An assessment of the cumulative effects of land use and management in SSN

Prepared For St’kemlupsemc Te Secwepemc Nation Review Panel for the proposed KGHM Ajax Mine Project

April 26, 2016

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EXECUTIVE SUMMARY

The St’kemlupsemc Te Secwepemc Nation (SSN) requested that ALCES Landscape and Land Use Ltd. (ALCES) conduct a cumulative-effects assessment for the SSN traditional territory, including any effects contributed by the proposed Ajax mining project. Simply put, cumulative effects are the changes caused by our actions today in combination with other past, and reasonably foreseeable human and natural disturbance. Critical components of this assessment include:

- assessment over the entire SSN traditional territory, as well as the Ajax Regional Study Area (RSA) where appropriate; and
- referencing current and forecast future conditions against ranges of natural variation approximating pre-contact conditions.

This report provides a summary of the undertakings, findings and any recommendations emerging from this work for consideration by the SSN Review Panel in its deliberations regarding the proposed KGHM Ajax project within the SSN Traditional Territory.

Simulation models are tools that provide insight into the potential outcomes of different land use management strategies. Models will not explicitly tell us what the “best” management objective or implementation approach is – this is the role of decision makers. ALCES is an acronym that stands for A Landscape Cumulative Effects Simulator. ALCES Online (AO) is a web-based GIS and landscape simulator for assessing the cumulative effects of multiple overlapping land uses and external stressors such as climate change. Indicators are measures of values of interest that help us understand the consequences of human land use and natural disturbance.

The ALCES simulation model was used to simulate ecosystems and forest fires during pre-contact conditions, and to additionally simulate the current and future effects of key human land uses, including mining (metal and aggregate), forest harvest, road construction, rural and urban residential growth, and recreation. These simulations were assessed for the cumulative effects on a range of land-use and ecosystem indicators, including five key indicators selected by SSN representatives:

1. land dispossession and tenure;
2. grasslands quantity and quality;
3. mule deer;
4. fish; and
5. an index of animal protein sources.

Results of this work demonstrate substantial effects for all of these indicators from the pre-contact period to current conditions. All grassland and wildlife indicators show estimated declines within the SSN Traditional Territory ranging from 13% to 100%. In addition, development of the proposed Ajax mine project is shown to further contribute to decline in
future indicator performance for the grasslands and protein indices. Performance for the key selected indicators is summarized below:

- **Land dispossession and tenure** – roughly 316,000 ha, or 25%, of the SSN traditional territory has been dispossessed through granting/sale of private lands, designation of provincial parks or other protected areas, and through direct construction of human footprint. These dispossessed areas are generally concentrated around the city of Kamloops and the grasslands to the south, as well as along the Thompson River valleys. Addition of non-forestry tenure types (mineral leases, guide-outfitter areas, range tenures, and the Agricultural Land Reserve) brings the total dispossessed land to 110% of the traditional territory. This analysis demonstrates that even without inclusion of forestry tenures that have granted forest-harvest rights and the ability to impose associated land management activities on the landscape, almost the entirety of the SSN traditional territory is occupied by at least one tenure type that is restrictive of SSN use of this land base.

- **Grasslands quantity and quality** – grasslands comprised approximately 15% of the SSN traditional territory in pre-contact times. An analysis of current conditions indicates the absolute loss due to human land uses of almost 26,000 ha within the traditional territory, or approximately 14% of the original grasslands. These metrics are further pronounced in an examination of the Ajax RSA. In pre-contact times there were approximately 63,000 ha of grasslands in the RSA, or about 1/3 of the grasslands in the SSN traditional territory. Roughly 8200 ha, or 13%, of these grasslands have been lost due to human development at present, and future development over the next 50 years is projected to remove another 3400 ha, or 6% of the remaining grasslands. One of the larger intact grasslands in the RSA is the 2200-ha area north of the proposed mine development, and south of the Aberdeen neighborhood in the city of Kamloops. Declines in grassland quality are also estimated to have occurred and to continue occurring, both at the scale of the SSN traditional territory and within the RSA for the proposed Ajax mine. These declines are due to the combined effects of fire suppression, cattle grazing, introduction of non-native and invasive species, and physical removal of grasslands due to construction of human footprints.

Integration of quantity and quality as an aggregate metric suggests that there has been an approximate 67% decrease in the integrity of native grasslands in the SSN traditional territory from pre-contact times to the present, and a 72% decrease within the Ajax RSA.

- **Mule deer** – the habitat-effectiveness index for mule deer is currently 21% below the estimated lowest pre-contact level. This index is predicted to recover over the 50-year forecast driven by changes in forest demographics, but will still remain well below the minimum pre-contact level for this species.
• **Fish** – fish habitat is estimated for species that occur within the mainstems of the Thompson Rivers, including interior Fraser coho, an at-risk population. Average fish-habitat values across the study area have declined by 27.5% from reference values, but some areas are higher, with declines in excess of 50%. These estimates of decline are conservative, in that they are based solely on a narrow assessment of mainstem habitat values, and do not account for temperature and flow effects within the river, nor population effects due to other factors. In addition, due to its limitation to the mainstem Thompson rivers, our analysis was not able to assess effects on fish inhabiting the Pipsell (Jacko Lake) area and associated watercourses.

• **Index of animal protein sources** - The index of primary pre-contact terrestrial animal protein sources has declined by approximately 49% in current conditions from the pre-contact period, due both to degradation of grouse and mule-deer habitat and due to extirpation of elk and caribou from the traditional territory. Combining the effects of habitat degradation, extirpation, and land dispossession indicates an even greater effect: a 62% decline in availability of these protein sources under current conditions in comparison to the pre-contact period, as the majority of the highest quality habitat for the traditional protein species is largely inaccessible due to the granting of private title and construction of human footprint. As with the grasslands analysis, these effects are further pronounced in the RSA for the proposed Ajax mine – in this area, the decline in accessible terrestrial animal protein sources is 74% in current conditions compared to the pre-contact period.

Addition of the fish indicator to the terrestrial protein indicators shows a total pre-contact protein indicator decline of 36% from pre-contact to current conditions. When the effects of tenure and direct displacement are added, the estimated decline is 42%.

These and supporting analyses conducted for this report show the already substantial cumulative effects of land-management decisions and use in the SSN traditional territory, with generally large changes estimated from the pre-contact period to the present. Although the proposed Ajax project is relatively small, it is an additional stressor on the territory’s ecosystems and the organisms that depend on them, and its development would cause further loss to key SSN indicators, particularly grasslands and related species.
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1 INTRODUCTION

In September 2015, St’kemlupsemc Te Secwepemc (SSN) representatives contacted ALCES Landscape & Landuse Ltd. (ALCES) to inquire about the completion of landscape simulation modelling and analysis to support a cumulative effects assessment by the SSN Review Panel in relation to the proposed KGHM Ajax Project. Prior to this, ALCES has assisted the SSN with pre-screening of the KGHM’s Environmental Impact Assessment (EIA) for the proposed Ajax Project with respect to the cumulative effects assessments completed therein.

This report is a summary of the undertakings, findings and any recommendations emerging from this work for consideration by the SSN Review Panel in its deliberations regarding the proposed KGHM Ajax project within the SSN Traditional Territory.

2 CONTEXT

2.1 ENVIRONMENTAL IMPACT ASSESSMENT FOR PROPOSED KGHM AJAX PROJECT

KGHM Ajax Mining Inc. (KAM) is proposing to develop the Ajax Project (the Project) located in the Thompson Nicola Regional District, in the south-central interior of British Columbia (BC). The proposed Project will be an open pit copper and gold mine. The proposed mine plan for the Project predicts an operation based on a mill throughput of 65,000 tonnes of ore per day. Total material movement from the pit is estimated at approximately 90 Mt on an average annual basis. Average annual production of the mine is estimated at 140 million pounds of copper and up to 130,000 ounces of gold in concentrate, based on a conceptual mine plan supplying up to 24 million tonnes of ore per year to the mill. For the purpose of the environmental assessment these rates have been assumed for a mine life of 23 years.

The Project is subject to a review under the BC Environmental Assessment Act (BC EAA; (2002)), and the transition provisions of the federal Canadian Environmental Assessment Act, 2012 (CEAA 2012; (2012)). The BC Environmental Assessment Office (BC EAO) initiated the provincial environmental assessment (EA) process by issuing an Order under section 10 of the BC EAA on February 25, 2011. The Order confirmed that “the proposed Project constitutes a reviewable project pursuant to Part 3 of the Reviewable Projects Regulation (BC Reg 370/2002), since the

\[ \text{KAM. 2015. Ajax Project: Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study. Assembled for KGHM Ajax Mining Inc. by ERM Consultants Canada Ltd.: Vancouver, British Columbia.} \]
The proposed project is a new mine facility that, during operations, will have a production capacity of 75,000 tonnes or more per year of mineral ore”. A section 11 Order was issued by the BC EAO on January 11, 2012, and subsequent Section 13 Order on July 23, 2015, which established the scope, procedures and methods for the EA of the proposed Project.

2.2 **ST’KEMLUPSEMC TE SECWEPEMC NATION PROJECT ASSESSMENT PROCESS**

The SSN requested an Independent Review Panel process for the assessment of the Ajax Mine Project. This level of review continues to be denied which led to the development of SSN’s project assessment process that runs alongside, and where appropriate, collaboratively with the Environmental Assessment Process (BC & Canada). This process is inclusive rather than exclusive and assesses the project using SSN’s laws and governance including assessments respecting Secwepemc cultural perspectives, knowledge & history. The Review is grounded in the Secwepemc Trout Children Stspetlékwle, the Memorial to Sir Wilfred Laurier (1910), the UN Declaration of the Rights of Indigenous People, and the laws of Canada.

The purpose of this process is to:

“Facilitate informed decision making by the SSN Communities in a manner which is consistent with our laws, traditions, and customs and assesses project impacts in a way that respects our knowledge and perspectives”

2.2.1 **WHAT ARE THE COMPONENTS OF THE PROCESS?**

The SSN Project Assessment Process is comprised of several components including the appointment of a 40-member SSN Review Panel, ceremonies, interviews, Community Information Sessions and information packages, site visits and traditional activities, independent expert reviews, and SSN assessments designed to review and assess both tangible and intangible impacts of the project such as those impacts of a cultural and spiritual nature (e.g. Sky World, the water people, x7ensq’t – “the land and sky will turn on you”). The Process will culminate with a Panel Hearing, two-week deliberation period and subsequent decision package for BCEAO, CEAA and KGHM regarding SSN’s land use objectives for the proposed project area.

2.2.2 **SSN REVIEW PANEL**

The SSN Review Panel will include T’kemlups te Secwepemc and Skeetchestn Chief and Councils, family appointed representatives, Elders, youth and traditional knowledge keepers who have been involved throughout the process and will sit for one week at the Panel Hearing to hear evidence, before deliberating and making their decision regarding the proposed project. The SSN Review Panel will review reports from KGHM, independent experts and SSN; review written

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submissions received from various organizations, Secwepemc Nation members and the public; and hear oral evidence pertaining to the SSN assessments, independent expert reviews, the proponent’s EIS, BCEAO and CEAA’s processes, stspentékwle, knowledge from Secwepemc knowledge keepers, and others to inform their decisions.

2.2.3 **SSN Decision Package**

Following the Panel Hearing and two weeks of deliberation with their families, the SSN Review Panel will come together for one week to develop recommendations for Joint Council. The Joint Council will consider the recommendations put forth by the Panel and prepare a decision package. The SSN Decision Package will include the Panel’s decisions as they relate to the proposed project. SSN decisions may be general such as the determination of the appropriate use of the area, or specific such as decisions regarding specific project design aspects (e.g. diversion of Peterson Creek). The decision package will be included in the Assessment Report and presented to BC and Canada Ministers during the Ministerial Decision Period.

2.3 **This Report**

This report is a summary of the undertakings, findings and any recommendations emerging from the ALCES cumulative effects assessment work for consideration by the SSN Review Panel in its deliberations regarding the proposed KGHM Ajax project within the SSN Traditional Territory.
3 CUMULATIVE EFFECTS ASSESSMENT

3.1 BACKGROUND
As the pace and scale of proposed development activities within SSN’s traditional territory continue to increase, it is vital that community members have a strong understanding of the changes that may happen over time to all resources and values across their traditional territory, Secwépemcúlecw. Meaningful engagement and participation of Secwépemc communities in land and resource management within the SSN Traditional Territory is strengthened by the development of strategic tools and processes that provide a unique opportunity for collaborative strategy development.

Through an initiative of the Secwépemc Reconciliation Framework Agreement (SRFA) ¹ signatory Bands which includes SSN, an initial cumulative effects model for the Secwépemc Traditional Territory within British Columbia has been developed using the ALCES® suite of tools. This includes strategic-level simulation models intended for use by progressive resource managers and planners. These products are fast, powerful, and user-friendly. A significant benefit of the ALCES approach is the collaborative development of scenarios to explore the long-term consequences of different land-uses on the economic, ecological, and social fabric of defined landscapes. The ALCES (A Landscape Cumulative Effects Simulator ) model is unique in its fully spatial capability to simultaneously simulate multiple proposed development projects in combination with other land and aquatic activities, natural disturbance and climate change over user defined time periods that typically cover a century and a half. Secwépemc-customized versions of these tools will be a tremendous asset for Aboriginal, government and industry partners to increase the collective understanding of cause and effect relationships between land use, natural system dynamics and people.

As a contributing member to the development of the SRFA ALCES model, SSN is building upon that initial work to develop an SSN Territorial model that is now being used to help inform the SSN Review Panel in its deliberations regarding the proposed KGHM Ajax project.

3.2 SSN Cumulative Effects Assessment re: Proposed KGHM Ajax Project
ALCES believes that a proper assessment of cumulative effects in the SSN traditional territory must include three things: 1) appropriate spatial scales of assessment; 2) appropriate temporal scales of assessment; and 3) reference to ranges of natural variation in comparison to current and anticipated future effects.

3.2.1 Spatial Scales of Assessment
In order for SSN to assess the effects of the Ajax project, and the contribution of those effects to overall cumulative effects, the study area needs to encompass a broader area than Regional Study Area (RSA) identified in the KGHM Ajax EIA. To address this, the study area for cumulative effects assessment is expanded to the SSN Traditional Territory as defined by SSN for the purposes of this assessment. The study area is approximately 12,543 km² and is shown in Figure 1. Sub-study area assessment is possible at any number of sub-regions including the EIA RSA and Local Study Area (LSA).

While the SRFA ALCES model provided a very strong starting point, because it was developed for a study area some 14 times larger than SSN, the existing map resolution of 4km² cells was considered too coarse for the SSN study area scale, particularly to examine effects specifically in and around the proposed mine. Therefore, the spatial grid resolution was increased to a 1/100 km² level (1ha). The appropriate spatial resolution can be reduced depending upon the indicator being forecast and the input resolution of inventories used. For most assessments in this work, a ¼ km² (25 ha) resolution was determined to be the most appropriate. Figure 2 shows the elevational relief across the SSN Traditional Territory viewed from the southwest.
In addition, new regions for assessment queries and higher resolution land use trajectories including growth of the proposed Ajax mine, human settlement, permanent recreation, surface mining, human and range cattle population, and forest harvesting were developed. Further information about spatial scales of assessment is provided in the Appendix.

3.2.2 **Temporal Scales Of Assessment**

The effects of the proposed Ajax project need to be assessed against a quantified pre-industrial or pre-contact baseline and an accounting of the rate of change associated with past industrial or post-contact activity to date so that the true cumulative effects of historic and future anthropogenic activity can be assessed. The project cumulative-effects assessment needs to include quantification of all reasonably foreseeable future activities, even if some details on these activities are lacking at this time.

This requirement was addressed through use of the ALCES tool to model changes from pre-industrial or pre-contact periods to the current state within the SSN traditional territory and forecasting expected future changes over the next 50 years. Further information about temporal scales of assessment is provided in the Appendix. Note that the SSN would prefer that the potential impacts of the proposed Ajax project be assessed for at least seven generations into the future, or approximately 175 years. This is very difficult to accomplish in a quantified way due to substantial uncertainty about longer-range forecasts for land-use trajectories and
natural-disturbance regimes, so this 175-year forecast was not conducted as part of this assessment. The lack of ability to do so is acknowledged as a limitation.

3.2.3 Ranges Of Natural Variation

Ranges of natural variation (RNVs) were modelled for ecologic indicators where appropriate. RNVs represent condition ranges for indicators due to changes in landscape composition resulting solely from natural disturbance regimes such as fire. In this way, these ranges are reflective of pre-contact / pre-industrial conditions, as they do not incorporate effects of modern human footprints on the landscape. RNVs are used to assess current and future relative risk to indicators: for instance, for wildlife indicators, RNVs represent a range of habitat conditions over which a population can be maintained. The degree by which current or future conditions depart from estimated RNV (particularly the lower boundary of RNV) is proportional to the degree of current or future risk to the indicator, as habitat values below RNV may not be sufficient to maintain pre-contact populations, or indeed any populations at all. The study area already has three examples of wildlife species that were present in the pre-contact environment – elk, mountain caribou and grizzly bear – but that have been extirpated due to a combination of land-use changes and management practices.

RNVs were modelled in this study by using a natural return interval specific to each forested landscape type for stand-replacing fires, using information contained in Wong et al., 2003, and B.C. Environment, 1995. Six 300-year simulations were run in ALCES, where the first two hundred years of each simulation was used to allow forest ages to equilibrate with the pre-fire-suppression stand-replacing fire-return interval, and the last hundred years were used to inform RNV conditions. For the last hundred years of each run, the observed maximum and minimum values were recorded, and then the lowest recorded minimum and highest recorded maximum were used to define the RNV for each indicator.

Pre-contact conditions for some indicators (grasslands, fish) made use of a reference-condition approach, where pre-contact conditions were assigned an index value of 1.0, and departure from these conditions was assessed. This approach was used as the simulation model does not currently include natural-disturbance regimes most relevant to these indicators, precluding the application of an RNV approach at this time.

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4 The term “pre-contact” is used here to refer to a period of sole indigenous occupation of the study area, prior to the arrival of immigrants of primarily European descent.
4 METHODOLOGY

4.1 SCENARIO MODELING APPROACH
Models will not explicitly tell us what the “best” management objective or implementation approach is – this is the role of decision makers. Rather, models are tools that provide insight into the potential implications for specific indicator performance as a result of management strategy implementation. Under the direction of the SSN Technical Working Group (TWG), and with guidance from the best available information publicly available, regional and sub regional-level scenario models have been developed to support the forecasting of anticipated land use and natural disturbance.

4.2 THE MODEL – ALCES ONLINE
ALCES is an acronym that stands for A Landscape Cumulative Effects Simulator. ALCES Online (AO) is a web-based GIS and landscape simulator for assessing the cumulative effects of multiple overlapping land uses and external stressors such as climate change. By integrating a wide range of environmental and socioeconomic data, the tool delivers comprehensive exploration of past, present, and future consequences of land use at local and regional scales. The tool is designed to be accessible and efficient in order to foster collaborative land-use planning. ALCES Online has been used for land-use planning decision support by governments, First Nations, and environmental organizations in Canada, Australia, and India.

To achieve a synoptic view of regional landscape dynamics and cumulative effects, a wide-range of land uses and ecological processes are incorporated into AO as drivers. Various land uses and ecological processes can be turned on or off depending on the needs of the scenario analysis. For each land use operating in a region, the user spatially defines the location, timing, shape, orientation and rate of landscape development and natural disturbance. The influence of plant succession on landscape composition can also be tracked. Hydrological processes can also be simulated with surface and groundwater modules incorporating meteorology, hydrology and climate change.

4.2.1 FORECAST PERIOD AND MODEL ARCHITECTURE
For the purposes of this study, the simulation is forecast forward annually but reported decadally for a period of 50 years, assumed to commence January 1, 2010.

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5 The SSN AO model is not currently populated with climate (temperature and precipitation) data. AO is fully capable of integrating this data from sources such as general circulation models and is hoped to be included in future iterations of the tool. A forecast scenario without wildfire suppression is available and may emulate future forest age demographics associated with climate change.
4.2.2 BACKCAST & PRE-CONTACT

Understanding cumulative effects requires not only a view of the future, but also an understanding of the past. In western Canada, the period prior to contact with European and American prospectors and settlers is an important baseline. It represents how ‘things were’ for countless generations prior to contact. Indigenous people were an important component of the landscape system hunting, gathering, and fishing to secure food, shelter and clothing. However, as caretakers of Mother Earth, they did this with an understanding to take only what was needed so that future generations would not be put in peril. We can look to this period as a benchmark to first of all understand the capability of the landscape to supply a broad range of ecological, social and economic goods and services, and secondly to compare it to the status of the landscape since then with the addition of significant non-indigenous immigration and the development of an industrialized society. These comparisons then provide insight into the cause and effect relationships associated with human land use.

Developing this baseline for a cumulative effects analysis involves removing all footprint from the landscape and limiting landscape change to natural disturbance events. This is the period for which Range Of Natural Variation (RNV) estimates are developed and is intended to emulate pre-contact conditions.

From there, a process known as backcasting is undertaken to document the addition periodic and cumulative addition of footprint and land use management to today. The current SRFA and SSN models include footprint backcasting in decadal increments from 1910 to 2010.

4.2.3 KEY LAND-USES

Key land-uses occurring in the study area and included in the Base Case:

- Forestry
- Surface mining including aggregate
- Agriculture including crops, forage, minor reservoirs and cattle
- Human Settlements including urban, acreage and farm residences
- Transportation networks including major roads (highways), minor roads (primarily logging access roads), and railways
- Energy including transmission lines and hydrocarbon transport via pipelines
- Recreation and tourism
- Industrial including manufacturing and landfill
- Provincial Parks, Protected Areas and Ecological Reserves
- Federal jurisdiction lands including Indian Reserves and military use
4.3 **FORECASTED DISTURBANCE**

Eight landscape disturbance types were entered into ALCES to model changes in footprint area within the SSN traditional territory from 2010 to 2060: surface mines – including Ajax; aggregate pits; forest harvest; forest fires; urban areas; acreage and rural residence; recreation; and minor roads. The specific inputs and assumptions comprising these landscape disturbance types are described below.

4.3.1 **SURFACE MINES**

Simulation of future growth of mines in the SSN traditional territory included footprint growth in the following three categories:

1. Expansion of the existing New Afton and Highland Valley Copper mines;
2. Development of the proposed KGHM Ajax mine; and
3. Simulated development of two new projects, the Maggie copper development in the west of the study area and the Bonaparte gold project in the north-central portion of the study area.\(^6\)

Overall growth of the mining sector in the simulated forecast was governed by the assumption that this growth would be similar to growth observed in the past five decades. There are currently approximately 5,000 ha of mine footprint within the SSN traditional territory, so we simulated growth of an additional 5,000 ha in the forecast. This growth was allocated to the five simulated operations by using public information on growth for Ajax, Highland Valley Copper, and New Afton, and then apportioning the remaining growth trajectory evenly to Maggie and Bonaparte to achieve a relatively linear increase in footprint over the forecast period.

For the Ajax development, final-extent footprint shapefiles were provided by KGHM and additional information on project development phases was sourced from the environmental assessment application. Mine development was broken down into three phases coinciding with years 2, 10, and 20 of development. Since the output of the ALCES model is decadal, these development phases coincide with years 2020, 2030, and 2040, respectively. Mine-feature polygons for Year 2 and Year 10 of development were delineated in ArcGIS based on maps provided in the environmental assessment application. The final-extent footprint shapefiles provided by KGHM were used for the Year 20 development phase (2040), representing the maximum extent of Ajax mine growth. Total simulated growth of the Ajax footprint includes approximately 1640 ha developed between 2017 and 2039.

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\(^6\) These two projects were selected based on their inclusion on the 2015 provincial mining projects map ([http://webmap.em.gov.bc.ca/mapplace/DL/web/OF2016-1_42x28_HiRes.pdf](http://webmap.em.gov.bc.ca/mapplace/DL/web/OF2016-1_42x28_HiRes.pdf)), but they are used in the simulation simply to represent expected additional mining development, and not intended as a prediction of the location and timing of that development.
Growth at New Afton was simulated at a rate of 5.4 ha per year for the period 2012-2024, for a total expansion of roughly 70 ha (Klohn Crippen Berger 2012). Growth at Highland Valley Copper was simulated at a rate of 47.1 ha per year for the period 2011-2027, for a total expansion of approximately 800 ha. Development of the Bonaparte gold project was simulated at a rate of 37.8 ha per year for the period 2028-2060, for a total footprint of roughly 1247 ha, and development of the Maggie copper project was simulated at a rate of 59 ha per year for the period 2040-2060, for a total footprint of 1239 ha. Total mining footprint growth over the forecast simulation was approximately 4997 ha.

4.3.2 *Urban areas*

Urban area footprint growth trajectories for four municipalities within the SSN (Kamloops, Cache Creek, Ashcroft and Barriere) plus other urban settlements around the SSN were modeled. The SSN is fully within the Thompson-Nicola Census Division and data from this census division was used to formulate population growth projections. The estimated current population density for urban and rural residential areas within the Thompson-Nicola census division is assumed to remain constant into the future (Table 4-1). With density held constant, future increases in population growth as forecasted by BC Statistics can be translated into area growth of settlement footprint.

<table>
<thead>
<tr>
<th>Table 4-1. Decadal growth projections for the Thompson-Nicola Census Division, derived from past SRFA research.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2020</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>6.68%</td>
</tr>
</tbody>
</table>

All natural land-cover types and farmland were eligible to transition to urban settlements. For each of the four municipalities, growth was projected to occur radially from a centroid placed in the most densely populated area of the municipality. Other urban growth was projected for the SSN as a whole. These areas were assigned a size class of 250,000 m² each and were randomly distributed across the SSN in areas within 100 m of developed urban settlements. No urban growth was projected to occur in old growth management areas, provincial parks, protected areas, First Nation reserve boundaries, and the agricultural land reserve.

4.3.3 *Aggregate pits*

Aggregate pits within the SSN are assumed to grow at the Thompson-Nicola population growth rate projection (Table 4-1); 1 ha of aggregate pit footprint is required per year for 25,628 people. We assume that the current population of the SSN traditional territory is 100,000

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8 Radial growth was project from two centroids for the municipality of Kamloops due to geographic sprawl of the urban area.
people and the population will grow to approximately 121,000 people over the next 50 years. Based on this, growth-rate projection, we assume an average annual aggregate-pit growth of 3.8 ha.

All natural land-cover types and farmland were eligible to transition to aggregate pits. Because 89% of aggregate-pit footprint within the SSN is within 2 km of a major road, aggregate pits 32,621 m² in area (the average size of aggregate pits within the SSN) were randomly allocated around the SSN in areas within 2 km of major roads. Aggregate pits were not placed in land identified as old growth management areas, provincial parks, protected areas, First Nation reserve boundaries or in the agriculture land reserve.

4.3.4 Forest harvest

Forest harvest of timber supply areas (TSAs) and tree farm licenses (TFLs) within the SSN were modeled. These areas include: the Kamloops TSA, Merritt TSA, Okanagan TSA, 100 Mile House TSA, TFL 35, and TFL 49. For the purposes of capturing all harvest, Community Forests and Woodlots have been included in the volume forecasts for TSAs. TFL and TSA boundaries do not always conform to the SSN study area boundaries. Therefore, Allowable Annual Cut (AAC) levels for each tenure (m³/year) were modified from those used in the SRFA base-case based on the proportion of each TFL and TSA that is in the SSN. AAC forecasts were then modified from m³/year to ha/year by assuming an average net volume of 274 m³/ha. This is based on information available for the Kamloops TSA, which accounts for the majority of the TSA/TFL area in the SSN. A constant volume per area assumption for the simulation is supported by the graph below, copied from the Kamloops TSA discussion paper, which demonstrates relatively consistent volume per hectare over time (i.e., the majority of harvest being within the 200 to 400 m³/ha category) (Figure 3).

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9 TFL35 (100% of 365.56 km²); TFL49 (520.53 km²/1419.08 km²=36.681%); 100 Mile House TSA (2433.05 km²/12359.79 km²=19.685%); Kamloops TSA (8071.62 km²/26586.23 km²=30.360%); Merritt TSA (587.36 km²/11311.63 km²=5.193%); and Okanagan TSA (548.91 km²/22518.42 km²=2.438%).

10 “A random sampling of 30% of Kamloops TSA cutting permits submitted into the ministry database Electronic Commerce Appraisals System (ECAS) in 2013 shows BCTS and licensees targeting a minimum net volume of 90 cubic metres per hectare; a maximum net volume of 778 cubic metres per hectare, and an average net volume of 274 cubic metres per hectare for cutting authorities within the THLB.” (page 34 of Kamloops TSA Timber Supply Review data Package Update September 2015)
Figure 3. Forecasted forest harvest within the SSN, where the x-axis represents years in the future, the y-axis represents harvest area, and the five colours represent different categories of harvest volume per hectare of land.

The simulation was written so that all forest types within the SSN were eligible for harvest, and cutblocks would be randomly distributed (cluster allocation) across the SSN. In addition, a minimum harvestable age (Table 4-2) was established for each forest type. Size-class distribution (
Table 4-3) was based on the SFRA base-case methodology. Old growth management areas, provincial parks, protected areas, and First Nation reserve boundaries were not deemed eligible for harvest.

Table 4-2. Size-class distribution of cutblocks within the SSN.

<table>
<thead>
<tr>
<th>Area (m²)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,000</td>
<td>49.21</td>
</tr>
<tr>
<td>1,200,000</td>
<td>48.78</td>
</tr>
<tr>
<td>1,700,000</td>
<td>2.00</td>
</tr>
</tbody>
</table>
### Table 4-3. Minimum harvestable age by forest type for natural (pyrogenic) tree stands within the SSN.

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Minimum Harvestable Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-elevation spruce</td>
<td>178</td>
</tr>
<tr>
<td>Mid- to low-elevation spruce</td>
<td>155</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>157</td>
</tr>
<tr>
<td>Interior cedar hemlock</td>
<td>221</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>143</td>
</tr>
</tbody>
</table>

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#### 4.3.5 ACREAGE AND RURAL RESIDENCES

Acreage and rural residence footprint within the SSN is assumed to grow at the Thompson-Nicola population-growth-rate projection (Table 4-1). All natural land-cover types and farmland were eligible to transition to acreages. Acreages 27,073 m² in area (the average size of an acreage within the SSN) were randomly distributed (random allocation) across the SSN in areas within 1 km of major or minor roads and water wells. Old growth management areas, provincial parks, protected areas, and First Nation reserve boundaries were excluded from acreage allocation.

#### 4.3.6 MINOR ROADS

Minor roads connecting major/minor roads to aggregate pits, acreages, surface mines, and cutblocks were modeled. Minor road was assumed to grow 1 m² per year. All natural land-cover types and farmland were eligible to transition to minor roads. Road width was assumed to be the average minor road width in the study area (11.6 m). The model assumed that minor roads would not be developed on old growth management areas, provincial parks, protected areas, and First Nation reserve boundaries.

#### 4.3.7 RECREATION

Three categories of recreation were considered: golf courses; fishing lodges; and Sun Peaks-related recreation. All recreation types were assumed to grow according to the Thompson-Nicola growth-rate projection (Table 4-1) and all natural land-cover types and farmland were eligible for transition to recreation. Old growth management areas, provincial parks, protected areas, First Nation reserve boundaries, and the agricultural land reserve were ineligible for recreation development within the model.

Golf course development makes up 25% of forecasted recreation development within the SSN, and is assumed to take place within the municipality of Kamloops only, within 2 km of major roads. Fishing lodges were also assumed to constitute 25% of future recreation development.

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11 Minimum harvestable ages do not apply to the 100 Mile House TSA, TFL 35, and TFL 49. These areas had a minimum harvestable age of 150 years for all forest types.
within the SSN, and were assumed to occur within 2 km of major roads and 500 m of lakes. Sun Peaks makes up the remaining 50% of recreation development within the SSN and growth is assumed to occur radially from the current centre of the development.

4.3.8 Human Population
Population forecasts for the next three decades are taken from the British Columbia Population Forecast: April 2014 produced by BC Statistics. This forecast is broken down by Census Division and forecasts population growth to 2041. The assessment accounts for the base population as well as anticipated fertility, mortality and migration. Trend lines were extrapolated from this data in order to forecast population growth through to 2060. Further, this population is segregated into 3 categories of settlement based upon their current distribution: urban, acreage, and farm residence.

4.3.9 Cattle Population
The cattle population forecast was based on historic growth rates in British Columbia (7.8%/yr) using a linear growth trajectory. Starting with the 2006 Census of Agriculture Profile data for the Thompson-Nicola Census Division (NTCD), we derived actual SSN herd population using an understanding of where in the NTCD and SSN ranching and dairy operations occur. A weighted average was calculated to determine a 2010 herd population of 47,660 animals. The vast majority of cattle in this region are beef cattle ranched on open range and so for the purposes of simulation, all animals are considered range beef cattle.

Ranching practices are assumed to apply the following feeding regime:

- late fall to early spring – herd is in low elevation areas on private land forage pasture as well as in the Bunchgrass and Ponderosa Pine ecosystems where they eat available grasses and are supplemented with additional feed by ranchers.
- Late spring to early fall – herd is moved up into higher elevation range tenures within the Interior Douglas-fir and spruce dominated ecosystems where they graze.

Key to simulating this spatially is to account for the fact that while the herd is not on any specific lands the entire year, they are assumed to largely consume available feed sources on the land they are on when they are on it. This happens because ranchers optimize the herd size relative to the available feed supply. The implication of this is that the entire herd is located in low elevation areas for approximately ½ the year and in higher elevation areas for the other ½ year.

For the purposes of simulating density impacts on wildlife on an annual basis, total herd population is divided by the area of 1) low elevation forage pasture, Bunchgrass and Ponderosa Pine, and 2) higher elevation Interior Douglas-fir and spruce dominated ecosystems. Range cattle are excluded from the Interior Cedar Hemlock areas of the SSN Traditional Territory.

For the purposes of determining nitrogen and phosphorous inputs into surface water, the number of animals is time weighted for 6 months in low elevation forage pasture, Bunchgrass
and Ponderosa Pine, and 6 months in higher elevation Interior Douglas-fir and spruce dominated ecosystems. Range cattle are excluded from the Interior Cedar Hemlock areas of the SSN Traditional Territory.

4.3.10 **Natural Disturbance**

Natural disturbance is a temporary change in environmental conditions that causes a pronounced change in an ecosystem. Disturbances often act quickly and with great effect, sometimes resulting in the removal of large amounts of biomass. Examples of natural disturbances include wildfires, insect and disease outbreaks, floods, avalanches, and landslides.

4.3.10.1 **Wildfire**

A common technique to model fire behavior is to calculate the mean wildfire return interval, which is simply the average period in years between fires under the presumed fire regime. Given the extensive diversity in ecosystems within the SSN, extensive research was conducted to attempt to determine a mean wildfire return interval for each landscape type.

Two key fire event types have occurred within the study area historically; forest stand and grassland structure replacing fires and stand maintaining fires. Stand replacing events would be intense enough to eliminate the structural attributes of the dominant vegetation and initiate the regeneration of a new stand. Stand maintaining events are typically low intensity fires that do not kill the dominant vegetative cover but act as a key disturbance necessary to maintain the existing stand structure. Stand maintaining fires are common in the dry Douglas-fir ecosystems where low intensity ground fires frequently burn up ground fuel, provide a nutrient flux and maintain the overstory forest. Stand maintaining fire return intervals are much more frequent than stand replacing return intervals however, these fires do not change the forest inventory stand age and so are not used in this analysis. For the purposes of the Base Case, only stand replacing fires are forecasted.

**SSN Base Case Wildfire With Suppression**

In order to estimate mean fire return interval including fire suppression in the SRFA Base Case, the BC Provincial Fire Database was used to calculate the average annual burn rate within the Study area over the past 50 yrs. The average annual burn rate return in the SRFA has been 0.076% across all forest types. There is little variability between landscape types. This is a significant reduction from the natural rate but it corresponds well with reports from the Province of BC. According to the BC Wildfire Service, “Confronted by an average of 2,000 wildfires each year, highly trained fire crews are successful in containing 92 percent of all wildfires in B.C. within the first 24-hours of discovery.” The calculated suppression fire return interval is 14% of the estimated natural fire rate.

The SSN contains 10,364.7532 km² of forest area and therefore we assume that 7,877,212 m² of forest within the SSN are burned annually. According to historical wildfire data, virtually all of the area burned in the SRFA is associated with fires that are larger than the annual fire schedule;
from 1960 to 2014, only 2.3% of area burned has been associated with fires smaller than 7.88 km². For this reason, we wrote the model to simulate two size-classes of fires, randomly distributed (cluster allocation) in the SSN. 97.7% of area burned is of size class 7,690,000 m² and 2.3% is of size class 90,000 m². As such, the size-class-distribution results in one large fire (almost 8 km²) and two small fires (almost 0.1 km² each) each year.

4.3.10.1.1 Natural Wildfire Return Intervals
Natural wildfire return intervals were developed using Wong, Carmen, 2004 - Historical variability of natural disturbances in British Columbia [electronic resource]: a literature review / Carmen Wong, Holger Sandmann, Brigitte Dorner. This compendium provided data from a number of sources including Delong 1998, Dorner et al. 2003, Pollack et al. 1997, Johnson et al. 1990, Francis et al. 2002, Hawkes et al. 1997, Steventon 2001, Blackwell et al. 2001 and van Wagner 1995, based on Masters 1990. Where fire return intervals for a Biogeoclimatic Ecosystem Classification (BEC) subzone were not available, the default Natural Disturbance Type (NDT) intervals as documented in the Forest Practices Code Biodiversity Guidebook 1995 were used as a default. Average Natural Fire Return Intervals used are shown below:

- High elevation spruce ecosystems: 0.57%/yr
- Mixed low elevation spruce: 0.71%/yr
- Douglas Fir: 0.4%/yr
- Interior Cedar and Hemlock: 0.62%/yr
- Ponderosa Pine: 0.4%/yr

4.3.10.2 Insect Outbreaks
The recent mountain pine beetle epidemic within the SSN has been a significant natural disturbance and its effects will be felt in the forests for a very long time. At this time, the epidemic is considered to be largely completed although salvage harvesting continues. While no future epidemics are forecast in the Base Case, all natural disturbance events affecting the dominant forest cover including the mountain pine beetle epidemic of the last two decades, are included in the model as they are captured in the vegetation resources inventory used to build the resultant file.
5 **INDICATOR PERFORMANCE**

5.1 **INDICATOR SELECTION**

Indicators are measurable variables that “indicate” the status or quantity of a value or attribute of interest. For landscape level planning such as this assessment, we select good indicators by screening them through the following indicator selection criteria:

1. Cultural, Economic or Ecological Relevance
2. Response Variability
3. Management Relevance
4. Feasibility of Implementation
5. Interpretation and Utility

Indicators included in this assessment cover landscape composition, land dispossession, wildlife habitat effectiveness and elements of food security. Natural cover and footprint classification follows the scheme used for the SRFA Base Case data set. Forest classifications are based upon the Biogeoclimatic Ecosystem Classification (BEC) of British Columbia.

5.1.1 **FOOTPRINT LINEAR EDGE DENSITY**

Linear edge density is a measure of fragmentation that is highly correlated with changes in wildlife habitat effectiveness, the generation of economic benefits associated with natural resource extraction and improvements in social well being associated with transportation infrastructure. Edge is created when an ecosystem is fragmented by either a linear or polygonal disturbance. Linear edge is primarily created by human transportation corridors; roads, railways, pipelines, transmission lines, trails, etc.

5.1.2 **LAND DISPOSSESSION AND TENURE**

Changes in land management and title/ownership from pre-industrial or pre-contact to the present was analyzed using four categories of information:

1. Direct alienation of land through construction of human footprint features;
2. Location of privately held land;
3. Locations of provincial parks, ecological reserves, and other protected areas;
4. Location of other tenure types (e.g., mineral titles, range tenures, guide-outfitter areas, and the Agricultural Land Reserve).

5.1.3 **GRASSLAND INTEGRITY INDEX**

Grasslands were defined as the combination of the bunchgrass (BG) and ponderosa pine (PP) biogeoclimatic zones, which closely approximates the map of B.C. grasslands used by Blackstock
and McAllister (2004). The grasslands indicator is composed of two components, quantity and quality, as discussed below.

- **Grassland quantity** – quantity of grasslands was defined as the direct removal of grasslands due to construction of anthropogenic features that fully remove these ecosystems (e.g., highways, urban settlement).

- **Grassland quality** – grassland quality was assessed using a “grasslands integrity index” (GII), where reference-condition grasslands (grasslands in the pre-contact period) are defined as having a value of 1.0, and factors that alter these grasslands from reference conditions result in a reduction in this value. For this study, factors leading to alteration include: fire suppression (present across the entire study area), the presence of cattle (ubiquitous throughout the grasslands in the study area with the exception of areas of exclusion such as Lac du Bois), and proximity to roads, which are vectors for invasive species. Weightings for the GII were influenced by information contained in Delesalle et al. 2009.

### 5.1.4 Mule Deer Habitat Effectiveness Index

Mule Deer Habitat Effectiveness Index (HEI) is the product of habitat availability and habitat quality as well as any land use dose response modifiers such as cattle density. Habitat Availability is greatest in Mule Deer Ungulate Winter Range and in the Interior Douglas-fir and Ponderosa Pine BEC’s. Habitat Quality is composed of weighted habitat elements and forest seral stage and structure are weighted as the most influential habitat elements for Mule Deer.

3 additional dose response curves were applied to account for the spatial and temporal implications of key land use factors beyond simply accounting for habitat availability within natural cover and footprint. Modifiers for the density of cattle, crop and forage land and road edge were applied for Mule Deer HEI.

Finally, this product is further adjusted to account for the effective reduction of habitat availability in the winter and spring in deep snow conditions by reducing HEI above 1200 m
above sea level (ASL) by 50% except within Ungulate Winter Range where the full habitat value was maintained regardless of the elevation. Details of these equations are provided in the Appendix.

5.1.5 **WHITE-TAILED DEER HABITAT EFFECTIVENESS INDEX**

White-tailed Deer Habitat Effectiveness Index (HEI) is the product of habitat availability and habitat quality as well as any land use dose response modifiers such as cattle density. Habitat Availability is greatest in White-tailed Deer Ungulate Winter Range and in the Interior Douglas-fir, Ponderosa Pine and Bunchgrass BEC’s. Habitat Quality is composed of weighted habitat elements and forest seral stage, density of crops and forage (benefit) and cattle density are weighted as the most influential habitat elements for Mule Deer.

Three additional dose response curves were further applied to account for the spatial and temporal implications of key land use factors beyond simply accounting for habitat availability within natural cover and footprint. Modifiers for the density of cattle, crop and forage land and road edge were applied for White-tailed Deer HEI.

Finally, elevation limits were used as a surrogate for slope aspect, snow depth, forest structure and snow interception with respect to winter habitat availability and quality, except in areas where ungulate winter ranges were defined. Ungulate winter ranges are considered the limiting habitat for White-tailed Deer and as such were rated as the highest quality habitat available. As such, White-tailed Deer HEI was reduced by 50% above 1100 m above sea level (ASL) except within Ungulate Winter Range where the full habitat value was maintained regardless of the elevation. Details of these equations are provided in the Appendix.

5.1.6 **FISH HABITAT SUITABILITY INDEX**

Fish were modelled generically as species inhabiting the Thompson River mainstems within the study area. This modelling was conducted in two steps: 1) developing a habitat modifier to describe the effects of land use on fish habitat; and 2) developing the final index.

The habitat modifier is based on road density (as a surrogate for sediment and stream morphology impacts), reservoir presence (as a migration barrier), and agriculture and urban areas (as a surrogate for nutrient inputs and riparian disturbance).

Weightings were applied to each of the land uses to reflect their relative influence on fish habitat. The product of all habitat modifiers was used to provide a final habitat modifier index. This habitat modifier index was then multiplied by all areas within a 1000 m buffer of rivers across the study area to provide the final fish habitat-suitability indicator.
5.1.7 **Moose**
Moose Habitat Effectiveness Index (HEI) is the product of habitat availability and habitat quality as well as any land use dose response modifiers. Habitat Availability is greatest in Moose Ungulate Winter Range and in the spruce dominated BEC’s. Habitat Quality is composed of weighted habitat elements and forest seral stage is weighted as the most influential habitat element for Moose, accounting for 70% of the value.

1 additional dose response curve is further applied to account for the spatial and temporal implications of road edge are applied for Moose HEI.

Finally, this product is further adjusted to account for the effective reduction of habitat availability in the winter and spring in deep snow conditions by reducing HEI above 1300 m above sea level (ASL) by 50% except within Moose Ungulate Winter Range where the full habitat value was maintained regardless of the elevation. Details of these equations are provided in the Appendix.

5.1.8 **Sharp-tailed Grouse**

Sharp-tailed Grouse Habitat Effectiveness Index (HEI) is the product of habitat availability and habitat quality as well as any land use dose response modifiers. Habitat Availability is greatest in Bunchgrass BEC. Habitat Quality is composed of weighted habitat elements and agricultural lands and livestock are weighted as the most influential habitat elements.

3 additional dose response curves are further applied to account for the spatial and temporal implications of road edge, range cattle and crops/forage land density are applied.

Finally, this product is confined to the Sharp-tailed Grouse range, which intersects approximately 47% of the SSN Traditional Territory. Details of these equations are provided in the Appendix.

5.1.9 **Elk, Caribou, Grizzly**
In pre-contact times, Elk, Caribou and Grizzly Bears all lived and thrived within the SSN Traditional Territory. However, since the arrival of prospectors and settlers, each of these species is now extirpated (the condition of a species (or other taxon) that ceases to exist in the
chosen geographic area of study, though it still exists elsewhere\textsuperscript{12} from the SSN Traditional Territory.

5.1.9.1 Elk
Deer and elk were the primary ungulates that grazed grassland in the Thompson-Pavilion region before Europeans arrived in 1811. Historical ungulate populations levels are unknown, but by the early 1800s, elk herds in the Thompson-Pavilion region were decimated and have never recovered.\textsuperscript{13} Even though elk are now considered absent from the SSN Traditional Territory, understanding the relative availability and quality of habitat for Elk historically is important and it is useful to understand how re-introduced populations might be expected to perform if that management action was ever taken.

For the purposes of calculating the Protein Index, Elk Habitat Effectiveness Index (HEI) is used. It is the product of habitat availability and habitat quality as well as any land use dose response modifiers. Habitat Availability is greatest in the spruce dominated BEC’s. There is no identified Elk Ungulate Winter Range within the SSN Traditional Territory. Habitat Quality is composed of weighted habitat elements and forest seral stage and cattle density are weighted as the most influential habitat element for Elk.

1 additional dose response curve is further applied to account for the spatial and temporal implications of agricultural lands. Finally, this product is further adjusted to account for the effective reduction of habitat availability in the winter and spring in deep snow conditions by reducing HEI above 1200 m above sea level (ASL) by 50%. Details of these equations are provided in the Appendix.

5.1.9.2 Mountain Caribou
Historically, Mountain Caribou ranges occupied 4,963 km\textsuperscript{2} or 40\% of the SSN Traditional Territory as shown in dark blue in Figure 4. These herds are now classified as extirpated.

\textsuperscript{12} https://en.wikipedia.org/wiki/Local_extinction

\textsuperscript{13} Wikeem, Brian & Sandra. The Grasslands of British Columbia. Grasslands Conservation Council of British Columbia, April 2004. pp 128
For the purposes of calculating the Protein Index, Caribou Habitat Effectiveness Index (HEI) is used. It is the product of habitat availability and habitat quality as well as any land use dose response modifiers. Habitat Availability is greatest in the high elevation spruce dominated BEC’s. Habitat Quality is composed of weighted habitat elements and forest seral stage and linear edge density are weighted as the most influential habitat elements for Mountain Caribou.

1 additional dose response curve is further applied to account for the spatial and temporal implications of road edge. Finally, this product is further adjusted to account for the effective reduction of habitat availability by reducing HEI below 1300 m above sea level (ASL) by 50%. Details of these equations are provided in the Appendix.

5.1.9.3 Grizzly Bear
Historically, 100% of the SSN Traditional Territory was home to viable populations of Grizzly Bears. Today, Grizzly Bears are extirpated from SSN Traditional Territory and beyond as shown in Figure 5. The cumulative effects of human development is the greatest threat to Grizzly bears in B.C.; these effects impact bears in three main (often overlapping) ways:

- Conflicts between bears and humans increase in frequency, often resulting in bears being killed or relocated;
- Bear populations become isolated because of human settlements, agriculture, and utility corridors in major valley bottoms;
- Habitat may be lost or degraded by development, alienated through bears’ avoidance of humans and human activities, or fragmented (for example, by high density road networks with high traffic volumes).  

Figure 5 SSN Traditional Territory (Green) Within the Area Where Grizzly Bears Are Extirpated (purple)

5.1.10  **AN INDEX OF PROTEIN SOURCES**

Wildlife and fish indicators were used to build a synthetic or “index” indicator of native pre-contact protein sources. Discussions with the SSN Technical Working Group indicated five primary animal sources of pre-contact protein: mule deer, elk, caribou, fish, and grouse. The terrestrial indicators in this index were assessed using mean HEI in the RNV (pre-contact) period, current conditions, and future forecast. Because the fish indicator provides information only on a small part of the study area (the Thompson River mainstems), changes in this indicator were incorporated mathematically into the overall index. All indicators in the index were given equal weightings.

The effects of land dispossession on accessibility of the terrestrial components of these protein sources was also examined, by applying a discounted habitat value in modelled cells with land-dispossession values ≤100%, and a zero habitat value to indicators in modelled cells with land-dispossession values >100%. For land-dispossession values ≤100%, the applied discount was a linear function as follows: adjusted HEI = HEI x (1.0 – 0.01 x land dispossession).

6 Results

6.1 Landscape Condition

Table 6-1 & Table 6-2 show the breakdown and area of current and future natural cover and footprint types change in the Base Case.

Table 6-1 Land Cover Area Changes in SSN Base Case

<table>
<thead>
<tr>
<th>Land cover</th>
<th>2010 Current State</th>
<th>2060 Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Area (ha)</td>
</tr>
<tr>
<td>High Elevation Spruce Forest</td>
<td>66,981</td>
<td>66,564</td>
</tr>
<tr>
<td>Mid &amp; Low Elevation Spruce Forest</td>
<td>355,367</td>
<td>354,455</td>
</tr>
<tr>
<td>Douglas-Fir Forest</td>
<td>565,738</td>
<td>563,718</td>
</tr>
<tr>
<td>Cedar Hemlock Forest</td>
<td>14,059</td>
<td>14,005</td>
</tr>
<tr>
<td>Ponderosa Pine Forest</td>
<td>33,825</td>
<td>32,923</td>
</tr>
<tr>
<td>Wetlands</td>
<td>5,696</td>
<td>5,682</td>
</tr>
<tr>
<td>Totals</td>
<td>1,041,666</td>
<td>1,037,347</td>
</tr>
</tbody>
</table>

Table 6-1 shows that the Douglas-fir forest land cover type is forecast to see the highest reduction of all natural land cover types accounting for approximately 47% of the total reduction within the SSN Traditional Territory.

Table 6-2 Footprint Area Changes In SSN Base Case

<table>
<thead>
<tr>
<th>Footprint</th>
<th>2010 Current State</th>
<th>2060 Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Area (km²)</td>
</tr>
<tr>
<td></td>
<td>% of SSN</td>
<td>% of SSN</td>
</tr>
<tr>
<td></td>
<td>2010 Current State</td>
<td>2060 Forecast</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Minor Roads</td>
<td>24,592</td>
<td>24,760</td>
</tr>
<tr>
<td></td>
<td>1.96%</td>
<td>1.97%</td>
</tr>
<tr>
<td>Surface Mine</td>
<td>4,921</td>
<td>10,771</td>
</tr>
<tr>
<td></td>
<td>0.39%</td>
<td>0.86%</td>
</tr>
<tr>
<td>Aggregate</td>
<td>653</td>
<td>875</td>
</tr>
<tr>
<td></td>
<td>0.05%</td>
<td>0.07%</td>
</tr>
<tr>
<td>Urban</td>
<td>6,362</td>
<td>7,920</td>
</tr>
<tr>
<td></td>
<td>0.51%</td>
<td>0.63%</td>
</tr>
<tr>
<td>Acreage</td>
<td>4,962</td>
<td>6,367</td>
</tr>
<tr>
<td></td>
<td>0.40%</td>
<td>0.51%</td>
</tr>
<tr>
<td>Farm Residence</td>
<td>1,184</td>
<td>1,182</td>
</tr>
<tr>
<td></td>
<td>0.09%</td>
<td>0.09%</td>
</tr>
<tr>
<td>Recreation</td>
<td>2,120</td>
<td>2,727</td>
</tr>
<tr>
<td></td>
<td>0.17%</td>
<td>0.22%</td>
</tr>
<tr>
<td>Transmission Line</td>
<td>7,673</td>
<td>7,584</td>
</tr>
<tr>
<td></td>
<td>0.61%</td>
<td>0.60%</td>
</tr>
<tr>
<td>Pipeline</td>
<td>1,670</td>
<td>1,656</td>
</tr>
<tr>
<td></td>
<td>0.13%</td>
<td>0.13%</td>
</tr>
<tr>
<td>Crop</td>
<td>20,567</td>
<td>20,273</td>
</tr>
<tr>
<td></td>
<td>1.64%</td>
<td>1.62%</td>
</tr>
<tr>
<td>Totals</td>
<td>74,704</td>
<td>84,114</td>
</tr>
<tr>
<td></td>
<td>5.96%</td>
<td>6.71%</td>
</tr>
</tbody>
</table>

Table 6-2 shows that Surface Mine footprint is forecast to see the highest increase of all footprint types accounting for approximately 63% of the total increase within the SSN Traditional Territory.

6.2 Linear Edge Density

Linear Edge Density is measured by calculating the number of kilometers of linear edge per square kilometer (km/km2). Current linear edge is composed of major roads, railways, minor roads, roads internal to forest harvest blocks, pipelines and transmission lines. In the Base Case forecast, only minor roads and roads within cutblocks are forecast to increase with the continuing harvest of the forest.

6.2.1 Forest Harvesting Edge

Compared with today, prior to 1950 there were few minor roads within the SSN. However with the establishment of a number of forestry tenures, minor roads grew quickly over the next 5 decades as harvesters accessed the surrounding forestlands. And it is likely that the proportion of logging roads within TSA’s are higher within the SSN than outside of it because of the location or very close location of a number of primary timber manufacturing locations in Kamloops, Vavenby, Merritt and 100 Mile House. Because of this, roads have been developed here first, rather than at the furthest extents of the valleys. Figure 6 shows the progression of minor roads (primarily logging access) within the SSN Traditional Territory over the last half century. The period between 1990 and 2000 saw an especially high increase in the amount of roads constructed.
Figure 6 Historic Increase In Minor Road Edge Density from 1950 - 2000 SSN Base Case

The current density of minor roads (largely Forest Service Roads) means the forested areas of the SSN Traditional Territory are currently highly accessible. The implication for future minor road construction is that fewer new roads are needed within this area than in the past. In many cases it is likely that 2nd pass harvesting is able to capitalize on these existing road networks and the majority of new roads will be “in block” roads with a simulated lifespan of only 20 yrs.

Figure 7 shows first the cumulative new cutblocks to be harvested over the 5 decade forecast. Figure 8 shows with the existing road network (2010) overlaid on this (white lines) clearly showing the extent to which the SSN is already roaded and how many of the scheduled harvest areas are either adjacent to or very nearby this existing road network.
Figure 7 Cumulative Harvest Area Forecast SSN Base Case
Figure 8 Existing Minor Road Network Overlaid On Cumulative Harvest Area Forecast

Figure 9 shows a closer view of forecast harvesting along with the existing road network in the Regional Study Area (RSA).
Table 6-3 shows the decadal changes in Total Linear Edge in the SSN Base Case Forecast. There are differences in the decadal growth because of the spatial distribution of harvest areas forecasted. In some decades like 2030-2040, most of the harvested area is very near the existing road network and so less new construction is required. More new road construction is needed in the other decades, particularly 2010-2020.

**Table 6-3 SSN Base Case Forecast Linear Edge**

<table>
<thead>
<tr>
<th>Decade</th>
<th>Total Linear Edge (km)</th>
<th>Average Linear Edge Density SSN (km/km²)</th>
<th>Decadal % Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>6,102</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>7,473</td>
<td>0.59</td>
<td>22.5%</td>
</tr>
<tr>
<td>2030</td>
<td>8,196</td>
<td>0.65</td>
<td>9.7%</td>
</tr>
<tr>
<td>2040</td>
<td>8,347</td>
<td>0.66</td>
<td>1.8%</td>
</tr>
<tr>
<td>2050</td>
<td>9,314</td>
<td>0.74</td>
<td>11.6%</td>
</tr>
<tr>
<td>2060</td>
<td>9,743</td>
<td>0.77</td>
<td>4.6%</td>
</tr>
</tbody>
</table>
The spatial change in total linear edge density is shown in Figure 10 Total Linear Edge Density SSN Base Case Forecast

![Linear Edge Density](image)

**Figure 10 Total Linear Edge Density SSN Base Case Forecast**

**6.3 Dispossession of Lands & Resources**

Area of the different categories of footprint and tenure that may be prohibitive to SSN use of the land for activities including traditional land uses, and that therefore represent forms of land dispossession, are provided in Table 6-4.

These dispossession types alone cover more than 110% of the SSN traditional territory, although there are areas of overlap such that some places within the territory have more than one type of dispossession limiting SSN use of the land, and others (very few, comprising approximately 2.5% of the traditional territory) have none. It should also be noted that provincial forestry tenures (Timber Supply Areas, Tree Farm Licenses, and B.C. Timber Sales Areas) are not included in this analyses, but on their own also fully occupy the traditional territory.
Table 6-4 Land Dispossession in the SSN Traditional Territory by Category in 2010

<table>
<thead>
<tr>
<th>Dispossession Category</th>
<th>Area (ha)</th>
<th>Proportion of SSN Traditional Territory (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provincial parks, Ecological Reserves, Protected Areas</td>
<td>53,224</td>
<td>4.2</td>
</tr>
<tr>
<td>Direct Anthropogenic Footprint</td>
<td>78,907</td>
<td>6.3</td>
</tr>
<tr>
<td>Private Land</td>
<td>183,779</td>
<td>14.7</td>
</tr>
<tr>
<td>Other non-forestry tenure types</td>
<td>1,062,663</td>
<td>84.7</td>
</tr>
</tbody>
</table>

The combination of the first three dispossession types discussed in Table 6-4 is shown spatially in 2010 in Figure 11. This information indicates that approximately 316,000 ha, or 25%, of the SSN traditional territory has been dispossessed through one of these modes. The map shows a concentration of dispossession around the city of Kamloops and the grasslands to the south, as well as along the Thompson River valleys.
Figure 11. Land dispossession from provincial parks, ecological reserves, protected areas, human footprint, and private land in the SSN traditional territory in 2010. Legend indicates the proportion of each pixel occupied by one of the noted tenure types, where values >100% indicate overlapping modes of dispossession.

The addition of the non-forestry tenure types to the dispossession categories presented in Figure 11 yields the map presented in Figure 12. This map demonstrates that even without inclusion of forestry tenures that have granted forest-harvest rights and the ability to impose associated land management activities on the landscape, almost the entirety of the SSN traditional territory is occupied by at least one tenure type that is restrictive of SSN use of this land base. Multiple restrictive tenure types generally exist in mining areas, provincial parks, and in the concentrations of private lands and footprint development around the city of Kamloops, the river valleys, and the valley bottom grasslands in the centre and south of the traditional territory.

Figure 12. Land dispossession from provincial parks, ecological reserves, protected areas, human footprint, private land, and other non-forestry tenures in the SSN traditional territory in 2010. Legend indicates the proportion of each pixel occupied by one of the noted tenure types, where values >100% indicate overlapping modes of dispossession.
6.4 Grasslands and Wildlife

All grassland and wildlife indicators show dramatic declines within the SSN Traditional Territory from the Pre-contact reference condition to today, ranging from -13% to -100%. HEI’s for Mule Deer, White-tailed Deer and Moose are all forecast to improve over the next 50 years but all will still remain well below the minimum RNV for that species. Elk, Mountain Caribou and Grizzly Bears are all expected to remain extirpated. All other indicators continue to decline from 2010 – 2060 within the SSN Traditional Territory. These results are summarized in Table 6-5. Detailed assessments of each indicator follow.

Table 6-5 Grasslands and Wildlife Changes In SSN Traditional Territory; Pre-contact - 2010 - 2060

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pre-contact Reference</th>
<th>2010</th>
<th>2010 Change (%)</th>
<th>2060</th>
<th>2060 Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassland Quantity</td>
<td>186,529 ha</td>
<td>160,863 ha</td>
<td>-14%</td>
<td>155,975 ha</td>
<td>-16%</td>
</tr>
<tr>
<td>Grassland Quantity, Ajax RSA</td>
<td>63,373 ha</td>
<td>55,137 ha</td>
<td>-13%</td>
<td>51,706</td>
<td>-18%</td>
</tr>
<tr>
<td>Grassland GII</td>
<td>1.00</td>
<td>0.33</td>
<td>-67%</td>
<td>0.32</td>
<td>-68%</td>
</tr>
<tr>
<td>Fish HSI</td>
<td>1.00</td>
<td>0.73</td>
<td>-27%</td>
<td>0.72</td>
<td>-28%</td>
</tr>
<tr>
<td>Mule Deer HEI</td>
<td>0.41</td>
<td>0.32</td>
<td>-23%</td>
<td>0.38</td>
<td>-8%</td>
</tr>
<tr>
<td>White-tailed Deer HEI</td>
<td>0.31</td>
<td>0.24</td>
<td>-22%</td>
<td>0.25</td>
<td>-18%</td>
</tr>
<tr>
<td>Elk HEI</td>
<td>0.22</td>
<td>Extirpated</td>
<td>-100%</td>
<td>Extirpated</td>
<td>-100%</td>
</tr>
<tr>
<td>Moose HEI</td>
<td>0.20125</td>
<td>0.15</td>
<td>-24%</td>
<td>0.17</td>
<td>-15%</td>
</tr>
<tr>
<td>Sharp-tailed Grouse HEI</td>
<td>0.083</td>
<td>0.05</td>
<td>-35%</td>
<td>0.05</td>
<td>-41%</td>
</tr>
<tr>
<td>Mountain Caribou HEI</td>
<td>n/a</td>
<td>Extirpated</td>
<td>-100%</td>
<td>Extirpated</td>
<td>-100%</td>
</tr>
<tr>
<td>Grizzly Bear</td>
<td>n/a</td>
<td>Extirpated</td>
<td>-100%</td>
<td>Extirpated</td>
<td>-100%</td>
</tr>
</tbody>
</table>

6.4.1 Grasslands Quantity

Grasslands comprised approximately 15% (or about 187,000 ha) of the SSN traditional territory in pre-contact times (Figure 13). An analysis of current conditions indicates the absolute loss due
to human land uses of almost 26,000 ha within the traditional territory, or approximately 14% of the original grasslands. This estimate is similar to that reported by other authors (e.g., the Pottinger Gaherty Environmental Consultants Ltd. [2015] cite an estimated loss of 11.8% of the region’s grasslands). Future development over the next 50 years is predicted to remove another 4900 ha, or 3% of the remaining grassland. This loss is primarily caused by urban growth and the development of the proposed Ajax mine.

Figure 13. Pre-contact grasslands in the SSN traditional territory. Displayed colour spectrum ranges from clear (where no grasslands exist in a pixel, showing the underlying satellite imagery) to red (low concentrations of grasslands within the pixel) to yellow (moderate concentrations of grasslands within the pixel) to green (high concentrations of grasslands within the pixel).

These metrics are further pronounced in an examination of the Ajax RSA. In pre-contact times there were approximately 63,000 ha of grasslands in the RSA, or about 1/3 of the grasslands in the SSN traditional territory. Roughly 8200 ha, or 13%, of these grasslands have been lost due to human development at present, and future development over the next 50 years is projected to remove another 3400 ha, or 6% of the remaining grasslands. This loss is shown over time in Figure 14.
Figure 14. Grasslands in the Ajax RSA over time, where the colour spectrum ranges from clear (where no grasslands exist in a pixel, showing the underlying satellite imagery) to red (low concentrations of grasslands within the pixel) to yellow (moderate concentrations of grasslands within the pixel) to green (high concentrations of grasslands within the pixel).

6.4.2 Grasslands Quality

Figure 15 shows the calculated grasslands integrity index (GII) in 2010 for the SSN traditional territory. The remaining least altered native grasslands are located to the northwest of Kamloops in the Lac du Bois grasslands, and to a lesser extent at Tunkwa Lake and Elephant Hill provincial parks to the southwest and west of Kamloops. Reference-condition grasslands have a GII value of 1.0, while the average GII in 2010 (including both remaining and removed grasslands) is 0.33. This value is projected to decline to 0.32 in 2060, primarily due to the physical removal of grasslands through urban expansion of Kamloops and through the proposed development of the Ajax mine.
Grassland integrity is shown at the Ajax RSA scale in Figure 16. Average GII in this area is 0.28 in 2010, and is projected to decline to 0.26 in 2060. One of the larger intact grasslands in this study area is the 2200-ha area north of the proposed mine development, and south of the Aberdeen neighborhood in the city of Kamloops. Development of the proposed Ajax mine will remove the southern portions of this grasslands complex. The high magnitude of alteration from reference conditions in the Ajax RSA is due to fire suppression, cattle grazing, introduction of non-native and invasive species, and physical removal of grasslands due to construction of human footprints (primarily the proposed development of the Ajax mine, and to a lesser extent the urban development of the city of Kamloops).

Integration of quantity and quality as an aggregate metric suggests that there has been an approximate 67% decrease in the integrity of native grasslands in the SSN traditional territory from pre-contact times to the present, and a 72% decrease within the Ajax RSA.
6.5 Fish Habitat Suitability Index

The current state of the fish habitat indicator relative to reference conditions is shown in Figure 17. Average values across the study area have declined by 27.5% from reference values, but some areas are higher, in excess of 50% declines. Our forecast simulation projects further marginal declines, due primarily to expansion of road networks and urban areas. These observations are corroborated by other authors including Pottinger Gaherty Environmental Consultants Ltd. 2015, whose review states that the Interior Fraser coho population is at risk, and that human activities are directly related to the population’s decline. According to a Committee On The Status Of Endangered Wildlife In Canada (COSEWIC) report, the Thompson River watershed supports most of the coho salmon of the interior Fraser. Logging, agriculture, cattle grazing, building dikes, and irrigation have all severely impacted coho habitat in this watershed. Between 1988 and 1998, coho spawner abundance in the South Thompson River declined more rapidly than spawners in the North Thompson River, which correlates to impacts of land use on each river; the South Thompson River has more human-related impacts than the North Thompson River.¹⁵

6.6 Mule Deer Habitat Effectiveness Index

At the SSN Traditional Territory scale, Mule Deer HEI is currently 23% below the estimated RNV. Over the forecast period of 5 decades Mule Deer HEI rises steadily at an average of 3.8%/decade to within 4.5% of the lower end of the RNV. This is shown in Figure 18 and Table 6-6. This is primarily due to a shifting in forest age class structure as a result of forest harvesting and wildfire. Mule Deer highly favors forest <60 yrs old and >140 yrs old and both of these demographics are increasing in proportion over the forecast period.
Table 6-6 Mule Deer HEI Base Case SSN

<table>
<thead>
<tr>
<th>Decade</th>
<th>Average HEI Across SSN</th>
<th>Decadal Change (%)</th>
<th>Difference</th>
<th>50yr % difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>0.32</td>
<td>0.36%</td>
<td>1.12%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>0.34</td>
<td>1.34%</td>
<td>4.15%</td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>0.35</td>
<td>1.79%</td>
<td>5.33%</td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>0.37</td>
<td>1.53%</td>
<td>4.33%</td>
<td></td>
</tr>
<tr>
<td>2060</td>
<td>0.38</td>
<td>1.51%</td>
<td>4.11%</td>
<td>20.5%</td>
</tr>
<tr>
<td>RNV max</td>
<td>0.4283</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RNV min</td>
<td>0.4009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 18 Mule Deer HEI SSN Base Case Forecast & RNV
Figure 19 Mule Deer HEI RNV and 2010 SSN Base Case

Figure 20 Mule Deer HEI 2010 - 2060 SSN Base Case
Very similar trends are observed at the RSA scale where HEI increases at a similar rate with changing forest demographics but remaining below the RNV. This is shown spatially and temporally in Figure 21.

Figure 21 Mule Deer HEI RNV, 2010, 2060 At RSA Scale - SSN Base Case

Mule Deer are considered to be relatively resilient with respect to disturbance footprints as long as there is food, some cover and good winter range. This resilience is reflected in the overall increase in HEI driven by an improvement in forest seral stage distribution.

At the SSN Traditional Territory scale, a sharp difference is observed spatially as a result of the elevation modifier and this is a noted limitation. A more refined Mule Deer HEI that incorporates slope aspect, and snow depth is a suggested improvement for future models.

6.7 WHITE-TAILED DEER

At the SSN Traditional Territory scale, White-tailed Deer HEI is currently 22% below the estimated RNV. Over the forecast period of 5 decades Mule Deer HEI rises steadily at an average of 1%/decade to within 6% of the lower end of the RNV but still 18% below the average
RNV. This is shown in Table 6-7 and Figure 22. The increase is a result of improving forest age class structure primarily due to a forest harvesting and wildfire. White-tailed Deer highly favors forest <60 yrs old and >160 yrs old and both of these demographics are increasing in proportion over the forecast period. In addition, White-tailed Deer benefit significantly from the presence of forage crops and grasslands despite competition from cattle.

Table 6-7 White-tailed Deer HEI SSN Base Case

<table>
<thead>
<tr>
<th>Decade</th>
<th>Average HEI Across SSN</th>
<th>Decadal Change (%)</th>
<th>Difference</th>
<th>50yr % difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>0.24</td>
<td>0.21%</td>
<td>0.86%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>0.24</td>
<td>0.02%</td>
<td>0.08%</td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>0.25</td>
<td>0.23%</td>
<td>0.96%</td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>0.25</td>
<td>0.35%</td>
<td>1.41%</td>
<td></td>
</tr>
<tr>
<td>2060</td>
<td>0.25</td>
<td>0.35%</td>
<td>1.42%</td>
<td>4.82%</td>
</tr>
<tr>
<td>RNV min</td>
<td>0.297</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RNV max</td>
<td>0.321</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 22 White-tailed Deer HEI SSN Base Case Forecast & RNV
Figure 23 White-tailed Deer HEI RNV & 2010 SSN Base Case

Figure 24 White-tailed Deer 2010 - 2060 SSN Base Case
The proposed Ajax mine footprint would largely connect the very low value habitat to the south with the loss of habitat in the city of Kamloops. The effects of this movement restriction are not fully known but it is a diversion from the much more connected state that exists there today.

![Figure 25 White-tailed Deer HEI RNV, 2010, 2060 At RSA Scale - SSN Base Case](image)

White-tailed Deer are relatively resilient with respect to disturbance footprints as long as there is food, some cover and good winter range and so respond positively to the forecast change in forest demography. As is observed with Mule Deer, a sharp difference in HEI spatially results from the elevation modifier and is a noted limitation. A more refined White-tailed Deer HEI that incorporates slope, aspect, snow depth along with forest structure and age is a suggested improvement for future models.
6.8 **MOOSE**

At the SSN Traditional Territory scale, Moose HEI is currently 21 % below the estimated RNV and this is quite obvious in the amount of red vs green between 2010 and RNV in Figure 27. Over the forecast period of 5 decades Moose HEI rises steadily at an average of 2.4%/decade but is still 10.5% below the lower end of the RNV. This is shown in Table 6-8 and Figure 26. This increase is primarily due to a shifting in forest age class structure as a result of forest harvesting and wildfire. Moose highly favors forest <60 yrs old and >180 yrs old and both of these demographics are increasing in proportion over the forecast period. Like Deer, Moose are relatively resilient with respect to disturbance footprints as long as there is food, some cover and good winter range and so respond positively to the forecast change in forest demography. A more refined Moose HEI that incorporates slope, aspect, snow depth along with forest structure and age is a suggested improvement for future models.

**Table 6-8 Moose HEI SSN Base Case**

<table>
<thead>
<tr>
<th>Decade</th>
<th>Average HEI Across SSN</th>
<th>Decadal Change (%)</th>
<th>Difference</th>
<th>50yr % difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>0.15</td>
<td>-0.01%</td>
<td>-0.05%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>0.15</td>
<td>0.14%</td>
<td>0.94%</td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>0.16</td>
<td>0.53%</td>
<td>3.46%</td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>0.16</td>
<td>0.53%</td>
<td>3.32%</td>
<td></td>
</tr>
<tr>
<td>2060</td>
<td>0.17</td>
<td>0.72%</td>
<td>4.36%</td>
<td>12.55%</td>
</tr>
<tr>
<td>RNV min</td>
<td>0.192</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RNV max</td>
<td>0.211</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 26 Moose HEI SSN Base Case Forecast & RNV
Figure 27 Moose HEI RNV & 2010 SSN Base Case

Figure 28 Moose 2010 - 2060 SSN Base Case
Similar to the trends observed at the SSN Traditional Territory scale, Moose HEI is quite degraded at the RSA scale and the proposed Ajax mine will result in more direct loss of habitat as shown in Figure 29.

Figure 29 Moose HEI RNV, 2010, 2060 At RSA Scale - SSN Base Case
6.9 Sharp-tailed Grouse

At the SSN Traditional Territory scale, Sharp-tailed Grouse HEI is currently 35% below the estimated RNV. Over the forecast period of 5 decades Sharp-tailed Grouse HEI continues to decline a further 10.4% at an average of 2%/decade to 41% below the average RNV. This is shown in Table 6-9 and Figure 30. The HEI is restricted spatially to the identified Sharp-tailed Grouse range and this area which is largely composed of grassland dominated ecosystems has and is forecast to continue to experience direct losses from footprint, structural shifts due to fire suppression and habitat quality degradation from cattle grazing.

Table 6-9 Sharp-tailed Grouse HEI SSN Base Case

<table>
<thead>
<tr>
<th>Decade</th>
<th>Average HEI Across SSN</th>
<th>Decadal Change (%)</th>
<th>Difference</th>
<th>50yr % difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.054</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>0.053</td>
<td>-0.09%</td>
<td>-1.66%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>0.052</td>
<td>-0.18%</td>
<td>-3.30%</td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>0.051</td>
<td>-0.10%</td>
<td>-1.86%</td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>0.050</td>
<td>-0.11%</td>
<td>-2.12%</td>
<td></td>
</tr>
<tr>
<td>2060</td>
<td>0.049</td>
<td>-0.09%</td>
<td>-1.84%</td>
<td>-10.4%</td>
</tr>
</tbody>
</table>

RNV midpoint 0.083

![Grouse HEI SSN](image)

Figure 30 Sharp-tailed Grouse HEI SSN Base Case Forecast & RNV Midpoint

In British Columbia, breeding populations are now extirpated from the Okanagan Valley, which has effectively isolated Canada’s populations from those in Washington. Columbian Sharp-
tailed Grouse are restricted to grasslands and large openings in forested areas of the South Central interior of British Columbia. Although it is believed that this subspecies has benefited from large-scale harvesting in the northern portions of their range, grassland populations have experienced significant declines.\footnote{16} Sharp-tailed Grouse are now a “Blue-listed” species acknowledging it as a provincial subspecies at risk, considered to be vulnerable.

\begin{figure}[h]
\centering
\includegraphics[width=\columnwidth]{sharp-tailed-grouse-hei.png}
\caption{Figure 31 Sharp-tailed Grouse HEI RNV & 2010 SSN Base Case}
\end{figure}

While degradation to date from Pre-contact has been significant, much of the future degradation of Sharp-tailed Grouse HEI is associated with direct footprint loss from the proposed Ajax mine. This is quite visible in Figure 33.
Figure 33 Grouse HEI RNV, 2010, 2060 At RSA Scale - SSN Base Case

6.10 **PROTEIN INDEX**

**Pre-contact Terrestrial Protein Index**

The index of primary pre-contact terrestrial animal protein sources is displayed during pre-contact (RNV) and current conditions (2010) in Figure 34 and Figure 35, respectively. This information shows the decline in the average of these pre-contact protein sources, primarily due to the extirpation of elk and caribou from the study area, of approximately 49% from RNV conditions. Note that this analysis shows that the highest quality habitat for these key protein species are in the valleys near Kamloops and downstream on the Thompson River, and south of Kamloops.
The effect of habitat loss and alterations that are reflected in the above analysis are compounded by the effects of land dispossession and loss of access discussed in Section 6.3. This combined analysis is presented in Figure 36, and demonstrates that the majority of the highest quality habitat for these species in the valley bottoms is largely inaccessible due to the
granting of private title and construction of human footprint in these areas. When these restrictions are accounted for, there is a 62% decline in availability of these protein sources under current conditions in comparison to the pre-contact period.

Figure 36. Index of pre-contact terrestrial protein sources showing effects of land dispossession, current conditions. Legend in inset.

A similar analysis\(^{17}\) is presented for the RSA for the proposed Ajax project in Figure 37. This figure clearly shows that the majority of the highest-quality habitat has already been removed from SSN access through a combination of tenure and direct-disturbance mechanisms. The area of the proposed Ajax project represents a remnant of relatively accessible remaining habitat that will be lost if the mine is developed. The analysis presented in Figure 37 indicates that the

\(^{17}\) This analysis is based only on mule deer, elk, grouse, and fish, as the Ajax RSA is not a known historic caribou range.
Decline in accessible terrestrial animal protein sources is 74% in current conditions compared to the pre-contact period.

Figure 37. Index of pre-contact terrestrial animal protein sources showing effects of land dispossession in the RSA for the proposed Ajax project during the pre-contact period, current conditions, and 2040.

Pre-contact Total Protein Index

Addition of the fish indicator to the terrestrial protein indicators shows a total pre-contact protein indicator decline of 36% from pre-contact to current conditions. When the effects of tenure and direct displacement are added, the estimated decline is 42%.

Note that all indicators show some improvement over the forecast period, despite the included development of the proposed Ajax mine. This is based on the projected improvement in mule deer habitat over time (for a more detailed discussion on reasons behind this improvement, see Section 6.6).
The discussed analyses of protein-index performance are summarized in Table 6-10.

**Table 6-10. Summary of changes in protein indicators from pre-contact to current conditions.**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pre-contact Reference (RNV)</th>
<th>2010</th>
<th>RNV - 2010 Change (%)</th>
<th>2060</th>
<th>RNV - 2060 Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial protein</td>
<td>0.18</td>
<td>0.09</td>
<td>-49%</td>
<td>0.11</td>
<td>-40%</td>
</tr>
<tr>
<td>Terrestrial protein + dispossession</td>
<td>0.18</td>
<td>0.07</td>
<td>-62%</td>
<td>0.08</td>
<td>-55%</td>
</tr>
<tr>
<td>Terrestrial protein + dispossession, Ajax RSA</td>
<td>0.29</td>
<td>0.08</td>
<td>-74%</td>
<td>0.09</td>
<td>-70%</td>
</tr>
<tr>
<td>Total protein index</td>
<td>0.34</td>
<td>0.22</td>
<td>-36%</td>
<td>0.23</td>
<td>-33%</td>
</tr>
<tr>
<td>Total protein index + dispossession</td>
<td>0.34</td>
<td>0.20</td>
<td>-42%</td>
<td>0.21</td>
<td>-39%</td>
</tr>
</tbody>
</table>

**6.11 SUMMARY OF RESULTS**

Results of this work demonstrate substantial effects for all of these indicators from the pre-contact period to current conditions. All grassland and wildlife indicators show estimated declines within the SSN Traditional Territory ranging from 13% to 100%. In addition, development of the proposed Ajax mine project is shown to further contribute to decline in future indicator performance for the grasslands and protein indices. Performance for the key selected indicators is summarized below:

- **Land dispossession and tenure** – roughly 316,000 ha, or 25%, of the SSN traditional territory has been dispossessed through granting/sale of private lands, designation of provincial parks or other protected areas, and through direct construction of human footprint. These dispossessed areas are generally concentrated around the city of Kamloops and the grasslands to the south, as well as along the Thompson River valleys. Addition of non-forestry tenure types (mineral leases, guide-outfitter areas, range tenures, and the Agricultural Land Reserve) brings the total dispossessed land to 110% of the traditional territory. This analysis demonstrates that even without inclusion of forestry tenures that have granted forest-harvest rights and the ability to impose associated land management activities on the landscape, almost the entirety of the SSN traditional territory is occupied by at least one tenure type that is restrictive of SSN use of this land base.
• **Grasslands quantity and quality** – grasslands comprised approximately 15% of the SSN traditional territory in pre-contact times. An analysis of current conditions indicates the absolute loss due to human land uses of almost 26,000 ha within the traditional territory, or approximately 14% of the original grasslands. These metrics are further pronounced in an examination of the Ajax RSA. In pre-contact times there were approximately 63,000 ha of grasslands in the RSA, or about 1/3 of the grasslands in the SSN traditional territory. Roughly 8200 ha, or 13%, of these grasslands have been lost due to human development at present, and future development over the next 50 years is projected to remove another 3400 ha, or 6% of the remaining grasslands. One of the larger intact grasslands in the RSA is the 2200-ha area north of the proposed mine development, and south of the Aberdeen neighborhood in the city of Kamloops.

Declines in grassland quality are also estimated to have occurred and to continue occurring, both at the scale of the SSN traditional territory and within the RSA for the proposed Ajax mine. These declines are due to the combined effects of fire suppression, cattle grazing, introduction of non-native and invasive species, and physical removal of grasslands due to construction of human footprints.

Integration of quantity and quality as an aggregate metric suggests that there has been an approximate 67% decrease in the integrity of native grasslands in the SSN traditional territory from pre-contact times to the present, and a 72% decrease within the Ajax RSA.

• **Mule deer** – the habitat-effectiveness index for mule deer is currently 21% below the estimated lowest pre-contact level. This index is predicted to recover over the 50-year forecast driven by changes in forest demographics, but will still remain well below the minimum pre-contact level for this species.

• **Fish** – fish habitat is estimated for species that occur within the mainstems of the Thompson Rivers, including interior Fraser coho, an at-risk population. Average fish-habitat values across the study area have declined by 27.5% from reference values, but some areas are higher, with declines in excess of 50%. These estimates of decline are conservative, in that they are based solely on a narrow assessment of mainstem habitat values, and do not account for temperature and flow effects within the river, nor population effects due to other factors. In addition, due to its limitation to the mainstem Thompson rivers, our analysis was not able to assess effects on fish inhabiting the Pipsell (Jacko Lake) area and associated watercourses.

• **Index of animal protein sources** - The index of primary pre-contact terrestrial animal protein sources has declined by approximately 49% in current conditions from the pre-contact period, due both to degradation of grouse and mule-deer habitat and due to extirpation of elk and caribou from the traditional territory. Combining the effects of habitat degradation, extirpation, and land dispossession indicates an even greater effect: a 62% decline in availability of these protein sources under current conditions in comparison to the pre-contact period, as the majority of the highest quality habitat for
the traditional protein species is largely inaccessible due to the granting of private title and construction of human footprint. As with the grasslands analysis, these effects are further pronounced in the RSA for the proposed Ajax mine – in this area, the decline in accessible terrestrial animal protein sources is 74% in current conditions compared to the pre-contact period.

Addition of the fish indicator to the terrestrial protein indicators shows a total pre-contact protein indicator decline of 36% from pre-contact to current conditions. When the effects of tenure and direct displacement are added, the estimated decline is 42%.

These and supporting analyses conducted for this report show the already substantial cumulative effects of land-management decisions and use in the SSN traditional territory, with generally large changes estimated from the pre-contact period to the present. Although the proposed Ajax project is relatively small, it is an additional stressor on the territory’s ecosystems and the organisms that depend on them, and its development would cause further loss to key SSN indicators, particularly grasslands and related species.
7 REFERENCES


