Climate Disruption and Connectivity in the West Kootenays:

An Introduction with Two Examples

Prepared for:

Kootenay Connect
Kootenay Conservation Program

With support from: Environment and Climate Change CANADA

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1.0 INTRODUCTION

1.1 Kootenay Connect: Riparian Wildlife Corridors for Climate Change

The recently launched Kootenay Connect initiative has identified a series of riparian-wetland complexes that can act as wildlife linkages across human-impacted valley bottoms (Proctor and Mahr 2019). Transportation routes, utility corridors, dam construction, resource extraction, agricultural clearing, and urban/ rural development have all contributed to fragmentation and reduced connectivity as ongoing threats to biodiversity and habitat availability for decades in Southeastern British Columbia (e.g., Holt et al. 2003, Proctor et al. 2012). The advancing impacts of climate disruption have amplified these threats with the need for many species to shift their ranges across the landscape in an attempt to adapt to rapidly changing climatic regimes (e.g., Holt et al. 2012, Carroll et al. 2018, McGuire et al. 2016).

This report was prepared to outline a potential approach to incorporating changes associated with climate disruption into threat assessments and management planning for Kootenay Connect wildlife linkage areas. The report will focus on the Creston Valley and the Bonanza Biodiversity Corridor (BBC) areas as examples. A summary of the information in the report was presented at recent Kootenay Connect planning workshops in Creston and Silverton.

1.2 Climate Change Vulnerability Assessments

Climate vulnerability assessments are commonly used tools for assessing vulnerability of a range of values that may be exposed to threats from climate disruption, including landscapes, ecosystems, habitats and species (e.g., Utzig and Holt 2012, Fussel and Klein 2006, Halofsky et al. 2011). Vulnerability assessments generally include a team of technical experts appropriate to the value under assessment, and fieldworkers with intimate knowledge of the value and its environment. For landscapes and ecosystems this could include participants familiar with downscaled climate data, a terrain/ soil specialist, an hydrologist, an ecologist with knowledge of disturbance regimes, biologist(s) with knowledge of the habitat requirements of applicable species, etc. The assessments generally have three primary components used to determine vulnerability: exposure, sensitivity,and adaptive capacity (see Fig. 1.1).

Exposure is a determination of the climatic changes that the value is projected to experience in the planning timeframe, including the rate of those changes. These typically include changes in annual, seasonal, minimums and/or maximums of temperature and precipitation, and frequency and intensity of extreme events. Exposure can also include secondary changes in geomorphic, hydrologic or disturbance regimes that have potential to impact the value under consideration. Exposure also includes consideration of factors that may moderate direct climate impacts, such as the presence of seepage or topographic conditions (e.g., aspect or cold air drainage).

Determination of ***sensitivity*** requires an evaluation of tolerances of a value in relation to the projected exposure. For example, will the projected changes result in conditions that the value has not experienced previously, does the value exist in a narrow niche or is it widely distributed, is the value sensitive to changes in disturbance regimes, can a species tolerate increased mortality rates, etc.

Combining exposure and sensitivity results in a determination of potential ***impacts***. Potential impacts will be specific to climate change exposure for that location, and the sensitivity of the value under consideration. The effects on species can be complex (see Fig.1.2). However, landscapes and ecosystems can be even more complex, as they will have to consider the sensitivities of various species, as well as the role of those species in the broader ecosystem ï with emphasis on potential keystone species, and alterations in functions such as herbivory or predator/ prey relationships.

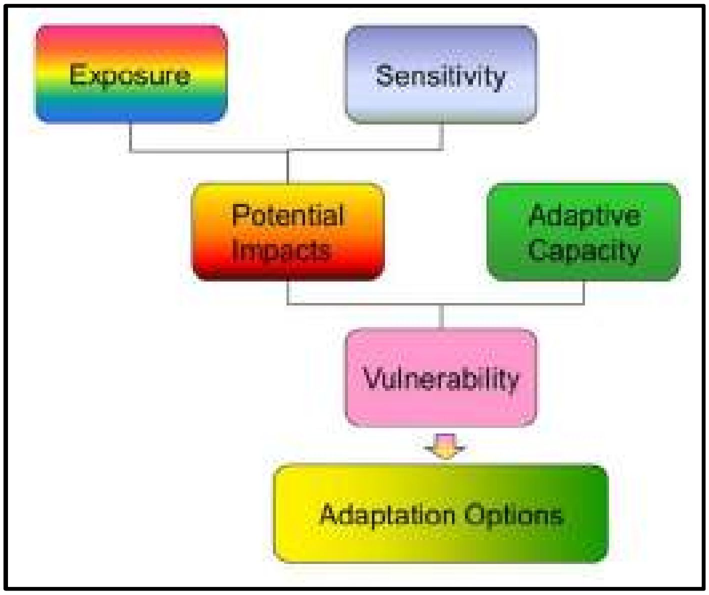

Figure 1.1. Climate change vulnerability assessment components.

Adaptive capacity refers to the inherent ability of the value itself to make changes necessary to overcome the projected impacts, and/or the capacity of management regimes to implement changes that may assist the value to survive the climate changes projected to occur. Inherent adaptive capacity for species may include the relative plasticity in behaviour and/or meeting their nutritional requirements, or for landscapes or ecosystems - the ability to maintain structure and function with the loss of vulnerable species or changes in disturbance regimes. Adaptive capacity may include the possibility for evolution, i.e. sufficient genetic variation within the population to shift speciesô fitness to the new climatic regime. However adaptive capacity must also take into account the rate of potential adaption, in relation to the rate that the climate changes will occur (e.g., can a species disperse to new areas rapidly enough to keep up with its niche changes). Adaptive capacity can also include the potential for management changes that may assist in adaptation, e.g., reducing mortality rates (predation and/or hunting), reducing wildfire risk and/or intensity, assisted migration, creating water storage devices, habitat enhancements or generally reducing other threats to increase resilience.

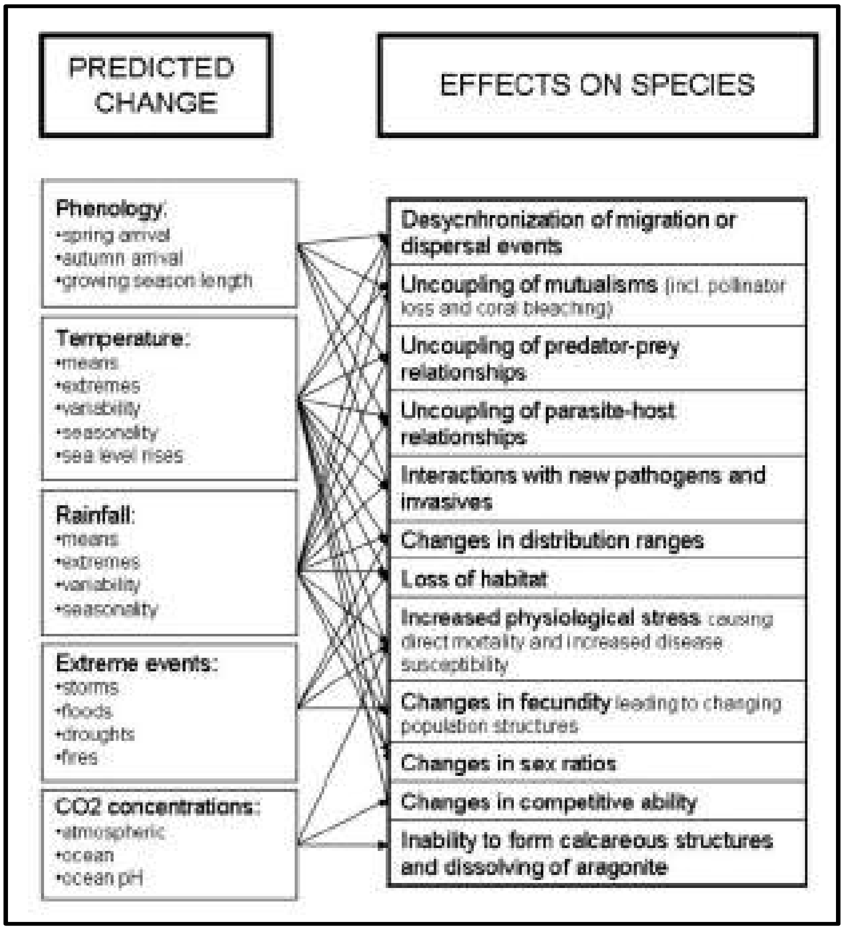

Figure 1.2. Potential impacts of various climate change variables on species (from Foden et al. 2008.

The combination of potential impacts with adaptive capacity leads to a determination of ***vulnerability***. Vulnerability outcomes are useful for setting priorities, and serve as a basis for planning and designing adaptation actions and measures. The specific types of impacts that may occur will determine what types of adaption actions may be required, or in the worst case, whether adaptation is feasible. In the case of landscapes or ecosystems where a complete regime change is inevitable (e.g., forest to grassland), adaptation options may consider assisting an orderly transition to avoid a catastrophic regime shift (e.g., stand treatments to avoid a high intensity stand-replacing wildfire).

When considering adaptation options, it is essential to recognize the significant uncertainty in how climate disruption will actually unfold. Rather than be stymied by uncertainty, one must learn to embrace uncertainty as the new normal. To reflect the uncertainty, more than one scenario of future climate change must be considered when planning adaptation actions. Decision makers must learn to seek robust ñno-regretsò options that have benefits across a range of possible future climates. Monitoring and adaptive management must be prioritized in all areas of climate change planning.

1.3 Kootenay Vulnerability Assessment and Conservation Planning

A recent regional vulnerability assessment identified a range of vulnerabilities to forest ecosystems of the West Kootenays (Holt et al. 2012). One result of that assessment was the initiation of a process for identifying conservation measures that could be applied at a regional scale to assist ecosystem adaptation in the WK ï the Kootenay Conservation Strategy (KCS; Utzig and Holt 2014 and 2015). The draft conservation plan includes increasing protected and conservation management areas to reduce human impacts in high priority areas and increase representation, as well as identifying potential regional linkage/connectivity areas to facilitate range shifts upslope and along north-south corridors. Management strategies compatible with increasing climate disruption resilience are proposed for each of the potential management zones, based on the objectives for each local area (see www.kootenayresilience.org).

The two Kootenay Connect wildlife linkage areas described below fall into two of the regional connectivity/ linkage areas identified in the KCS. The Kootenay Connect linkage areas were initially selected on the basis of their riparian and wetland values, and their importance for providing connectivity to adjacent upland habitats. However, these two areas also play a key role in the regional conservation strategy for adapting Kootenay ecosystems to climate disruption. The focus on wetlands and riparian corridors as prime locations for climate change connectivity has been recognized by other studies (e.g., Krosby et al. 2018). The Creston Valley wildlife linkage area plays a key role in a north-south linkage from the west side of the Kootenai Valley in northern Idaho to north along the east shore of Kootenay Lake. The BBC is an integral part of a north-south linkage from the Valhalla Wilderness Protected Area leading north of Slocan Lake to the Arrow Reservoir portion of the main Columbia River Valley near Nakusp.

As a basis for more in-depth vulnerability assessments for the Creston Valley and the BBC, the following sections provide an introduction to the exposure, sensitivities, adaptive capacity and potential adaptation actions for those areas. It should be emphasized that this report is only an introduction to the application of vulnerability assessment concepts ï it is ***NOT*** a vulnerability assessment.

2.0 CRESTON VALLEY CONNECTIVITY CORRIDOR

The Creston Valley wildlife linkage area is focused on the wetlands occurring at the south end of Kootenay Lake, where the Kootenay River enters the lake from across the US border in Idaho. Prior to European settlement, the valley bottom was dominated by extensive wetlands and riparian forest. The adjacent upland valley bottom and southern aspects were open fire-maintained stands, with frequent low intensity fire regimes, while the lower slopes were more closed stands with mixed fire regimes typical of the driest subzones of the Interior Cedar-Hemlock (ICH). The mid and upper slopes were closed stands with mixed fire regimes and frequent stand-replacing fire regimes grading upslope to closed stands with moderately infrequent stand-replacing fire regimes, typical of the moister ICH and drier Engelmann Spruce-Subalpine Fir (ESSF) subzones. Due to fire exclusion, many stands in the area are denser than they would have been in the past.

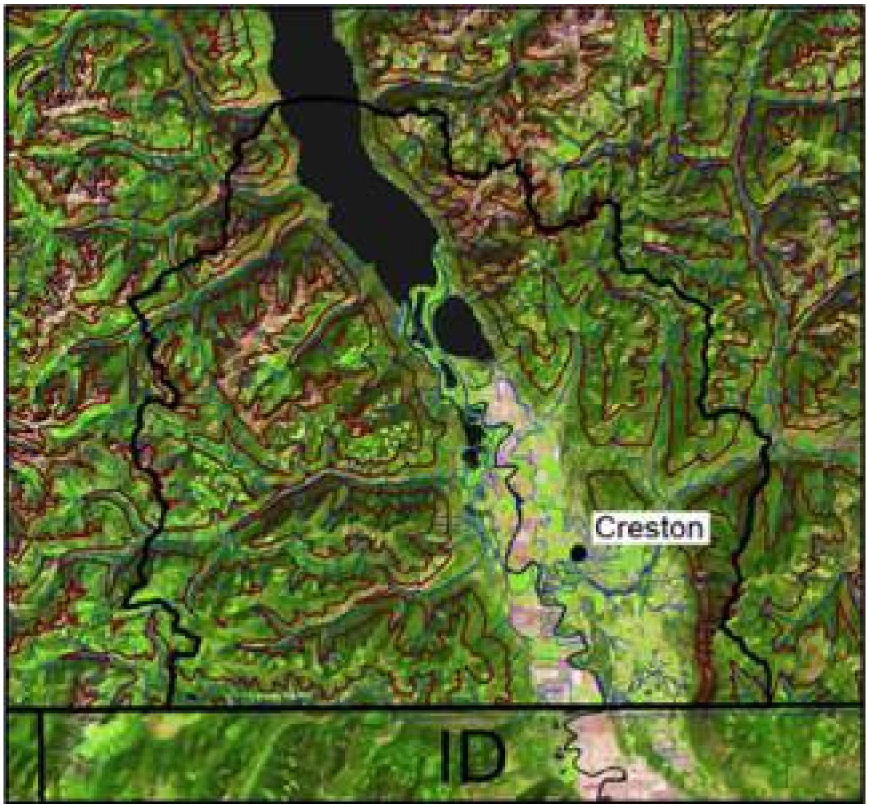

Figure 2.1. Creston Valley connectivity corridor study area.

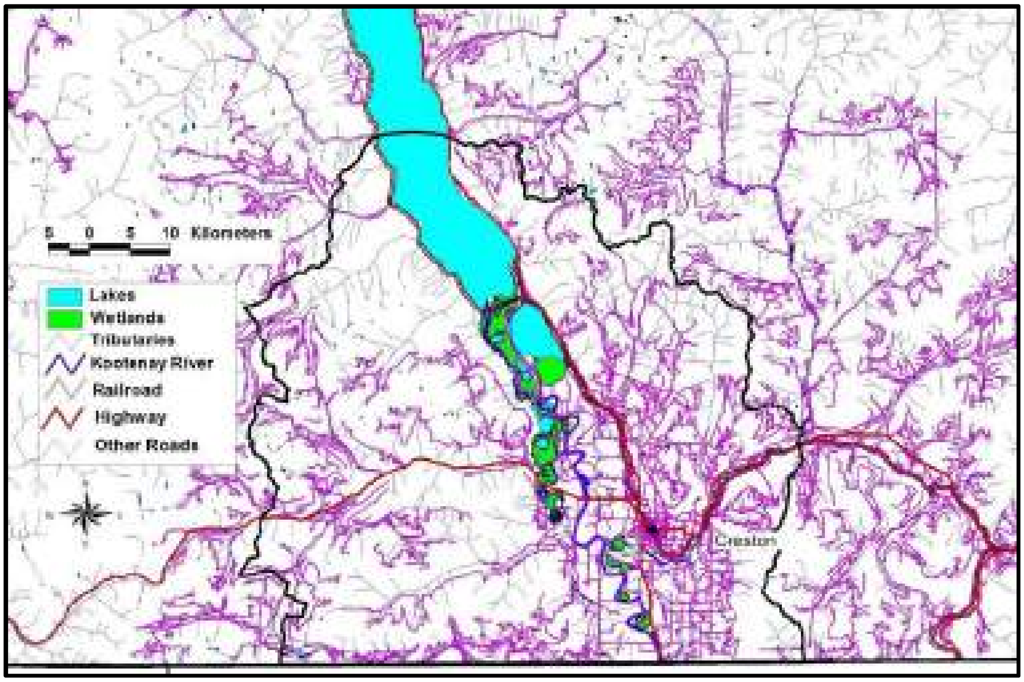

Figure 2.2. Creston Valley road and railroad development. Wetlands in green.

As visible in Fig. 2.1, large areas of floodplain forest and wetlands have been drained and diked to create productive agricultural lands. Upland terraces have also been developed for agriculture, and the mountain slopes are actively used for forest harvesting. All this development has resulted in an extensive road network, along with a natural gas pipeline, powerlines and a railroad (see Fig. 2.2). The Libby dam upstream in the US, as well as the Duncan and Corra Linn dams in Canada are managed to minimize flooding in the area, and have affected the annual hydrologic cycle. Invasive species are also a growing issue for the area. Cumulative effects have resulted in significant impacts to aquatic ecosystems, fish habitat, wetlands and riparian ecosystems.

With these stressors as a background climate disruption will add another level of stress to ecosystems in the Creston Valley. Global Climate Model (GCM) outputs for the area generally project an increase in temperatures in all seasons (see Fig. 2.3). Precipitation is projected to increase in all seasons except summer, when it is likely to decrease (one of four scenarios shows a minor increase). The main difference between the four scenarios[1] is the degree of change, rather than any differences in direction of change. Recent temperature data indicates that these changes have already begun. Other modelling

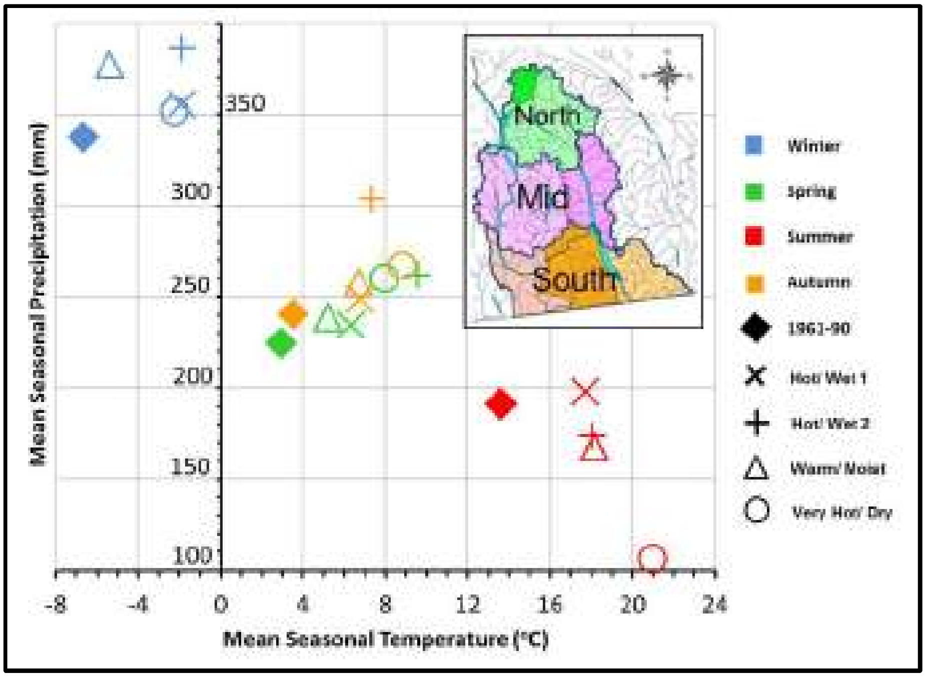

Figure 2.3. Seasonal climate projections for the reference period (1961-90) and the 2080s for four GCM/ emission scenarios for the southern West Kootenays (from Utzig 2012).

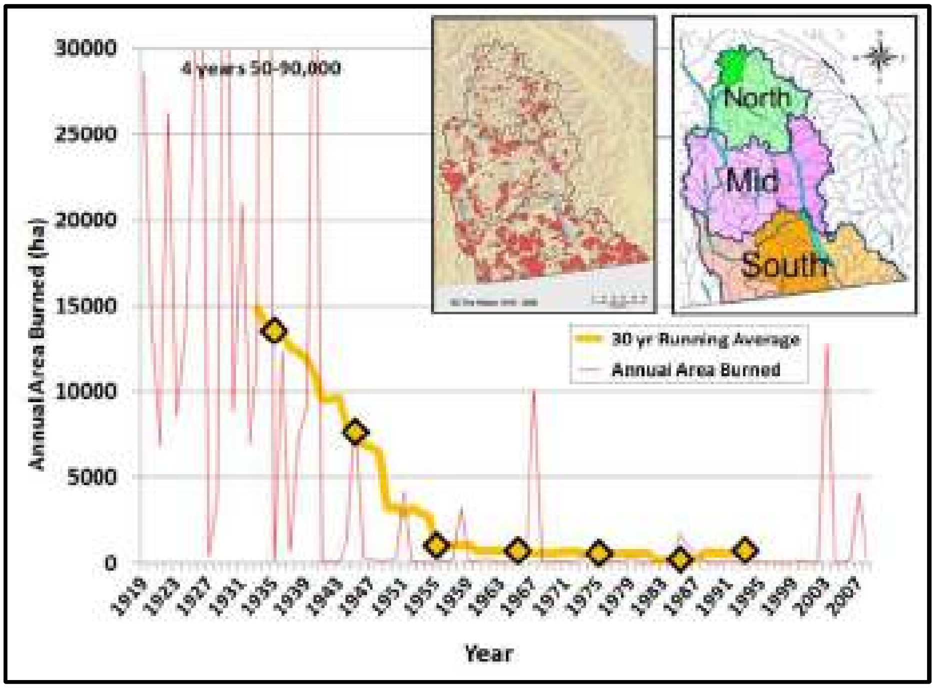

Figure 2.4. Historical annual area burned for the southern West Kootenays (from Utzig et al. 2011).

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[1] The four scenarios represent the warm/cool and dry/wet edges of forty different scenarios for BC. For detailed information on the scenarios see Report 3, Climate Changes, available at: www.kootenayresilience.org/ev-reports

also indicates that there will be an increase in extreme events such as high intensity rainstorms, wind storms, heat waves and climate whiplash events such as early spring thaws immediately followed by severe frosts.

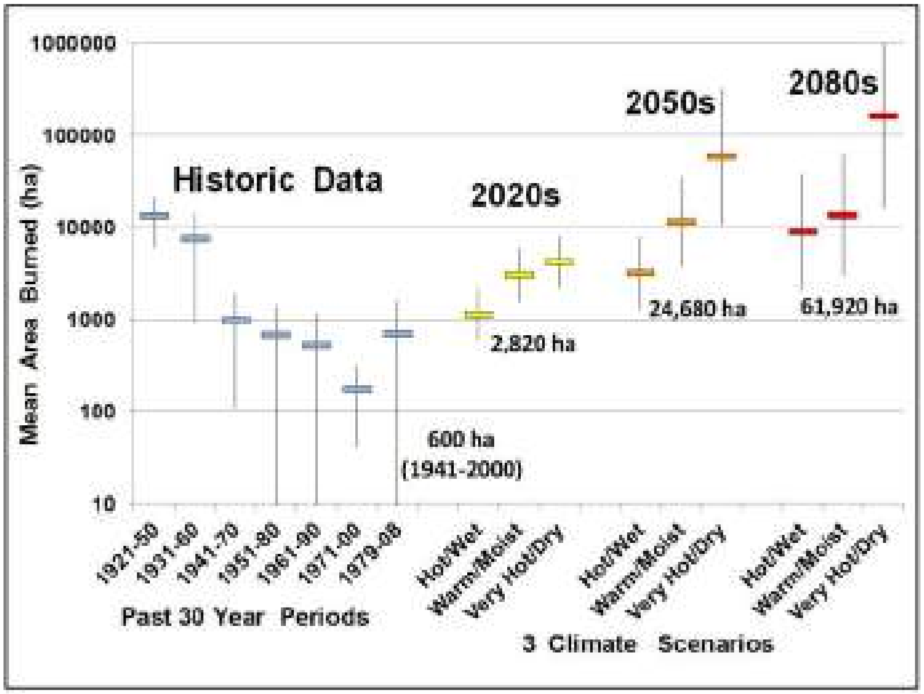
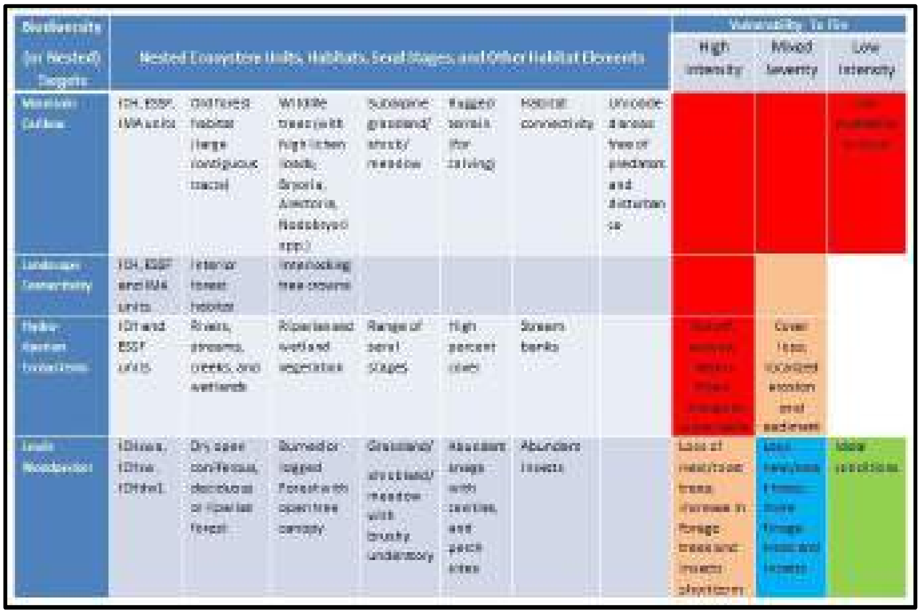


Figure 2.5 Projected annual area burned for the southern West Kootenays – note log scale (from Utzig et al. 2011).

The combination of warmer and drier summers is one of the projected changes that will have far-reaching impacts. Recent modelling of the average annual area burned for the southern WKs has shown that the area burned has recently begun to increase, and is projected to increase further in coming decades (see Figs. 2.4 and 2.5). The increase in area burned indicates that in the lower elevations natural disturbance regimes may shift to very frequent low intensity fires typical of grasslands or steppe environments where trees are limited to riparian or protected locations. Upper elevations are likely to shift from rare stand-replacing fires to more frequent stand-replacing fires and mixed fire regimes, or even frequent stand-maintaining fires under the Very Hot/Dry scenario.



Biodiversity (or Nested) Targets	Nested Ecosystem Units, Habitats, Seral Stages, and Other Habitat Elements							Vulnerability To Fire		
								High Intensity	Mixed Severity	Low Intensity
Mountain Caribou	ICH, ESSF, IMA units	Old forest habitat (large contiguous tracts)	Wildlife trees (with high lichen loads; Bryoria, Alectoria, Nodobryoria spp.)	Subalpine grassland/ shrub/ meadow	Rugged terrain (for calving)	Habitat connectivity	[illegible] areas free of predators and disturbance	🟥	🟥	🟥 [illegible]
Landscape Connectivity	ICH, ESSF and IMA units	Interior forest habitat	Interlocking tree crowns					🟥	🟧	
Hydro-riparian Ecosystems	ICH and ESSF units	Rivers, streams, creeks, and wetlands	Riparian and wetland vegetation	Range of seral stages	High percent cover	Stream banks		🟥 [illegible]	🟧 Cover loss, localized erosion and sediment	
Lewis Woodpecker	[illegible]	Dry open coniferous, deciduous or riparian forest	Burned or logged forest with open tree canopy	Grassland/ shrubland/ meadow with brushy understory	Abundant snags with cavities, and perch sites	Abundant insects		🟧 Loss of nest/roost trees; increase in forage trees and insects [illegible]	🟦 Loss nest/roost [illegible] more forage trees and insects	🟩 Ideal conditions

Figure 2.6. Impacts of various types of wildfire on species and ecosystems in the Darkwoods conservation lands (Utzig et al. 2016).

A recent study undertaken in the Darkwoods conservation property at the NW corner of the Creston Valley study area has examined the potential impacts of changing wildfire disturbance regimes on various ecosystem components and recommended various adaptation strategies to protect the values associated with those components (Utzig et al. 2016). An example of assessing sensitivity and exposure from changing wildfire regimes from Darkwoods is shown in Fig. 2.6.

Increased incidence of extreme events in the form of high intensity precipitation, heat waves/ drought, windstorms, freeze/ thaw events, floods and landslides will result in further types of disturbance. These in combination with increased tree stress will contribute to increased mortality from various insects and disease. Mortality from fire and/or these disturbances will likely serve as the catalysts for the vegetation shifts implied by the bioclimate shifts shown in Fig 2.8. An example of two processes working in combination was the intensive 2003 Kuskanook fire creating hydrophobic soils, followed by a high intensity precipitation event, and the resulting debris flow into Kootenay Lake (see Fig. 2.7).

Figure 2.7. Wildfire (2003) in Kuskanook Creek headwaters with hydrophobic soils (upper). Subsequent debris flow into Kootenay Lake (lower). Photos by P. Jordan.

Another approach to visualizing the potential exposure and impacts of climate disruption is the use shifting bioclimatic envelopes[2]. Broad zonal ecosystem types (e.g., BEC zones) can be represented by the climate envelope that is associated with the location where each type occurs. GCMs can then be utilized to determine what climate envelope is projected to occur in that location in the future.

The projected bioclimate envelopes for the Creston Valley extracted from the West Kootenay regional vulnerability project are presented in Fig. 2.8. The projections are based on the three scenarios mentioned earlier, for the period 2070 to 2099 (i.e. the 2080s).

Although there is significant variation between the three scenarios, there are also distinct areas of agreement. All the scenarios reflect trends to warmer and drier conditions at the lower elevations ï shifts from climates associated with mixed closed and open forests to those of open savanah forests or even grassland/ steppe. The disagreement is only the extent or speed of the trend. The second major point of agreement is the almost complete disappearance of climate envelopes associated with ESSF forests. However in this case there is some disagreement on what will replace it, with some scenarios favouring warmer wetter forest bioclimates in contrast to the Very Hot/Dry scenario favouring climates associated with significantly hotter and drier forest types.

The results of the bioclimate shift analysis and projected wildfire increases suggest that increasing resilience to drought and wildfire are likely the highest priorities for adaptation in forested ecosystems. Building resilience into wetland water management is also a priority to consider.

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[2] For detailed information on the methodology utilized and further interpretation, see Report 1, Summary, Report 5 Bioclimate Shifts and Report 7, Vulnerability Assessment, available at: www.kootenayresilience.org/ev-reports

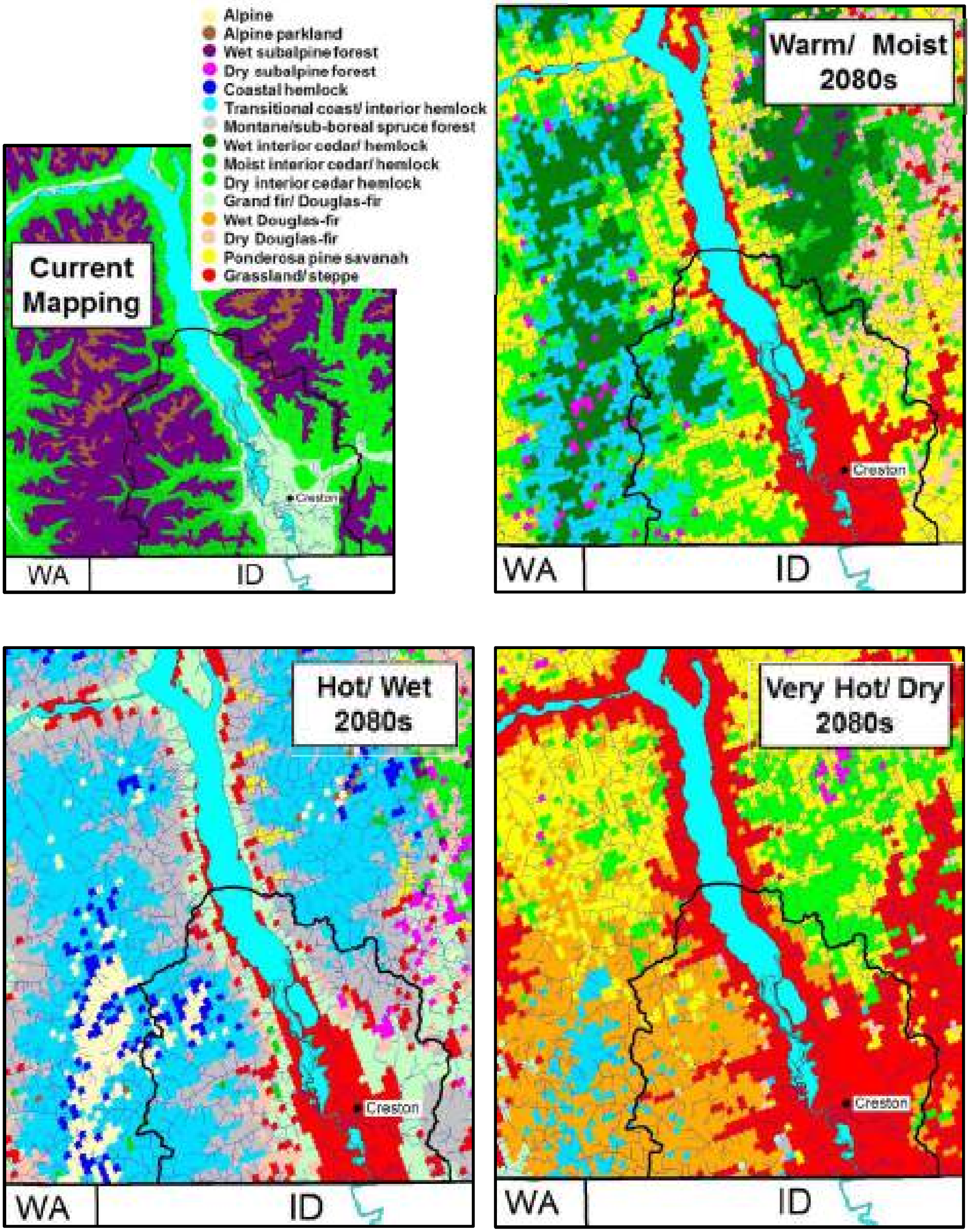

Figure 2.8. Current and projected bioclimatic envelopes for the Creston Valley area for three climate change scenarios (Original data from: Roberts and Hamann, U of A; HadCM3_B1, CGCM3_A3, HadGEM_A1B, and MacKillop and Ehman 2016)

As mentioned in the introduction, the Kootenay Conservation Strategy has taken the results of the regional vulnerability assessment, in combination with analysis of existing development threats and potential high value biodiversity sites, to develop a conservation plan for the region. The Creston Valley area is an important cross-valley component of a linkage corridor running up the west side of the Kootenai Valley in Idaho, extending to the Darkwoods conservation area on the west side of Kootenay Lake, and providing a connection to a further linkage zone up the east side of Kootenay Lake (see Fig. 2.9).

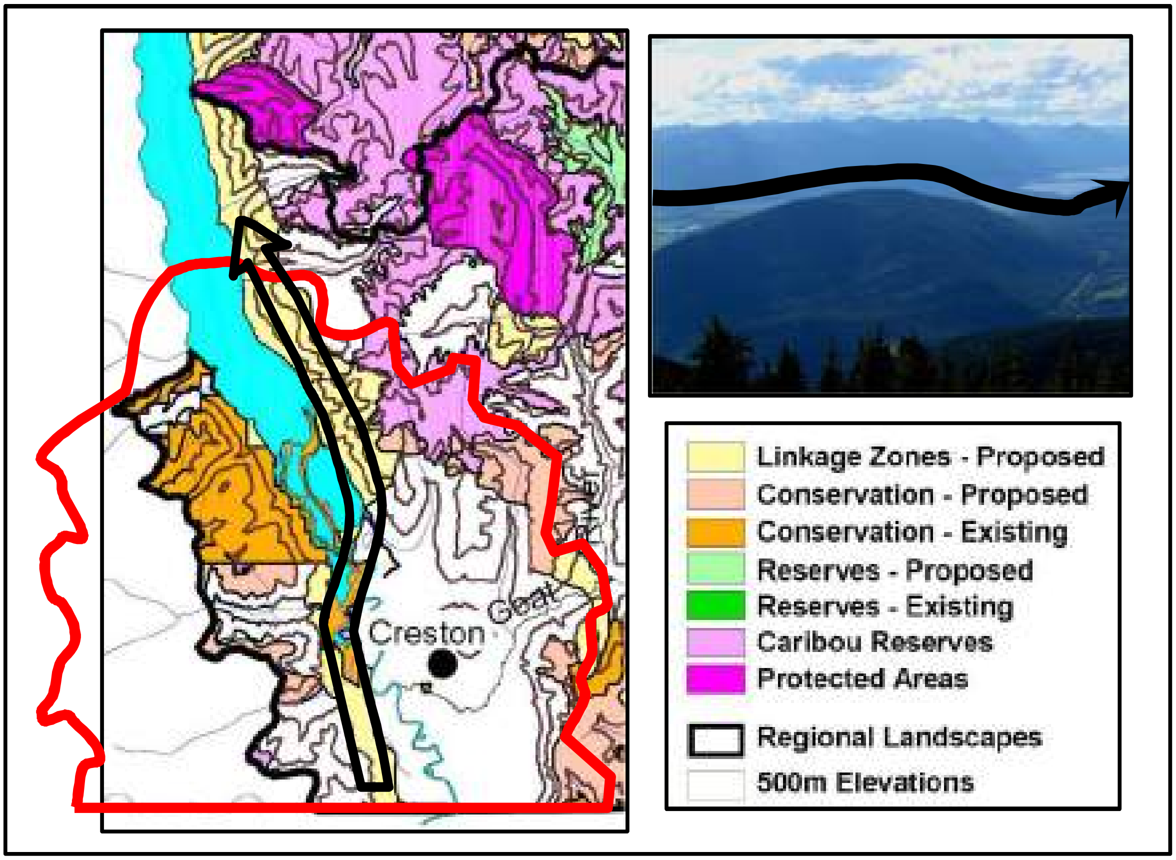

Figure 2.9. The Creston Valley study area as it relates to a proposed regional linkage zone.

3.0 BONANZA CREEK CONNECTIVITY CORRIDOR

The Bonanza Biodiversity Corridor (BBC) wildlife linkage area is focused on the Bonanza Creek watershed, which drains the southern portion of the valley that links the north end of the Slocan Valley with the main Columbia River Valley near Nakusp. Summit Lake is found at the northern end of the BBC, while Bonanza Creek flows south out of Summit Lake, eventually flowing into the northern end of Slocan Lake. A series of wetlands occurring along Bonanza Creek creates a biodiversity-rich riparian floodplain. Additional wetlands occur sporadically on benches above the main floodplain. The lower to mid slopes consist of closed forest typical of the moist Interior Cedar-Hemlock Zone (ICH) in the valley bottom grading to those of the wet ICH on the mid slopes. The upper slopes are characterized by closed stands typical of the wet Engelmann Spruce Subalpine Fir zone (ESSF) grading to woodland and parkland types at the highest elevations. The natural disturbance regimes are dominated by moderately frequent stand-replacing fires and occasional mixed-severity burns, which are more common lower slopes and southern aspects.

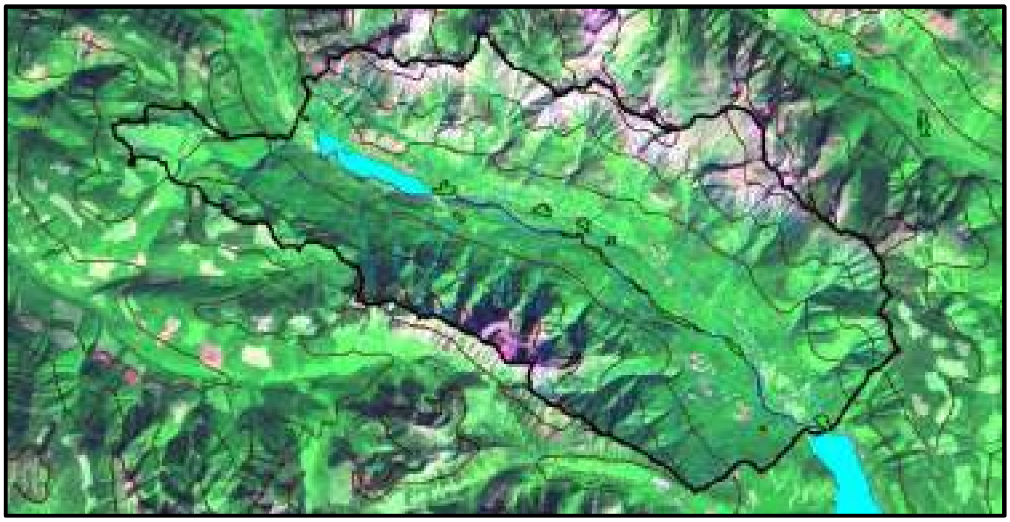

Figure 3.1. Bonanza Biodiversity Corridor study area.

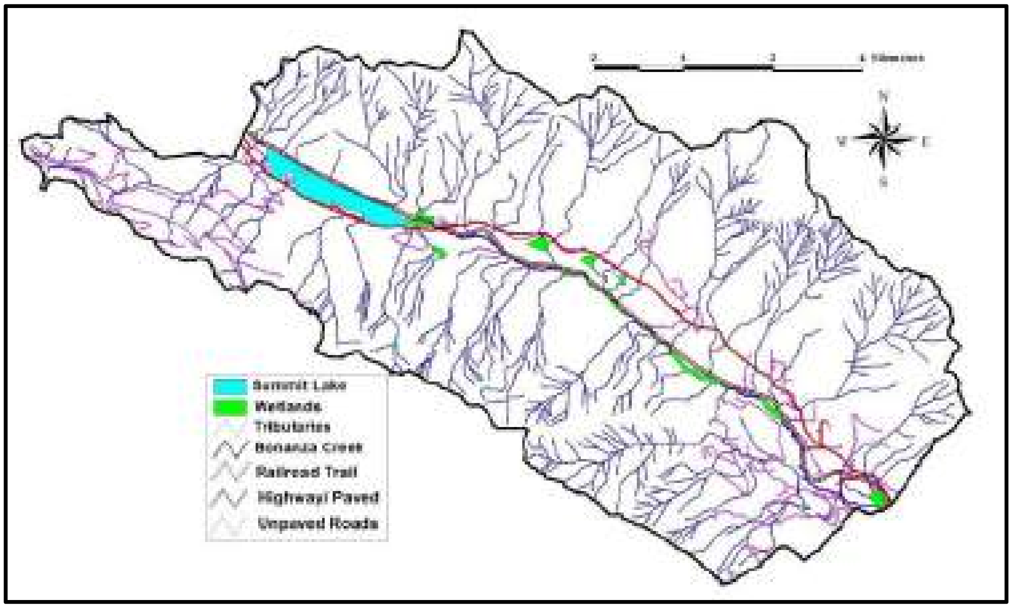

Figure 3.2. Bonanza road and railroad development. Wetlands in green.

As visible in Fig. 3.1, most of the study area is covered with closed forest, with some openings resulting from forest harvesting, mainly on the lower slopes at the extreme western end and eastern third of the watershed. There is some land clearing on private land at the upper end of Summit Lake and in the rural community of Hills near the head of Slocan Lake. Road development consists of a highway traversing the valley bottom from end-to-end, and a series of unpaved forest development roads generally localized at the western and eastern ends of the valley. A railroad line also traverses the valley, but it is now converted into a recreational trail. The railroad line and highway run through, adjacent to and/or immediately upslope of some wetlands creating drainage disruptions (see Fig 3.2). With the exception of the valley bottom and extreme eastern and western ends, the valley is generally intact.

With these stressors as a background, climate disruption will add another level of stress to ecosystems in the BBC. Global Climate Model (GCM) outputs for the area generally project an increase in temperatures in all seasons (see Fig.3.3). Precipitation is projected to increase in all seasons except summer, when it is likely to decrease (one of four scenarios shows a minor increase). The main difference between the four scenarios[3] is the degree of change, rather than differences in direction of change. Recent temperature data indicates that these changes have already begun. Other modelling also indicates that there will be an increase in extreme events such as high intensity rainstorms, wind storms, heat waves and climate whiplash events such as early spring thaws immediately followed by severe frosts.

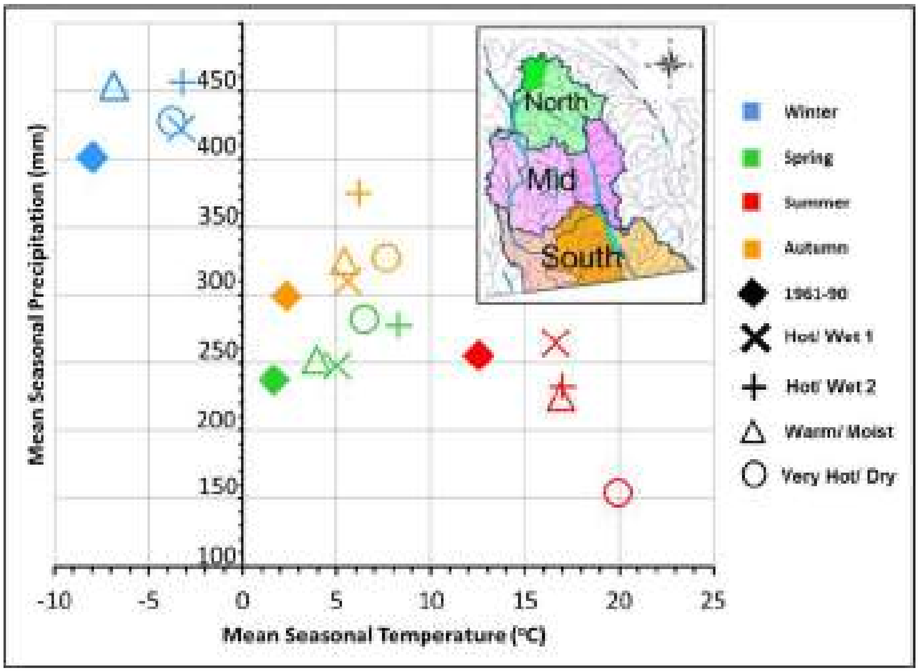

Figure 3.3. Seasonal climate projections for the reference period (1961-90) and the 2080s for four GCM/ emission scenarios for the mid West Kootenays (from Utzig 2012).

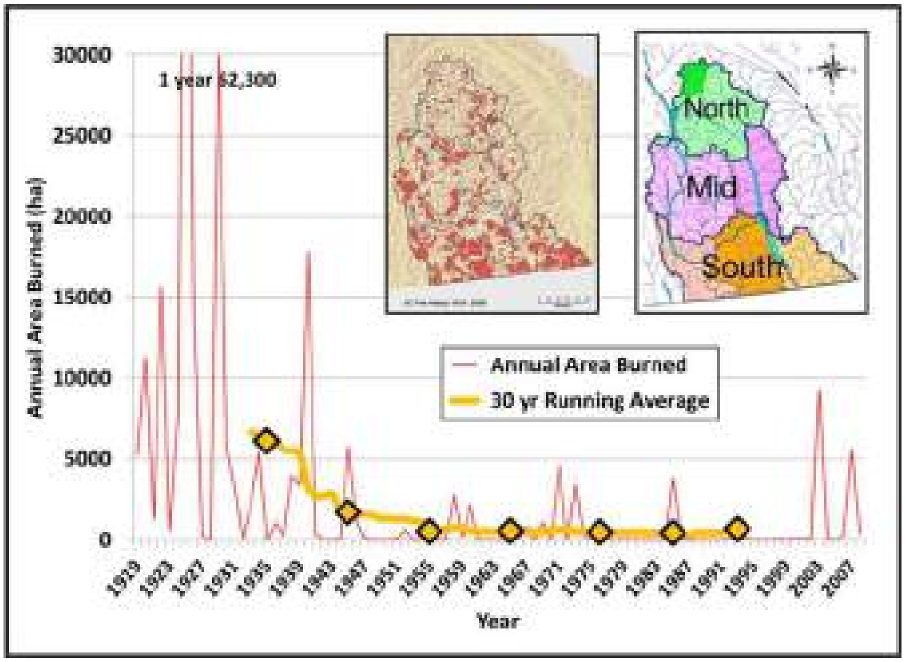

Figure 3.4. Historical annual area burned for the mid West Kootenays (from Utzig et al. 2011).

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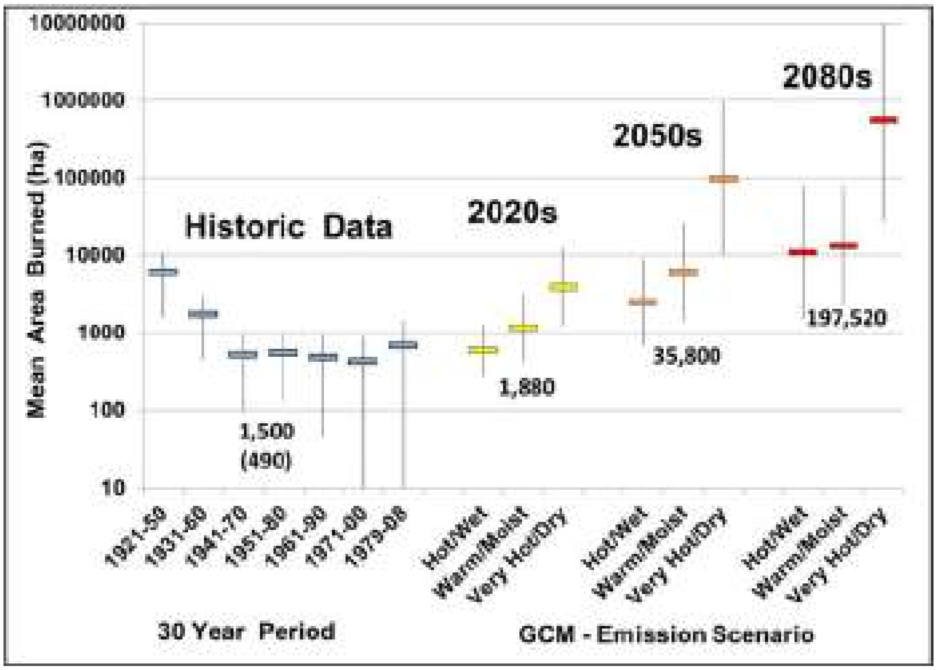

Figure 3.5. Projected annual area burned for the mid West Kootenays – note log scale (from Utzig et al. 2011).

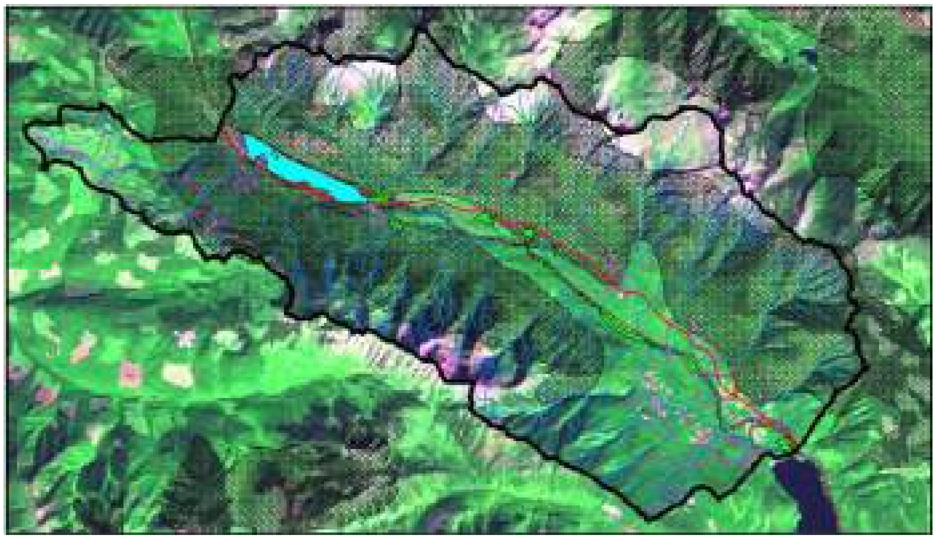

Figure 3.6. Stippled area shows the extent of the 1925 Bonanza watershed wildfire.

The combination of warmer and drier summers is one of the projected changes that will have far-reaching impacts. Recent modelling of the average annual area burned for the mid WKs has shown that the area burned has recently begun to increase, and is projected to increase further in coming decades (see Figs. 3.4 and 3.5). The increase in area burned indicates that in the lower elevations natural disturbance regimes are likely to shift to mixed fire regimes and/or frequent low intensity stand-maintaining fires with open stands or even grassland/ steppe ecosystems. Upper elevations are likely to shift from rare stand-replacing fire regimes to more frequent stand-replacing fires, or even frequent stand-maintaining fires in the Very Hot/Dry scenario.

The climate early in the 20th century was generally warmer and/or drier than the latter half of the century, and those changes are reflected in the fire history of the BBC (see Fig. 3.4). A single fire in July of 1925 burned about 75% of the BBC, sparing only the lower valley bottom, the SE and SW corners where forest harvesting has been focused, as well as some high elevation parkland area (Fig. 3.6). Climate projections and fire modeling project that we are moving to similar conditions to the 1920s in the next few decades.

Another approach to visualizing the potential exposure and impacts of climate disruption is the use shifting bioclimatic envelopes[4]. Broad zonal ecosystem types (e.g., BEC zones) can be represented by

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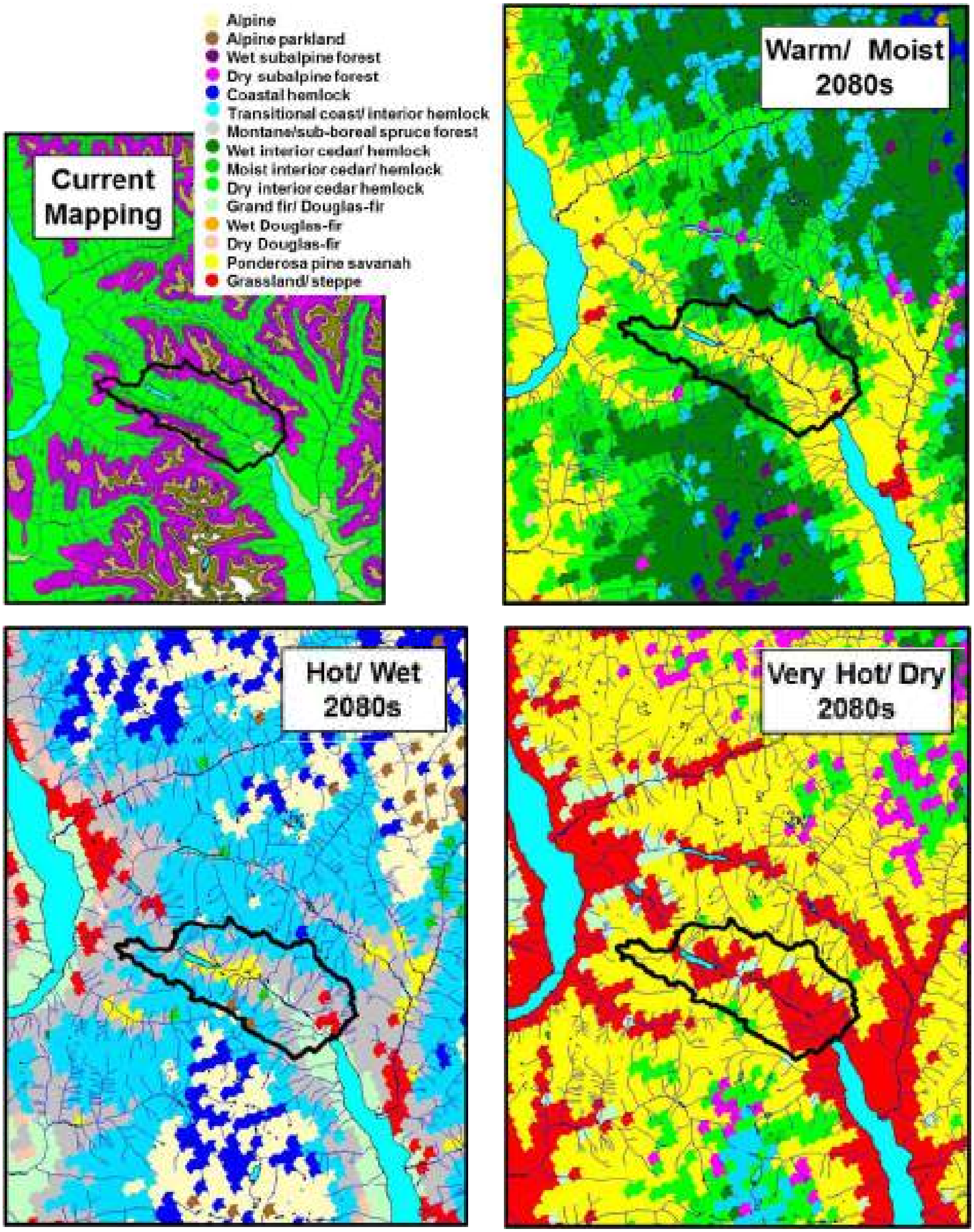

Figure 3.7. Current and projected bioclimatic envelopes for the Bonanza Biodiversity Corridor for three climate change scenarios (Original data from: Roberts and Hamann, U of A; HadCM3_B1, CGCM3_A3, HadGEM_A1B, and MacKillop and Ehman 2016)

the climate envelope that is associated with the location where each type occurs. GCMs can then be utilized to determine what climate envelope is projected to occur in that location in the future. The projected bioclimate envelopes for the BBC are extracted from the West Kootenay regional vulnerability project are presented in Fig 3.7. The projections are based on the three scenarios mentioned earlier, for the period 2070 to 2099 (i.e. the 2080s).

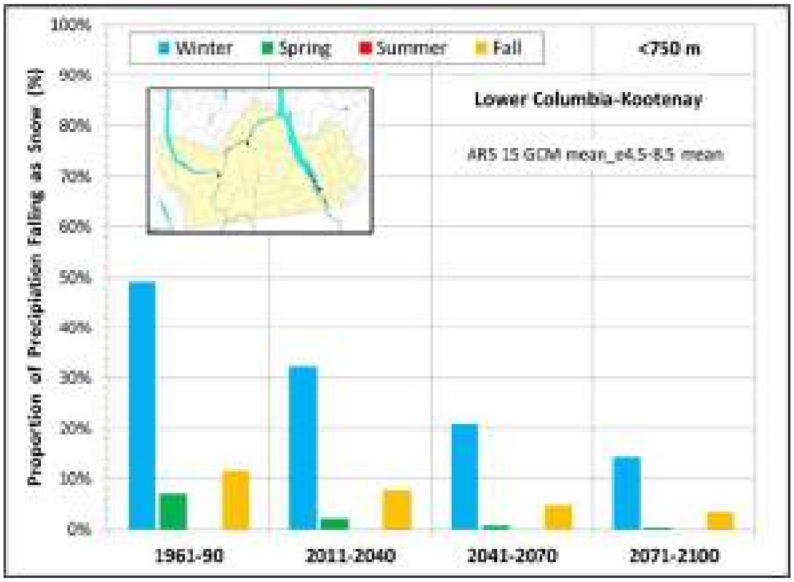

Figure 3.8. Projected decrease in seasonal snow as a percentage of seasonal precipitation for southern West Kootenays at low elevations.

As with the Creston Valley, there is significant variation between the three scenarios, there are also distinct areas of agreement. All the scenarios reflect trends to warmer and drier conditions at the lower elevations ï shifts from climates associated with closed forests to those of open savanah forests or even grasslands. The disagreement is only the extent or speed of the trend. The second major point of agreement is the almost complete disappearance of climate envelopes associated with ESSF forests. However in this case there is some disagreement on what will replace it, with some scenarios favouring warmer closed forest bioclimates in contrast to the Very Hot/Dry scenario favouring climates associated with significantly hotter and drier open forest types.

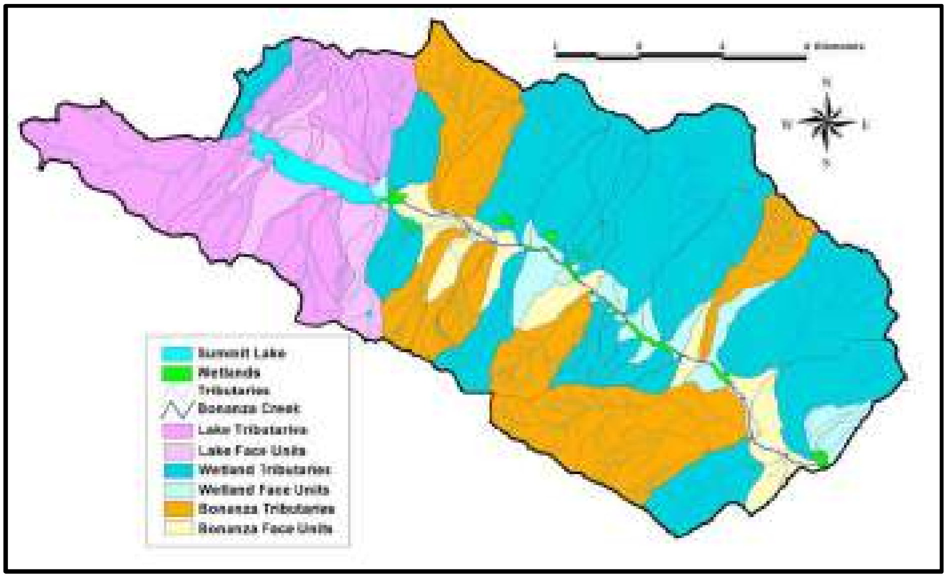

Figure 3.9. Classification of tributaries to Bonanza Creek and their roles in supplying various wetland and aquatic ecosystems.

Increased incidence of extreme events in the form of high intensity precipitation, heat waves/ drought, windstorms, freeze/ thaw events, floods and landslides will result in further types of disturbance. These in combination with increased tree stress will contribute to increased mortality from various insects and disease. Mortality from fire and/or these disturbances will likely serve as the catalysts for the vegetation shifts implied by the bioclimate shifts shown in Fig 3.7.

Another projected result of climate disruption (i.e. a component of ñexposureò) is the increased occurrence of winter precipitation as rain rather than snow, especially at lower elevations (see Fig.3.8). Understanding how this change may affect riparian, wetland and aquatic ecosystems in the BBC requires and understanding of the watersheds that supply runoff to the various wetlands and aquatic components that occur (see Fig 3.9). As an example of a ñsensitivityò analysis, the wetlands occurring in the BBC were grouped according to their water source, and whether that water source was sensitive to a reduction in snowpack. It is assumed that the wetlands adjacent to the mainstem Bonanza Creek are less sensitive, whereas those supplied only by tributary streams are more sensitive, and those supplied with streams from lower elevation watersheds the most sensitive of all (see Figs 3.10). The results of this simple analysis could be used to prioritize wetlands for field assessments, and investigation of potential adaptation measures, such as installation of water retention and/or water storage structures.

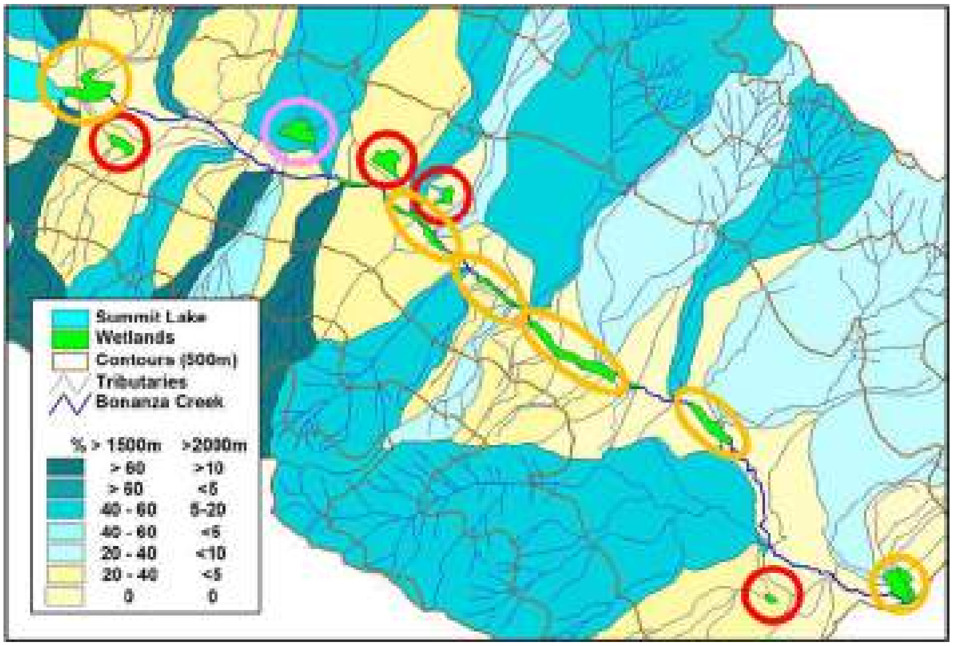

Figure 3.10. Wetland sensitivity based on water source. Orange-circled wetlands along Bonanza mainstem, pink-circled with higher elevation water source, red-circled wetlands with lower elevation water sources.

Another important component of climate disruption adaptation may be the identification of potential cool refugia and/ or wildfire refugia. Areas that survived the 1925 fire may offer clues as to which types of environments may offer these unique characteristics. The old growth forests that survive the 1925 fire are highlighted in Figure 3.11. GIS analysis of topography, aspect, seepage and solar radiation inputs may be a further method of identifying such sites.

As mentioned in the introduction, the Kootenay Conservation Strategy has taken the results of the regional vulnerability assessment, in combination with analysis of existing development threats and potential high value biodiversity sites, to develop a conservation plan for the region. The BBC area is an important component of a linkage corridor running from the Valhalla Park Protected Area to the south, along Bonanza Creek to Summit Lake, and then extending down Nakusp Creek and along Box Lake to the main Columbia Valley (see Fig. 3.12).

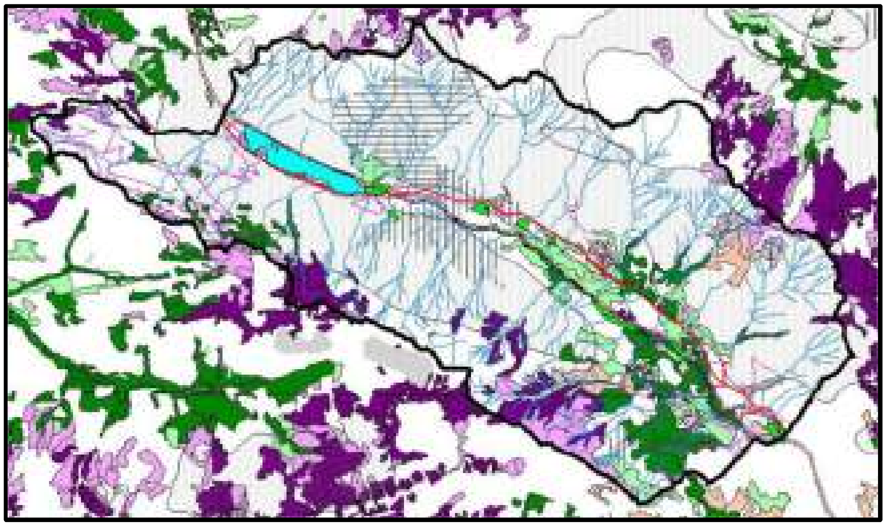

Figure 3.11. Old growth and mature Cedar-Hemlock (green) and Engelmann Spruce-Subalpine Fir stands (purple) and Kootenay Mix (tan) in relation to the 1925 wildfire (stippled area). Darker colours are older stands.

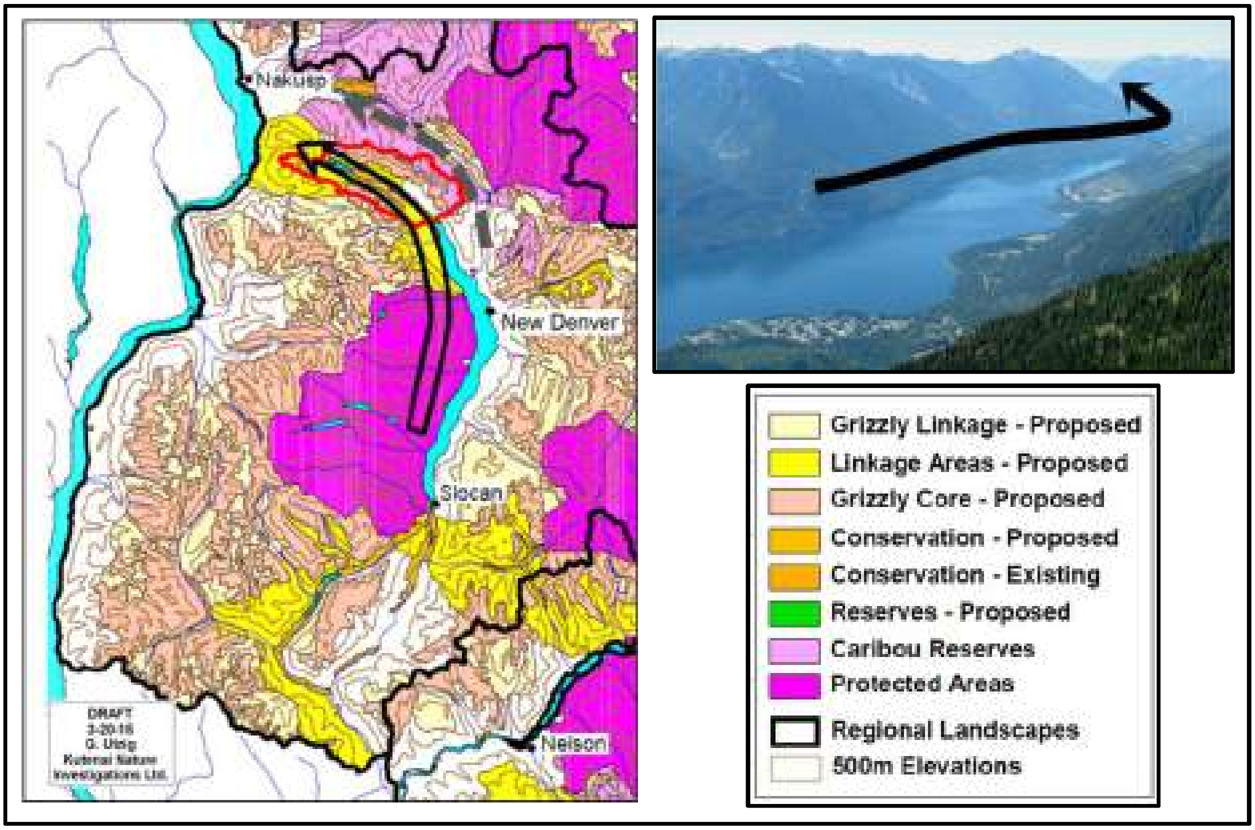

Figure 3.12. The BBC study area (red outline) as it relates to a proposed regional linkage zone. The dashed arrow indicates a possible back-up linkage area in the Wilson Creek drainage.

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