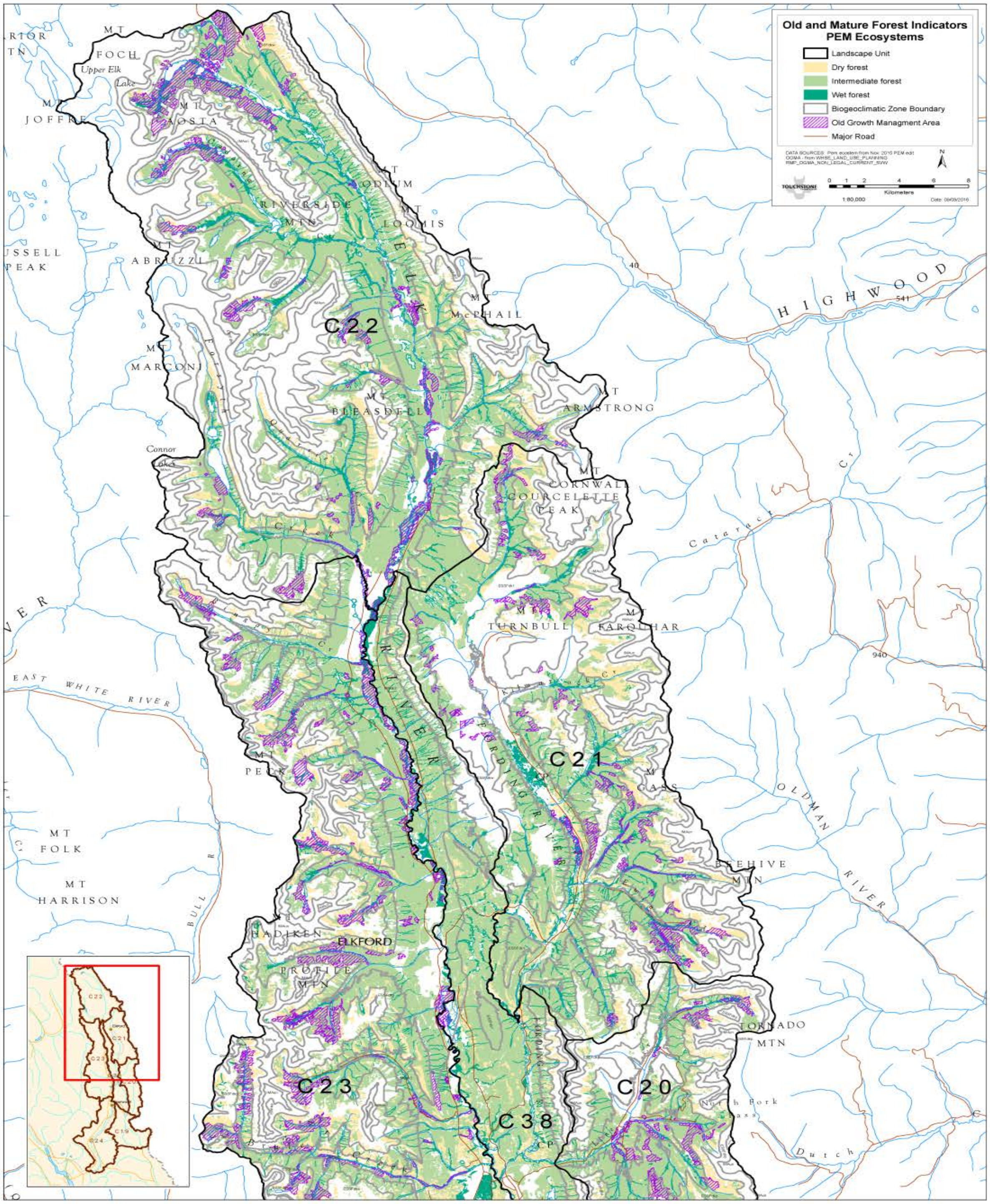

Figure 12 The spatial distribution of dry, intermediate and wet forest ecosystems by landscape unit and their representation in OGMAs in the North Elk Valley.

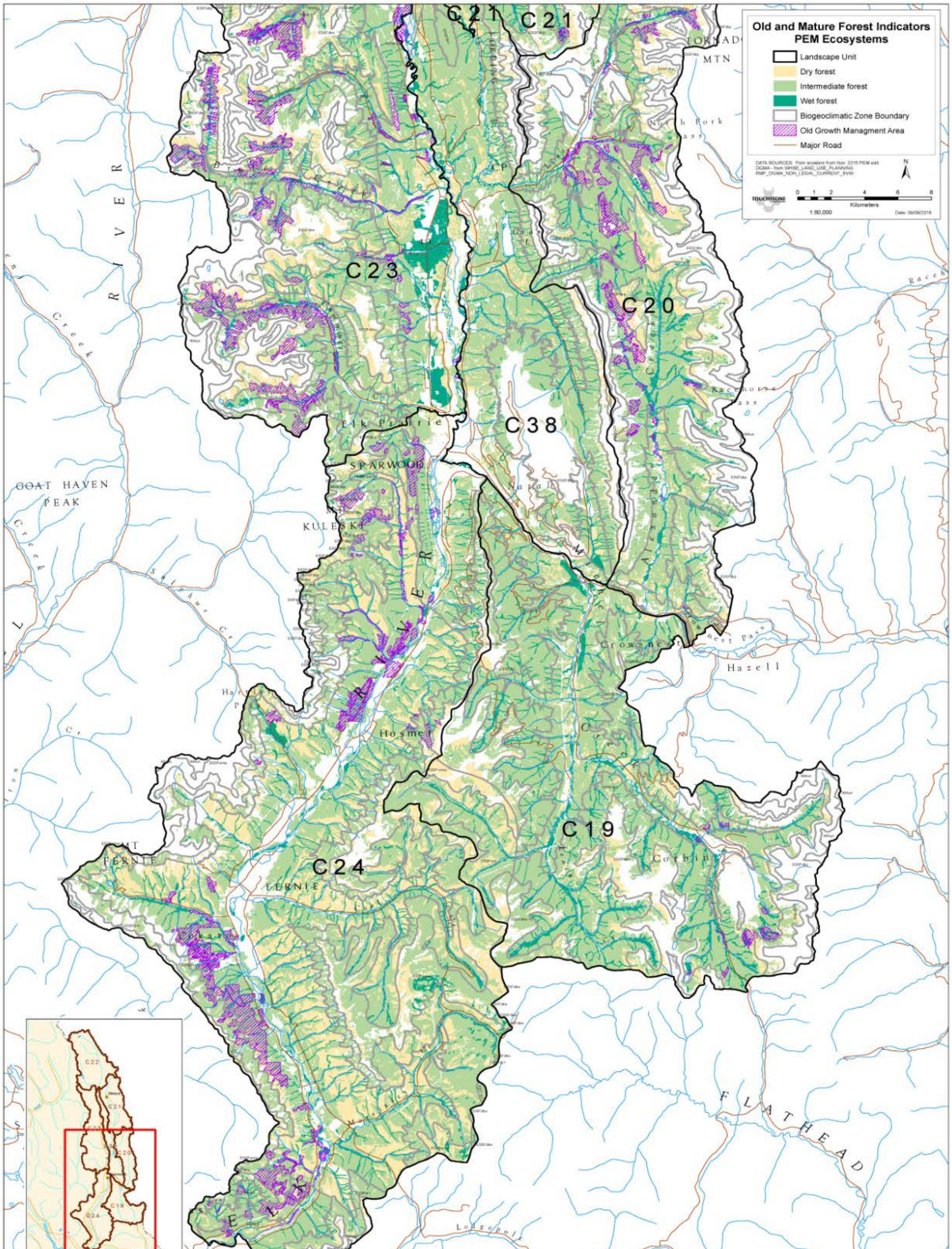

Figure 13 The spatial distribution of dry, intermediate and wet forest ecosystems by landscape unit and their representation in OGMAs in the South Elk Valley.

3.4 DISTRIBUTION WITH RESPECT TO LAND TENURE

The Elk Valley is a complex mix of land tenures. It is dominated by Crown land, but has a very high proportion of private lands that include a large private Managed Forest parcel, 6 coal mines, several conservation lands, and rural and urban areas. The crown portion includes a large provincial park. Within the crown area (outside of the park) there are a number of range, recreation, and mining tenures, as well as woodlots and a community forest (Table 12).

In the analysis for the forested landbase (crown and private), mature and old forests were unevenly distributed across land tenures and landscape units (Table 12). The highest amount of old and mature forest is on crown land, but private lands contain a significant amount of mature stands, as do private managed forest lands, to a lesser degree (Figure 14). Since there are no regulations governing the retention of mature or old forest on private or private managed forest lands, these stands may be at risk. Conservation easements on private land could help contribute to the maintenance of mature forest, and to the recruitment of old forest over time.

Since the analysis was completed in May 2016, extensive harvesting of mature and old forest has occurred in the private managed forest lands, so the amounts of mature and old are likely significantly less than shown, as are opportunities to recruit old forest from the private managed forest landbase.

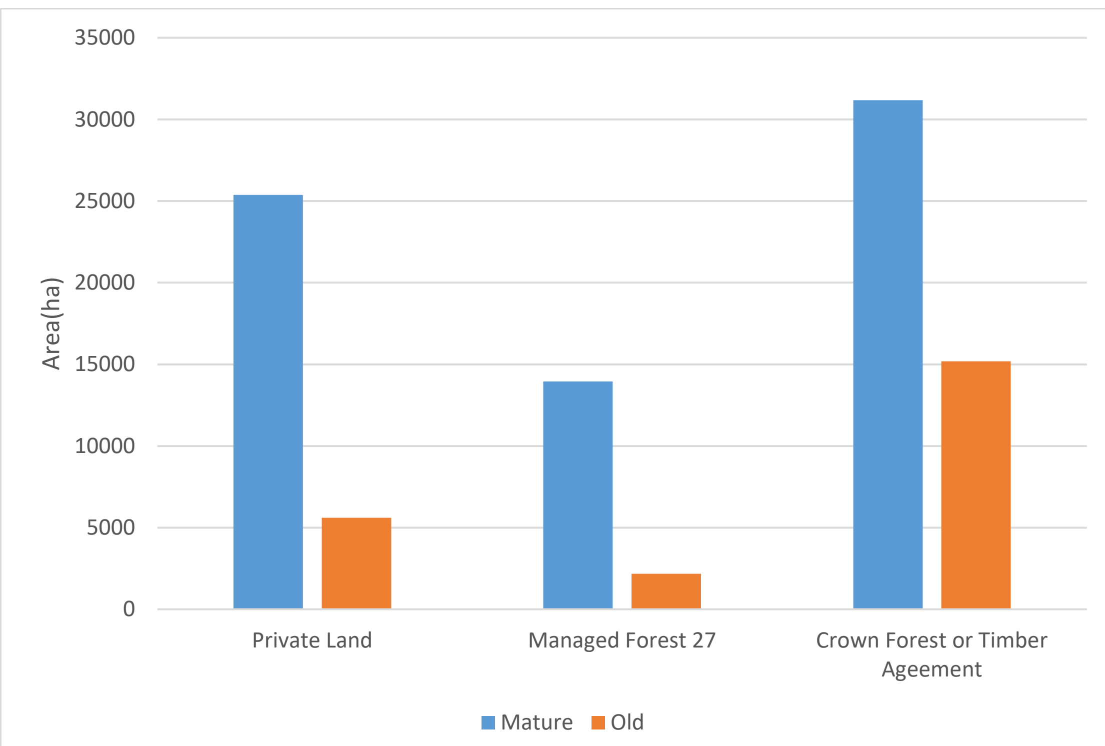

Figure 14. Total area (ha) of mature and old forest on private land, private managed forest land, and Crown Forest Land as of May 2016.

Table 12. Land use distribution by landscape unit (C19-C22) and amount (ha) of mature and old forest by land use category. *

Land Use designation	Total (ha)	C19 (ha)			C20 (ha)			C21 (ha)			C22 (ha)		
		Mature	Old	Total	Mature	Old	Total	Mature	Old	Total	Mature	Old	Total
Private Land	114,589	4701	865	22274	1572	862	11586	1846	562	8616	152	46	1540
Conservation Property	12,640	0		0	624	424	5336	0	0	0	0	0	0
Private Managed Forest	50,290	3696	688	17971	63	32	640	326	162	1475	0	0	0
Community Forest	12,541	828	716	7097	0	0	0	0	0	0	0	0	0
Crown Biodiversity, Mining and Tourism Area	129			7	3		10				1	7	62
Crown Forest Manag. Unit or Timber agreement land	242,026	5336	1106	28810	2438	2717	28408	3552	1913	39008	1758	1343	31855
Crown Misc Reserve	426	0	0	0	0	0	0	0	0	0	0	0	0
Crown Use, recreation and Enjoyment of the Public Reserve	139	0	0	0	0	0	0	0	0	0	0	0	0
Crown/Private Woodlot License	599	0	0	0	0	0	0	0	0	0	0	0	0
Indian Reserve	385	0	0	0	0	0	0	0	0	0	1		66
Recreation Tenure (dissolved)	2,746	0	0	0	0	0	0	0	0	0	1	0	24
Range Tenure (dissolved)	101,509	0	0	0	552	716	12327	1	0	19	2892	4206	65324
Mineral Tenure	103,618	3819	1013	22403	1574	1412	16129	1647	1002	21147	1007	888	16277
TECK Footprint	15,192			1017	17	0	2028	38	16	6403			8
Class A Park	33,512	0	0	0	12		45	0	0	0	1132	2857	33129

Table 12 (cont.)

Land Use designation	Total (ha)	C23 (ha)			C24 (ha)			C38 (ha)		
		Mature	Old	Total	Mature	Old	Total	Mature	Old	Total
Private Land	114,589	1105	97	4700	9780	462	35861	6216	2713	30012
Conservation Property	12,640	162	0	485	168	24	4606	784	207	2212
Private Managed Forest	50,290	98	0	168	7286	197	20809	2482	1089	9227
Community Forest	12,541				372	263	5443	0	0	0
Crown Biodiversity, Mining and Tourism Area	129	9	10	35			15	0	0	0
Crown Forest Landbase	242,026	7327	6367	58463	7973	742	43520	2803	1000	11963
Crown Misc Reserve	426	111	5	426	0	0	0	0	0	0
Crown Use, recreation and Enjoyment of the Public Reserve	139	8	10	138	0	0	1	0	0	0
Crown/Private Woodlot	599	242	42	599	0	0	0	0	0	0
First Nations Reserve	385				15		319	0	0	0
Recreation Tenure (dissolved)	2746	15	39	245	555	187	2476	0	0	0
Range Tenure (dissolved)	101,509	1142	795	9384	1061	114	14052	38	0	402
Mineral Tenure	103,618	1046	513	6464	6368	249	18932	243	353	2267
TECK Footprint	15,192	0	0	0			0	164	4	5737
Class A Park	33,512	0	0	0	92	3	337	0	0	0

* Note that many of the categories are overlapping, so the sum of the categories is greater than the total area

4.0 PROSPECTIVE ASSESSMENT

The prospective assessment was conducted to assess potential future conditions and trends in the land cover (amount of old and mature forest) and interior patch size indicators only.

4.1 AMOUNT OF OLD FOREST AND MATURE FOREST

Results differ greatly for the amounts and hazards associated with old forest compared to mature forest (assessed as mature+old forest, combined[3]). Across the study area, old forest hazard declines over time (although likely remains below the Range of Natural Variability for all i.e. moderate to high hazard; Figure 15), but at a much slower rate than the hazard ratings for mature (mature+old) forest (as expressed using z-scores in Figure 28). This is because large forested areas are currently in age classes that can reach the minimum age for mature forest definitions within the next 50 years, but fewer forests are currently old enough to reach minimum age for old forest definitions.

Increases in old forest are more evenly distributed across the study area than mature; however, most increases are primarily at higher elevations (Figure 16). Modelling suggests that increases in mature forest are likely to be greatest in the headwaters of the Elk River (in Elk Lakes Provincial Park) and at upper elevations throughout the study area (Figure 17). Although no assessment of ecosystem representation was done for the prospective analysis, this may result in disproportionate areas of future old and mature forests in steep slopes and other areas where harvesting does not occur.

[3] Throughout the prospective analysis, values for mature forest were calculated using data for mature+old. As per the Biodiversity Guidebook, the minimum requirement for the old seral stage must be met in order to achieve targets for mature+old; where old targets are not met, the risk to mature+old is a better reflection of the hazards and targets for mature only. For this reason, reporting of “mature” results in this section is based on the mature+old data and reporting for “old” results are presented separately.

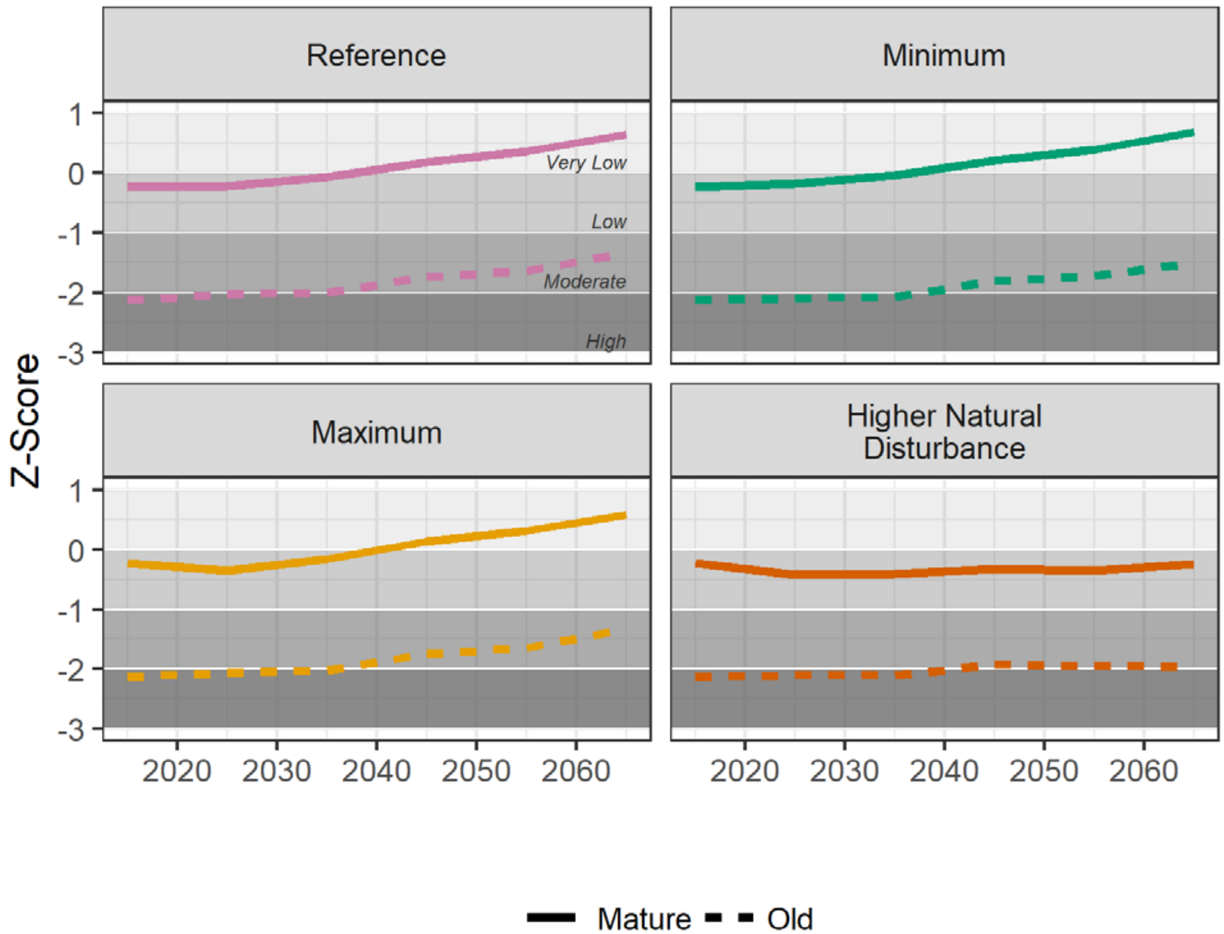

Figure 15 Simulated temporal trend in mature forest (solid) and old forest (dashed) hazard averaged over the study area under the Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios. Hazard rating: $z > 0$ = very low; $0 > z > -1$ = low; $-1 > z > -2$ = moderate; $-2 > z > -3$ = high; $z < -3$ = very high

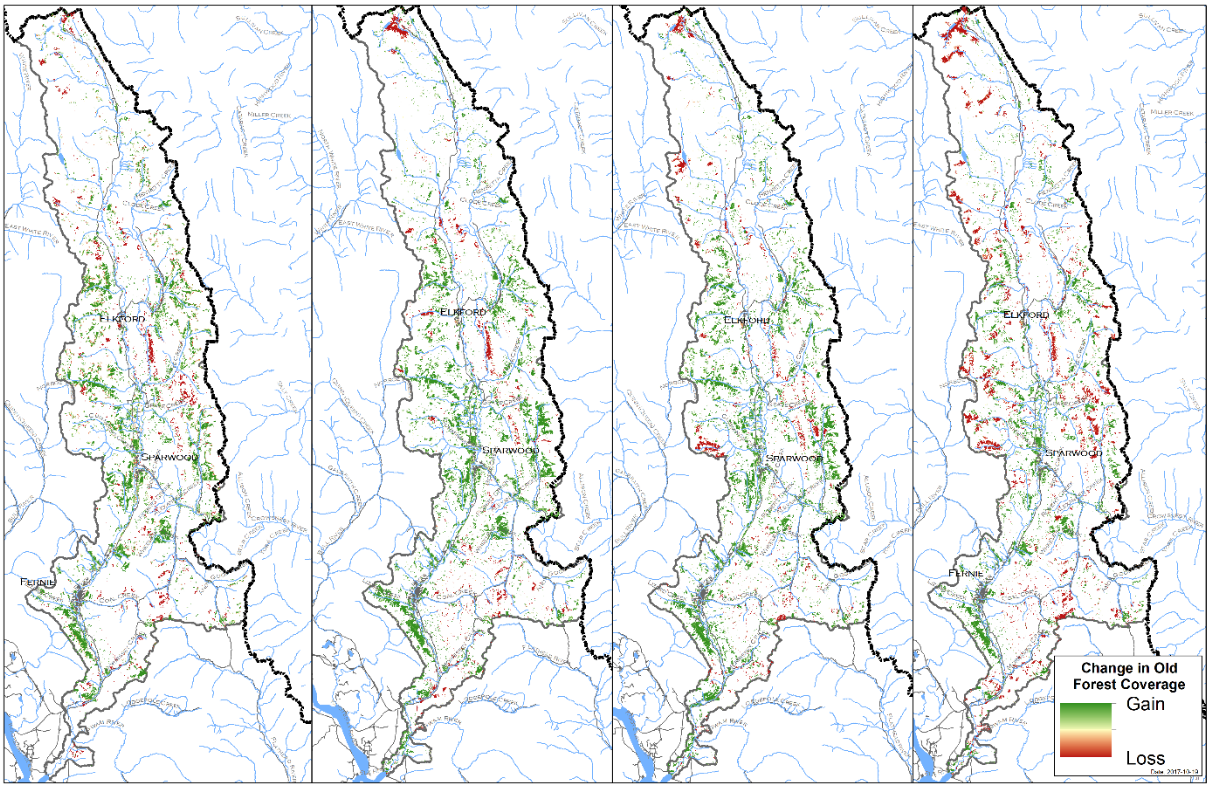

Figure 16 Change from current (2016) to 2065 in old forest coverage over the simulation, under the Reference, Minimum, Maximum development scenarios, and Higher Natural Disturbance scenario (left to right). Green indicates areas where forests shift into the old forest age class by the end of the simulation, while red indicates areas where mature forest is lost by the end of the simulation.

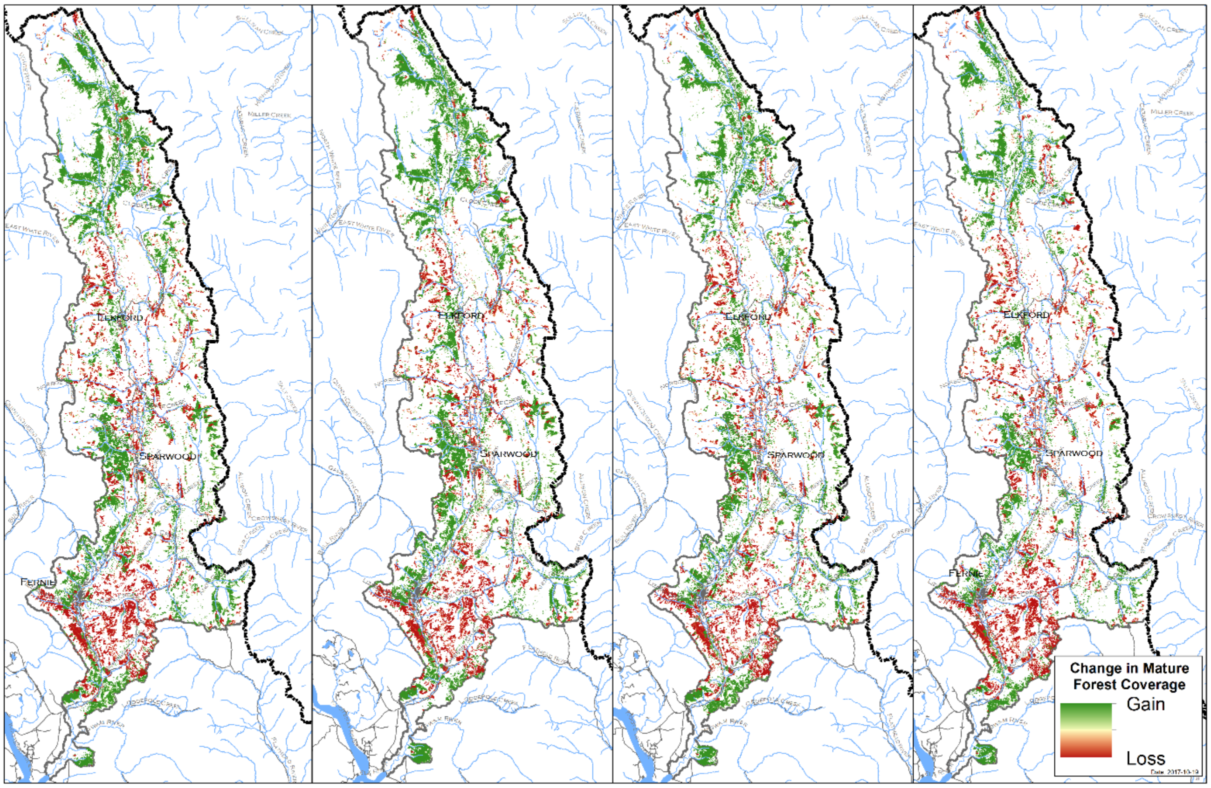

Figure 17 Change from 2016 to 2065 in mature forest coverage over the simulation, under the Reference, Minimum, Maximum development scenarios, and Higher Natural Disturbance scenario (left to right). Green indicates areas where forests shift into the mature forest age class by the end of the simulation, while red indicates areas where mature forest is lost by the end of the simulation.

4.1 HAZARD ANALYSIS

The analysis of old forest hazard shows that by the end of the prospective simulations, old forest hazard will likely remain outside of the Range of Natural Variability for all scenarios (Figure 15). The results for mature forest hazard are less severe and mature forest hazard will likely remain within the Natural Range of Variability (and therefore hazard ratings will be very low) except in the higher natural disturbance scenario (which includes climate change assumptions related to both pest and fire) where the hazard rating does not improve. It is important to distinguish between old and mature forest hazard, as old forests support more biodiversity and provide more ecosystem services relative to mature forests. Therefore, relatively lower hazard in mature forests (as calculated by mature+old) cannot compensate for the increased old forest hazard, which must be addressed directly.

Another important finding was that both old forests and mature forests were more sensitive to increased natural disturbance at the end of the simulation, rather than altered rates of anthropogenic development. Although in some BGC units (ESSFwm1 and ESSFwmw), the Maximum Scenario caused high hazard in old forests and mature forests, by the end of the simulation, mature forests had recovered, resulting in lower hazard relative to the Higher Natural Disturbance Scenario

(Figure 15). This dichotomy in hazard is important, as it demonstrates that some ESSF BGC zones are likely to be sensitive to development and will require time to recover in order to reduce hazard.

4.1.1 OLD FOREST HAZARD

Recruitment into old forest age classes may be able to help decrease the associated old forest hazard slightly; however, at the end of the simulation period, for all scenarios, the total area of old forest remains below the area expected from the range of natural variability (negative z-scores) for all BGC units (Figure 15). Slight reductions in hazard are simulated to occur for the three development-based scenarios (Reference, Minimum, and Maximum), suggesting that old forest hazard, at the scale of the study area, could shift from high to moderate by 2065 (Figure 15). However, under the Higher Natural Disturbance Scenario there is a negligible increase in z-score and old forest hazard remains high by year 2065 (Figure 15), a potential scenario if some climate change predictions are accurate. These results suggest ongoing hazards for old forests and associated biodiversity are likely to persist into the future across the study area.

Spatial variability within the study area is important to consider, and old forest hazard is not equal across all BGC subzones/variants. Figure 18 shows the variability in old forest hazard (represented as z-score) across BGC subzones/variants under each scenario. In the present time, the lower-elevation units (ICHmk4, MSdw, MSdk) as well as the ESSFdk1, ESSFwm1, and ESSFwmw are in a high old-growth deficit and have high hazard ratings for old forests. Modelling suggests that these BGC units could recover to moderate hazard by the end of the simulation period due to regeneration of historic fire, although the improvement is lower in the Higher Natural Disturbance Scenario. This analysis also suggests that old forest in the ESSF could be most dramatically affected by higher natural disturbance. This is most notably shown in the ESSFdk1 and ESSFdk2. Figure 19 demonstrates these dynamics spatially, clearly showing that the lower elevation BGC zones do not recover substantially and that the Higher Natural Disturbance Scenario results in negligible recovery or increases in hazard for old forests.

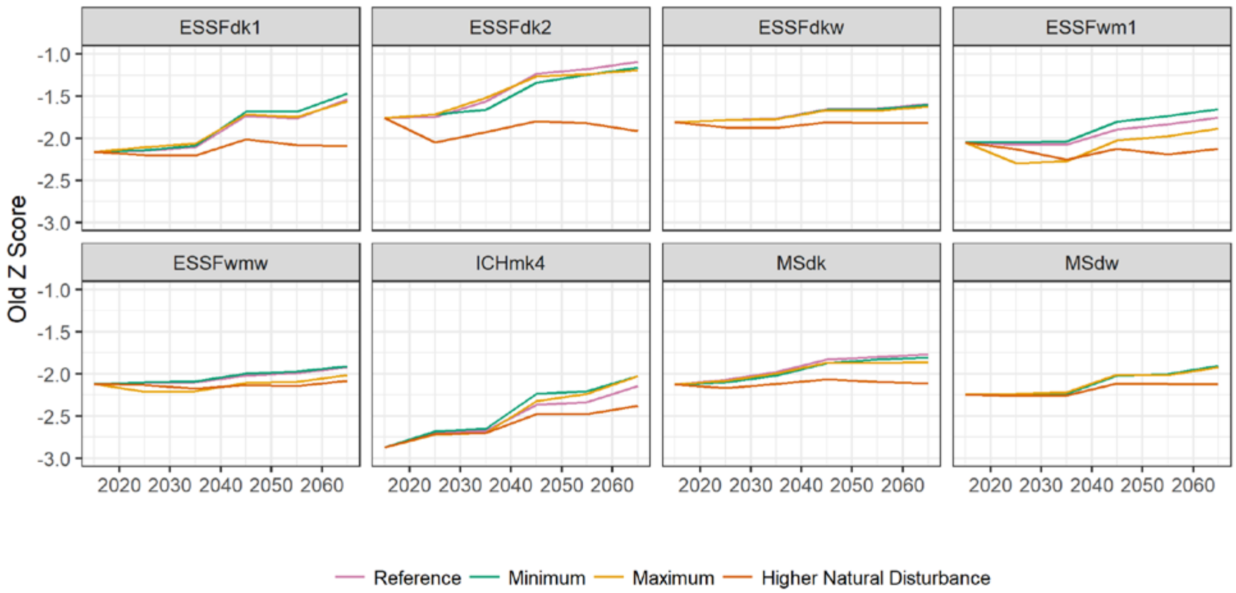

Figure 18 Simulated temporal trend of old forest hazard ratings, by individual BGC subzone/variant, for the Reference Scenario (pink), Minimum Scenario (green), Maximum Scenario (orange), and Higher Natural Disturbance Scenario (red). Hazard rating: z > 0 = very low; 0 > z > -1 = low; -1 > z > -2 = moderate; -2 > z > -3 = high; z < -3 = very high.

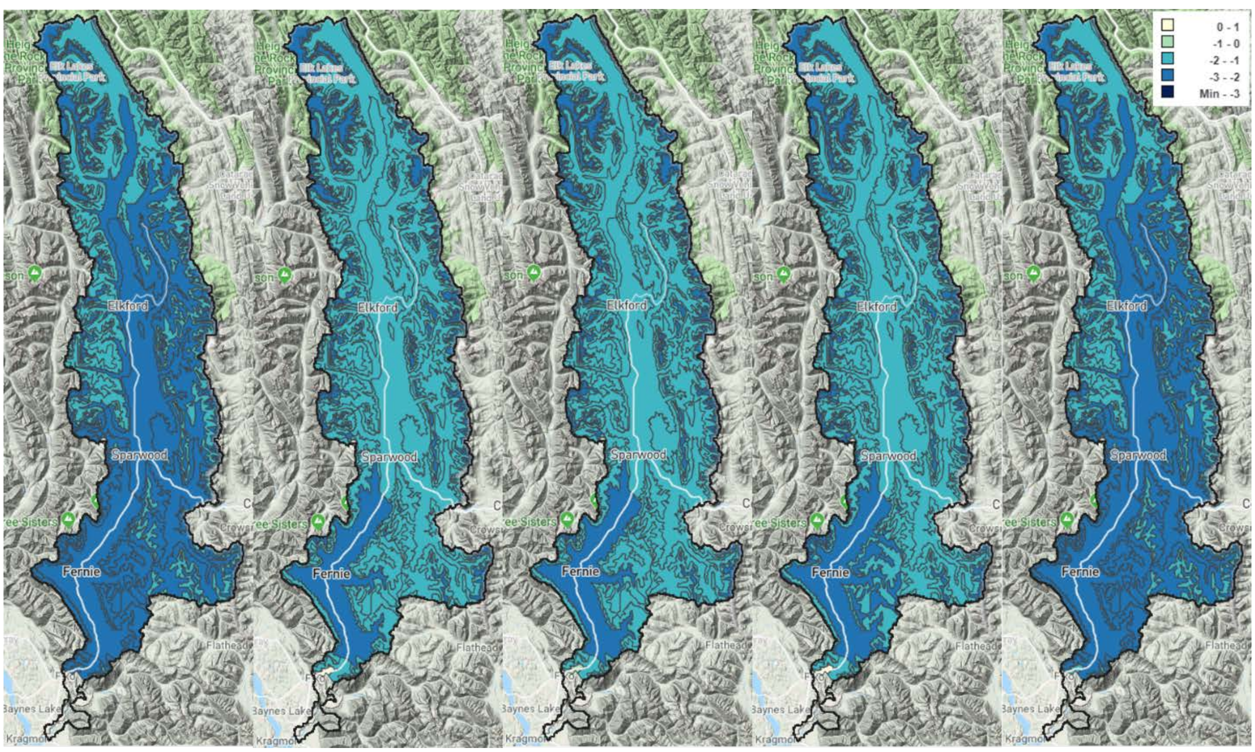

Figure 19 Current and potential future (2065) old forest hazard ratings by BGC subzone/variant in the Elk Valley under Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios (left to right). Hazard rating: z > 0 = very low; 0 > z > -1 = low; -1 > z > -2 = moderate; -2 > z > -3 = high; z < -3 = very high.

4.1.2 MATURE FOREST HAZARD

The increase in mature forest over time may be able to provide recruitment to old forest, but the timeframes are very long (> 50 years) in relation to current habitat needs of dependent wildlife and biodiversity. In the three scenarios based primarily on anthropogenic development (Reference, Minimum, and Maximum), simulations suggest that mature forest hazard, averaged across the study area, will be within the expected range of natural variability and will drop to very low by approximately 2045 (Figure 15). At the end of the simulation period using the Higher Natural Disturbance Scenario, the mature forest hazard is projected to remain below the range of natural variability and will remain in the moderate hazard category. Given the length of time required to recruit forests into these age classes, measures to maintain habitat for both old-forest associated species and species reliant on mature forests will need to occur immediately and continue over the short and medium term.

Future mature forest hazard varies spatially, but with slightly different patterns than old forest hazard. The hazard declines during each of the decades in the simulation for all scenarios but is markedly lower in the three scenarios focused primarily on human development activities (Figure 20). This suggests that, across BGC subzones/variants in the Elk Valley, land use development rate has a smaller effect on hazards associated with mature forests than the influence of increased natural disturbances, such as fire and insect outbreaks, over this time period. The Higher Natural Disturbance Scenario, which reflects a higher level of predicted climate change impacts while also incorporating the maximum development scenario, resulted in a substantially higher hazard rating for all BGC units. Interestingly, simulations suggest hazard to mature forest is likely to increase from very low to low or moderate over the simulation period in the ESSFwmw. This is because a large proportion of the ESSFwmw is occupied by private managed forest land and, although harvest levels are generally low in the lower productivity ESSFwmw on crown lands, the simulation assumes extensive harvesting of mature forest across the private lands. Figure 21 demonstrates these dynamics spatially, showing that overall, mature forest hazard decreases across the study area except in the Higher Natural Disturbance Scenario, where hazard in the lower elevation portions of the Elk Valley, particularly the MSdw, remains fairly constant. Figure 21 also demonstrates that mature forest hazard increases in the private lands just east of Fernie in the ESSFwmw, shifting from low to moderate hazard.

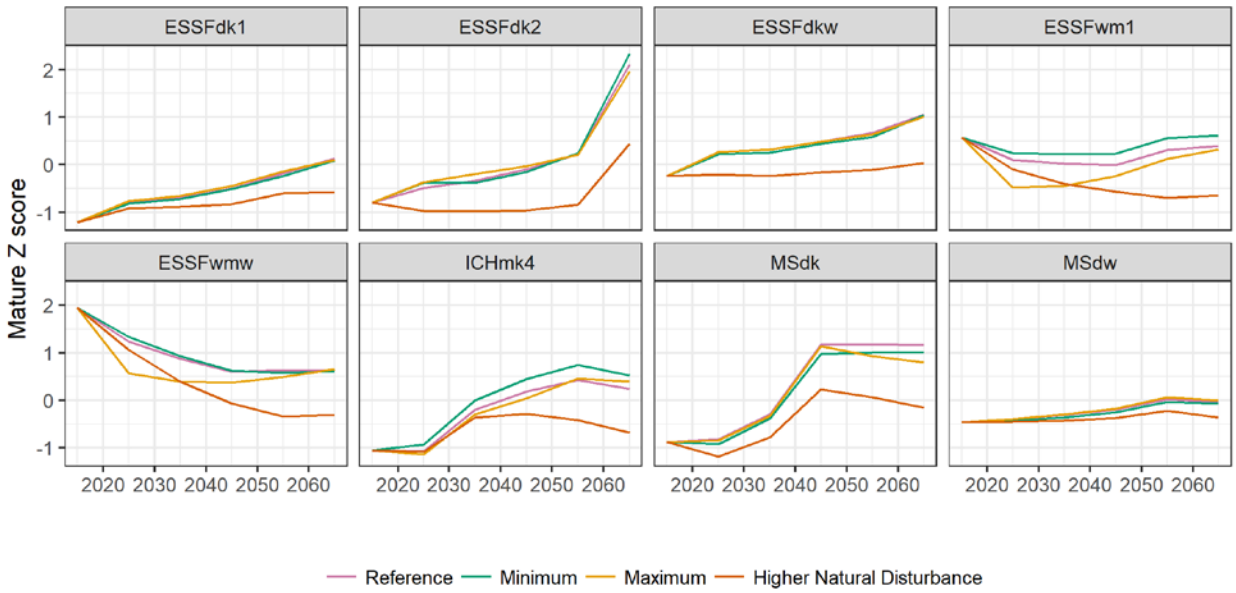

Figure 20 Simulated temporal trend of mature (mature+old) forest hazard ratings, by individual BGC subzone/variant, for the Reference Scenario (pink), Minimum Scenario (green), Maximum Scenario (orange), and Higher Natural Disturbance Scenario (red). Hazard rating: z > 0 = very low; 0 > z > -1 = low; -1 > z > -2 = moderate; -2 > z > -3 = high; z < -3 = very high.

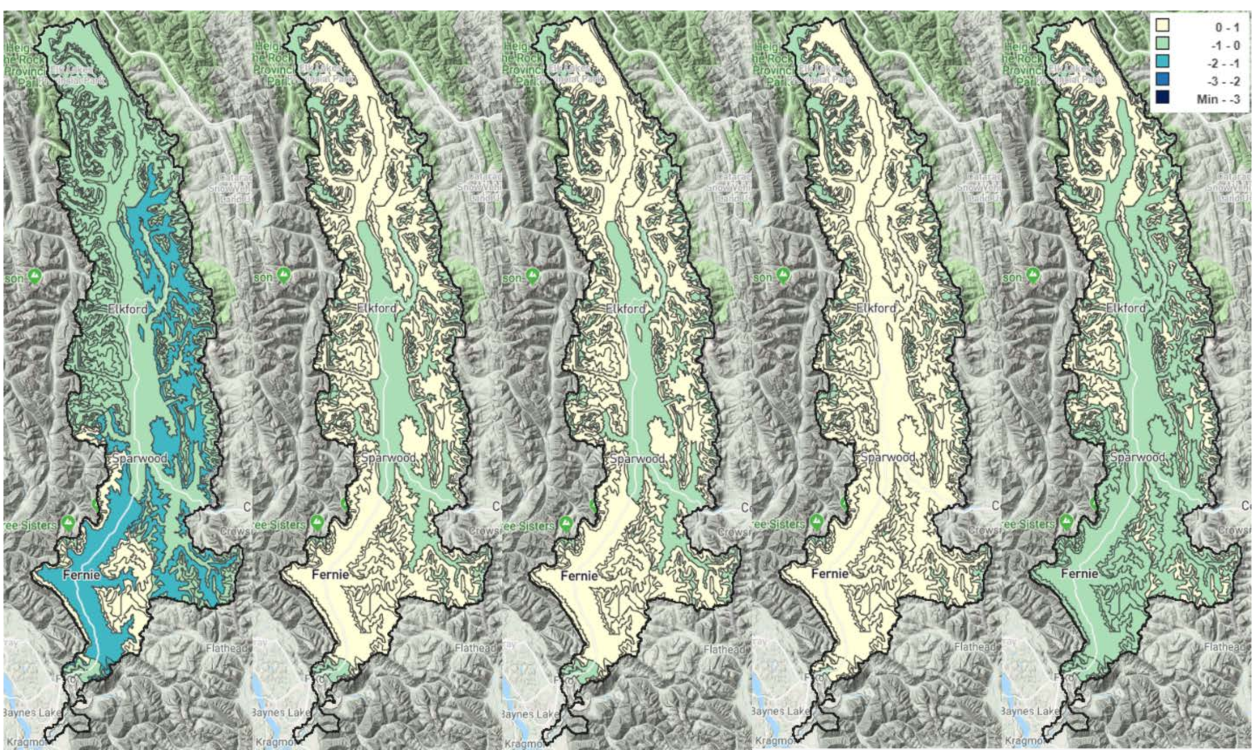

Figure 21 Current and future (2065) mature forest hazard ratings by BGC subzone/variant in the Elk Valley under Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios (left to right). Hazard rating: z > 0 = very low; 0 > z > -1 = low; -1 > z > -2 = moderate; -2 > z > -3 = high; z < -3 = very high.

4.2 Patch Size Analysis

An important distinction from this analysis is the comparison of patch size between old forests and mature forests. Both forest types behaved fairly similarly in the model, in that the Higher Natural Disturbance Scenario resulted in the smallest patch sizes; however, the mature patch sizes are approximately 37 times larger than the old patch sizes (under the Reference Scenario). This is because there is much more recruitment into the mature forest age classes than there is into the old forest age classes. These results suggest that large patches of old forest will continue to be uncommon or absent from the Elk Valley for the foreseeable future. Had the modelling approach used a longer timeframe (> 50 years), more insight into the dynamics of recruitment to old forest age class may have been available.

4.2.1 Old Forest Patch Size

The average old forest patch size increased slightly in the Minimum Scenario (2.9x), Reference Scenario (2.8x), and Maximum Scenario (2.2x) by the end of the simulation timeframe. Conversely, the Higher Natural Disturbance Scenario showed no notable increase in patch size (1.2x), with variability between BGC subzones/variants (Figure 22). When modelled separately, the ESSFdkw, ESSFdk2, ESSFdk1, and MSdk2 demonstrate relatively large increases in old forest patch size under the Reference, Minimum, and Maximum scenarios, but decrease under the Higher Natural Disturbance Scenario. Decreases in patch size in the Higher Natural Disturbance Scenario can be attributed to the fact that fire rate is substantially higher under this scenario and mature forests in pine and spruce leading stands are dramatically affected by pest outbreak. Interestingly, patch size is simulated to increase in all scenarios in the wetter climates of the ICHmk4, ESSFwm1, and ESSFwmw (Figure 22).

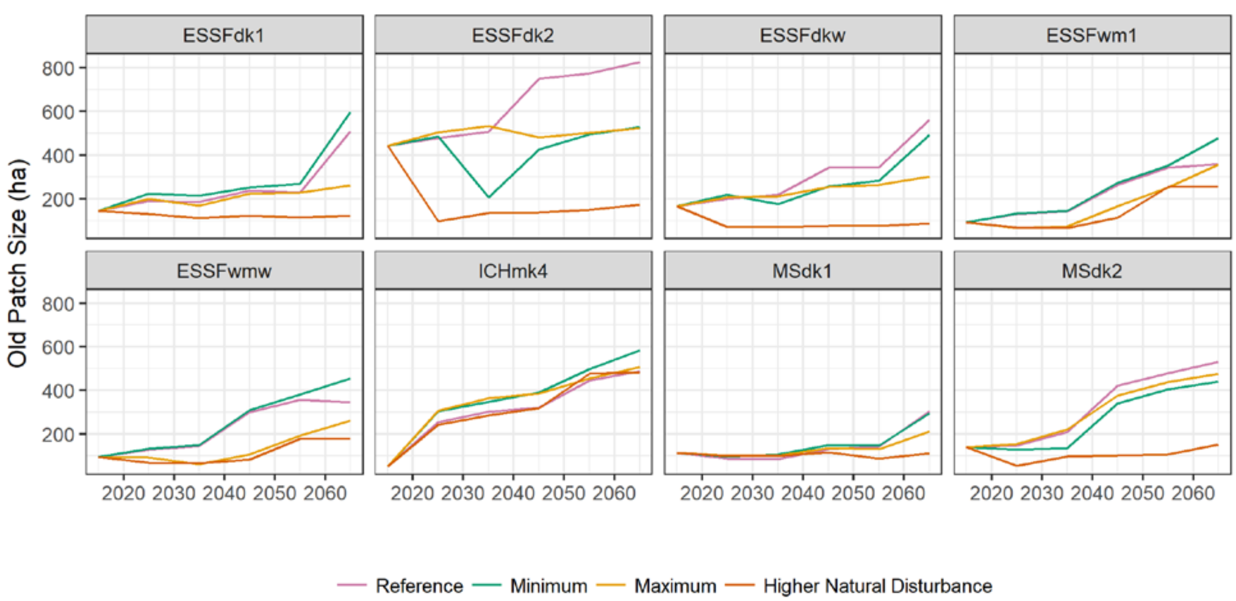

Figure 22 Simulated temporal trend of old forest patch size, by individual BGC subzone/variant, for the Reference Scenario (pink), Minimum Scenario (green), Maximum Scenario (orange), and Higher Natural Disturbance Scenario (red).

The distribution of old forest patch sizes across the study area is very skewed towards smaller patch sizes, with the largest proportion of the patches being made up of the 1-5 ha class. These small patches have low interior habitat function and have lower longevity (due to factors such as windthrow, blowdown, and snowpress). The 80-100 ha class has almost no patches (Figure 23). There is a slight shift in the distribution towards larger patch sizes under all scenarios by the end of the 50-year simulation period. However, this shift is very minor under the Higher Natural Disturbance Scenario (Figure 22).

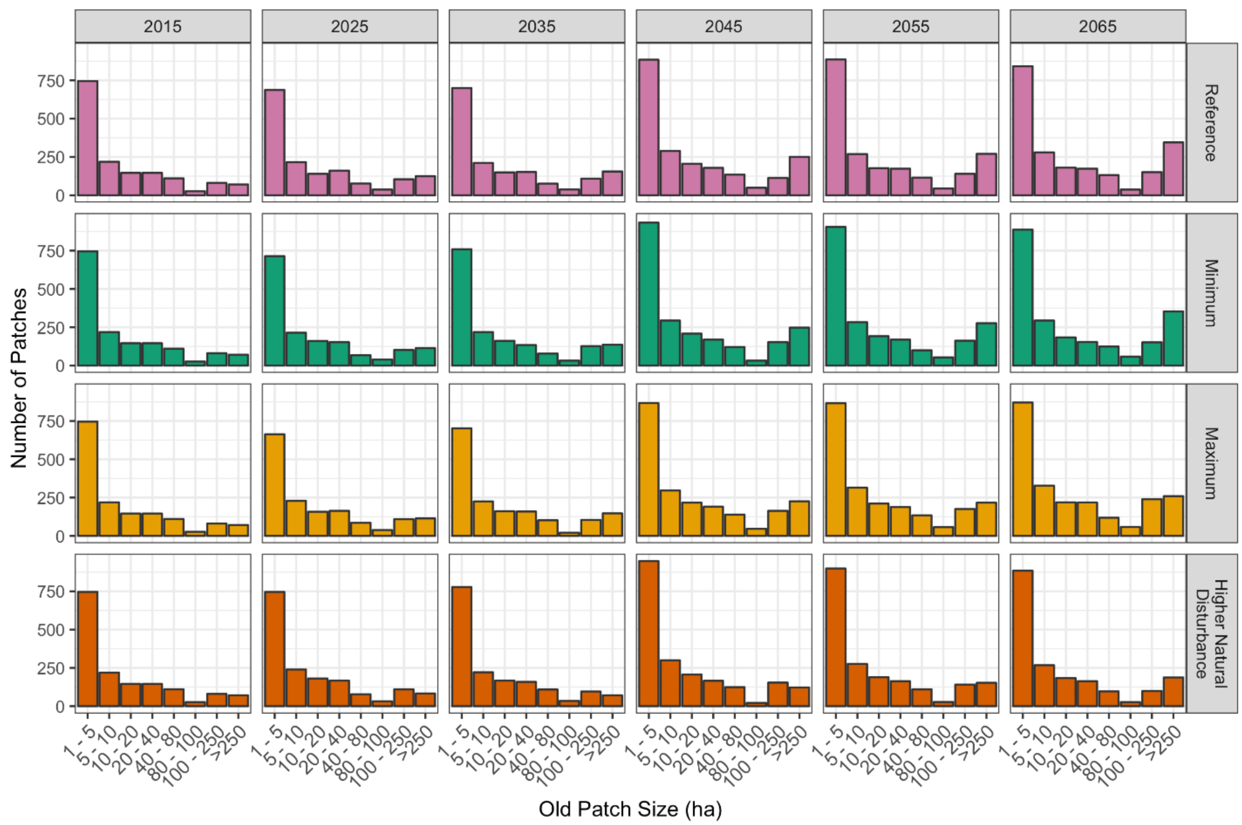

Figure 23 Old forest patch size distribution across Reference, Minimum, Maximum development scenarios and Higher Natural Disturbance scenario by decade from 2015 (current) to 2065.

4.2.2 Mature Forest Patch Size

The average mature patch size increased substantially in the Reference (25x) and Minimum (16x) scenarios and to a lesser extent in the Maximum Scenario (7x) for all BGC subzones/variants by the end of the simulation timeframe, but the Higher Natural Disturbance Scenario showed no notable increase in patch size for any BGC units (Figure 24). Patch sizes are currently much smaller than those projected at the end of the simulation period. This suggests that with enough time for forests to age, and with management activities that support larger patches, increases are possible within the simulation period. However, patch size will likely remain a concern well into the future and will require that recruitment strategies be in place to help build resiliency to natural disturbance.

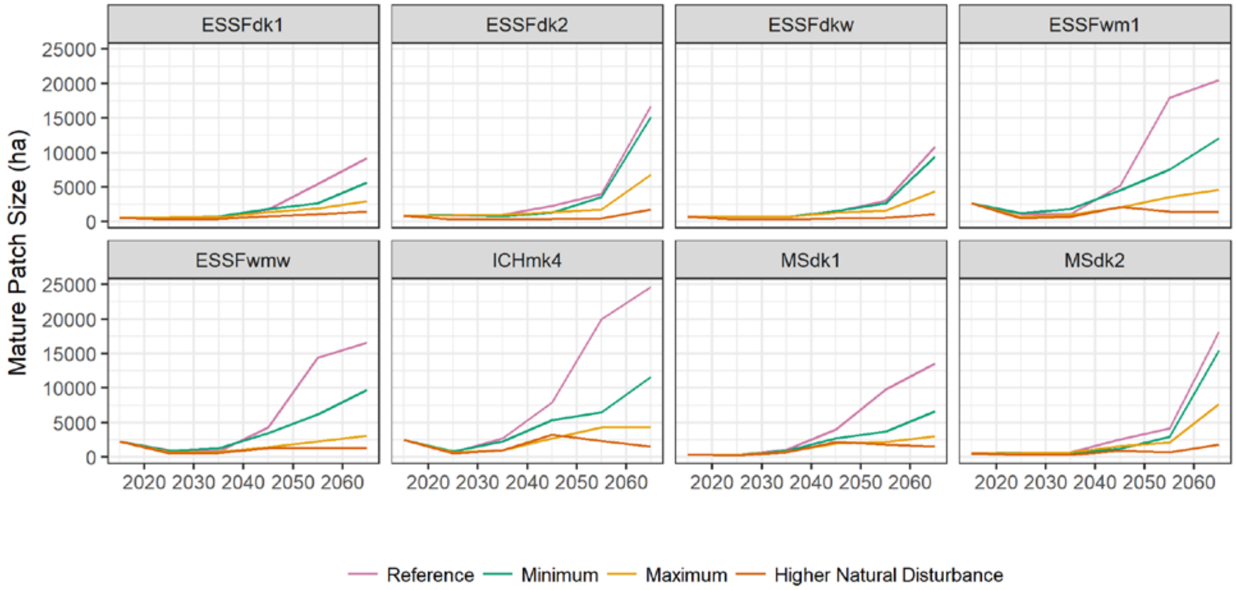

Figure 24 Temporal trend of old forest patch size, by individual BGC subzone/variant, for the Reference Scenario (pink), Minimum Scenario (green), Maximum Scenario (orange), and Higher Natural Disturbance Scenario (red).

Similar to old forest patch size, the distribution of mature forest patch sizes across the study area is currently skewed towards smaller patch size classes. However, unlike the old forest patch sizes, there is a substantial shift towards a bi-modal distribution, with larger patches under the Reference, Minimum, and Maximum scenarios. This shift also occurs under the Higher Natural Disturbance Scenario; however, it is not as dramatic (Figure 25). Again, patch sizes in the middle of the distribution appear to be relatively sparse across the study area, with the 80-100 ha class representing the lowest number of patches (Figure 25).

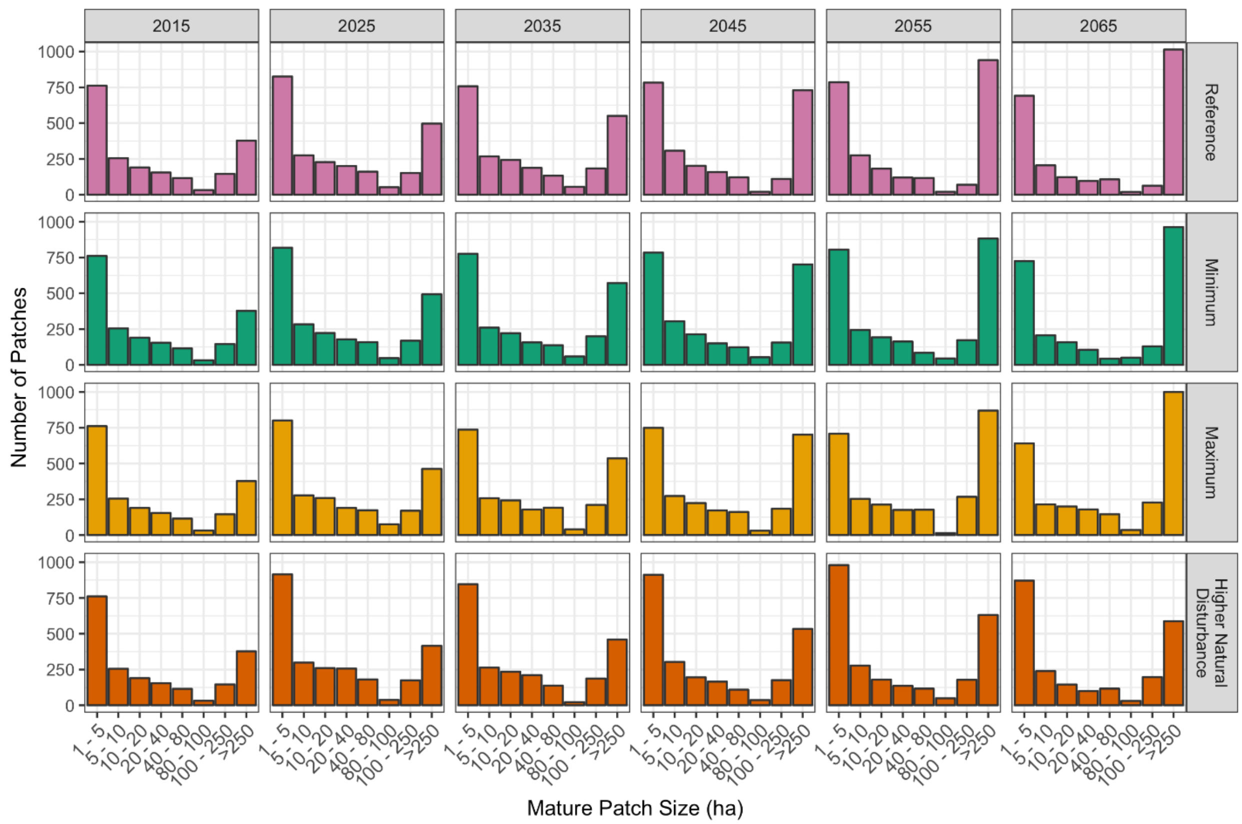

Figure 25 Mature forest patch size distribution across Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios by decade from 2015 (current) to 2065.

4.3 PRIVATE MANAGED FOREST LANDS ANALYSIS

The results presented thus far reflect the average for each BGC subzone/variant at the scale of the study area; considering harvest activities are generally restricted to the timber harvesting landbase (THLB), it is important to assess old forest and mature forest hazard at a more local scale. Given the large area covered by private managed forest lands in the Elk Valley, trends on these lands were examined separately. The hazard ratings demonstrate substantially different patterns at the scale of private managed forest lands where harvest rates are considerably higher.

The analysis demonstrated a drastic contrast between hazard and patch size at the scale of publicly owned crown forest lands, relative to the scale of private managed forest lands. In the analysis for private managed forest lands, old forest hazard remains high throughout the simulation period (Figure 26), whereas mature forest hazard increases notably (Figure 27). This is in contrast to the patterns on crown lands where mature forest hazard declines throughout the simulation period. These results suggest that there is very little old forest recruitment potential on these lands, and that management activities are reducing the potential for future recruitment by substantially reducing the amount of mature forest in the private land area. Given the large area of private managed forest lands in the Elk Valley (and the fact that considerable harvesting has taken place since May 2016 such that actual results may pose even greater risks than those presented here), these will have detrimental impacts on habitat availability for old and mature forest-dependent wildlife and associated biodiversity.

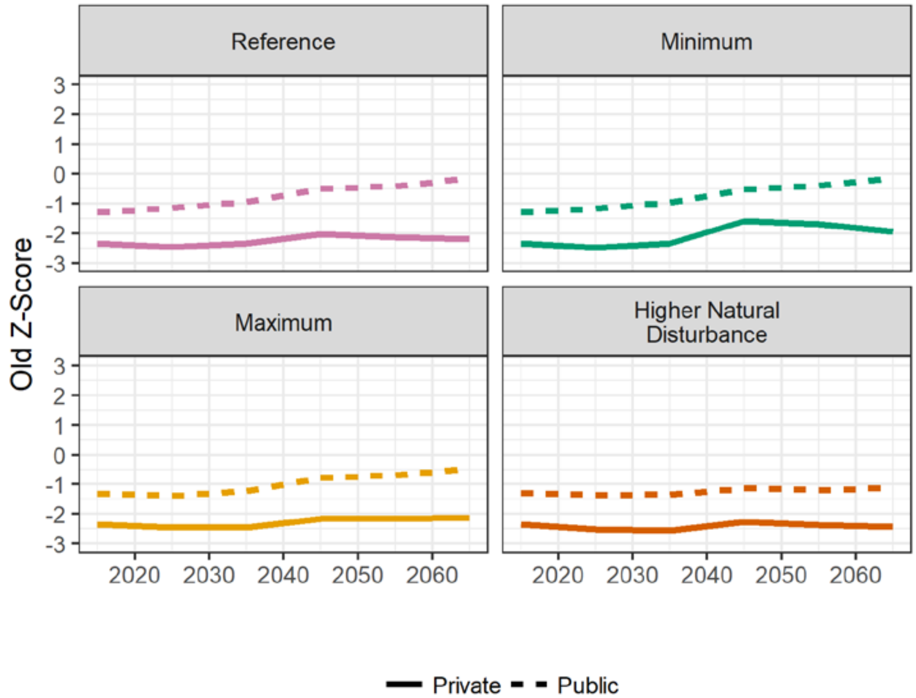

Figure 26 Old forest hazard on private lands compared to crown (public) lands under Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios over the 50-year simulation timeframe. Hazard rating: z > 0 = very low; 0 > z > -1 = low; -1 > z > -2 = moderate; -2 > z > -3 = high; z < -3 = very high.

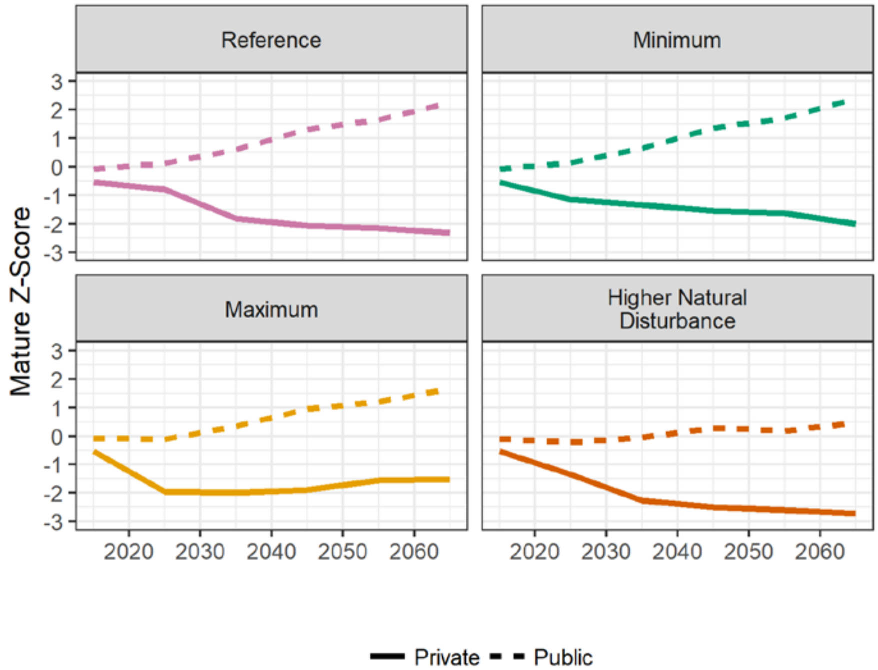

Figure 27 Mature forest hazard on private lands compared to crown (public) lands under Reference, Minimum, Maximum, and Higher Natural Disturbance scenarios over the 50-year simulation timeframe. Hazard rating: $z > 0$ = very low; $0 > z > -1$ = low; $-1 > z > -2$ = moderate; $-2 > z > -3$ = high; $z < -3$ = very high.

At the end of the reference scenario, average mature forest patch size is projected to decrease by approximately 263 ha. Average old patch size is projected to decrease by only 3.5 ha, although patch sizes in the private managed forest lands are already extremely small (average of 3.6 ha) (Figure 28). These results demonstrate a disproportionately intense development pressure on mature forests in private managed lands under the Reference Scenario.

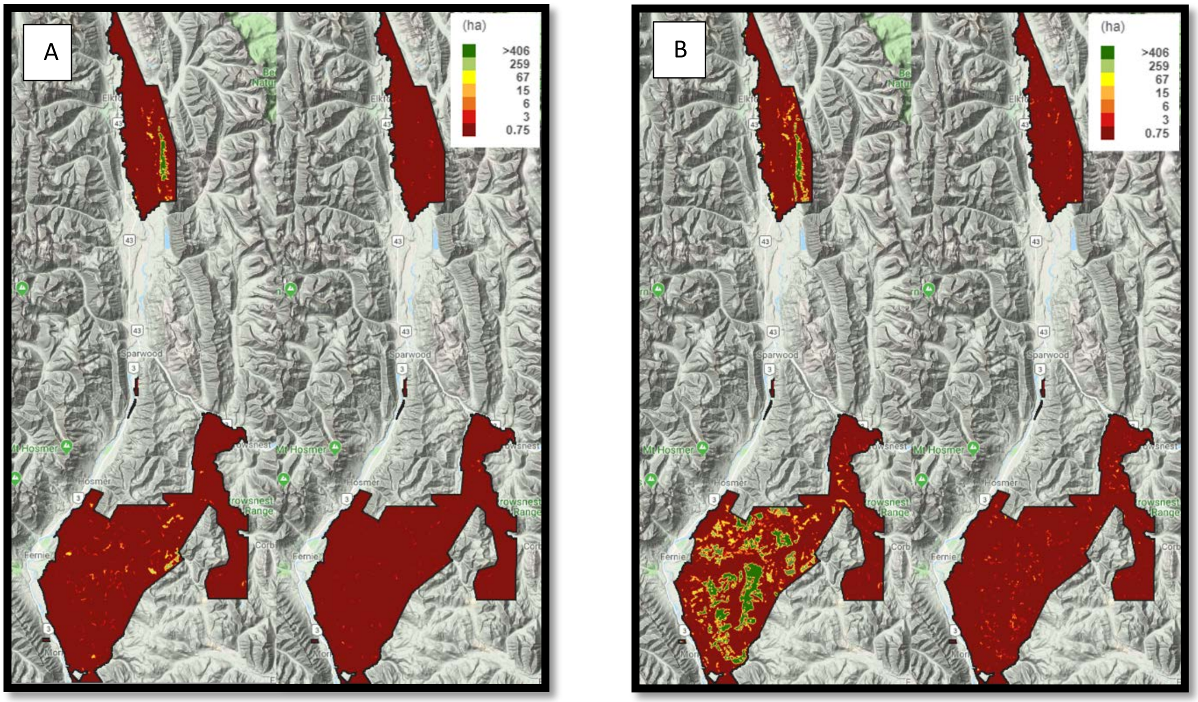

Figure 28 A) Old forest patch size (ha) on private managed forest lands in 2016 (left) and as projected in 2065 (right) under the Reference Scenario. B) Mature (mature+old) forest patch size (ha) on private managed forest lands in 2016 (left) and as projected in 2065 (right) under the Reference Scenario.

By the end of the simulation, the majority of old forest patches greater than 5 ha are removed (Figure 28A). Although there is currently a substantial area of mature forest patches over 250 ha, by the end of the simulation there remains fewer than 30 patches of this size, with the majority of patches within the 1-5 ha category (Figure 28B). Together, these results demonstrate that retention of old and mature forests on private managed forest lands should be a management priority if cumulative effects are to be effectively managed in the Elk Valley.

5.0 MITIGATION AND MANAGEMENT

5.1 CURRENT MANAGEMENT AND MITIGATION PRACTICES

Numerous management and mitigation strategies are currently applied on the landscape by various land managers and owners that positively affect the amount and distribution of old growth and mature stands in the study area. As previously described, forest licensees, including BCTS, follow legal requirements for old and mature forests outlined in FRPA and the KBHLPO, which results in anywhere from 3-52% of the old forest a BCG subzone/variant in each LU retained and in some LUs an additional percentage of mature forest retained. Legal requirements for riparian reserves along larger fish-bearing streams also result in mature and old forest being retained during forestry operations, although this is typically in narrow strips (20-50+m, depending on stream size). Finally, forest management for other values such as water quality and quantity (through ECA levels), visuals, and wildlife habitat (Wildlife Habitat Areas, Wildlife Features and Ungulate Winter Ranges), results in additional old and mature forest being retained throughout the landscape.

Canfor has a Standard Work Procedure for OGMA replacement that emphasizes the designation of replacement OGMAs in stands adjacent to existing OGMAs (where stand conditions meet requirements for equal or better old conditions), in order to make the existing OGMAs larger. Finally, because Canfor is certified by the Forest Stewardship Council (FSC), the company has designated High Conservation Value Areas throughout the East Kootenay region in areas where exceptional ecological and cultural values occur. Old and mature forest is retained in some of these areas in amounts greater than standard practices.

Other land managers such as Teck Coal manage their private forested land for biodiversity values (in partnership with Canfor), giving high consideration to retention of old and mature forest. Conservation groups such as the Nature Conservancy have conservation covenants or own land outright in the Elk Valley, and manage it primarily for biodiversity values, which again results in retention of old and mature forest.

5.2 Mitigation Scenarios for Modelling

To determine what measures, if any, could mitigate the impacts of development and natural disturbance on old and mature forest, the Expert Team developed a set of potential mitigation strategies that could be applied within the Elk Valley (

Moderate Mitigation	**Intensive Mitigation**
Manage to full old targets within the 7 Low Emphasis Biodiversity Emphasis Option (BEO) BGC/LU units (remove the 2/3 drawdown, e.g., increase old from 3 to 9% in wet ESSF and from 4.5 to 14% in others).	Require mature forest retention in each BGC/LU that does not already have this requirement, according to the percentages specified in the Biodiversity Guidebook (27 of the 33 do not currently have this requirement).
	Purchase key biologically productive habitats on private managed forest land and designate these as conservation land.
No urban expansion into old forests.	No urban expansion into old and mature forests.
	Increase the amount of mature forest around existing OGMAs to increase their size, by avoiding harvest of mature trees within 100 m of existing OGMAs.

Regenerating riparian forests on the CFLB.	Regenerating riparian forests on CFLB and private land – it is assumed that no harvest occurs within a 30 m riparian buffer.
No harvest >30% equivalent clearcut area in sensitive watersheds and no harvest >40% in other watersheds	No Harvest above H60 line*; No harvest >30% equivalent clearcut area in sensitive watersheds and no harvest >40% in other watersheds

). These strategies were developed only to explore which measures could best mitigate the impacts on old and mature forest hazards; economic or social factors were not considered at this stage.

The proposed Mitigation Measures were defined in three categories, each with different objectives:

1. ***Current mitigation practices***: Business as usual with regard to development and current mitigation practices.
2. ***Moderate mitigation***: Improved mitigation on future developments, and/or restoration on past developments.
3. ***Intensive mitigation***: Forward management and mitigation of development, and retrospective reclamation.

Mitigation measures amenable to modelling were assessed in ALCES, using the higher natural disturbance scenario as the base run, reflective of increased fire and insect outbreak possible with climate change. However, since it was impractical to run and interpret the results of many different mitigation scenarios for each of the VCs, only one set of mitigation scenarios was run for the project. These scenarios combined measures proposed for each of the VCs. The measures proposed for riparian and Westslope Cutthroat Trout that influence old forests and mature forests are shown in

Moderate Mitigation	**Intensive Mitigation**
Manage to full old targets within the 7 Low Emphasis Biodiversity Emphasis Option (BEO) BGC/LU units (remove the 2/3 drawdown, e.g., increase old from 3 to 9% in wet ESSF and from 4.5 to 14% in others).	Require mature forest retention in each BGC/LU that does not already have this requirement, according to the percentages specified in the Biodiversity Guidebook (27 of the 33 do not currently have this

	requirement).
	Purchase key biologically productive habitats on private managed forest land and designate these as conservation land.
No urban expansion into old forests.	No urban expansion into old and mature forests.
	Increase the amount of mature forest around existing OGMAs to increase their size, by avoiding harvest of mature trees within 100 m of existing OGMAs.
Regenerating riparian forests on the CFLB.	Regenerating riparian forests on CFLB and private land – it is assumed that no harvest occurs within a 30 m riparian buffer.
No harvest >30% equivalent clearcut area in sensitive watersheds and no harvest >40% in other watersheds	No Harvest above H60 line*; No harvest >30% equivalent clearcut area in sensitive watersheds and no harvest >40% in other watersheds

, together with the measures that were specifically modelled for old and mature. The response variable in the modelling was the z-score for old forests and mature forests (mature+old combined), and for the interior patch size of old and mature forest combined.

Moderate Mitigation	**Intensive Mitigation**
Manage to full old targets within the 7 Low Emphasis Biodiversity Emphasis Option (BEO) BGC/LU units (remove the 2/3 drawdown, e.g., increase old from 3 to 9% in wet ESSF and from 4.5 to 14% in others).	Require mature forest retention in each BGC/LU that does not already have this requirement, according to the percentages specified in the Biodiversity Guidebook (27 of the 33 do not currently have this requirement).

	Purchase key biologically productive habitats on private managed forest land and designate these as conservation land.
No urban expansion into old forests.	No urban expansion into old and mature forests.
	Increase the amount of mature forest around existing OGMAs to increase their size, by avoiding harvest of mature trees within 100 m of existing OGMAs.
Regenerating riparian forests on the CFLB.	Regenerating riparian forests on CFLB and private land – it is assumed that no harvest occurs within a 30 m riparian buffer.
No harvest >30% equivalent clearcut area in sensitive watersheds and no harvest >40% in other watersheds	No Harvest above H60 line*; No harvest >30% equivalent clearcut area in sensitive watersheds and no harvest >40% in other watersheds

Table 13. Mitigation scenarios proposed for Old and Mature forests in the Elk Valley.

* The H60 line is the elevation above which 60% of the watershed lies

5.2.1 Mitigation Modelling Results

The application of moderate and intensive mitigation scenarios resulted in a slight increase in old forest z-scores (lower hazard) in all BGC units assessed. The greatest effect of intensive mitigation was in the ICHmk4, where mitigation resulted in a shift from high hazard to near moderate hazard. Interestingly, the moderate mitigation scenario resulted in lower old forest hazard than intensive mitigation in the MSdk, MSdw, and ESSFdk2. This was due to the model randomly distributing fire and insect outbreak in each scenario. This suggests that more conservative mitigation strategies should be adopted to increase resiliency due to the uncertainty around the location and extent of natural disturbance in the future. There was almost no effect of mitigation in the ESSF units, with the exception of the ESSFdk1 and ESSFwm1 (Figure 29). This is largely due to the fact that mitigation is implemented through harvest strategies and these units are not being extensively harvested in these scenarios.

Old forest patch size increased under moderate and intensive mitigation due to the effect of the recruitment strategy with a focus on increasing patch size by buffering OGMAs. In some cases (ESSFwm1, ESSFwmw, and ICHmk4), the old patch size decreased under moderate mitigation (Figure 30). This is likely due to the fact that this scenario did not buffer OGMAs and harvest could have removed some of the forest adjacent to OGMAs. The response over time is somewhat linear but given the rate of harvest on private managed forest lands at the onset of the simulation, mitigation became more effective after three decades when there was not enough wood to continue harvesting. The majority of timber on the private managed forest lands is modelled to be harvested in the first decade.

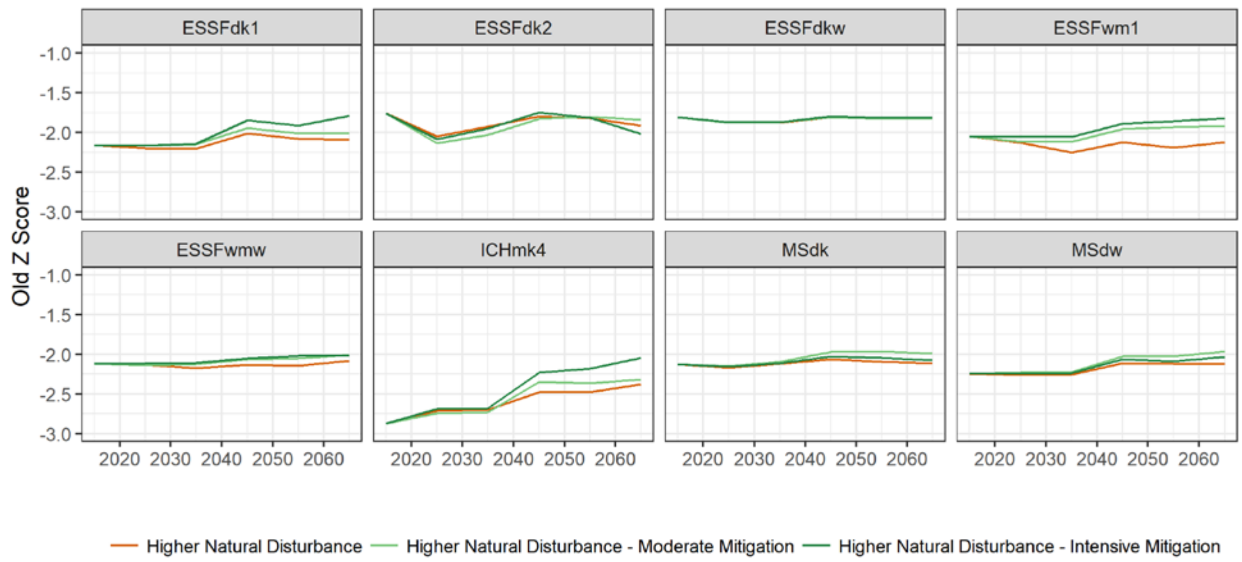

Figure 29 Effect of moderate and intensive mitigation on old forest hazard by BGC subzone/variant under the Higher Natural Disturbance Scenario. Hazard rating: *z* > 0 = very low; 0 > *z* > -1 = low; -1 > *z* > -2 = medium; -2 > *z* > -3 = high; *z* < -3 = very high.

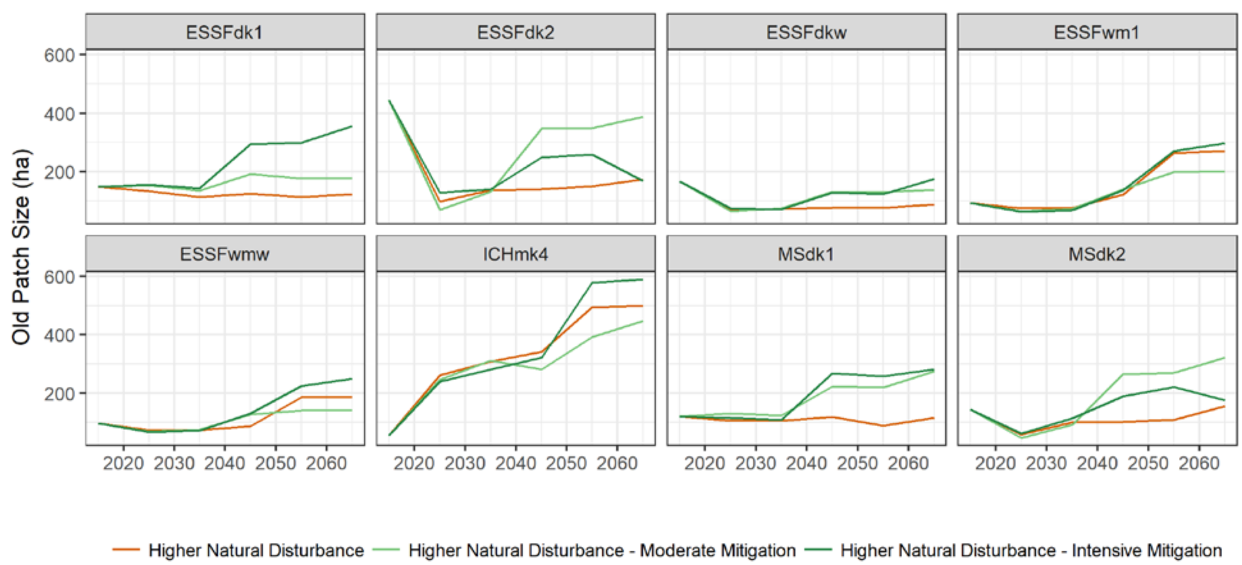

Figure 30 Effect of moderate and intensive mitigation on old forest patch size by BGC subzone/variant under the Higher Natural Disturbance Scenario.

Similar to the old forest z-score, mature forest z-scores also increased with moderate and intensive mitigation, with the largest effects in the ESSFwm1, ESSFwmw, and ICHmk4. Mitigation had a relatively small or negligible effect in the other BGC zones assessed (Figure 31).

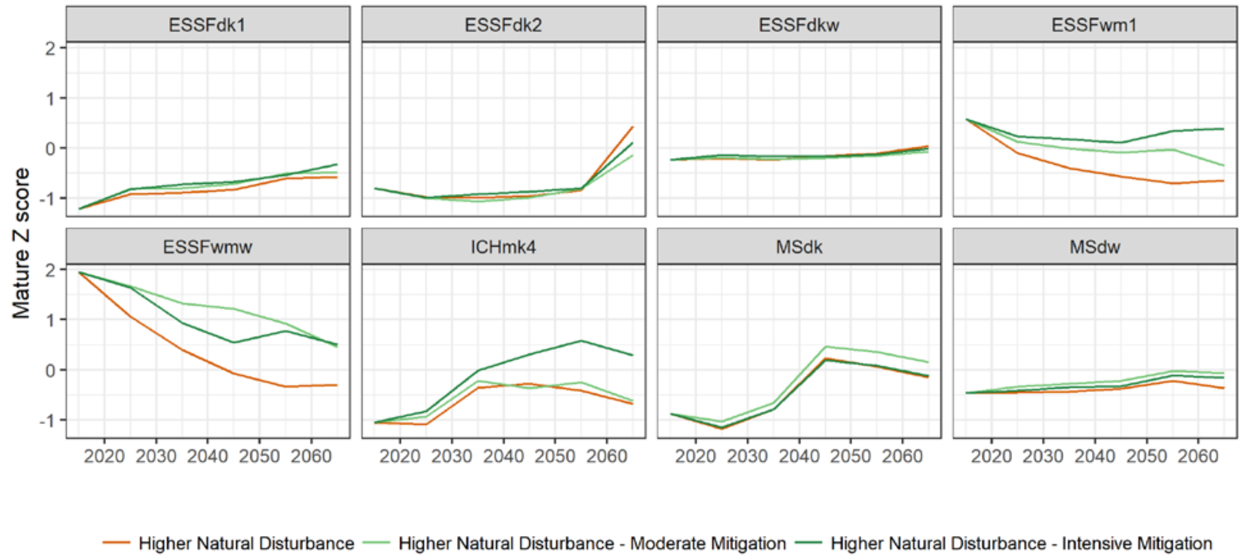

Figure 31 Effect of moderate and intensive mitigation on mature forest hazard by BGC subzone/variant under the Higher Natural Disturbance Scenario. Hazard rating: z > 0 = very low; 0 > z > -1 = low; -1 > z > -2 = moderate; -2 > z > -3 = high; z < -3 = very high.

Mature forest patch size was also most influenced by mitigation in the ESSFwm1, ESSFwmw, and ICHmk4. The private managed forest lands do occupy relatively large proportions of these BGC zones; therefore, the effect of implementing these strategies is most noticed in these particular units (Figure 32).

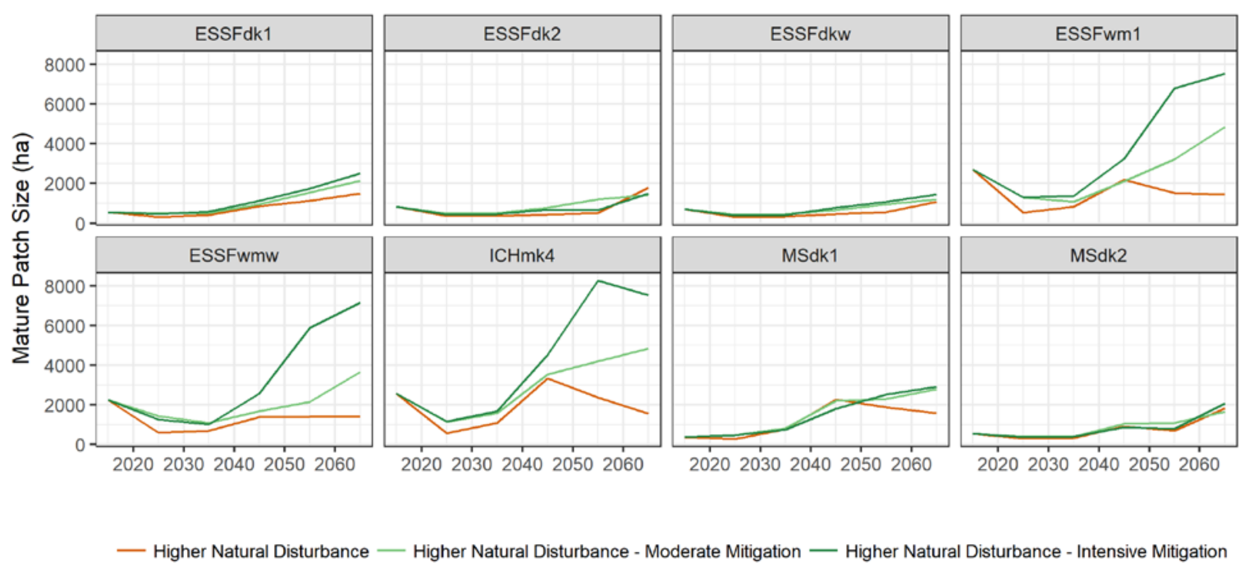

Figure 32 Effect of moderate and intensive mitigation on mature forest patch size by BGC subzone/variant under the Higher Natural Disturbance Scenario.

These results show that, although the higher natural disturbance rates in this scenario have a greater impact on old forest and mature forest amounts and patch size than logging, mitigation measures directed at forest harvesting still help to reduce the hazard ratings for old forests and mature forests at the scale of the study area, and thereby potentially decrease the risk to old and mature forest biodiversity.

In order to evaluate the effectiveness of mitigation strategies spatially, the differences in old forest z-score performance were calculated for the implementation of intensive mitigation within each BGC zone. The improvement in performance was then normalized by dividing each BGC subzone/variant's improvement by the maximum improvement occurring across BGC subzone/variant. The result was a mitigation effectiveness index ranging from 0 to 1, with a higher value indicating greater improvement. An effectiveness score of zero would indicate that mitigation had no influence on the outcome of the simulation.

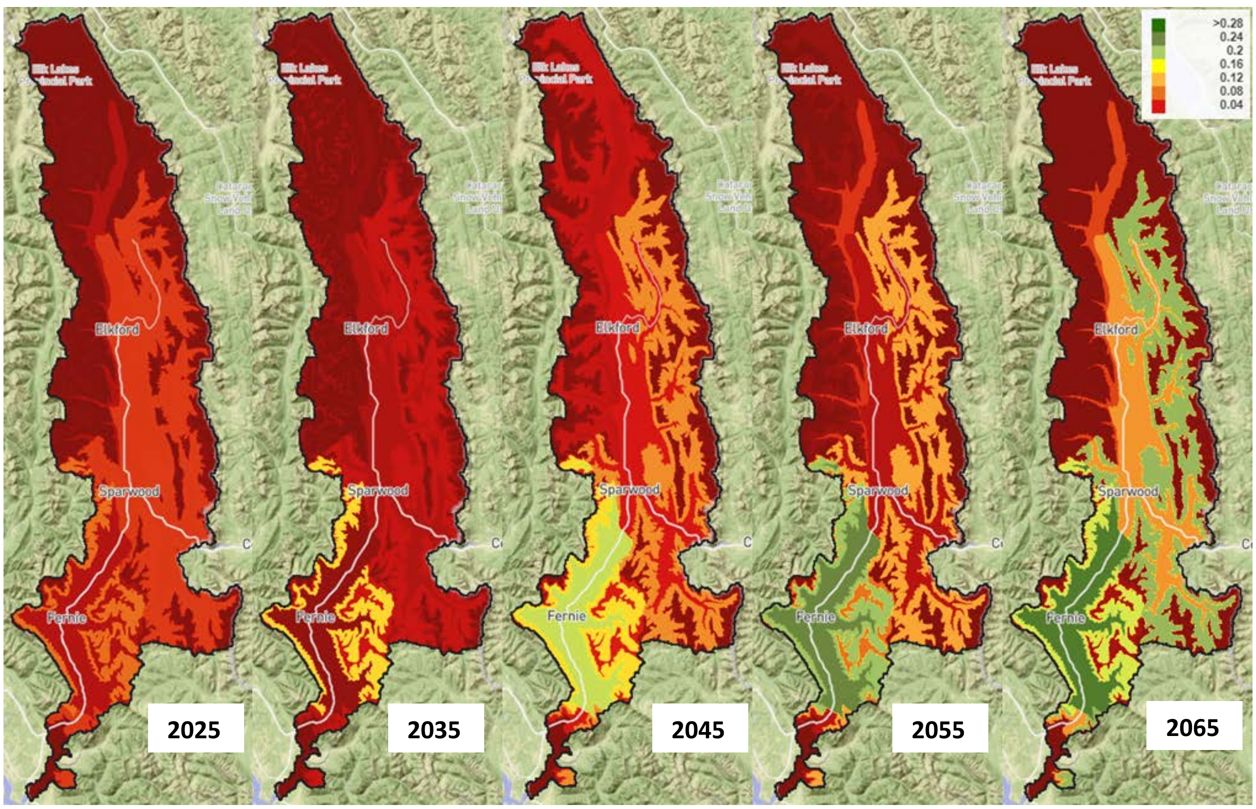

Figure 33 Effect of mitigation on old forest hazard at the scale of BGC zones for each future decade, as assessed by a mitigation effectiveness index. Higher values (green) indicate greater improvement.

Results show that the greatest effect of mitigation was achieved on private managed forest lands in the lower Elk Valley and the eastern portion of the Elk Valley. The greatest mitigation effect is in the ICHmk4 and secondarily in the ESSFdk1, ESSFwm1, and MSdk1 BGC subzone/variants (Figure 33). The results also demonstrate that it will take time for the effects of mitigation to be noticed, as these strategies largely involve ensuring there is more recruitment from mature into old age classes.

5.3 Operational Management Responses

Operational management responses *include consideration of site- or project-level guidance or implementation of measures to mitigate the effects of projects or activities, typically undertaken by proponents.*

Operational management responses that could be employed by government or industry to protect and recruit old forests include:

- The establishment of landscape-level fuel breaks to protect high value old-growth stands. FLNRORD is currently examining the use and placement of landscape-level fuel breaks to break up continuous fuels and protect various values, so important old-growth stands could be a value added to the list.
- The establishment of covenants on private land (including private managed forest land) with existing old and mature forest (and even younger forest with good potential to recruit to older age classes) to protect and recruit old forest. To be effective, the covenants must be detailed enough to spell out the protection measures and timeframes.
- The application of forestry and silvicultural practices designed to accelerate the development of old forest attributes in younger stands, particularly on productive sites. For example, thinning-from-below (removal of stems smaller than a specified diameter) will increase incremental growth on residual stems through reduced competition and result in large diameter trees more quickly than if the stand was left un-thinned; fungal inoculation can accelerate decay processes and the development of heart rot and high value snags for cavity nesting species; and removal of dense small trees and ladder fuels on dry sites will increase the resiliency of these stands and increase their similarity to historic stands when low-intensity fires occurred frequently.
- Treating stands surrounding valuable old growth to improve their resiliency to wildfire and insect pests, so that they can better protect old stands.
- Increasing the amount of partial harvest retention in 50% of the dry ecosystems to maintain old-growth attributes for future recruitment. Running prescribed fire through some of these sites, where practicable, would also assist in maintenance of old-growth structure.
- In certain second-growth stands, the construction of nest boxes or artificial dens for bats, marten and cavity nesters can be beneficial to support old-growth species. Nest boxes in the dry PP and IDF can also support species such as bluebirds and swallows.

5.4 Tactical management responses

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.*

The expert team identified tactical management actions that could be undertaken to mitigate impacts on old and mature forest. These included:

- In all applicable landscape units, spatially identify old forest retention opportunities to address existing deficits, and mature forest recruitment opportunities to support old forest targets in future.
- Research the value and effectiveness of currently identified OGMAs in meeting their intended objectives with respect to ecosystem structure, composition and function and patch size and longevity. Evaluate whether the best old-growth stands are represented in OGMAs and if not, consider additions and swaps to increase current OGMA quantity, quality, patch size, interior forest habitat value, representation, etc. Ask licensees to document the rationale for any OGMA swaps and make these rationales accessible to a range of stakeholders for review and consultation purposes.
- Through research projects in collaboration with academic institutions, obtain better information on the structure (e.g., diameter class distributions) of complex old-growth stands in the MS and ICH variants, for use in active management to restore the structure and function of these stands (e.g., old-growth western larch stands).
- BC Wildfire Service should be made aware of high value OG stands and have them on a “list to action” if threatened.
- The forest health specialists should be made aware of where the high value OG stands are so that preventative action can be taken if required.
- Improve coordination between proponents and the provincial government to ensure that datasets on old and mature forests, OGMAs, the CFLB, etc., are regularly updated, use the best available data, and are accessible to a range of stakeholders.
- Ensure that 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.
- Mining companies and conservation groups could include old forest and mature forest values in their assessments of land parcels for purchase and covenants rather than focusing primarily on wildlife values.

5.5 Strategic Management Responses

Strategic management responses *include measures to define or establish strategic direction for the management of land and/or resource values, typically led or coordinated by government. This can include new objectives for valued components, new acts and/or regulations.*

Strategic management responses include:

- Policy makers in British Columbia should consider results from other cumulative effects assessments throughout the province. If significant impacts on old growth from private managed forest lands are seen, consider adjusting the Private Forest Managed Land Regulations to require retention of old forest.
- Encourage private landowners to retain existing forest on their land by offering a tax credit or carbon credit for doing so.

- Re-deploy OGMA/MMAs as required to account for changes in the BEC version to BEC V11, for changes in the CFLB over time, and for minor errors in the original OGMA layer.
- Develop OGMA replacement guidelines and policy that address wildfire, forest health, and impact from industries other than forestry, as well as forestry-related impacts.
- High value OGMAs could be legally spatialized and, where necessary, actively managed to maintain old-growth values (e.g., protection from wildfire and insects, fuel reduction).

6.0 CONCLUSIONS

This component of the Elk Valley Cumulative Effects Management Framework project clearly showed that the amount of old forest was well below historic levels throughout most of the Elk Valley in 2016, especially so in the lower Elk Valley in the ICHmk4 around Fernie. Mature forest was also below historic levels, although not to the same degree as old forest. Patch sizes of interior mature+old forest were skewed towards patches < 40 ha in size (in fact, patches measuring 1-5 ha were the most common size in all BGC units evaluated), suggesting high fragmentation of existing mature and old forests. Based on conservation biology principles, these results indicate a high risk to species associated with old and mature forests and/or requiring interior forest habitat, which will not be alleviated for some time, if at all, under a higher natural disturbance scenario associated with climate change.

It is important to note there are caveats associated with the results that have been detailed under the methods section for each indicator. Key caveats to consider include the potential over-estimation of some fire return intervals for BGC subzones affecting the range of natural variability calculations and the discrepancy between the BEC version used in the analysis (v. 10) and that used to create OGMAs in the past (v. 6).

Hazard is predicted to remain greater over the next 50 years for old forests than for mature forests. This is largely because there are not enough stands that are within 50 years of the minimum age for old forests, and recruitment into old forest seral stages will take longer than the timeframe modelled in the analysis. At the end of the simulation, there were slight reductions in the hazard for old in the reference, minimum and maximum scenarios (from high to moderate hazard), but hazard remained relatively stable in the higher natural disturbance scenario due to a combination of low recruitment coupled with projected increases in fire and insect outbreaks.

The prospective modelling suggested that the hazard to mature forest will decrease substantially over the next 50 years, as the forests burned in the 1919 and 1930s fires age into mature age classes. This depends on assumptions around the extent of wildfire and insect occurrence–at higher rates of natural disturbance (which are expected under current climate change projections) amounts of old forest and mature forest still remain well below historic means. The mitigation measures applied in the model help alleviate this to a limited extent, but their effect is overshadowed by the impact of natural disturbance.

The importance of natural disturbance in shaping the landscape indicates that measures such as increasing the resiliency of forest stands through fuel reduction and ecosystem restoration, distributing old and mature forest reserves (OGMAs and MMAs) amongst different forest types and in landscape positions less likely to burn (e.g., riparian areas, rugged topography or topographically isolated areas), and implementing landscape-level fuel breaks are going to become more important in the future. Such measures should be undertaken now, in light of existing old and/or interior forest deficits for a range of dependent at-risk species. The updated BEC system (version 1, released 2018) offers an opportunity to re-deploy the OGMAs and MMAs throughout the landscape.

According to the prospective modelling, the greatest relative improvement in old and mature hazard in the Elk Valley can come from applying mitigation on private forest managed land. This result is largely due to the high proportion of managed forest land in the Elk Valley, in combination with the high projected harvest rates on that land. Currently, the only legislation around old forest and mature forest retention pertains to the Crown Forest Landbase – there are no requirements for conservation on private managed forest lands. Given that this land is managed forest land, and not simply private fee-simple land, policy makers in British Columbia should consider adjusting the Private Forest Managed Land Regulations to require retention of old forest.

Regarding fee-simple private lands, several opportunities exist for implementing higher levels of management for old and mature forest:

- Mining companies and conservation groups could include old forest and mature forest values in their assessments of land parcels for purchase and covenants rather than focusing primarily on wildlife values.
- Consider using tax or carbon credit incentives to achieve old and mature conservation objectives
    - There is the potential for changes in the tax status of various land parcels.
- Covenants could be put in place to assign and manage conservation lands with special attention to old forest protection and recruitment.

Lessons Learned

- In the future, it is recommended that old and mature forest amounts be calculated separately instead of mature being calculated ad mature+old.
- Patch size analysis should include additional patch size categories (in addition to the < 40 ha and < 5 ha categories used) in order to better describe the size distribution of patches and determine what number/proportion are in fact functional in terms of interior forest habitat.
- Future scenarios for only 50 years are limiting for range of natural variability. 100-200 years into the future could help to further understand potential impacts related to natural disturbance such as fire and insect outbreak.
- Variation between reference, minimum and high development scenarios should be increased for greater understanding of potential impacts. Additional climate change related scenarios (high natural disturbance) would be beneficial for understanding risks.
- The seral stage distribution within OGMAs should be evaluated to assess the effectiveness of OGMAs in conservation old seral forests.

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APPENDIX 1 BIOGEOCLIMATIC CLASSIFICATION IN THE ELK VALLEY

BEC is a multi-scaled (regional, local and chronological), ecosystem-based classification system that groups ecologically similar sites based on climate, soils, vegetation and topography. This classification is widely used throughout British Columbia as a framework for resource management and scientific research. Biogeoclimatic subzones are the most basic unit of this classification system. Subzones with similar climate, soils and vegetation are grouped into biogeoclimatic zones to create more generalized units and separated into variants to delineate subregional variation in climate or soils.

Within the Elk Valley, there are three principal forested BGC zones; the Engelmann Spruce-Subalpine Fir (ESSF), Mountain Spruce (MS) and Interior Cedar-Hemlock (ICH), and 13 different BGC subzone/variants (Figure A.1). The majority of the basin is comprised of the ESSFdk1, ESSFdkw, MSdk1, and ESSdk2 variants (Figure A.2).

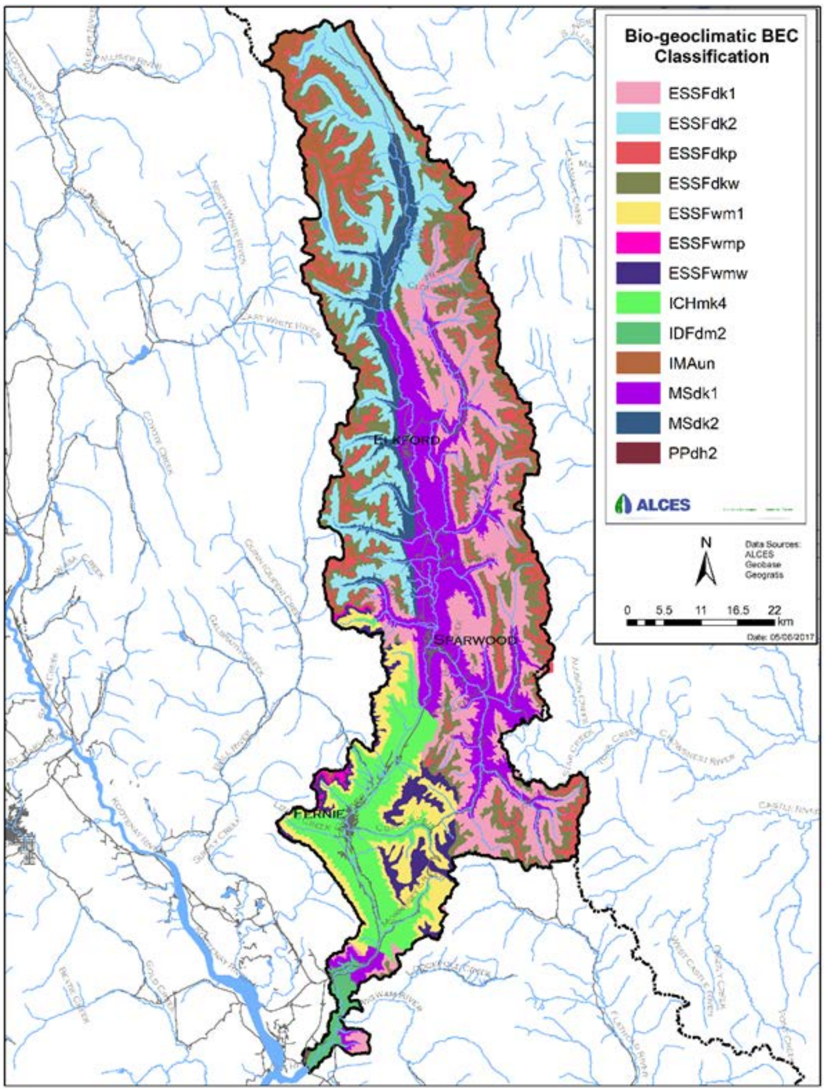

Figure A.1 BEC classification in the Elk Valley

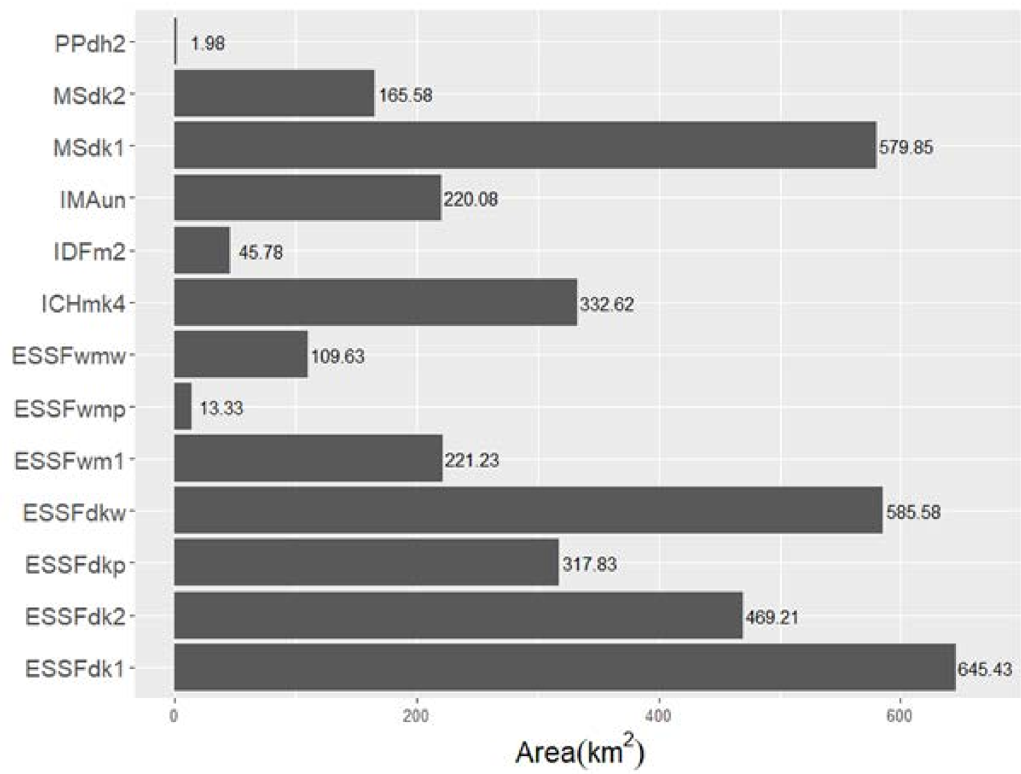

Figure A.2 Area (km2) within each BGC variant in the Elk Valley.

ESSF Subzones and Variants

In the Elk Valley, the predominant subzone of the Englemann Spruce – Subalpine Fir is the 'dk', representing dry precipitation and cool temperature regimes. The four subzone/variants (1, 2, w, and p) represent the Kootenay and Spillimacheen variants and the woodland and parkland subzones, respectively. In the ESSFdk units, winters are usually long and cold, and summers cool and short. The ESSFdk occurs at upper elevations of the Rocky Mountains, usually beginning around 1550-1650 m ASL. The forests in this subzone are dominated by Englemann spruce and subalpine fir (Figure A3). Douglas-fir may be present, particularly at lower elevations; deciduous trees are rare, and are generally absent at higher elevations.

The lower Elk valley also contains the ESSFwm subzone, which is representative of Englemann Spruce – Subalpine Fir in a wet and mild climate. There is one variant, wm1 (Fernie) and two subzones, p and w, which represent the parkland and woodland areas, respectively. Similar to the ESSFdk subzone, the wm subzone is still characteristic of a subalpine climate, however the precipitation is much greater with higher snowpack in winter, and the temperature is milder (MacKillop, et al., 2018).

Figure A.3. High elevation Englemann spruce and subalpine fir representative of the ESSF zone.

MS Subzones and Variants

The MSdk subzone characterizes the Montane Spruce in a dry cool climate. Occupying an elevation band between the ESSF and the IDF zones, the MSdk subzone comprises approximately 20% of the Elk Valley basin. It has a climate characteristic of cold winters and dry summers. Lodgepole pine is the major species of this subzone, forming widespread even-aged stands following fire (Figure A.4). Tree species diversity is generally high, with interior spruce, Douglas-fir and western larch covering a high proportion of the MSdk. Trembling aspen, paper birch and western red cedar are also prevalent in the MSdk (MacKillop, et al., 2018). There are 2 variants of the MSdk – 1 (Elk) and 2 (Columbia) – and both occur within the study area.

Figure A.4. Lodgepole pine representative of the MS zone.

ICH Subzones and Variants

The ICHmk subzone characterizes the Interior Cedar-Hemlock zone in a moist and cool environment. In the study area, the ICHmk4 (Kootenay variant) occurs in the Rocky Mountains, primarily in the Fernie Basin. The ICH zone has a cool temperate climate and is the wettest of the interior montane zones. A moist climate contributes to high levels of forest productivity and diversity in this zone. Western hemlock, normally the most common species in the ICH zone, is generally absent from the ICHmk subzone (Meidinger & Pojar, 1991). Western redcedar and interior spruce are commonly abundant in the ICHmk4 with Douglas fir, lodgepole pine, western larch, and, at upper elevations and on cooler sites, subalpine fir as common species. Trembling aspen, paper birch, and black cottonwood provide broadleaf diversity to the landscape (Figure A.5).

Figure A.5. Hemlock forest representative of the ICHmk subzone.

IDF subzones and variants

The Kootenay dry mild Interior Douglas-Fir zone (IDFdm2) is located at mid to low elevations in the southern Rocky Mountains. In the Elk Valley study area, it is situated at the low elevations along the lower reaches of the Elk River and is bordered by the MSdk1 variant at higher elevations and the IDFxx2 (formerly mapped as PPdh2) at lower elevations near the confluence of the Elk and Kootenay Rivers. Growing seasons in the IDFdm2 are warm and dry and winters are cool with little snow. Growing season soil-water deficits, and associated droughty conditions, are common. Douglas-fir is the most common species (Figure A.6). Western larch, ponderosa pine and lodgepole pine are also common. Trembling aspen is a widespread minor species, and both black cottonwood and interior spruce occur on the wettest sites.

Figure A.6. Douglas fir forest, representative of the IDFdm subzone.

IMA

The undifferentiated Interior Mountain-heather Alpine subzone (IMAun) occurs at upper elevations above the treeline. Within the study area, it is relatively small, comprising only 5.9% of the Elk valley. Precipitation varies substantially across the IMA, but all seasons are cold relative to lower elevations. Rocky terrain and alpine tundra ecosystems, dominated by low-growing dwarf shrubs, forbs, and sedges, are common in the IMA in the Elk Valley(Figure A.7). Cold temperatures and high snow depth are the most limiting factors for plant growth in the alpine.

Figure A.7. Mountain-heathers, representative of the IMA zone.

APPENDIX 2 DISTURBANCE RETURN INTERVALS USED FOR THE RANGE OF NATURAL VARIABILITY ANALYSIS

The assignments of BGC units to disturbance return intervals is defined in the Biodiversity Guidebook (1995) and updated by the Regional Ecologist for those BGC variants added to the BEC system since 1995 (Table A2.1). The Upper, Mid, and Lower estimates were made by the Old and Mature Expert Team based on a review of studies on fire return intervals in the East Kootenay region and similar ecosystems (Canfor 2017). Examples of how different disturbance return intervals affect the expected percentages of forests of different age categories within a landscape is shown in Table A2.2. (BC Ministry of Forests and BC Environment, 1995).

Table A2.1. Estimated Disturbance Return Intervals for the forested BGC units in the Elk Valley.

NDT	BGC Unit	Disturbance Return Interval (Stand-replacing)			
		Upper	Mid	Lower	BDG
2	ESSFwm1	250	200	150	200
2	ESSFwmw	250	200	150	200
3	ICHmk4	200	150	125	150
3	MSdw (was MSdk1)	150	125	100	150
3	MSdk (was MSdk2)	150	125	100	150
3	ESSFdk1	200	150	125	150
3	ESSFdk2	200	150	125	150
3	ESSFdkw	200	150	125	150

Table A2.2. The percentage of a landscape expected to occur in different age classes with different mean disturbance return intervals (from the Biodiversity Guidebook, Table A4.2).

	Disturbance return interval (yr)					
Age (yr)	100	125	150	200	250	350
<20	18	15	12	10	8	6
<40	33	27	23	18	15	11
>80	45	53	59	67	73	80
>100	37	45	51	61	67	75
>120	30	38	45	55	62	71
>140	25	33	39	50	57	67
>250	8	14	19	29	37	49

APPENDIX 3 THE DISTURBANCE LAYER

The disturbance layer was created using:

- Private land footprint from ICIS cadastre
- Age class 1 and 2 from the VRI or PEM (Nov 2015) structural stage 1-3 where no VRI (includes harvest, fire, pest)
- Permanent and Linear Structures including roads, rail, transmission lines, sewer/effluent lines, trails and ski lifts and settlements- from BC TANTALIS, TRIM
- Mining footprint including pipelines, sand and gravel, drill/well sites and mineral production- from Teck, BC TRIM, BC TANTALIS

The data were merged together as a disturbance feature class and then buffered by 100 m. Patches were extracted as the area excluding the buffered disturbance layer. Each patch was assigned a single BGC unit by calculating the BGC unit that covered the MAJORITY of the polygon on the CFLB or FLB.

APPENDIX 4 CLASSIFICATION OF SITE SERIES INTO ECOSYSTEM GROUPINGS.

The classification was completed by the Regional Ecologist Deb McKillop and the full file is available from her.

Table 3.1. Site series within each BGC variant/subzone that were classified as either dry, intermediate, or wet forest using site classifications from the Cranbrook PEM (Ketcheson, 2015) (Ehman, et al., 2017).

Category	Site Series - ESSF	Site Series – ICH and MS
	ESSFdk 1 /102	ICH dm /102
	ESSFdk 1 /103	ICH dw 1 /102
	ESSFdk 2 /102	ICH dw 1 /102x
	ESSFdk 2 /103	ICH dw 1 /103
	ESSFdkw /102	ICH mk 4 /102
	ESSFdkw /103	ICH mk 4 /103
	ESSFwh 2 /102	ICH mw 2 /102
	ESSFwh 2 /103	ICH mw 2 /103
	ESSFwm 1 /102	IDF dm 2 /102
	ESSFwm 1 /103	IDF dm 2 /103
	ESSFwm 2 /102	IDF xx 2 /102
	ESSFwm 2 /103	IDF xx 2 /103
	ESSFwm 4 /102	MS dk /102
	ESSFwm 4 /103	MS dk /103
	ESSFwmw /102	MS dw /102
Dry Forest	ESSFwmw /103	MS dw /103
	ESSFdk 1 /101	ICH dm /101
	ESSFdk 1 /104	ICH dm /103
	ESSFdk 2 /101	ICH dw 1 /101
	ESSFdk 2 /104	ICH dw 1 /104
	ESSFdkw /101	ICH mk 4 /101
	ESSFwh 2 /101	ICH mw 2 /101
	ESSFwh 2 /104	ICH mw 2 /104
	ESSFwm 1 /101	IDF dm 2 /101
	ESSFwm 1 /104	IDF dm 2 /104
	ESSFwm 2 /101	IDF xx 2 /101
	ESSFwm 2 /104	IDF xx 2 /104
	ESSFwm 4 /101	IDF xx 2 /110
	ESSFwm 4 /103x	MS dk /101
	ESSFwmw /101	MS dk /105
		MS dw /101
Intermediate Forest		MS dw /104

Category	**Site Series - ESSF**	**Site Series – ICH and MS**
	ESSFdk 1 /110	ICH dm /110
	ESSFdk 1 /111	ICH dm /111
	ESSFdk 2 /11112	ICH dm /112
	ESSFdk 2 /110	ICH dw 1 /112
	ESSFdk 2 /112	ICH dw 1 /113
	ESSFdkw /110	ICH dw 1 /110
	ESSFwh 2 /11112	ICH dw 1 /111
	ESSFwh 2 /110	ICH mk 4 /11112
	ESSFwh 2 /111	ICH mk 4 /11213
	ESSFwm 1 /11112	ICH mk 4 /110
	ESSFwm 1 /110	ICH mk 4 /111
	ESSFwm 1 /111	ICH mk 4 /112
	ESSFwm 2 /11112	ICH mw 2 /113
	ESSFwm 2 /110	ICH mw 2 /114
	ESSFwm 2 /111	ICH mw 2 /110
	ESSFwm 4 /11112	ICH mw 2 /111
	ESSFwm 4 /110	ICH mw 2 /113
	ESSFwm 4 /111	IDF dm 2 /110
	ESSFwmw /110	IDF dm 2 /111
		IDF xx 2 /111
		IDF xx 2 /112
		MS dk /110
		MS dk /111
		MS dw /110
Wet Forest		MS dw /111

APPENDIX 5 INTERIOR PATCH SIZE DISTRIBUTION OF OLD FOREST BY BGC UNIT WITHIN THE CFLB

Table 6.1. Size distribution of patches of interior old forest within the CFLB, by landscape unit and BGC variant/subzone.

BGC unit	<1 ha	1-5 ha	6-10 ha	11-20 ha	21-40 ha	41-80 ha	81-100 ha	101-250 ha	>250 ha	Total Patch CFLB
C19	4.6	29.7	46.7	26.2	58.4	58.3				**223.9**
ESSFdk1	2.5	20.8	19.8	26.2	32.6	58.3				**160.2**
ESSFdkw	0.9	8.7	26.9		25.7					**62.2**
MSdw	1.3									**1.3**
C20	14.7	78.4	38.5	118.6	94.0	252.1		106.1		**702.5**
ESSFdk1	12.4	68.5	27.5	101.5	66.4	117.3				**393.5**
ESSFdkw	1.3	8.8	11.1	17.1	27.7	134.8		106.1		**306.9**
MSdw	1.0	1.1								**2.1**
C21	15.6	98.3	59.0	110.3	102.1	234.1				**619.5**
ESSFdk1	8.0	67.8	44.6	87.4	50.8	88.1				**346.7**
ESSFdkw	5.8	20.4	7.9	10.7	51.3	146.0				**242.2**
MSdw	1.9	10.1	6.6	12.2						**30.7**
C22	34.9	183.8	95.4	194.1	134.2	264.5	69.6	531.3	1165.6	**2673.3**
ESSFdk2	22.4	107.4	66.1	133.0	67.9	235.3	69.6	295.2	958.3	**1955.0**
ESSFdkw	9.9	28.0	21.4	23.0	38.8	29.1		236.2	207.3	**593.7**
MSdk	2.6	48.4	7.9	38.1	27.6					**124.6**
C23	48.7	342.4	422.9	379.1	809.5	1053.9		787.6	225.6	**4069.7**
ESSFdk1	1.0	11.5	10.2		50.0	50.0				**122.8**
ESSFdk2	18.4	226.7	306.0	177.0	504.6	763.3		686.1	225.6	**2907.8**
ESSFdkw	19.2	31.6	24.3	76.3	108.3	29.0		101.4		**390.1**
ESSFwm1	0.4	6.5	30.9	30.3	23.8	56.2				**148.0**
ESSFwmw	1.1	0.1	0.2		0.1	44.2				**45.6**
ICHmk4	0.4									**0.4**
MSdk	6.5	40.4	23.4	54.8	31.0	62.7				**218.8**
MSdw	1.8	25.6	28.0	40.7	91.7	42.5				**230.2**
C24	9.0	39.0	66.4	57.7	25.7	49.1				**246.8**

ESSFdk1	1.0	6.4	23.4	13.2		49.1				**93.1**
ESSFwm1	0.1	2.9	9.4	30.8	25.7					**68.9**
ESSFwmw	1.6		0.1							**1.6**
ICHmk4	5.6	25.3	33.5							**64.3**
MSdw	0.8	4.4		13.7						**18.8**
C38	0.4	2.5	18.8	16.0						**37.7**
MSdk	0.0			16.0						**16.1**
MSdw	0.3	2.5	18.8							**21.6**
(blank)	0.5	0.8			0.2	45.2			0.0	**46.6**
ESSFdk2		0.0				0.0			0.0	**0.0**
ESSFdkw					0.2					**0.2**
ESSFwmw	0.0					1.6				**1.6**
Total Patch CFLB	**128.4**	**774.9**	**747.8**	**901.9**	**1224.2**	**1957.1**	**69.6**	**1425.0**	**1391.2**	**8620.0**

APPENDIX 6 LIST OF CURRENT CEMF WORKING GROUP MEMBERS

#	Name	Organization
1	Taye Ayele	Chair, FLNRORD
2	Marcin Haladaj	FLNRORD
3	Lyle Saigeon	FLNRORD
4	Cassidy van Rensen	FLNRORD
5	Bill Green	KNC
6	Alison Burton	KNC
7	Warn Franklin	Teck Coal Ltd.
8	Steve Hilts	Teck Coal Ltd.
9	Kevin Podrasky	Teck Coal Ltd.
10	Lee-Anne Walker	Elk River Alliance
11	Kari Stuart-Smith	CANFOR
12	Terry Melcer/ Scott Beeching	District of Sparwood/Elkford
13	Brian Dureski	Canwel
14	Mark Hall	MoE

15	Darin Welch	MoTI
16	Mark Vendrig	CanAUS Coal Ltd
17	John Pumphrey	CanAUS Coal Ltd
18	Jeff Berdusco	CanAUS Coal Ltd
19	Art Palm	Jameson Resources Crown Mountain Project
20	Michael Keefer	Jameson Resources Crown Mountain Project

VC TEAM LEADS

1	Peter Holmes	Old & Mature Forest, FLNRO (now retired)
2	Herb Tepper	WCT, FLNRORD
3	Alan Davidson	Riparian Habitat. FLNRO (now retired)
4	Kim Poole	BHS, Aurora Wildlife Research
5	Garth Mowat	Grizzly bear, FLNRORD

TECHNICAL SUPPORT

1	William Burt	FLNRORD
2	Rhian Davies	FLNRORD
3	Ryan MacDonald	ALCES Group
3	Kathleen McGuinness	Touchstone GIS Services Inc.